Intra-Household Allocation of Time and Money

Ivor Ko
Magdalen College
University of Oxford

A thesis submitted for the degree of
Doctor of Philosophy

Trinity 2012

Acknowledgements

Particular thanks are due to my supervisor, Martin Browning, for his advice and guidance, and to Steve Bond for helpful comments at an earlier stage. I am also very grateful to the Department of Economics and Magdalen College for their financial support and for providing a most pleasant and constructive working environment. Deepest gratitude is also due to Geraldina Mattsson for the many long walks and discussions. Finally, I am especially grateful to my family for their support and encouragement throughout this journey.

Abstract

There are four parts to this thesis: the first chapter analyses the structure of leisure in couples with particular emphasis on joint leisure. We take a structural approach and model the household as a two-stage decision making unit. The findings suggest that couples see joint leisure as a distinct good from private leisure. Specifically when a household decides to have more leisure, almost 40 percent of this increase is allocated to joint leisure as opposed to only 8 to 15 percent allocated to male private leisure. Furthermore, couples prefer to spend leisure together (synchronisation) relative to spending time independently, giving joint leisure the largest weight in the utility function. The findings further suggest that demographics can play a large role in determining the patterns of spousal leisure, with ethnicity and job characteristics being important factors. Finally, when analysing weekend time use patterns, there is evidence to suggest that Saturdays should be distinguished from Sundays as approximately 41 percent more joint leisure is observed on Sundays.

The second chapter of the thesis begins our examination of the UK income taxation reform in 1990. The UK went from a system of joint taxation to independent taxation of couples and this reform may have had important implications for households. Across countries, there is a large variation in the income tax treatment of couples. Over the last three decades, many countries have undergone reforms in their tax systems, some have moved from joint to independent taxation, some from independent to joint, while others have begun the practice of allowing couples to choose the system they prefer. This chapter aims to give an overview of the tax treatment of couples and outlines the differences across countries, with particular emphasis on the tax reform in the UK.

The third chapter investigates the UK income taxation reform in 1990 and examines how the change from a system of joint to independent taxation of couples has shifted women's relative earning potentials in the household,

and how this in turn has led to changes in intra-household assignable clothing expenditures. I apply my method to a sample of UK couples with children and the findings of this chapter show that an exogenous increase in women's income relative to their spouse significantly and substantially increases female clothing expenditure and decreases male clothing expenditure ceteris paribus. However an increase in relative female earnings does not necessarily mean that children will do better relatively. The final outcome may depend on the type of transfer in question. In addition, there is evidence that the final allocations of expenditures on each partner and children may depend significantly on distribution factors such as spousal relative incomes, age gap and educational gap, despite the fact that these variables do not impact on preferences nor on budgets directly. This provides further evidence against the unitary framework in favour of the collective approach and the sharing rule interpretation of how households make decisions in practice.

The final chapter of this thesis examines the effects of the tax reform in 1990 with particular emphasis on female labour supply. A method of clarifying the concept of a spouse's individual net income under a joint tax regime is proposed and following the methodology of Blundell et al (2007), the labour supply elasticities for both male and female are estimated. The analysis is extended further to include children in the model and the results show that both the number of children and their age are highly significant for women's labour supply and to a smaller extent also for men. Testing the income pooling hypothesis, the unitary model is not rejected. However, the results strongly reject the hypothesis that distribution factors have no effect on labour supply. The results also suggest that for the group of women affected, the reform generated two opposing effects on their labour supply: a positive effect from an increase in net wage and a negative effect from an increase in bargaining power. On balance, we find that a typical female decreased her labour supply by approximately 2.6 hours per week, yet she still experienced a 22 percent increase in her net income.

Contents

1 Time Use In Many-Person Households **11**

1.1 Introduction 13

1.2 Theory of household leisure allocation 16

1.2.1 Modelling leisure allocation within the household 16

1.2.2 Zero observations: Infrequency versus choice 18

1.2.3 The Stone-Geary model 19

1.2.4 Parameterisation choice 21

1.2.5 Capturing heterogeneity 22

1.3 The Structure of the data 23

1.3.1 The United Kingdom Time Use Survey 2000 23

1.3.2 Data description 24

1.4 Empirical specification 33

1.4.1 Methodology 33

1.4.2 Endogeneity and instrumental variables 33

1.4.3 Empirical specification and structural identification 36

1.5 Results 38

1.5.1 Test for weak instruments 41

1.6 Structural estimates and implications 44

1.7 Specification checks 45

1.7.1 Test for underidentification 45
1.7.2 Test for weak instruments 46
1.7.3 Test for overidentifying restrictions(OIR) 46
1.7.4 Hausman test for endogeneity 47
1.8 Conclusion 48
1.9 Appendix 50
1.9.1 Activities coding 50
1.9.2 The identification of $(\gamma_A, \gamma_B, \gamma_L)$ in the Stone-Geary model 51
1.10 Separability between weekday and weekend 53

2 Taxation of Married Couples **55**
2.1 Introduction 57
2.1.1 Joint and independent taxation 57
2.1.2 Principal features of income taxation systems 58
2.2 Theoretical analysis of the taxation of married couples 60
2.2.1 Optimal taxation of married couples 60
2.2.2 Economic implications of the two systems 62
2.2.3 Examples: Taxing married couples 64
2.3 Motivation behind UK 1990 tax reform 66
2.4 Tax systems across countries 68
2.5 An overview of the UK income tax system 70
2.6 Conclusion 73
2.7 Appendix 75

3 Taxation of Couples and Intra-Household Outcomes **77**
3.1 Introduction 79
3.2 Theory and evidence on intra-household allocation 81
3.2.1 Unitary models and rationale for household models 81

3.2.2 Household models . . . 84
3.2.3 A general collective approach . . . 86
3.2.4 Household expenditure and the sharing rule . . . 89
3.2.5 Characterising the demand functions . . . 91
3.3 Using tax reform to generate a distribution factor . . . 93
3.4 Structure of the data . . . 95
3.4.1 Family Expenditure Survey . . . 96
3.4.2 Constructing a pseudo panel dataset . . . 97
3.4.3 Data description . . . 98
3.5 Empirical results . . . 102
3.5.1 Methodology . . . 102
3.5.2 Estimation . . . 104
3.5.3 Results . . . 105
3.6 Specification checks . . . 112
3.6.1 Test for overidentifying restrictions(OIR) . . . 113
3.6.2 Test for weak instruments . . . 113
3.6.3 Test for underidentification . . . 114
3.6.4 Hausman test for fixed effects . . . 115
3.6.5 Including a full set of time dummies . . . 115
3.7 Conclusion . . . 118
3.8 Appendix . . . 127
3.8.1 Joint Test of significance for *Power* and *Powerzero* . . . 127
3.8.2 Joint test of significance for other distribution factors . . . 127
3.8.3 Joint test of significance for *numkids* and *kidsu*5 . . . 127

4 Taxation and Labour Supply of Married Couples **129**
4.1 Introduction . . . 131

4.2 Theory 134
4.2.1 Unitary model 134
4.2.2 Collective model 137
4.2.3 Household utility: Prices, income and distribution factors 145
4.2.4 Sharing rule and the Pareto weight 146
4.3 Unitary model and Income taxation 147
4.3.1 Independent taxation with private consumption goods 147
4.3.2 Joint taxation with private consumption goods 148
4.4 Collective model and Income taxation 150
4.4.1 Independent taxation 150
4.4.2 Joint taxation 152
4.5 Definition of net income 155
4.6 Structure of the data 157
4.7 Estimation 166
4.7.1 Non-participation and sample selection bias 167
4.7.2 Empirical specification 171
4.7.3 Identification and exclusion restrictions 176
4.8 Results 180
4.8.1 Model diagnostics 180
4.8.2 Baseline results 181
4.8.3 Estimating the effect of the tax reform 183
4.8.4 Testing the restrictions of the unitary model 187
4.9 Conclusion 188
4.10 Appendix 194
4.10.1 Proportionality Property of Distribution Factors 194

Bibliography **195**

List of Figures

1.1 A sample diary 25

1.2 Household Leisure for Weekday 27

1.3 Household Leisure for Weekend 28

1.4 Relationships between Joint and Private Leisure 29

1.5 Household Weekly Total Leisure and Joint Leisure 30

1.6 Household Total Leisure and Joint Leisure on Weekend & Weekday . . . 30

3.1 Female and Male Gross Weekly Earnings (1986 - 1993) 121

3.2 Household Net Annual Income (1986 - 1993) 122

3.3 Household Power Measure (1986 - 1993) 122

3.4 Power against Age of Wife by Cohort and Education Level. Low Education Level (Left) and High Education Level (Right) 123

3.5 Female Clothing Expenditure Share against Tax Year by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right) 123

3.6 Male Clothing Expenditure Share against Tax Year by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right) 124

3.7 Children Clothing Expenditure Share against Tax Year by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right) 124

3.8 Female Clothing Expenditure Share against Age of Wife by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right) 125

3.9 Male Clothing Expenditure Share against Age of Wife by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right) 125

3.10 Children Clothing Expenditure Share against Age of Wife by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right) 126

3.11 Histogram for Power Measure 126

4.1 Labour Force Participation Rates (1986 - 1993) 161

4.2 Male and Female Labour Supply Per Week (1986 - 1993) 162

4.3 Labour Force Participation Rates by Age (1986 - 1993) 163

4.4 Male and Female Gross Weekly Earnings (1986 - 1993) 164

4.5 Male and Female Net Weekly Earnings (1986 - 1993) 165

Chapter 1

Time Use In Many-Person Households

Abstract

This paper provides a different approach to understanding the underlying preference structure of leisure in couples. In particular, one of the key aims is to highlight the central role of joint leisure as it is often neglected in economic analysis. In this study, we employ a structural approach and model the household as a two-stage decision making unit. Our findings suggest that couples see joint leisure as a distinct good from private leisure. Specifically when a household decides to have more leisure, almost 40 percent of this increase is allocated to joint leisure as opposed to only 8 to 15 percent allocated to male private leisure. Furthermore, couples prefer to spend leisure together (synchronisation) relative to spending time independently, giving joint leisure the largest weight in the utility function. The findings further suggest that demographics can play a large role in determining the patterns of spousal leisure, with ethnicity and job characteristics being important factors. Finally, when analysing weekend time use patterns, there is evidence to suggest that Saturdays should be distinguished from Sundays as approximately 41 percent more joint leisure is observed on Sundays.

1.1 Introduction

In recent years, detailed data of time use of individuals and households have become increasingly available across countries, making it finally possible to observe many household activities that simply could not be quantified in the past. In particular, this advancement in data collection has made possible the improvement in economic modelling of leisure choices. It has been suggested that in modern society, household leisure patterns could be the single most important factor in determining household cohesion and healthy relationships between spouses and their children (Zabriskie and McCormick (2004)). Couples who spend a lot of time together are likely to have more common friends, and could form a joint lifestyle. This creates a type of dependency, and more of their well-being is dependent on each other. Naturally this raises the cost of a dissolution of partnership and could have implications for policy considerations such as partnership break-downs and divorce. (Kalmijn and Bernasco (2004), Milardo (1987))

This paper is certainly not the first to ask the question about how households spend their time. Time use was first introduced to economics by Becker (1965). In Becker's original model, time and market goods are combined into basic commodities via a household production function. However, the concept of different types of leisure simply did not exist. The next advancement in the study of time use was Gronau (1977)'s model on the allocation of time in market work, housework and leisure. Gronau's original model contains only one person, making the analysis of joint leisure choices impossible. Even when his model was extended by Solberg and Wong (1992), there was still no reference to joint leisure as a commodity in a household.

The next wave of research on spousal time use focused on the "gains of marriage" such as the specialisation of household production and the desire for simultaneous leisure. Hamermesh (2000) finds that synchronisation in couples is greater than random male-female pairing would predict. Similarly, Hallberg (2003) compares the activities timing of real couples with that of matched pseudo couples and finds that real couples have approximately 45 minutes more synchronised leisure in a day. Other studies such as Sullivan (1996), Jenkins and Osberg (2005) also find active synchronisation in real couples compared with statistically matched couples. Recent work by Connelly and Kimmel (2009) finds some evidence that private leisure of husbands and wives appear to be complementary but Prowse (2004) finds that time allocation behaviour of husbands and wives differ substantially.

There has also been extensive research into the economic variables affecting joint leisure. However, the results are mixed. For example, Hamermesh (2000) finds that all economic variables analysed such as children, age and education are important, in particular the effect of children affecting joint leisure negatively on weekdays. Jenkins and Osberg (2005) finds that only some variables play a role. Ruuskanen (2004) also finds that some variables like age and gender were important. Hallberg (2003) on the contrary, finds that none are relevant. However, there are significant problems with comparing and assessing these existing results in the literature. First of all, each study uses datasets from different countries. In addition to the differences in the data collection process, there is as yet no consensus as to whether time use patterns could be generalised across countries as culture and habits could play an important role. Secondly, most studies have only focused on weekdays, despite the fact that one would expect most joint time use to be observed on weekends. Even when weekends were included in such as Connelly and Kimmel (2009), households were only observed once either on a weekday or weekend day but not both, making comparisons impossible. Moreover, when considering weekend leisure patterns, it is unclear if Saturdays could be treated as equivalent to Sundays. Finally, in many studies female and male leisure patterns have been assumed to be identical except for a dummy variable. This may not be entirely satisfactory because husbands and wives may not simply differ by a shift factor. It is therefore not entirely clear as to how these results would change once these elements have been considered.

This paper is a modest attempt to extend the existing research in the literature and endeavours to provide some answers to the questions raised in the literature. First of all, we take a more practical approach and focus on actual observed joint leisure choices made by couples, as opposed to some previous studies where matching or predictions were used. We are able to exploit the rich diary information in the UK Time Use Survey 2000 (UKTUS)[1], which allows us to directly observe whom each individual was spending time with over the 24 hour diary period. Thus making it possible to disentangle private leisure from joint leisure. Secondly, the UKTUS allows us to observe the same couple twice, once during a weekday and once during a weekend day. This enables us to compare how household leisure choices may change over weekdays versus weekend days and establish whether leisure on a weekday behaves like a substitute or complement for weekend leisure. Finally, this paper attempts to verify the divergent findings in the literature on the economic variables that affect leisure decisions in households. By extending the household joint decision making model in Browning and Chiappori (1998) and Browning and Gørtz (2006) to include joint leisure, it is possible to model how different types of leisure is allocated within a household by examining their preference parameters.

This paper is organised as follows: Section 2 presents an overview of the literature and outlines how this paper's approach differs from existing research in this area. Section 3 discusses the dataset and data structure used in this paper. Section 4 presents the theory of household leisure allocation, which provides the backbone structure for the structural modelling presented in Section 5. A discussion about empirical specification and identification is given in Section 6, and the estimation results are detailed in Section 7. In Section 8, the economic interpretations and implications of the results are analysed

[1]A number of government and independent studies have also exploited the UKTUS in other contexts, such as investigating how parents and children spend time together, what they do and where they do it; how much time teachers spend in teaching activities outside of normal working hours; joint retirement decisions of couples; the level of physical activity of households, travel and commute times, and hours of work. The interested reader may find more information in Short (2006) and `http://www.esds.ac.uk/government/timeuse/usage/`.

with respect to the theoretical model. And finally, the key conclusions from this paper are presented in Section 9.

1.2 Theory of household leisure allocation

1.2.1 Modelling leisure allocation within the household

In this paper we follow the basic framework in Browning and Gørtz (2006) in modelling household leisure choices. One advantage of adopting a structural approach is that estimation can be based on a specific preference structure and hence allows for clarity of interpretation. Under this framework, the household is analysed as one single optimising unit and it is assumed that individuals within the household agree on all decisions and that the outcomes are efficient. These are highly specific assumptions and in general the decision process within a household may be much more complex. Extending the collective household model in Browning and Chiappori (1998) and the time use framework in Browning and Gørtz (2006) to include joint leisure in couples while setting the power distribution as equal and the alturistic parameter as zero, the following baseline model could be obtained:

$$\max U(l_A, l_B, L, q_A, q_B, G) \tag{1.1}$$

Subject to

$$\Gamma = 2T - m_A - m_B - c_A - c_B - h_A - h_B \tag{1.2}$$

$$q_A + q_B + x = w_A m_A + w_B m_B + y \tag{1.3}$$

$$G = h_A^{\alpha} h_B^{\beta} x^{1-\alpha-\beta} \tag{1.4}$$

All variables satisfy non-negativity constraints, also $0 \leq \alpha \leq 1$, $0 \leq \beta \leq 1$.

where $U(.)$ is the household utility function, Γ is the total household leisure per week, l is the private leisure of an individual, L is the joint leisure of the couple, q is the private goods consumed by the individual per week, $G(.)$ is the household public good production function and subscripts A and B indicate male and female respectively. For the budget constraints, which will be further discussed below, T is the total time available to each individual in a week, h is time spent on housework by the individual per week, x is the expenditure on household good production per week, w is the wage of the individual, m is the time spent on market work by the individual per week, c is the time spent on personal care by the individual per week and y is the non-labour income of the household per week. To keep our analysis simple, we assume that time spent on market work and personal care are exogenous to the model. Thus the household makes decisions over nine choice variables $(l_A, l_B, L, q_A, q_B, x, h_A, h_B, G)$. We also assume no externalities, meaning that for example individual A's consumption of their private leisure will have no effects on individual B. Of course this may be unrealistic in reality as there could be complementarities in private leisure, but for the purposes of this section we shall abstract from this consideration.

Equation (1.1) gives the household utility function and it depends on leisure (joint and private) and consumption of private and household public goods. Equations (1.2) is the household time use constraint. It is assumed that any time spent not working (market or housework) is spent on leisure and personal care. Equation (1.3) is the household budget constraint, and it is assumed that the household spends all its income. Equation (1.4) is the household good production function. This framework allows for home production and it is assumed that money for home production from male and female are perfect substitutes. The notations above will be kept throughout this paper.

1.2.2 Zero observations: Infrequency versus choice

In addition to modelling the decision process in the household, the model must also be able to handle the zero observations present in the time use data. There are two ways of evaluating these zero observations. On one hand, the zero entries may purely be an artefact of the infrequency of sampling. Since individuals are only asked to report what they did on one weekday and one weekend day, it could be the case that on those specific days, they did not have any private and/or joint leisure time. Under this assumption, it may be acceptable to assume that the zero observations are occurring at random.

On the other hand, these zero leisure entries could be conscious choices and may not be random at all. This has serious implications for understanding how leisure choices are made because if households are choosing zero private or joint leisure, it may be that their desired level of leisure is genuinely zero, or it could be that their true desired level of private or joint leisure is in fact negative. In other words, the true desired level of private or joint leisure could be censored at zero.

In the following section, a baseline model with Stone-Geary preferences will first be presented. This specification of preferences is restrictive, but is chosen because of its simplicity and it allows the modelling of the zeros as optimal choices made by the household. In a later section, a model which allows for censoring will be introduced. For the purpose of this section, additive separability in the household utility function is assumed. This is a highly specific assumption. This simple formulation allows the optimisation problem of the household to be analysed as a two-stage maximisation problem. In the first stage, the overall problem, the household maximises the household utility function subject to budget constraints and chooses the optimal total household leisure, consumption and housework simultaneously given market work hours, wage rates, non-labour income, time spent on personal care and expenditure on household good production. In the second stage, the household decides on how to allocate their total leisure time across joint and private leisure. This two-stage problem is solved by backward induction, starting from stage two, where the optimal private and joint leisure demands are solved for in terms of total household leisure, these are then substituted into the stage one problem and the optimal demands are solved for.

1.2.3 The Stone-Geary model

The Stone-Geary Model takes the following form and the household faces the following Stage 1 maximisation problem:

$$\max_{q_A,q_B,l_A,l_B,L} lnU(q_A,q_B,l_A,l_B,G,L) =$$
$$\theta lnq_A + \psi lnq_B + \pi_A ln(l_A - \gamma_A) + \pi_B ln(l_B - \gamma_B) + \phi ln(L - \gamma_L) + lnG \tag{1.5}$$

Subject to

$$L + l_A = T - m_A - c_A - h_A \tag{1.6}$$
$$L + l_B = T - m_B - c_B - h_B \tag{1.7}$$
$$q_A + q_B + x = w_A m_A + w_B m_B + y \tag{1.8}$$
$$G = h_A^{\alpha} h_B^{\beta} x^{1-\alpha-\beta} \tag{1.9}$$

where π represents the weights the household decides to put on each type of private leisure and ϕ represents the weights on joint leisure in the utility function. θ and ψ are the weights on the two private consumption goods and household public good respectively. γ_A, γ_B and γ_L represent the 'subsistence' levels of leisure required by the household. This specification requires that $q_A > 0, q_b > 0, G > 0$, but l_A, l_B, L can be corner solutions at zero. Solving the model backwards from the Stage 2, the household decides on the allocation between private versus joint leisure:

$$\max_{l_A,l_B,L} U(l_A, l_B, L) = \pi_A ln(l_A - \gamma_A) + \pi_B ln(l_B - \gamma_B) + \phi ln(L - \gamma_L) \tag{1.10}$$

$$s.t. \;\; l_A + l_B + 2L = \Gamma \tag{1.11}$$

As is standard in a Stone-Geary model, the proportions of commodities consumed by the household must sum to one. The Lagrange problem is given by:

$$\Lambda = \pi_A ln(l_A - \gamma_A) + \pi_B ln(l_B - \gamma_B) + \phi ln(L - \gamma_L) + \kappa(\Gamma - l_A - l_B - 2L) \tag{1.12}$$

$$\frac{\partial \Lambda}{\partial l_A} = \frac{\pi_A}{l_A - \gamma_A} - \kappa = 0 \tag{1.13}$$

$$\frac{\partial \Lambda}{\partial l_B} = \frac{\pi_B}{l_B - \gamma_B} - \kappa = 0 \tag{1.14}$$

$$\frac{\partial \Lambda}{\partial L} = \frac{\phi}{L - \gamma_L} - 2\kappa = 0 \tag{1.15}$$

Using equations (1.13)-(1.15) and the restriction that $(\pi_A + \pi_B + \phi) = 1$ in the Stone-Geary model, the Stage 2 maximisation problem yields the following optimal leisure choices

$$l_A* = \gamma_A + \pi_A(\Gamma - \gamma_A - \gamma_B - 2\gamma_L) \tag{1.16}$$

$$l_B* = \gamma_B + \pi_B(\Gamma - \gamma_A - \gamma_B - 2\gamma_L) \tag{1.17}$$

$$L* = \gamma_L + \frac{\phi}{2}(\Gamma - \gamma_A - \gamma_B - 2\gamma_L) \tag{1.18}$$

Substituting the optimal leisure choices in equations (1.16)-(1.18) back into the household utility function (1.5) and solving the Stage 1 overall optimisation problem would yield the Marshallian demands for each of the commodity:

$$q_A^* = \frac{\theta(1-\alpha-\beta)(w_A m_A + w_B m_B + y)}{(1-\alpha-\beta+\theta)(1-\alpha-\beta+\psi)-\theta\psi} \tag{1.19}$$

$$q_B^* = \frac{\psi(1-\alpha-\beta)(w_A m_A + w_B m_B + y)}{(1-\alpha-\beta+\theta)(1-\alpha-\beta+\psi)-\theta\psi} \tag{1.20}$$

$$h_A^* = \frac{\alpha(2T - m_A - m_B - c_A - c_B - \gamma_A - \gamma_B - 2\gamma_L)}{1+\alpha+\beta} \tag{1.21}$$

$$h_B^* = \frac{\beta(2T - m_A - m_B - c_A - c_B - \gamma_A - \gamma_B - 2\gamma_L)}{1+\alpha+\beta} \tag{1.22}$$

$$\Gamma^* = \frac{(2T - m_A - m_B - c_A - c_B) + (\alpha+\beta)(\gamma_A + \gamma_B + 2\gamma_L)}{1+\alpha+\beta} \tag{1.23}$$

The private good consumption demands, the optimal household production levels for each individual and the total leisure demand are given above. Using this information on private consumption and household production one can easily compute the optimal public good expenditure and hence the level of public good consumption by using the household budget constraint in equation (1.8). Furthermore, to obtain the overall optimal leisure choices one could simply substitute the expression for total leisure in equation (1.23) back into equations (1.16)-(1.18).

1.2.4 Parameterisation choice

In the above treatment of the model for household leisure allocation a simple parameterisation was chosen. This simple formulation has the obvious advantage of allowing for clear derivation of the core theoretical results and the identification of the parameters of interest when taken to the data. As also discussed in Browning and Gørtz (2006), the value of following an explicit structural model for empirical analysis is that, firstly, it enables the identifying assumptions to be stated explicitly; secondly, it gives economic interpretations for the estimated parameters; and thirdly, it produces testable implications that could indicate how well the model actually fits and where it could be improved.

However, despite these attractive properties this simple treatment does come with some important shortcomings. Because our empirical strategy is based on an assumed structural functional form, if this underlying structural form is incorrect it could raise some serious questions about the empirical interpretations and meanings of the parameter estimates. In addition, the implementation of the two stage budgeting approach relies on the assumption of additive separability in the utility functions. This is a highly specific assumption, and although for certain commodities this may be an acceptable assumption, it is possible that for example, the hours of work and total leisure are jointly determined in the first stage and that the model is invalid. Though perhaps the assumption of separability between the hours of work and leisure patterns may not be a totally unrealistic assumption for men as their labour supply tend to be highly inelastic and insensitive to other factors. Finally, as the objective of this paper is mainly to study leisure time use patterns, labour supply choices are not modelled explicitly and are assumed to be exogenously determined in order to reduce the complexities in estimating the household time use choices. It is therefore very important to bear all of these issues in mind when evaluating the results.

1.2.5 Capturing heterogeneity

In the theoretical model considered, the parameters $(\pi_{Ai}, \pi_{Bi}, \phi_i)$, as well as $(\gamma_{Ai}, \gamma_{Bi}, \gamma_{Li})$ in the Stone-Geary model are allowed to vary across households $(i = 1...N)$ to reflect this heterogeneity structure. Conceptually the optimal leisure choices become:

$$l_{Ai}* = \gamma_{Ai} + \pi_{Ai}(\Gamma_i - \gamma_{Ai} - \gamma_{Bi} - 2\gamma_{Li}) \tag{1.24}$$

$$l_{Bi}* = \gamma_{Bi} + \pi_{Bi}(\Gamma_i - \gamma_{Ai} - \gamma_{Bi} - 2\gamma_{Li}) \tag{1.25}$$

$$Li* = \gamma_{Li} + \frac{\phi_i}{2}(\Gamma_i - \gamma_{Ai} - \gamma_{Bi} - 2\gamma_{Li}) \tag{1.26}$$

In the empirical section of this paper, a cross-section of UK households is used as a sample from the population. The above theoretical relationships (1.24)-(1.26) are estimated using our data. And economic variables $(m_A, m_B, c_A, c_B, h_A, h_B, l_A, l_B, L, w_A, w_B)$ are observed for each household. In addition, demographics such as age, education, ethnicity, employment status, household composition and household income are observed. The effects of these observable heterogeneities will be captured with the parameters (π_A, π_B, ϕ) hence these parameters will reflect the observable tastes for private versus joint leisure for each household.

The hypothesis is that if households do make their decisions in a way not too dissimilar to the two-stage model, once total household leisure is controlled for, other variables that feature in the overall first stage problem should no longer be important for the determination of joint and private leisure shares. In deciding the optimal total amount of leisure to consume, the household had already solved the first stage optimisation problem. Thus the variable total household leisure should capture all the information required for the leisure decision problem in the final stage.

1.3 The Structure of the data

1.3.1 The United Kingdom Time Use Survey 2000

The sample used in this study is taken from the UK Time Use Survey 2000 (UKTUS). This survey provides detailed information on time use for more than 11,000 individuals living in 6,414 households in 2000. (Response rate 45%) There are three parts to the survey. Firstly, each individual was asked to complete two 24-hour time use diaries, one for a weekday and one for a weekend day, stating their primary and secondary activities every 10 minutes over a 24-hour period and whom they were with during those activities. See Figure.1.1 for a sample diary illustration. Within each household, every member was assigned the same weekday and weekend day. Secondly, all respondents aged 8 or over were asked to complete an individual questionnaire. Finally, the selected household heads or their partners completed a household questionnaire. The questionnaires were used to gather background and demographic information and were carried out via a face-to-face or telephone interview.

For the purpose of this study, attention is restricted to couples aged between 24 and 60 living together only. These couples may be married or cohabiting, with or without children. If children are present, attention is restricted to households with children under the age of 15. Households with singles, students, retired or economically inactive individuals, and siblings or friends cohabiting are excluded. Diary entries that reported the diary day to be unusual for any reason are also excluded. The sample consists of 2388 diaries, corresponding to 1194 unique individuals, 597 male and 597 female respectively.

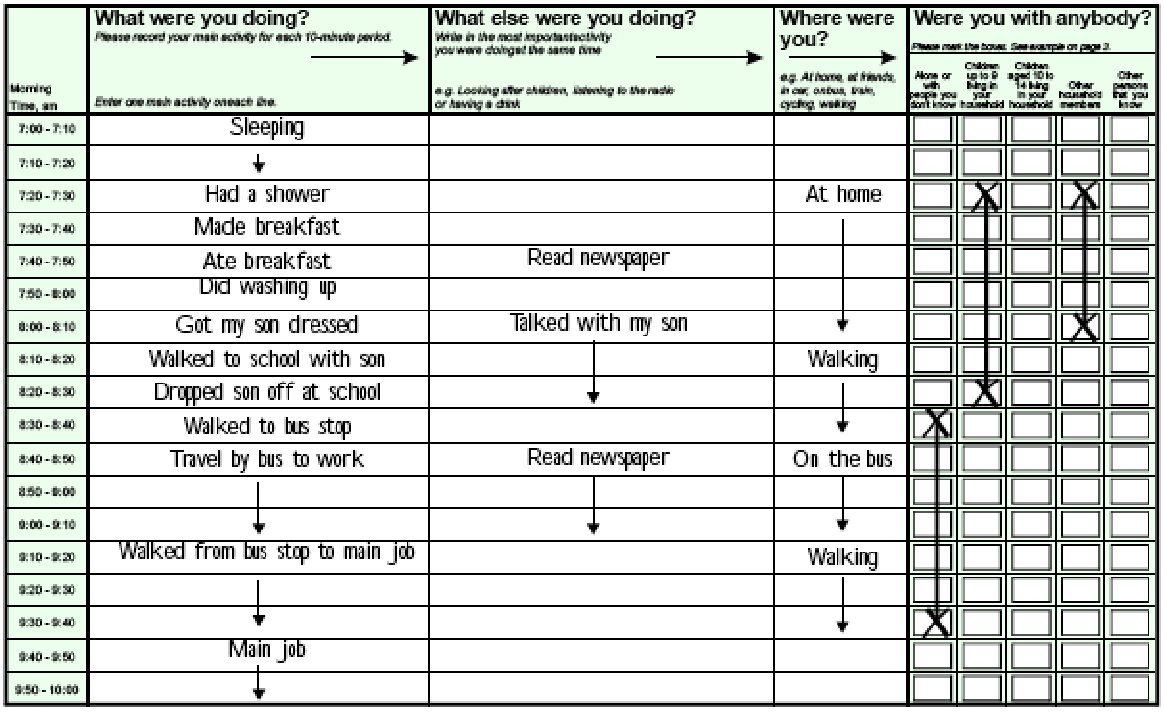
An additional dataset comprising imputed net income and childcare expenditure variables [2] derived from the UKTUS and the 2000/1 Family Resources Survey (SN4498) is used in conjunction with the UKTUS dataset to enhance the information on household characteristics.

1.3.2 Data description

In the UKTUS, each 24-hour day is divided up into 144 10-minute slots. For the purpose of this study all time units are normalised in terms of hours. Leisure is defined to be total time available minus personal care (sleep, wash, dress etc), market work, housework, other employment or work related time use and help given to others. Joint leisure is defined to be leisure time that is spent with a spouse, and private leisure here refers to leisure time that is not spent with their spouse but not necessarily leisure time in solitude[3]. Total household leisure is defined to be male's private leisure plus female's private leisure plus two times joint leisure. Some activities are harder to classify than others. For example, "Reading, playing and talking with child" may be considered leisure by some but housework by others. In this study, the latter definition is chosen as it is

[2] Compiled by Tania Burchardt of the London School of Economics and Political Science. SN5536

[3] For example, leisure time with friends will be counted as private leisure.



Morning Time, am	What were you doing? *Please record your main activity for each 10-minute period. Enter one main activity on each line.*	What else were you doing? *Write in the most importantactivity you were doingat the same time. e.g. Looking after children, listening to the radio or having a drink*	Where were you? *e.g. At home, at friends, in car, on bus, train, cycling, walking*	Were you with anybody? *Please mark the boxes. See example on page 3.* Alone or with people you don't know	Children up to 9 living in your household	Children aged 10 to 14 living in your household	Other household members	Other persons that you know
7:00 - 7:10	Sleeping							
7:10 - 7:20	↓							
7:20 - 7:30	Had a shower		At home		X		X	
7:30 - 7:40	Made breakfast		↓		↓		↓	
7:40 - 7:50	Ate breakfast	Read newspaper						
7:50 - 8:00	Did washing up							
8:00 - 8:10	Got my son dressed	Talked with my son					X	
8:10 - 8:20	Walked to school with son	↓	Walking					
8:20 - 8:30	Dropped son off at school		↓		X			
8:30 - 8:40	Walked to bus stop			X				
8:40 - 8:50	Travel by bus to work	Read newspaper	On the bus	↓				
8:50 - 9:00	↓	↓	↓					
9:00 - 9:10								
9:10 - 9:20	Walked from bus stop to main job		Walking					
9:20 - 9:30	↓		↓					
9:30 - 9:40				X				
9:40 - 9:50	Main job							
9:50 - 10:00	↓							

Figure 1.1: A sample diary

arguably more similar to childcare. A sample list of activities are given in the Appendix A.1.

Figures 1.2 and 1.3 below show the histograms of household leisure for weekdays and weekends. As expected, households tend to enjoy more leisure on weekends. Households range from having no leisure to about 30 hours of total leisure between two individuals on weekdays and on weekend days this rises to about 40 hours. Most households enjoy approximately 8 hours of leisure between the two individuals for a given weekday and approximately 14 hours of leisure for a weekend day.

Another interesting observation here is that joint leisure increases substantially on weekend days, in fact the mean value almost doubles, rising from 2.39 on weekdays to 4.57 on weekend days. In terms of private leisure the difference is much more subtle. The standard deviations for both male and female private leisure increase slightly for weekends and is accompanied by a small increase in their mean values. A table with summary statistics on each variable is given in Table 1.1 below.

The raw correlation between the leisure variables is given in Tables 1.2 and 1.3. Perhaps surprisingly households that have higher weekday total leisure also tend to have higher weekend total leisure. Household joint leisure also tends to move closely with total leisure. Husbands' and wives' private leisure are also positively correlated on both weekdays and weekend days. On the contrary, household joint leisure is negatively correlated with both male and female private leisure on both weekdays and weekend days. This negative relationship between joint leisure and private leisure continues to hold across weekdays and weekend days. Households that prefer higher private leisure on the weekdays tend to have lower joint leisure on weekends and similarly households that prefer higher private leisure on weekends have lower weekday joint leisure.

Figures 1.4 to 1.6 show the scatter plots between household leisure, joint leisure and individual private leisure. First of all, we see from Figure 1.4 that there is a tentative positive correlation between household joint leisure on weekdays and weekends. This is

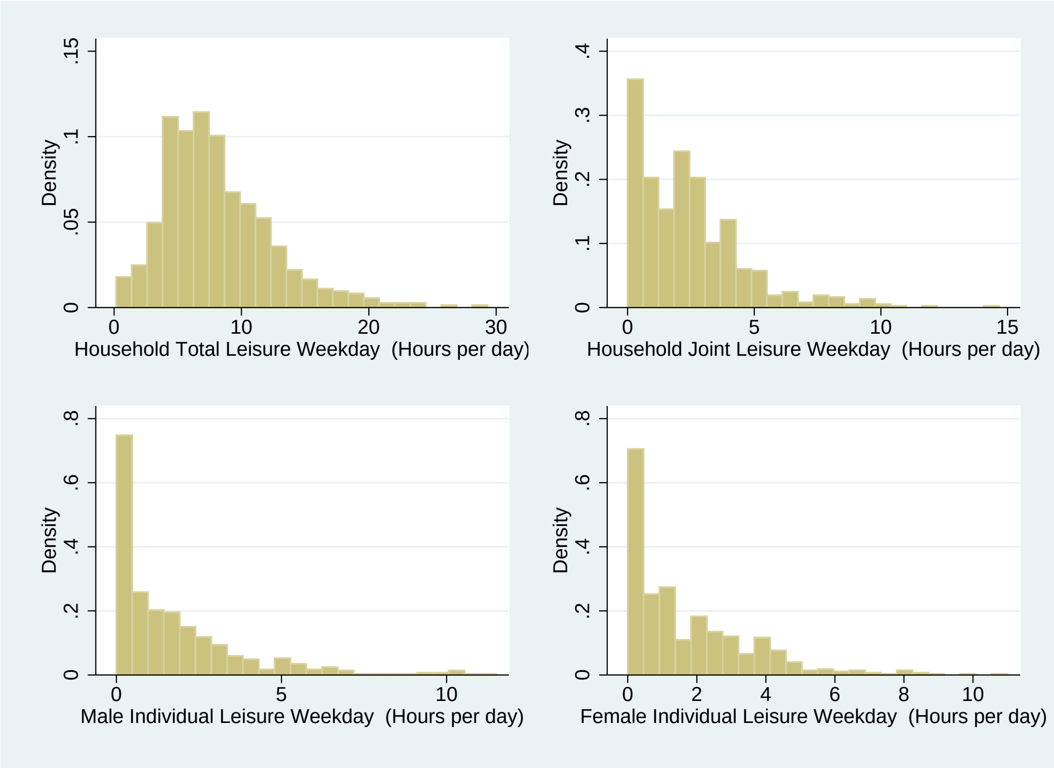


Figure 1.2: Household Leisure for Weekday

also true for female private leisure, but less strong for male private leisure. Figure 1.5 shows the difference between joint leisure on weekend and weekday and their relationship with household weekly total leisure. With both exhibiting a positive relationship as expected, but the patterns are much more dispersed for weekend joint leisure. Finally in figure 1.6, if households only have joint leisure and no private leisure at all, we would see a straight line through the origin. We see that some households in our sample fall into this category, but most households have differing amounts of private leisure. In general, households with no joint leisure enjoy proportionately more private leisure. On weekends, households tend to have more dispersed patterns in private leisure.

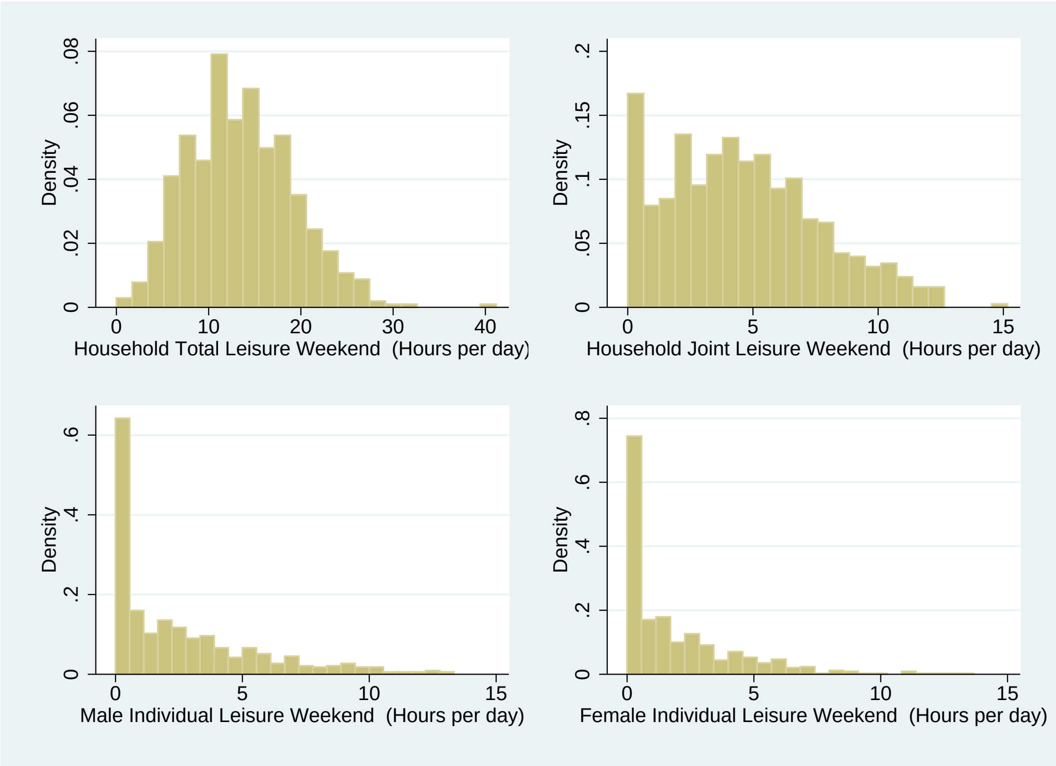


Figure 1.3: Household Leisure for Weekend

Table 1.1: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Total Leisure (Weekday)	8.145	4.317	0.167	29.333	597
Joint Leisure (Weekday)	2.392	2.163	0	14.667	597
Male Private (Weekday)	1.675	2.069	0	11.5	597
Female Private (Weekday)	1.686	1.824	0	11	597
Total Leisure (Weekend)	13.542	5.741	0	41.167	597
Joint Leisure (Weekend)	4.571	3.073	0	15.167	597
Male Private (Weekend)	2.547	2.928	0	13.333	597
Female Private (Weekend)	1.852	2.338	0	13.667	597
Male age	41.037	9.064	25	60	597
Female age	38.977	8.961	24	60	597
No. child	1.085	1.067	0	5	597
meduclevel	2.59	0.801	1	4	597
feduclevel	2.695	0.805	1	4	597
HH Weekly Net Earnings	452.049	318.275	0	3371.824	597
HH Net Non-Labour Y	19.224	45.469	-24.639	224.545	597
White	0.982	0.135	0	1	597
Manager	0.492	0.5	0	1	597
Car Available	1.047	0.212	1	2	597

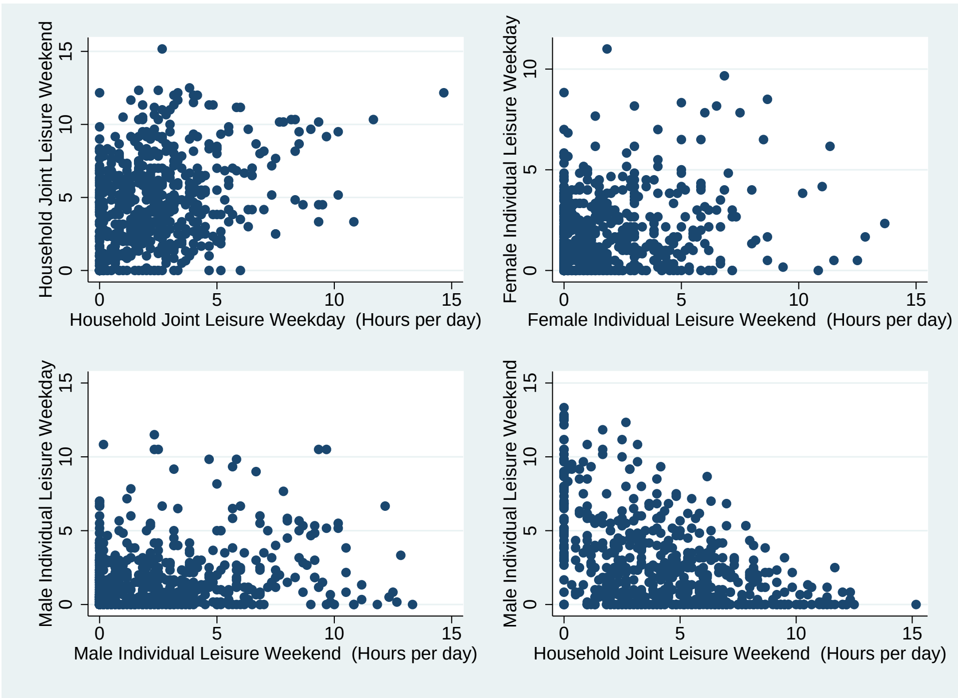


Figure 1.4: Relationships between Joint and Private Leisure

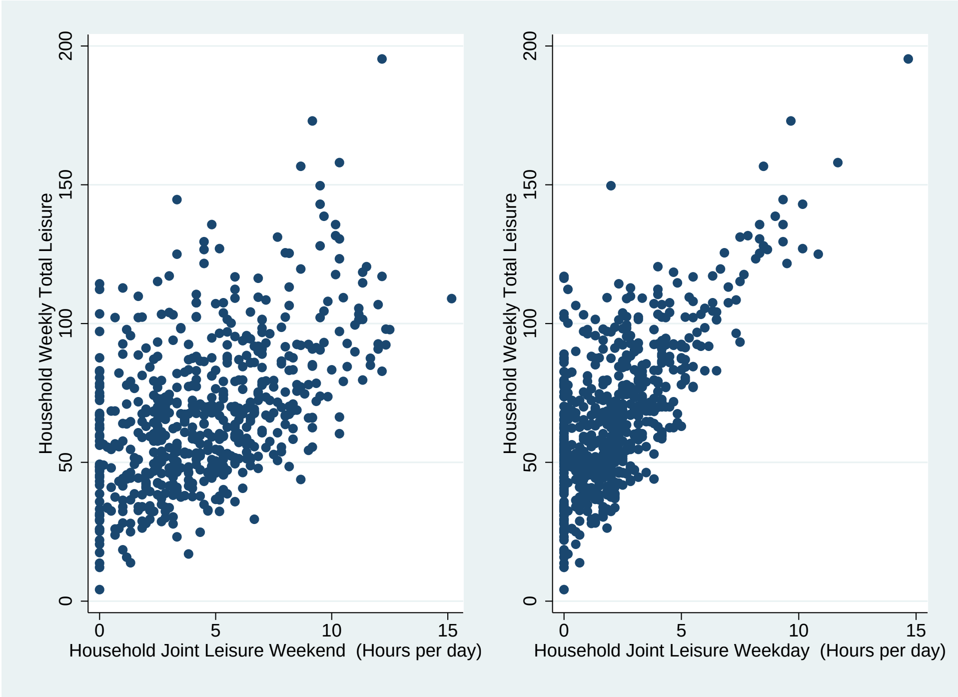


Figure 1.5: Household Weekly Total Leisure and Joint Leisure

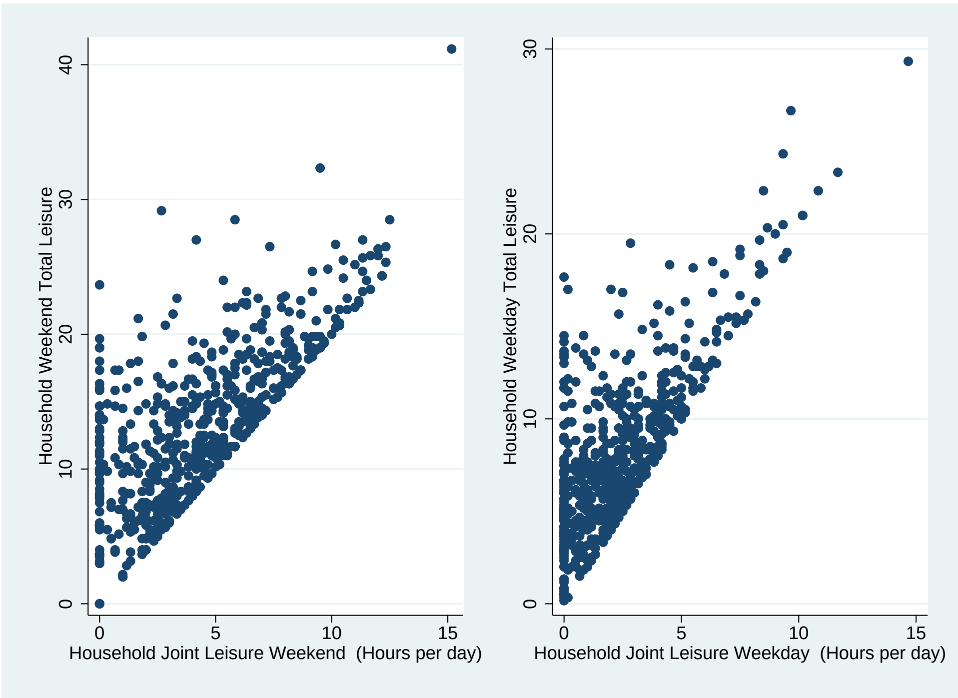


Figure 1.6: Household Total Leisure and Joint Leisure on Weekend & Weekday

Table 1.2: Raw Correlation Between Leisure Variables

Variables	Total(Weekly)	Total(Wday)	J(Wday)	M(Wday)	F(Wday)	Total(Wend)	J(Wend)	M(Wend)	F(Wend)
Total Leisure (Weekly)	1.000								
Total Leisure (Weekday)	0.909	1.000							
Joint Leisure (Weekday)	0.693	0.756	1.000						
Male Private (Weekday)	0.262	0.283	-0.279	1.000					
Female Private (Weekday)	0.211	0.252	-0.265	0.198	1.000				
Total Leisure (Weekend)	0.621	0.239	0.193	0.079	0.018	1.000			
Joint Leisure (Weekend)	0.500	0.230	0.321	-0.071	-0.135	0.733	1.000		
Male Private (Weekend)	0.031	-0.042	-0.207	0.219	0.143	0.151	-0.474	1.000	
Female Private (Weekend)	0.173	0.033	-0.111	0.107	0.220	0.341	-0.236	0.365	1.000

Table 1.3: Raw Correlation Between Economic Variables

Variables	Total (Weekly)	Total (Weekday)	Total (Weekend)	No. child	Male age	Educlevel	manager	Car
Total Leisure (Weekly)	1.000							
Total Leisure (Weekday)	0.909	1.000						
Total Leisure (Weekend)	0.621	0.239	1.000					
No. child	-0.172	-0.135	-0.148	1.000				
Male age	0.109	0.105	0.055	-0.252	1.000			
meduclevel	0.047	0.059	-0.002	0.018	-0.068	1.000		
manager	0.037	0.029	0.030	-0.010	-0.016	0.367	1.000	
Car	0.029	0.009	0.049	-0.003	0.029	-0.025	-0.028	1.000

1.4 Empirical specification

1.4.1 Methodology

In terms of estimation, previous studies on time use in the literature have followed various routes such as ordinary least square, probit, fractional logisitic[4] or SUR Tobit approaches. This paper takes a slightly different approach. As discussed in the theoretical section, the household is modelled as a two-stage decision making unit: In the first stage, the household decides on how much total leisure to consume, and in the final stage it divides the total leisure available into joint or private leisure. Thus total household leisure is an endogenous variable in the sub-problem of time allocation and must be instrumented for.

The estimator of choice in this case is the "continuously-updated" GMM estimator (CUE) of Hansen, Heaton and Yaron (1996). The CUE estimator is the GMM generalisation of the limited-information maximum likelihood (LIML) estimator to the case when heteroskedastic and autocorrelated disturbances may be present. In the robustness check section, the analysis is extended further by verifying if bottom censoring in leisure choices generates significantly different results. An IV Tobit estimation is carried out and the tobit model is fitted using maximum likelihood estimation with the Newton-Raphson (NR) optimisation algorithm where a regressor is endogenously determined.

1.4.2 Endogeneity and instrumental variables

As briefly mentioned above, there could be unobserved heterogeneities that are affecting both joint leisure (or private leisure) and total household leisure time simultaneously. The potential endogeneity of total household leisure could cause it to be correlated with the error term in the joint (or private) leisure equation and OLS or SUR regressions will yield inconsistent results. To generate only exogenous variations in total household

[4] Essentially OLS but with the dependent variable as a fraction.

leisure an instrumental variable approach is taken. An instrument has the property that changes in the instrument are associated with changes in the endogenous variable but do not lead to changes in the dependent variable. However, if the instruments chosen are weak the IV estimates will also be inconsistent. Hence, determining which variables to use as valid instruments are of great importance.

By appealing to the structural theory, it is possible to form exclusion restrictions that could help identify which variables could serve as the instruments. There are many alternative methods suggested for obtaining valid instruments, but the advantages of appealing to the structural theory for exclusion restrictions are that it does not rely heavily on the choice of functional form and the exclusion restrictions are stated very explicitly. From the two-stage leisure choice model, it is clear that wages, income and hours of work are theoretically exogenous to leisure choices in the final stage once total household leisure time is conditioned for. The economic intuition here is that the choice of total household leisure captures all the relevant information on household income, labour supply and wages, and therefore once it is controlled for in the first stage, the variables relating to income, hours of work and wages become exogenous to leisure time use allocation. In other words, some variables directly determine the total amount of household leisure, but they do not determine how this total leisure is divided up between the three leisure categories. These are the variables that would be the ideal instruments, as it is precisely this 'leisure-dividing preference' that is of interest here. There are, however, other potential problems with using wages or hours of work as instruments. Wages is not directly observable in the dataset and hours of work is linked to leisure time use via the time use budget constraint (24 hours in a day), thus leaving us with labour and non-labour income as potential valid instruments.[5]

More potential instruments become available if one is willing to exploit the possible separability between weekday and weekend leisure choices. If weekday and weekend

[5] In the robustness check section hours of work is included as one of the instruments and the theoretical model is tested.

leisure choices are essentially separable then weekday total household leisure could serve as a valid instrument for weekend total household leisure, and vice versa. Several tests are carried out in order to verify the validity of this assumption and the results are positive. Once weekday total household leisure is conditioned for in the weekday equations, weekend total household leisure ceases to be significant in any of the regressions. This is also true vice versa. Furthermore the results from overidentifying restrictions tests (OIR) for instrument exogeneity also confirms the validity of the instrument choice. (See Appendix for the tests on separability.) In order to minimise the chance of having many more instruments than needed whereby generating the problem of weak instruments, the set of instruments have been kept to a parsimonious size.

For the CUE GMM specification, the final set of instruments for the weekday leisure equation are: Total Household Leisure (Weekend), Household Weekly Net Earnings, Household Net Non-Labour Income; and for the weekend equation: Total Household Leisure (Weekday), Household Net Non-Labour Income. The assumption that the instruments Z are exogenous can be expressed as $E(Z_i\epsilon_i) = 0$, where ϵ is just the disturbance term. Thus the L instruments will yield a set of L moments,

$$g_i(\beta) = Z_i'\epsilon_i = Z_i'(l_{Ai} - X_i'\eta_A - \Gamma_i\rho_A) \tag{1.27}$$

where g_i is $L \times 1$. The exogeneity of the instruments will yield L moment conditions:

$$E[g_i(\beta)] = E[Z_i'\epsilon_i] = E[Z_i'(l_{Ai} - X_i'\eta_A - \Gamma_i\rho_A)] = 0 \tag{1.28}$$

For each of the leisure demand equations for weekday, there are three instruments and one endogenous variable; for the weekend leisure demand equations, there are two instruments and one endogenous variable. Hence in each case the equation is overidentified, i.e. we have more equations than unknowns. A series of robustness checks including tests for weak instruments, underidentification, overidentifying restriction and endogeneity were then carried out to verify if the set of instruments are indeed valid. The results strongly reject a weak instrument problem and underidentification. Furthermore, the test for overidentifying restrictions were satisfied in all cases. The test statistics are presented in a later section Robustness Checks.

1.4.3 Empirical specification and structural identification

Using the optimal leisure choices from the theoretical model (Equations (1.24)-(1.26)), the empirical specification for the Stone-Geary Model would therefore take the following form:

$$l^j_{Ai} = X^{j'}_i \eta^j_A + \rho^j_A \Gamma^j_i + \epsilon^j_{Ai} \tag{1.29}$$

$$l^j_{Bi} = X^{j'}_i \eta^j_B + \rho^j_B \Gamma^j_i + \epsilon^j_{Bi} \tag{1.30}$$

$$L^j_i = X^{j'}_i \eta^j_L + \rho^j_L \Gamma^j_i + \epsilon^j_{Li} \tag{1.31}$$

where X_i is a vector containing individual and household observable characteristics including an intercept dummy, Γ_i is total leisure, η_i and ρ_i are the parameters of interest and superscript $j = \{1, 2\}$ indicates weekday and weekend respectively. As the dependent variables in each of the three equations above add up to the regressor Γ_i, only two of the three equations need to be estimated.

$$\eta^j_A = [(1 - \pi^j_{Ai})\gamma^j_{Ai} - \pi^j_{Ai}\gamma^j_{Bi} - 2\pi^j_{Ai}\gamma^j_{Li})] \tag{1.32}$$

$$\eta^j_B = [(1 - \pi^j_{Bi})\gamma^j_{Bi} - \pi^j_{Bi}\gamma^j_{Ai} - 2\pi^j_{Bi}\gamma^j_{Li})] \tag{1.33}$$

$$\eta^j_L = [(1 - \phi^j_i)\gamma^j_{Li} - \frac{\phi^j_i}{2}\gamma^j_{Ai} - \frac{\phi^j_i}{2}\gamma^j_{Bi}] \tag{1.34}$$

The conditional estimates of the parameters of interest are therefore,

$$\rho_A^j = \pi_{Ai}^j \tag{1.35}$$

$$\rho_B^j = \pi_{Bi}^j \tag{1.36}$$

$$\rho_L^j = \frac{\phi_i^j}{2} \tag{1.37}$$

In other words, private and joint leisure are first regressed on X and Γ. For each equation, the coefficient on Γ leads to the identification for ϕ and π. Then these estimates together with the estimate of η allow for the identification of γ. A key element here is that this specification allows the identification of the parameters (π_A, π_B, ϕ) using (1.35)-(1.37) as well as $(\gamma_A, \gamma_B, \gamma_L)$ from (1.32)-(1.34). The full derivation for the identification of $(\gamma_A, \gamma_B, \gamma_L)$ is given in Appendix A.3.

One final note about the potential problem of measurement error due to the empirical specification used. As leisure is present on both the left and right hand side of the leisure demand equations, if there are measurement errors present in the quantification of leisure, the errors will be transmitted to both total and individual leisure quantities leading to a spurious positive correlation between the total household leisure and each of the dependant variables. In Deaton (1997), a discussion of the work of Bouis and Haddad (1992) is given in a similar context. In our case, Bouis and Haddad's findings would suggest that a mismeasurement of total leisure in general would lead to a standard attenuation effect and bias the estimates downwards. However, there is also an additional effect of common measurement error, which will have the effect of biasing the estimates upwards. Bouis and Haddad's paper suggests that the latter effect may dominate. Hence caution is called for when evaluating the magnitude of the estimates as the problem of common measurement error may not be negligible especially in this type of survey data.

1.5 Results

The four equation Seemingly Unrelated Regression (SUR) model and CUE GMM estimation results are presented in Table 1.4 and 1.7 respectively. Coefficients in each case represent the marginal effect of a unit change in the explanatory variable on joint or private leisure. The unit of time remains in terms of hours. It is also worth mentioning that when estimating this model, a much larger list of variables were included initially and some were gradually dropped due to their irrelevance[6].

First of all, examining the results from the SUR model, it is clear that the marginal effect of a change in total leisure on joint leisure does not vary much across weekday and weekend. On average, a one hour increase in weekday total household leisure is associated with a 22 minutes increase in weekday joint leisure, an equivalent rise in weekend total leisure is associated with 23 minutes rise in joint leisure. However, the marginal effect of total leisure on male private leisure almost halves going from weekday to weekend. On average, a one hour increase in total household leisure on weekdays is associated with a 9 minutes increase in male private leisure, as opposed to only five minutes on weekends. In any case male private leisure appears to be more insensitive to a change in total household leisure. Comparing the marginal effects of total leisure on male private leisure versus joint leisure reveals a difference in marginal effect of about 2.5 times on weekday and this difference jumps to 4.6 times on weekend. Formal tests were carried out to test if these marginal effects were significantly different from one another and it was found that except for the marginal effects on joint leisure (weekend versus weekday), all the other marginal effects were significantly different from one another.

Interestingly once total household leisure is controlled for, the split between private and joint leisure appears largely independent on the number of children in household. Having one extra child is linked with a 10 minutes rise in male private leisure on week-

[6]Examples of variables that were found to be irrelevant: cohabitation(versus marriage), age of children, female eduction level, female age, income and non-labour income.

days. The effect on joint leisure is slightly small at about 6 minutes but just marginally insignificant. One possible explanation may be that children break up joint leisure into private leisure and childcare. Other demographic characteristics are also important. For example, being ethnically white is associated with a 53 minutes increase in spousal joint leisure on weekdays and 158 minutes on weekends. Being ethnically white also means that male private leisure is likely to decrease by approximately 164 minutes on weekends. Having an age gap also appears to affect leisure patterns. For example, a 5 year age gap could lead to a 21 minutes increase in weekday male private leisure. Male education level is only relevant on weekdays, going from having no qualifications to the highest qualified is associated with a fall in approximately 40 minutes in weekday private leisure. On weekdays, having a managerial occupation is also linked with a fall in approximately 20 minutes joint leisure, but male private leisure tends to rise by about 41 minutes. Intriguingly, similar to the education effect, this managerial effect is completely absent on weekends, suggesting that weekend leisure structure is less sensitive to occupational characteristics. Another interesting finding is that owning or having access to a private motor vehicle could potentially increase male private leisure on weekend days by approximately 94 minutes and decrease joint leisure by 57 minutes. The difference between Saturdays and Sundays matter only for joint leisure and on a Sunday households typically have 24 minutes more spousal joint leisure than on a Saturday. At the bottom of the table, the R^2 and a joint significance test for all explanatory variables are reported. In each case we find that the explanatory variables are highly jointly significant.

Lastly it may be worth examining the correlation between the residuals for each of these equations. The results are reported in Table 1.5. The Breusch-Pagan Lagrange multiplier test for error independence is computed using the chi-square(6) distribution. The result indicates statistically significant correlation between the errors. In particular we can see that the errors for joint and private leisure on weekdays are highly correlated, the same is found for weekends. This is expected as the two types of leisure have similar

SUR Regressions of Joint & Private Leisure				
	Weekday		Weekend	
Variable	Joint Leisure	Male	Joint Leisure	Male
Total Leisure (Weekday)	0.366***	0.152***		
	(0.01)	(0.02)		
Total Leisure (Weekend)			0.385***	0.083***
			(0.01)	(0.02)
agegap	-0.035	0.070**	-0.053	0.071
	(0.02)	(0.03)	(0.03)	(0.04)
agegap2	0.001	-0.004	0.005	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)
No. child	-0.103	0.164*	-0.076	0.091
	(0.06)	(0.08)	(0.08)	(0.11)
manager	-0.326**	0.677***	0.016	0.024
	(0.12)	(0.17)	(0.18)	(0.25)
meduclevel	0.073	-0.224*	0.152	-0.235
	(0.08)	(0.11)	(0.11)	(0.16)
Ethnically white	0.887*	-0.553	2.063***	-2.732**
	(0.43)	(0.60)	(0.63)	(0.87)
Car	0.029	0.207	-0.950*	1.570**
	(0.27)	(0.38)	(0.40)	(0.55)
Sunday			0.405*	-0.378
			(0.16)	(0.22)
cons	-1.362*	0.772	-2.174*	3.083**
	(0.57)	(0.80)	(0.85)	(1.17)
R^2	0.585	0.121	0.562	0.072
χ^2	879.112	92.415	821.674	46.705
p	0.000	0.000	0.000	0.000
N	597	597	597	597

Table 1.4: SUR Regressions of Joint & Private Leisure for Weekdays & Weekends. Coefficients in each case represent the marginal effect of a unit change in the explanatory variable on joint or private leisure. The unit of time remains in terms of hours. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level.

determinants in this model. This suggest a high degree of efficiency gains when using SUR estimation.

Correlation matrix of residuals				
	Weekday		Weekend	
Variable	Joint Leisure	Male	Joint Leisure	Male
Joint (Weekday)	1.0000			
Male (Weekday)	-0.7821	1.0000		
Joint (Weekend)	0.2974	-0.2042	1.0000	
Male (Weekend)	-0.2616	0.2265	-0.8630	1.0000
Breusch-Pagan test	of independence:		chi2(6) = 958.960,	Pr = 0.0000

Table 1.5: Correlation matrix of residuals

Table 1.7 reports the results from adopting the CUE approach. As mentioned in Section 4, this specification allows for the endogeneity of total household leisure. The results from the regressions are very similar to the previous SUR specification. This is particularly true for weekdays. For weekends, the coefficients on total leisure have adjusted slightly with the coefficient in the joint equation seeing the biggest increase. An extra hour of household leisure is now associated with a 31 minutes extra joint leisure as opposed to 23 minutes before. The effect on male private leisure on weekends is no longer significant. This could be partly due to a decrease in efficiency as the standard errors have increased by almost five folds. The coefficients on the other variables have remained very similar to before, with demographics such as age gap, ethnicity, education levels and car ownership being the main determinants, whilst the number of children have a smaller effect. Once again Sundays are significantly different from Saturdays in terms of joint leisure.

1.5.1 Test for weak instruments

If the correlation between the instrument and the endogenous variable being instrumented is very weak the instrument is called a weak instrument. The estimated model will be weakly identified and this could lead to a large loss in efficiency and this loss of precision will be concentrated on the endogenous variable. The Kleibergen-Paap rk Wald F statistic is computed and compared against the Stock-Yogo weak identification test critical values (Stock-Yogo (2005)). The degrees of freedom adjustment for the rk statistic is (N-L)/L1, where N is the number of observations, L is the number of instruments and L1 is the number of excluded instruments. The test statistics are reported in Table 3.6 below:

Weak Identification Test				
	Weekday		Weekend	
	Joint	Male	Joint	Male
Kleibergen-Paap rk Wald F-Statistic	10.560	10.560	16.812	16.812
Stock-Yogo weak ID test critical values:				
10% maximal LIML size	6.46	6.46	8.68	8.68
15% maximal LIML size	4.36	4.36	5.33	5.33
20% maximal LIML size	3.69	3.69	4.42	4.42
25% maximal LIML size	3.32	3.32	3.92	3.92

Table 1.6: Stone-Geary Model: Weak Identification Test

The test clearly rejects the null hypothesis of weak instruments in all cases.

CUE GMM Regressions of Joint & Private Leisure for Stone-Geary Model				
	Weekday		Weekend	
Variable	Joint Leisure	Male	Joint Leisure	Male
Total Leisure (Weekday)	0.383***	0.173*		
	(0.06)	(0.09)		
Total Leisure (Weekend)			0.514***	-0.083
			(0.07)	(0.09)
agegap	-0.034	0.072**	-0.043	0.058
	(0.02)	(0.02)	(0.03)	(0.04)
agegap2	0.001	-0.005	0.004	-0.003
	(0.00)	(0.00)	(0.00)	(0.00)
No. child	-0.093	0.167	0.025	-0.040
	(0.06)	(0.09)	(0.11)	(0.14)
manager	-0.325**	0.677***	-0.027	0.078
	(0.12)	(0.17)	(0.18)	(0.26)
meduclevel	0.073	-0.235*	0.163	-0.246
	(0.08)	(0.11)	(0.12)	(0.16)
Ethnically white	0.875*	-0.582	1.865**	-2.484*
	(0.42)	(0.36)	(0.69)	(1.10)
Car	0.025	0.195	-1.135*	1.792**
	(0.24)	(0.36)	(0.47)	(0.66)
Sunday			0.429*	-0.430
			(0.18)	(0.24)
_cons	-1.499*	0.671	-3.665**	5.024**
	(0.69)	(0.84)	(1.25)	(1.81)

Table 1.7: CUE GMM Regressions of Joint & Private Leisure for Weekdays & Weekends for Stone-Geary Model. Coefficients in each case represent the marginal effect of a unit change in the explanatory variable on joint or private leisure. The unit of time remains in terms of hours. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level. Instruments: Weekday: Total Household Leisure (Weekend), Household Weekly Net Earnings, HH Net Non-Labour Y; Weekend: Total Household Leisure (Weekday), HH Net Non-Labour Y.

1.6 Structural estimates and implications

Using the results from the Section 5, it is possible to derive the conditional structural estimates of the theoretical model. These are conditional estimates after controlling for other covariates. Recall that the optimal leisure choices equations (1.24)-(1.26) were derived and estimated, and the parameters of the Stone-Geary model is given by equations (1.35)-(1.37). Table 1.8 summarises the structural estimates for the parameters of interest.

Structural Estimates for the Stone-Geary Model				
	Weekday		Weekend	
	Joint	Private	Joint	Private
Parameter	ϕ	π_A	ϕ	π_A
SUR	0.732	0.152	0.770	0.083
s.e	(0.02)	(0.02)	(0.02)	(0.02)
CUE GMM	0.766	0.173	1.028	-0.083
s.e	(0.12)	(0.09)	(0.14)	(0.09)

Table 1.8: Structural Estimates for the Stone-Geary Model. Robust standard errors in parenthesis.

The first interesting observation is that the two types of leisure are not valued in equal fashion in the utility function. In particular, moving across from weekday to weekend sees the weights for private leisure falling by almost a half. However, this is in direct contrast to the pattern for joint leisure. The weight for joint leisure actually rises on weekends. Overall this strongly suggests that households treat joint leisure very differently from private leisure, as if it were a different good. Also comparing the two types of leisure, joint leisure is the most important element in the household utility function. In our model, this would imply that couples assign more weight to spending time together as opposed to leisure alone or with other friends. This could suggest that couples do prefer to spend time together, and would actively synchronise their leisure patterns to suit each other. This observed form of synchronisation is present and substantial for both weekdays and weekends, but is especially important on weekends.

These may be rudimentary calculations, but these structural estimates help shed light on the how a household values and organises its leisure time. Of course other economic variables such as having children would in turn add to this baseline structure. But the central insight here is that a household appears to be systematically distinguishing between joint leisure, male private leisure and female private leisure. The findings also suggest that households favour joint leisure over private leisure. Furthermore, weekdays are seen as very different from weekends especially for private leisure and households tend to allocate weekends for joint leisure, leaving private leisure for weekdays. Couples prefer to actively synchronisation their leisure time use and there is likely to be systematic co-ordination even with private leisure. This also raises the wider question of how households should be modelled and further supports the view that there may be more complex dynamics at work on an intra-household level.

1.7 Specification checks

In this section, the results from four misspecification tests for the Stone-Geary model are reported: 1) Test for Underidentification, 2) Test for Weak Instruments, 3) Overidentifying Restrictions(OIR) Tests for Instrument Exogeneity and 4) Hausman Test for Endogeneity.

The misspecification tests in this section confirm that the hypotheses of underidentification and weak instruments are strongly rejected in all cases. There is also strong evidence that the instruments are indeed valid in all cases considered.

1.7.1 Test for underidentification

The underidentification test is an LM test of whether the regression equation is identified. The test verifies the rank of a matrix: under the null hypothesis that the equation is underidentified, a rejection of the null indicates that the matrix is full column rank, i.e., the model is identified.

Underidentification Test				
	Weekday		Weekend	
	Joint	Male	Joint	Male
Kleibergen-Paap rk LM statistic	28.429	28.429	26.505	26.505
Chi-sq D.o.F	Chi-sq(3)	Chi-sq(3)	Chi-sq(2)	Chi-sq(2)
Chi-sq P-value	0.0000	0.0000	0.0000	0.0000

Table 1.9: Stone-Geary Model: Underidentification Test

The LM test clearly rejects the null hypothesis of underidentification in all cases.

1.7.2 Test for weak instruments

If the correlation between the instrument and the endogenous variable being instrumented is very weak the instrument is called a weak instrument. The estimated model will be weakly identified and this could lead to a large loss in efficiency and this loss of precision will be concentrated on the endogenous variable. The Kleibergen-Paap rk Wald F statistic is computed and compared against the Stock-Yogo weak identification test critical values (Stock-Yogo (2005)). The degrees of freedom adjustment for the rk statistic is (N-L)/L1, where N is the number of observations, L is the number of instruments and L1 is the number of excluded instruments. The test statistics are reported in Table 3.6 below:
The test clearly rejects the null hypothesis of weak instruments in all cases.

1.7.3 Test for overidentifying restrictions(OIR)

If a set of instruments is to be used, the instruments must be exogenous for the estimates to be consistent. For overidentified models a test for exogeneity of instruments is possible. The OIR is distributed as $\chi^2(r-K)$ under H_0, where $(r-K)$ is the number

Weak Identification Test				
	Weekday		Weekend	
	Joint	Male	Joint	Male
Kleibergen-Paap rk Wald F-Statistic	10.560	10.560	16.812	16.812
Stock-Yogo weak ID test critical values:				
10% maximal LIML size	6.46	6.46	8.68	8.68
15% maximal LIML size	4.36	4.36	5.33	5.33
20% maximal LIML size	3.69	3.69	4.42	4.42
25% maximal LIML size	3.32	3.32	3.92	3.92

Table 1.10: Stone-Geary Model: Weak Identification Test

of overidentifying restrictions. If the OIR statistic is large then the moment conditions are rejected and the instruments are endogenous, or it could also be evidence of model misspecification. In either case, rejection indicates serious problems for the IV estimator. The Hansen-J statistics are reported in Table 3.5 below, in all cases H_0 of instrument exogeneity cannot be rejected at 5% or 10% level.

Overidentifying Restrictions Test				
	Weekday		Weekend	
	Joint	Male	Joint	Male
Hansen J statistic	0.124	0.324	0.074	0.050
Chi-sq(2) P-val	0.9399	0.8503	0.7862	0.8229
N	597	597	597	597

Table 1.11: Stone-Geary Model: OIR Test

1.7.4 Hausman test for endogeneity

Instrumental variables estimators should only be used if total household leisure is endogenous since OLS or SUR estimates will be more efficient and should be used if it is exogenous.The Hausman test statistics are summarised in Table 3.8 below. The results indicate that the SUR estimates may be valid and more appropriate as it is likely to be more efficient.

Hausman Test for Endogeneity				
	Weekday		Weekend	
	Joint	Male	Joint	Male
chi2(8)	0.04	0.13	3.64	3.26
D.o.F.	chi-sq(8)	chi-sq(8)	chi-sq(9)	chi-sq(9)
Prob>chi2	1.0000	1.0000	0.9335	0.9529
N	597	597	597	597

Table 1.12: Stone-Geary Model: Hausman Test for Endogeneity

1.8 Conclusion

This paper provides a different approach to understanding the underlying preference structure of leisure in couples. In particular, one of the key aims is to highlight the central role of joint leisure as it is often neglected in economic analysis. In this study, we employ a structural approach and model the household as a two-stage decision making unit. Our findings suggest that first of all, joint leisure appears to be the most important type of leisure in a household. This is confirmed by estimations from different specifications and also the structural estimates. Specifically when a household decides to have more leisure, almost 40 percent of this increase is allocated to joint leisure as opposed to only 8 to 15 percent allocated to male private leisure. This effect of an extra hour of total household leisure on joint leisure is very significant and its effects are similar on weekdays and weekends. However, the same cannot be said about private leisure. On weekdays an extra hour of total household leisure has twice the effect on male leisure compared to weekends. Interestingly the number of children only has a small but negative impact on spousal joint leisure. An extra child translates to approximately a fall of 6 minutes in leisure time for the couple jointly, but brings about 10 minutes of extra male weekday private leisure; and on weekends the corresponding gain in male private leisure is about 5 minutes per child, this is achieved almost entirely by breaking up joint leisure.

Another interesting finding is that demographics can play a large role in determining the patterns of spousal leisure. In particular ethnicity is one of the principal factors, being ethnically white translates to a 53 minutes increase in joint leisure on weekdays and a 158 minutes increase on weekends. Thus in terms of time use, cultural factors should not be neglected. The relationship between education, earnings and leisure time is more complex. Groups with higher educational levels tend to have less private leisure but managerial positions are associated with a much higher level of private leisure and correspondingly lower joint leisure. However one intriguing observation is that career related characteristics such as education level and managerial positions only affect leisure allocation on weekdays but not on weekends. This again implies a degree of separation between weekdays and weekends, which is confirmed by all three regression models and also by the structural estimates of the Stone-Geary model. Lastly, when analysing weekend time use patterns, there is evidence to suggest that Saturdays should be distinguished from Sundays as approximately 41 percent more joint leisure is observed on Sundays.

Finally, this project could be extended in several ways, for instance there is room for improvement in terms of the modelling of the household. This paper follows a structural approach based on a Stone-Geary model with two-stage budgeting. We have already discussed some of the potential drawbacks with this framework and perhaps this paper could be seen as a first step towards building a more sophisticated model. Specifically a model that allows the relaxation of the additive separability assumption in the utility functions would be a potential area for future investigation. With respect to joint and private leisure, it would be interesting to identify the underlying relationship between these different types of leisure time use. In addition, the possibility of joint determination of the hours of work and leisure choices also deserves a more thorough treatment. Lastly, changes in external institutional factors such as the tax and benefit systems, which are outside the scope of this paper, could add further implications for the co-determination of work hours and leisure time.

1.9 Appendix

1.9.1 Activities coding

A sample list of activities individuals could choose from when filling in their diaries. The full activity list runs from code value 0 to 9990.

Activities & Coding

Value = 0	Label = Unspecified personal care
Value = 10	Label = Unspecified Sleep
Value = 110	Label = Sleep
Value = 120	Label = Sick in bed
Value = 210	Label = Eating
Value = 300	Label = Unspecified other personal care
Value = 310	Label = Wash and dress
Value = 390	Label = Other specified personal care
Value = 1000	Label = Unspecified employment
Value = 1110	Label = Working time in main job
Value = 1120	Label = Coffee and other breaks in main job
Value = 1210	Label = Working time in second job
Value = 1220	Label = Coffee and other breaks in second job
Value = 1300	Label = Unspecified activities related to employment
Value = 1310	Label = Lunch break
Value = 1390	Label = Other specified activities related to employment
Value = 1391	Label = Activities related to job seeking
Value = 1399	Label = Other specified activities related to employment
Value = 2000	Label = Unspecified study
Value = 2100	Label = Unspecified activities related to school or university
Value = 2110	Label = Classes and lectures
Value = 2120	Label = Homework
Value = 2190	Label = Other specified activities related to school or university
Value = 2210	Label = Free Time Study
Value = 3000	Label = Unspecified household and family care
Value = 3100	Label = Unspecified food management
Value = 3110	Label = Food preparation
Value = 3120	Label = Baking
Value = 3130	Label = Dish washing
Value = 3140	Label = Preserving
Value = 3190	Label = Other specified food management
Value = 3200	Label = Unspecified household upkeep
Value = 3210	Label = Cleaning dwelling
Value = 3220	Label = Cleaning yard
Value = 3230	Label = Heating and water
Value = 3240	Label = Various arrangements
Value = 3250	Label = Disposal of Waste
Value = 3290	Label = Other specified household upkeep
Value = 3300	Label = Unspecified making and care for textiles
Value = 3310	Label = Laundry
Value = 3320	Label = Ironing
Value = 3330	Label = Handicraft and producing textiles
Value = 3390	Label = Other specified making and care for textiles
Value = 3400	Label = Unspecified gardening and pet care
Value = 3410	Label = Gardening
Value = 3420	Label = Tending domestic animals
Value = 3430	Label = Caring for pets
Value = 3440	Label = Walking the dog
Value = 3490	Label = Other specified gardening and pet care
Value = 3500	Label = Unspecified construction and repairs
Value = 3510	Label = House construction and renovation
Value = 3520	Label = Repairs of dwelling
Value = 3530	Label = Unspecified making, repairing and maintaining equipment
Value = 3531	Label = Woodcraft, metal craft, sculpture and pottery
Value = 3539	Label = Other specified making, repairing and maintaining equipment
Value = 3540	Label = Vehicle maintenance
Value = 3590	Label = Other specified construction and repairs
Value = 3600	Label = Unspecified shopping and services
Value = 3610	Label = Unspecified shopping
Value = 3611	Label = Shopping mainly for food
Value = 3612	Label = Shopping mainly for clothing
Value = 3613	Label = Shopping mainly related to accommodation
Value = 3614	Label = Shopping or browsing at car boot sales or antique fairs
Value = 3615	Label = Window shopping or other shopping as leisure
Value = 3619	Label = Other specified shopping
Value = 3620	Label = Commercial and administrative services
Value = 3630	Label = Personal services
Value = 3690	Label = Other specified shopping and services
Value = 3710	Label = Household management not using the internet
Value = 3720	Label = Unspecified household management using the internet
Value = 3721	Label = Shping for&ordring unspec gds&srvs via internet
Value = 3722	Label = Shping for&ordring food via the internet
Value = 3723	Label = Shping for&ordring clothing via the internet
Value = 3724	Label = Shping for&ordring gds&sry related to acc via internet
Value = 3725	Label = Shping for&ordring mass media via the internet
Value = 3726	Label = Shping for&ordring entertainment via the internet
Value = 3727	Label = Banking and bill paying via the internet
Value = 3729	Label = Other specified household management using the internet
Value = 3800	Label = Unspecified childcare
Value = 3810	Label = Unspecified physical care & supervision of a child
Value = 3811	Label = Feeding the child

1.9.2 The identification of $(\gamma_A, \gamma_B, \gamma_L)$ in the Stone-Geary model

Using the optimal leisure choices from the theoretical model equations (1.24)-(1.26) could be rewritten as:

$$l_{Ai} = [(1 - \pi_A)\gamma_A - \pi_A\gamma_B - 2\pi_A\gamma_L)] + \pi_A\Gamma_i \tag{1.38}$$

$$l_{Bi} = [(1 - \pi_B)\gamma_B - \pi_B\gamma_A - 2\pi_B\gamma_L)] + \pi_B\Gamma_i \tag{1.39}$$

$$L_i = [(1 - \phi)\gamma_L - \frac{\phi}{2}\gamma_A - \frac{\phi}{2}\gamma_B] + \frac{\phi}{2}\Gamma_i \tag{1.40}$$

The empirical specification for the Stone-Geary Model was given by:

$$l_{Ai} = X_i'\alpha_A + \beta_A\Gamma_i + \epsilon_{Ai} \tag{1.41}$$

$$l_{Bi} = X_i'\alpha_B + \beta_B\Gamma_i + \epsilon_{Bi} \tag{1.42}$$

$$L_i = X_i'\alpha_L + \beta_L\Gamma_i + \epsilon_{Li} \tag{1.43}$$

where

$$X_i'\alpha_A = [(1 - \pi_A)\gamma_A - \pi_A\gamma_B - 2\pi_A\gamma_L)] \tag{1.44}$$

$$X_i'\alpha_B = [(1 - \pi_B)\gamma_B - \pi_B\gamma_A - 2\pi_B\gamma_L)] \tag{1.45}$$

$$X_i'\alpha_L = [(1 - \phi)\gamma_L - \frac{\phi}{2}\gamma_A - \frac{\phi}{2}\gamma_B] \tag{1.46}$$

(π_A, π_B, ϕ) were identified as shown in section 1.4.3 and $(X_i'\alpha_A, X_i'\alpha_B, X_i'\alpha_L)$ are the estimated constants from the regressions (1.41)-(1.43). Hence, there are three equations and three unknowns, which could be solved for.

Substituing (1.46) into equations (1.44) and (1.45) ,

$$\alpha_A = \frac{1-\phi-\pi_A}{1-\phi}\gamma_A - \frac{\pi_A}{1-\phi}\gamma_B - \frac{2\pi_A}{1-\phi}\alpha_L \tag{1.47}$$

$$\alpha_B = \frac{1-\phi-\pi_B}{1-\phi}\gamma_B - \frac{\pi_B}{1-\phi}\gamma_A - \frac{2\pi_B}{1-\phi}\alpha_L \tag{1.48}$$

Substituting (1.48) into (1.47) and rearranging the expression yields,

$$\gamma_A^* = \frac{(1-\phi)[(1-\phi-\pi_B)\alpha_A + \pi_A\alpha_B + 2\pi_A\alpha_L]}{(1-\phi-\pi_A)^2 - \pi_A\pi_B} \tag{1.49}$$

This allows the identification of γ_A. Subsequently, the values of γ_B, γ_L can be obtained by first substituting (1.49) into (1.50) and then (1.49) and (1.50) into (1.51).

$$\gamma_B^* = \frac{(1-\phi)\alpha_B + \pi_B\gamma_A^* + 2\pi_B\alpha_L}{1-\phi-\pi_B} \tag{1.50}$$

$$\gamma_L^* = \frac{1}{1-\phi}\left(\alpha_L + \frac{\phi}{2}\gamma_A^* + \frac{\phi}{2}\gamma_B^*\right) \tag{1.51}$$

This completes the identification for parameters $(\gamma_{Ai}, \gamma_{Bi}, \gamma_{Li})$ in the Stone-Geary case.

1.10 Separability between weekday and weekend

OLS Regressions of Joint & Private Leisure for Stone-Geary Model				
	Weekday		Weekend	
Variable	Joint Leisure	Male	Joint Leisure	Male
Total Leisure (Weekday)	0.373***	0.142***	0.039	-0.050
	(0.01)	(0.02)	(0.02)	(0.03)
Total Leisure (Weekend)	0.002	0.007	0.381***	0.091***
	(0.01)	(0.01)	(0.02)	(0.02)
Ethnically white	0.878*	-0.555	2.034**	-2.696**
	(0.43)	(0.60)	(0.63)	(0.87)
agegap	-0.035	0.070**	-0.050	0.068
	(0.02)	(0.03)	(0.03)	(0.04)
agegap2	0.001	-0.004	0.005	-0.004
	(0.00)	(0.00)	(0.00)	(0.00)
No. child	-0.098	0.164*	-0.057	0.066
	(0.06)	(0.08)	(0.08)	(0.11)
manager	-0.327**	0.675***	0.019	0.019
	(0.12)	(0.17)	(0.18)	(0.25)
meduclevel	0.071	-0.220*	0.137	-0.213
	(0.08)	(0.11)	(0.11)	(0.16)
Car	0.024	0.199	-0.940*	1.551**
	(0.27)	(0.38)	(0.40)	(0.55)
Sunday			0.485**	-0.501*
			(0.17)	(0.23)
_cons	-1.435*	0.754	-2.432**	3.409**
	(0.59)	(0.82)	(0.86)	(1.19)

Table 1.13: OLS Regressions of Joint & Private Leisure for Weekdays & Weekends. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level.

CUE GMM Regressions of Joint & Private Leisure for Stone-Geary Model		
	Weekday	Weekend
Variable	Joint Leisure	Joint Leisure
Total Leisure (Weekday)	0.392***	0.003
	(0.09)	(0.04)
Total Leisure (Weekend)	-0.001	0.499***
	(0.02)	(0.12)
Ethnically white	0.864*	1.884**
	(0.42)	(0.68)
agegap	-0.033	-0.044
	(0.02)	(0.03)
agegap2	0.001	0.004
	(0.00)	(0.00)
No. child	-0.089	0.012
	(0.07)	(0.10)
manager	-0.326**	-0.024
	(0.12)	(0.19)
meduclevel	0.072	0.162
	(0.08)	(0.12)
Car	0.021	-1.117*
	(0.24)	(0.49)
Sunday		0.433*
		(0.19)
_cons	-1.544*	-3.497*
	(0.77)	(1.43)
r2	0.584	0.520
N	597	597

Table 1.14: CUE GMM Regressions of Joint & Private Leisure for Weekdays & Weekends. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level. Instruments: Weekday: Household Weekly Net Earnings, HH Net Non- Labour Y, Nssecb; Weekend HH Net Non- Labour Y, Nssecb.

Chapter 2

Taxation of Married Couples

Abstract

Across countries, there is a large variation in the income tax treatment of couples. Over the last three decades, many countries have undergone reforms in their tax systems, some have moved from joint to independent taxation, some from independent to joint, while others have begun the practice of allowing couples to choose the system they prefer. This chapter aims to give an overview of the tax treatment of couples and outlines the differences across countries, with particular emphasis on the tax reform in the United Kingdom.

2.1 Introduction

Across countries, there is a large variation in the income tax treatment of couples. Over the last three decades, many countries have undergone reforms in their tax systems, some have moved from joint to independent taxation, some from independent to joint, while others have begun the practice of allowing couples to choose the system they prefer. This chapter aims to give an overview of the tax treatment of couples and outlines the differences across countries, with particular emphasis on the tax reform in the United Kingdom.

2.1.1 Joint and independent taxation

There are two main types of taxation applied to married couples: joint and independent taxation. Under joint taxation, spouses are required to file a joint tax return. Incomes from both spouses are summed (less any allowances) and then applied to the tax schedule. There are three main types of joint taxation: aggregation, income splitting and the family quotient. Aggregation and income splitting are the most common systems in countries that allow or require joint filing. Under an aggregation system, the gross incomes of the spouses are aggregated and then applied to the given tax schedule as one tax unit. Under the latter, the taxable incomes from the two individuals are summed (less allowances), divided by two, and then applied to the given tax schedule. Another form of income splitting is where instead of dividing total household income by two, a family quotient is used. This 'quotient' is calculated based on household size and dependent children. Total household income is divided by the family quotient and then applied to the relevant tax schedule to obtain the amount of tax per family unit, this is then multiplied by the quotient to obtain the total tax due. In contrast, under independent taxation, spouses are individually required to file separate tax returns. Taxes are calculated based on personal income and is independent of their spouse's earnings.

2.1.2 Principal features of income taxation systems

This section outlines the essential features of income taxation systems. The aim is to provide the reader with a good understanding of the basic building blocks of any modern income taxation system and the variables that determine its structure.

The first basis of any tax system is the 'Tax Base', this defines which incomes are taxable. The tax base is also closely related to a second concept, the 'Tax Unit', which is the focus of the current paper, as the UK 1990 tax reform was essentially a change to the tax unit from couples to individuals. In addition, governments frequently allocate annual 'Tax Allowances' in order to reinforce the progressive nature of income tax systems. These are simply the amounts deducted from the tax base, resulting in the taxable income, upon which the tax is levied. If the taxable income is zero or negative, naturally no tax is payable. Examples of tax allowances include, the personal allowance, married couple's allowance and other age-related allowances. It is also important to distinguish between tax allowances and tax credits. The former is applied to the tax base pre-tax, and the latter is subtracted from the tax bill after tax calculations. Finally, in order to calculate the amount of tax due, a 'Tax Schedule' is required to set the thresholds and tax rates that determine the amount of tax payable from the taxable income. In reality tax schedules are often progressive with gradually rising marginal tax rates applicable to each higher band of income.

As mentioned above, the tax reform in 1990 altered the tax unit from a married couple to an individual. To illustrate the effect of this, we can first consider the simpler individual taxation system. In a household with a married couple, each spouse is subject to their own tax schedule, the resulting total tax bill, T, of the household is thus given by:

$$T = g(E_m) + g(E_f) \tag{2.1}$$

Where E_m and E_f are the gross earnings of the husband and wife respectively and $g(.)$ is the (progressive) tax function. Now we turn to examine the systems of joint taxation. The most common type being joint taxation with aggregation. In this case, the gross incomes of the couple are summed and then jointly assessed. The total tax bill is given by:

$$T = \tilde{g}(E_m + E_f) \tag{2.2}$$

Here $\tilde{g}(.)$ denotes the joint tax schedule. If instead, the income splitting method is used, the resulting tax bill will be given by the expression below. Once again $\hat{g}(.)$ simply denotes the relevant tax schedule.

$$T = 2 * \hat{g}\left(\frac{E_m + E_f}{2}\right) \tag{2.3}$$

The family quotient method takes into account the presence of dependent children and whether or not they contribute to the household tax base. In the absence of children, this just collapses into the income splitting case. To calculate the tax payable, a rule similar to the following is applied to the family aggregate gross income:

$$T = \theta * \breve{g}\left(\frac{E_m + E_f + \sum_1^N E_i}{\theta}\right) \tag{2.4}$$

Where $\breve{g}(.)$ denotes the tax schedule in this case. $i = 1...N$ is the number of dependents and θ is the quotient. The quotient is usually dependent on the number of children and marital status. As an example, Table 2.1 below illustrates how the quotient is calculated for the case of France.

The tax schedule in most countries also follow a piecewise linear structure. This means that there is a sequence of n threshold income values, $E_1, E_2, ..., E_n$, that form the respective tax brackets, $[0, E_1], (E_i - 1, E_i], i = 2, ..., n$ and (E_n, ∞). Correspondingly

Table 2.1: Definition of the family quotient θ

Number of Children	Lone Parent	Married
0	1.0	2.0
1	2.0	2.5
2	2.5	3.0
3	3.5	4.0
4	4.5	5.0

Source: Bourguignon, O'donoghue, Sastre-Descals, Spadaro, and Utili (1997)

there is a marginal tax rate, $t_0, t_1, ..., t_n$, associated with each income bracket. The taxpayer may also be eligible for a lump sum transfer, $b \geq 0$, if their gross earnings, E, falls below a certain level. The tax function would typically take a form similar to the example below:

$$T_0 = -b + t_0 E \qquad E \in [0, E_1] \quad (2.5)$$

$$T_1 = -b + t_0 E_1 + t_1(E - E_1) \qquad E \in (E_1, E_2] \quad (2.6)$$

$$T_2 = -b + t_0 E_1 + t_1(E_2 - E_1) + t_2(E - E_2) \qquad E \in (E_2, E_3] \quad (2.7)$$

$$... \quad (2.8)$$

$$T_n = -b + t_0 E_1 + t_1(E_2 - E_1) + t_2(E_3 - E_2) + ... + t_n(E - E_n) \qquad E \in (E_n, \infty) \quad (2.9)$$

2.2 Theoretical analysis of the taxation of married couples

2.2.1 Optimal taxation of married couples

The question of how couples should be taxed is potentially one of the most important questions in personal income taxation. The natural justification for treating couples as a unit is that the majority of individuals live in households that are centred around couples. However, following the seminal paper by Mirrlees (1971) the literature on optimal income taxation has concentrated almost exclusively on individuals. It was the papers by Rosen (1977) and Boskin and Sheshinski (1983) that eventually provided arguments for independent taxation based on efficiency, and only until recently has the discussion on optimal taxation of couples begun to regather momentum, see Kleven, Kreiner, and Saez (2008), Kleven and Kreiner (2007), Alesina, Ichino, and Karabarbounis (2007) and Cremer, Lozachmeur, and Pestieau (2012).

The fundamental argument for independent taxation stems from the empirical observation that labour supply elasticities for the primary and secondary earners are likely to differ substantially. In general, secondary earners are likely to have much higher labour supply elasticities. A straightforward application of the classic Ramsey rule would suggest a higher tax rate on the more inelastic tax base, i.e. the income of primary earners, hence independent taxation of each spouse at different tax rates would be the more efficient policy instrument as joint taxation naturally implies the equalisation of marginal tax rates of both spouses. However, in addition to distorting the labour-leisure choice as in a standard model, if one also considers household production in a framework as in Becker (1965), the taxation of labour income could cause a further distortion in the primary-secondary input ratio in household production. Piggott and Whalley (1996) were first to highlight this additional distortion and using Australian data and a general equilibrium framework, they argued that the severity of the distortion of household production could outweigh the gains from taxing each spouse at different rates to reflect the differences in labour supply elasticities. However, this result was rejected by Apps and Rees (1999), Goutfried and Richter (1999) and Kleven and Kreiner (2007) on the basis that Piggott and Whalley (1996) were essentially comparing joint taxation to an existing suboptimal independent taxation structure. Kleven and Kreiner (2007) further demonstrated that the optimal tax system depends on the restrictions on commodity taxes, but not simply on the magnitude of labour supply elasticities. Their findings also suggest that in reality, restricted commodity taxation would mean that independent taxation could typically dominate joint taxation.

2.2.2 Economic implications of the two systems

In addition to the efficiency arguments given above, it is important to recognise other economic implications of the two systems. The principle difference between the two systems is clearly the tax unit. Under the joint system, the tax unit is the married couple, while under the independent system, the tax unit is the individual. However, more importantly, the implication of the joint system is that the marginal tax rates faced by the two individuals are interdependent and automatically equalised, regardless of the degree of inequality in earnings between couples. This has serious implications for cross-sectional household equality as it means that all married couples with the same total income will pay the same amount of tax. A household with a single high earner would pay the same amount of tax as a household containing two middle or low income earners with the same total income. This may seem like a fair treatment, but the equalisation of marginal tax rates between spouses does come with further implications.

Joint taxation is sometimes associated with the creation of a marriage penalty especially from the perspective of the female individual (Rosen (1988), Feenberg and Rosen (1995), Alm, Dickert-Conlin, and Whittington (1999)). A marriage penalty occurs if the tax liability of a couple is higher when they are married than when they are two singles. Under joint taxation, a married woman with the same job and same earnings as a single woman would in many cases be paying more in tax than their single counterparts due to their husband's higher earnings, and thus, higher marginal tax rate depending on their spouse. Entering a marriage could therefore penalise the lower earner. Indeed, with the continuing increase in the number of women entering the job market and the consequent rise in two-earner households, the system of joint taxation which encourages the traditional family with one high earner could potentially lead to a growing number of couples choosing to remain unmarried, even in the presence of children, and this is further complicated by the tax and benefit systems for single parent families. Furthermore, subsequent to marriage, the lower earner in the household would in general face higher tax disincentives to work under the joint system, as any additional income earned would be taxed at the highest rate paid by the higher earner, thus discouraging labour force participation after marriage.

Several papers have used policy changes to quantify the economic effects of joint taxation. LaLumia (2008) examines the US reform in 1948. Using a difference-in-difference estimation strategy, she exploits the differences in tax treatment of property law across states. She finds that joint taxation lowered the marginal tax rates of husbands and raised that of the wives. Her results show that joint taxation is associated with a decline of approximately two percentage points in employment rate of married women. Gustafsson (1992) examines the labour supply of Swedish and German women facing independent and joint taxation respectively. Using tax simulations and regression analysis, he finds a significant difference in the behaviour of German and Swedish women. In addition, he estimates that the participation rates of Swedish married women would fall from 80% to 60% if the German system of joint taxation was adopted. His study also highlights the importance of children for German women's labour force participation but less so for Swedish women. Besides employment and participation effects, a reform may also affect how couples allocate their assets for taxation. Stephens Jr and Ward-Batts (2004) is the only study to date that examines the UK reform in 1990. They investigated asset ownership shares between spouses and found significant evidence of tax avoidance following the reform, by shifting investment income to the spouse with lower earnings.

This thesis provides a fresh look at the UK 1990 reform from an intra-household perspective. As demonstrated above and again with examples in the next section, a shift from joint to independent taxation could have serious repercussions for the secondary earner's economic position within the household even if the household is not affected as a whole. If intra-household outcomes depend on economic factors such as outside options and relative net incomes, then this suggests that secondary earners would tend to be better off under an independent taxation system despite little or no change to the household as a whole. The policy reform provides an exogenous shift in intra-household net incomes and this in turn allows us to identify changes in intra-household allocations. In addition, we could exploit this large exogenous shift in the net wages of women over the period for labour supply analysis. Chapter 3 of the thesis investigates how the reform has shifted intra-household allocation of expenditures on clothing. In Chapter 4, I explore how the significant changes to work incentives, particularly for women with middle or high income husbands have affected their labour supply.

2.2.3 Examples: Taxing married couples

Some examples are given below to illustrate the differences between the two systems in practice and how the marriage penalty could arise from the joint taxation system. For instance, one could take the UK tax schedule in 1989, any income up to £20,700 was taxed at 25%, any income above this threshold was taxed at 40%. For the purposes of these examples, we ignore any tax allowances for simplicity, as these do not affect the key implications of the marginal tax rates. We examine two cases involving two different hypothetical households, but both households are earning the same aggregate household income of £45,000. The first case involves a more traditional type of household where the secondary earner contributes a smaller proportion to household income. The second case examines a type of household where both spouses are earning very similar levels of income.

Case 1: Traditional household with high primary earner

Take a hypothetical couple who are both working, with person A earning £40,000 and person B earning £5,000:

Under independent taxation

Individuals are taxed separately. Applying the tax schedule to both spouses:

A: 20,700*.25 + (40,000-20,700)*.40 = £12,895

B: 5,000*.25 = £1,250

Total Tax = £14,145

Under joint taxation with aggregation

Household income pooled £(40,000+5,000) = £45,000.

A and B: 20,700*.25 + (45,000-20,700)*.40 = £14,895

Total Tax = £14,895

Case 2: Couple with equal earning power

A hypothetical couple who are both working, with person A earning £22,500 and B earning £22,500.

Under independent taxation

A: 20700*.25 + (22,500-20700)*.40 = £5,895

B: 20700*.25 + (22,500-20700)*.40 = £5,895

Total Tax = £11,790

Under joint taxation with aggregation

Household income pooled £(22,500+22,500) = £45,000.

A and B: 20700*.25 + (45,000-20,700)*.40 = £14,895

Total Tax = £14,895

These simple examples illustrate why joint taxation is sometimes associated with the creation of a marriage penalty. Indeed this tax penalty is greater when the secondary earner is earning a high level of income. For instance, in case 2, the individuals may consider that upon marriage their individual tax liability is now £7,447.50, as opposed to £5,985 previously, thus attracting an extra £3,105 in taxes. This is equivalent to about 7 percent of their total gross household income.

The couple in case 1 would also experience a tax penalty upon marriage, but because the level of income of person B is low, the penalty is correspondingly lower even though the two households have the same total household gross income. With joint taxation, the couple may therefore consider that upon marriage, any additional income brought in by B is taxed at the higher rate under the joint system. Under independent taxation, B's marginal tax rate is 25 percent for their earnings, but under joint taxation their marginal tax rate is 40 percent due to their spouse's earnings. Hence in additional to the marriage penalty, joint taxation could also have a distortionary effect on the secondary earner's labour supply.

Of course in this simplistic analysis we have taken no account of other tax benefits, but the crucial insight here is that the nature of joint taxation renders the second earner's marginal earnings less efficient and poses disincentives for the lower earner to work. Hence the tax system could have serious implications for labour supply especially for the secondary earner. Moreover, if intra-household distribution of resources are important, after the reform the secondary earner could experience significant relative welfare improvements within the household despite the household as a whole being similar as before.

2.3 Motivation behind UK 1990 tax reform

In April 1990, the UK went from a system of joint income taxation with aggregation of married couples to a system of independent taxation. On the surface, this was a swift reform and was passed through parliament without much disagreement. In reality, this reform was the subject of more than a decade of debates and enquires within the European Community. It began in the 1960s when the European Community initiated steps to ensure equal pay and treatment for men and women. By 1979, three Directives had been issued by the Council of the European Communities. First covering equal pay in 1975[1], then equal treatment in access to employment, vocational training and promotion and working conditions in 1976[2], and finally, the progressive implementation of the principle of equal treatment for men and women in matters of social security in 1979[3]. As a result of these Directives, the European Parliament issued a Resolution on 11 February 1981, demanding the Community institutions to "intensify and broaden Community activity in this area", and a Directive on equal treatment for men and women in tax legislation was proposed. The European Commission and the European Parliament subsequently began a series of enquiries into the position of women and taxation systems.[4] These reports addressed the issue of joint taxation and concurred that the taxation system should be neutral in terms of its effect on women's work. These led to the preparation of the "Directive on equal treatment of men and women in fiscal legislation" in 1984.

The UK reform was announced in the 1988 Budget by the Chancellor John Major. The main reason given for the reform was to provide women with "privacy and independence". This was cited as the primary reason most likely because before the reform, a married woman's income was legally considered to belong to her husband. In fact, the Income and Corporation Taxes Act 1988 CH. II Taxation Of Income Of Spouses states this plainly:

Income and Corporation Taxes Act 1988 (c.1)

CHAPTER II

TAXATION OF INCOME OF SPOUSES

[1]European Communities Legislation (1975)

[2]European Communities Legislation (1976)

[3]European Communities Legislation (1979)

[4]See Commission of the European Communities (1984), European Parliment Committee of Enquiry (1984). These form part of the 18 reports from the European Committee of Enquiry on the situation of women in the European Community.

General rules

Section 279: Aggregation of wife's income with husband's

(1)Subject to the provisions of this Chapter, a woman's income chargeable to income tax shall, so far as it is income for –

(a)a year of assessment; or

(b)any part of a year of assessment, being a part beginning with 6th April, during which she is a married woman living with her husband, be deemed for income tax purposes to be his income and not to be her income.

This was clearly inconsistent with the European Directives on equal treatment of men and women, and it formed the main rationale behind the UK reform. In July 1990, during a debate in the House of Commons, the question of eliminating the tax penalty on marriage was also raised because under the joint taxation system, the tax payable by a married woman could exceed that payable by a single woman on the same income. The government anticipated that almost three million wives (just under half of all wives on whose income tax is charged) would benefit from the tax reform. However, there were no references at all to possible economic consequences of the reform on intra-household outcomes or women's labour supply. The reform was primarily brought in to enhance women's "privacy and independence". It is likely that this reform could have had much more far-reaching economic effects than the government had anticipated.

2.4 Tax systems across countries

Since 1970, many OECD countries have moved to independent taxation. These include Austria, Denmark, Finland, Italy, the Netherlands, Sweden and the United Kingdom. On the other hand, the United States converted from independent to joint taxation in 1948. It is important to note that joint filing does not automatically mean joint assessment[5]. Some countries like Greece, Norway and Spain allow joint filing, but does not accommodate joint assessment. In contrast, other countries such as the United States allow couples to file jointly or separately but use a mandatory joint taxation system, thus giving rise to three different tax schedules: one for singles, one for married couples filing jointly, and one for married couples filing separately. This means that filing status is not in itself meaningful, instead it depends on how the tax assessment is made.

As of 2010, out of 30 OECD countries[6], there are 21 that only allow independent taxation, and nine allow income splitting or the use of a family quotient.[7] Belgium operates a limited income splitting system whereby labour income is taxed individually but income from other sources is taxed jointly. It is also possible to transfer income allowances to the spouse up to a certain limit. Switzerland currently operates a joint taxation system and is considering a reform. Finally, the way tax schedules are defined is also an important consideration. Income splitting is particularly beneficial for couples with very different incomes under a progressive tax system combined with narrowly defined tax brackets, e.g. Luxembourg. This is because even a small difference in relative incomes can translate into a substantial tax saving. (See Alm and Melnik (2004) and Messere (1998) for complete surveys across countries and OECD (2005) for the OECD tax policy review.)

In summary, there has been a clear global shift towards independent taxation since 1970. 70 percent of OECD countries now operate an independent taxation system. Undoubtedly, some of the motivating forces behind the reforms could be traced back to the progress made within the European Community. Recently the European Union passed a directive recommending all countries to rule against aggregation of married couple income for taxation[8], thus we are likely to see further reforms in the next decade

[5]The assessment of husband and wife as one tax unit.

[6]Excluding Chile, Estonia, Israel and Slovenia, all of which joined after 2010.

[7]Countries with joint taxation: Belgium, France, Germany, Ireland, Luxembourg, Poland, Portugal, Switzerland and the United States.

[8]Alesina, Ichino, and Karabarbounis (2007).

or so.

2.5 An overview of the UK income tax system

In the UK, income tax is the single largest source of government revenues, generating around 30 percent of total government revenues annually. The tax system has undergone many reforms and simplifications over the last four decades, with numerous changes to the tax schedule, tax bands and allowances. The number of income taxpayers have also risen steadily over the last 30 years. According to the HMRC, in 1972, there were about 18.9 million taxpayers in the UK, this grew to 20.8 million in 1981 and 25.3 million in 1994. For comparison, around 29.9 million individuals paid income tax in the UK in 2011, 42.4 percent of which were women.[9] Table 2.2 below shows the number of taxpayers over the sample period 1986 to 1994 in the UK. Immediately following the reform, which came into effect in 1990, there was a 47 percent increase in the number of married women who were income taxpayers. The associated fall in the number of tax paying married men was 0.02 percent.

To determine the total amount of tax payable, tax allowances must first be deducted from a person's or couple's gross income. Singles are eligible for a personal tax allowance every tax year, the structure of which has changed very little over the years. Prior to 1990, the wife's income was deemed to be the husband's income upon marriage. The wife is given a 'Wife's Earned Income Limit', which is similar to the personal allowances that singles receive. The husband, on the other hand, receives a slightly more generous 'Married Men Allowance', which can be set against both his and his wife's earned incomes. In addition to the aforementioned tax allowances, there are also other types of tax reliefs, such as the blind person's tax relief and many age-related tax reliefs for individuals and married couples aged over 65, 75 and 80 respectively. These

[9]Tables 2.1 and 2.2a in HMRC (1994) and HMRC (2011).

Table 2.2: Number of Income Taxpayers 1986-1994

Year	Number of Individual Taxpayers	Singles	Husbands[a]	Wives[a]	High Tax Rate Payers
1986-87	23,900	9,830	10,360	3,690	1,120
1987-88	24,300	10,250	10,280	3,750	1,190
1988-89	25,200	10,360	10,640	4,150	1,350
1989-90	25,000	11,210	9,880	3,880	1,500
1990-91	26,100	10,730	9,660	5,710	1,700
1991-92	25,700	10,940	9,170	5,780	1,620
1992-93	25,400	-	14,900[b]	10,500[c]	1,720
1993-94	25,000	-	14,600[b]	10,300[c]	1,720

Sources: Tables 2.1 and 2.1a in HMRC (2011), published in Inland Revenue Statistics in 1994.
Numbers: Thousands
[a]After 1991, the data for husbands and wives were no longer available, instead the numbers shown are for Males and Females respectively.
[b]Number of Males, including singles.
[c]Number of Females, including singles.

allowances are usually reviewed and small adjustments are made by the Chancellor of the Exchequer on an annual basis. Table 2.3 below provides a brief overview of the relevant period.

Most individuals pay their income tax via their employers and banks[10] through the Pay-As-You-Earn(PAYE) system. This system can be traced back to the Income Tax Act of 1803, which established the British principle of taxing salaries before employees were paid and is also known as the 'Collection At The Source' principle. Income tax is calculated on an annual basis, but most employees are paid on a monthly or weekly basis. Thus employers have to work out the amount of tax due thus far bearing in mind taxes are calculated for the whole tax year. This cumulative system should yield very similar results to a non-cumulative one for individuals with stable incomes. However, for individuals with volatile incomes, it may be necessary to have end-of-year adjustments addressing outstanding tax owed or the amount due for refund.

[10]For income from savings and investments.

Table 2.3: Income Tax Personal Allowances 1986-1994

Year	Singles[a]	Married Men
1986-87	2,335	3,655
1987-88	2,425	3,795
1988-89	2,605	4,095
1989-90	3,005	4,375
	Personal	Married Couples[b]
1990-91	3,295	1,720
1991-92	3,445	1,720
1992-93	3,445	1,720
1993-94	3,445	1,720

Source: Tables TA.1 (1973-74 to 1989-90 and 1990-91 to 2008-09), HMRC. `http://www.hmrc.gov.uk/stats/tax_structure/incometax_pa-and-reliefs_1974to1990.pdf` and `http://www.hmrc.gov.uk/stats/tax_structure/table-a1a.pdf`.
[a]Same value as the wife's earned income limit.
[b]From 1990 onwards, this was given to married couples in addition to the personal allowance.

Similar to many countries, the UK generally operates a progressive income tax schedule with gradually rising marginal tax rates applicable to each higher band of income. The income tax schedule has undergone many adjustments over the last four decades, most notably the number of tax brackets has decreased substantially over the years. The evolution was not straightforward however. In 1973, there were nine different tax brackets, with the highest marginal tax rate at 75 percent. These peaked in 1978, with eleven narrow tax brackets and a top rate of 83 percent. After 1978, the income tax schedule saw numerous simplifications. In 1979, the number of brackets was lowered to seven, with a top rate of 60 percent, this was further reduced in the following year. However, the most significant overhaul took place in 1988, which saw the total number of brackets reduced to just two, with a basic rate of 25 percent and a top rate of 40 percent. This remained the fundamental structure until 1992, when a third middle bracket was introduced. However the top rate remained unchanged at 40 percent from 1988 and it was only in 2010 that a new 50 percent top rate was introduced for individuals with taxable income above £150,000. Table 2.4 gives some examples of how the tax rates and income brackets have evolved since 1978 and over the sample period. For a full account of the rates and brackets over the sample period, please refer to Table 2.5 in the Appendix.

Table 2.4: Income Tax Brackets & Rates 1986-1994

Bands of Taxable Income For Each Tax Year £				
Rate of Tax %	1978	1986	1988	1989
25	Up to 750		19,300	20,700
29		Up to 17,200		
33	750-8,000			
40	8,000-9,000	17,200-20,200	Over 19,300	Over 20,700
45	9,000-10,000	20,200-25,400		
50	10,000-11,000	25,400-33,300		
55	11,000-12,500	33,300-41,200		
60	12,500-14,000	Over 41,200		
65	14,000-16,000			
70	16,000-18,500			
75	18,500-24,000			
83	Over 24,000			
Rate of Tax %	1990	1992	1993	1994
20		Up to 2,000	Up to 2,500	Up to 3,000
25	Up to 20,700	2,000-23,700	2,500-23,700	3,000-23,700
40	Over 20,700	Over 23,700	Over 23,700	Over 23,700

Sources: Tables TA.2, HMRC.

2.6 Conclusion

From a theoretical point of view, given the presence of household production and constrained commodity taxation, independent taxation would typically dominate joint taxation on efficiency grounds. Furthermore, from an empirical point of view, if women's compensated labour supply elasticities are indeed higher than men's as found in numerous studies (see Blundell and MaCurdy (1999) for a comprehensive survey), then given the progressive structure of income tax rates, a shift from joint to independent taxation could reduce deadweight losses by reducing the marginal tax rates on women's incomes, as well as eliminating the marriage penalty and encouraging labour market participation after marriage.

The following chapters provide a fresh examination of the 1990 UK tax reform. If intra-household outcomes depend on economic factors such as outside options and relative net incomes, then this suggests that secondary earners would tend to be better off under an independent taxation system despite little or no change to the household as a whole. The central observation is that the policy reform provides an exogenous shift in relative intra-household net incomes, and this in turn allows us to isolate the changes in intra-household allocations. Chapter 3 investigates how the reform has shifted intra-household allocation of expenditures on clothing. In Chapter 4, I explore how the significant changes to work incentives, particularly for women with middle or high income husbands has affected their labour supply.

2.7 Appendix

Table 2.5: Income Tax Brackets & Rates 1986-1994

	Bands of Taxable Income For Each Tax Year £				
Rate of Tax %	1978	1986	1987	1988	1989
25	Up to 750			19,300	20,700
27			Up to 17,900		
29		Up to 17,200			
33	750-8,000				
40	8,000-9,000	17,200-20,200	17,900-20,400	Over 19,300	Over 20,700
45	9,000-10,000	20,200-25,400	20,400-25,400		
50	10,000-11,000	25,400-33,300	25,400-33,300		
55	11,000-12,500	33,300-41,200	33,300-41,200		
60	12,500-14,000	Over 41,200	Over 41,200		
65	14,000-16,000				
70	16,000-18,500				
75	18,500-24,000				
83	Over 24,000				
Rate of Tax %	1990	1991	1992	1993	1994
20			Up to 2,000	Up to 2,500	Up to 3,000
25	Up to 20,700	Up to 23,700	2,000-23,700	2,500-23,700	3,000-23,700
40	Over 20,700	Over 23,700	Over 23,700	Over 23,700	Over 23,700

Sources: Tables TA.2, HMRC.

Chapter 3

Taxation of Couples and Intra-Household Outcomes

Abstract

There is clear evidence that relative earnings matter for intra-household outcomes. Previously it was difficult to identify the effects of a change in relative income on intra-household allocation as relative incomes tend to lack variation over time. This paper investigates the UK income taxation reform in 1990 and examines how the change from a system of joint to independent taxation of couples has shifted women's relative earning potentials in the household, and how this has in turn led to changes in intra-household assignable expenditures. I apply my method to a sample of UK couples with children and the findings of this paper show that an exogenous increase in women's income relative to their spouse significantly and substantially increases women clothing expenditure and decreases male clothing expenditure ceteris paribus. However, an increase in relative female earnings does not necessarily mean that children will do better as suggested by some. In addition, there is evidence that the final allocations of expenditures on each partner and children may depend significantly on distribution factors such as spousal relative incomes, age and education gaps, despite the fact that these variables do not impact on preferences or on budgets directly. This provides further evidence against the unitary framework in favour of the collective approach and the sharing rule interpretation of how households make decisions in practice.

3.1 Introduction

According to the traditional models of household behaviour, individuals in a household behave as a single decision maker maximising a single utility function. There is often an implicit assumption of consensus amongst family members, or household preference would follow that of the dominant member of the household. (Becker (1981); Samuelson (1956)) As such these models ignore any cooperation or conflict within the household. Furthermore, the assumption of common preference would imply income pooling amongst household members. This in turn would mean that any policy that changes intra-household distribution of income will have no effect on the final outcomes, as any exogenous intervention will be neutralised by the household's own allocation process. If this is indeed the case, any policy that targets intra-household inequality would be ineffective.

However, there is growing evidence in the literature to suggest that relative earnings do matter for intra-household outcomes. Many studies have highlighted that multiple-member households do not behave as though they are a single decision maker maximising one objective. For example, Lundberg, Pollak, and Wales (1997) investigate a policy reform in the UK in 1979, which diverted child benefit payments to wives from husbands. They find that the policy reform which transferred benefit payments from husbands to wives had generated a substantial increase in the ratio of women's and children's clothing expenditure relative to men's clothing expenditure. Their conclusion is that children do better when their mothers are in control of a larger proportion of family resources. In another study, using data from four Canadian surveys, Browning, Bourguignon, Chiappori, and Lechene (1994) are able to observe annual clothing expenditure of households. They find that spousal differences in incomes and age for couples matter for clothing demands of households in a way not predicted by the unitary model. Other studies such as Thomas (1990), Bourguignon, Browning, Chiappori, and Lechene (1993), Browning

(1995) and Attanasio and Lechene (2002) suggest similar findings, and some of these are discussed in more details in the following section on the collective model.

Despite the mounting evidence against the unitary approach and the income pooling hypothesis, some remain skeptical about the way tests were carried out as many of these tests relied on changes in observed intra-household differences in incomes, which could potentially be endogenous. Yet in empirical terms, it is notoriously difficult to observe an exogenous source of variation in relative incomes, as it tends to lack variation over time. Some authors have sought to utilise natural experiments in order to identify exogenous variations in intra-household resources. Lundberg, Pollak, and Wales (1997) and Ward-Batts (2000) examine the changes in the UK child benefit system in the late 1970s, both studies reject the income pooling hypothesis. Attanasio and Lechene (2002) investigate a welfare program in rural Mexico in 1998 using a large scale data set. They were able to observe exogenous variation in the share of women's income through a randomised implementation of the government transfer program. Their results show that the income pooling hypothesis is again consistently rejected using their data.

This paper is an attempt to add to this growing branch of the literature. We exploit the UK income taxation reform in 1990 and examine how the change from a system of joint to independent taxation of couples has shifted women's relative earning potentials in the household, and how this has in turn led to changes in intra-household assignable clothing expenditures. We apply our method to a sample of UK couples with children and find that there is evidence that the final allocations of expenditures on each partner depend significantly on spousal relative incomes, ages and education levels, despite the fact that these variables do not impact on preferences or on budgets directly. To the best of my knowledge, no other existing studies have examined the effect of this reform on intra-household expenditures and this paper is an attempt to explore some of the policy's many interesting implications.

This paper is organised as follows: We begin by examining some of the relevant theoretical models in the next section. This is followed by a discussion on the tax reform in Section 3.3 and how a distribution factor could be generated for empirical analysis. An overview of the data is given in Section 3.4 and the empirical results are presented in Section 3.5. Section 3.6 details the specification checks for the empirical model and finally, the conclusion is presented in Section 3.7.

3.2 Theory and evidence on intra-household allocation

In this section, various theoretical approaches that extend the standard consumer model to a household setting will be reviewed. The main focus however, is on the general collective household model of Browning and Chiappori (1998). Before examining the collective approach, a review of the unitary framework will be presented and subsequently its shortcomings will be examined in detail.

3.2.1 Unitary models and rationale for household models

When analysing household behaviour and welfare, it is not uncommon in the literature to assume a standard unitary framework. Here the standard consumer (or unitary) framework refers to the basic model of consumer demand and labour supply which provides the benchmark analytical framework for labour and public economics. The main advantage of this type of model is that it is analytically simple. The household's preferences are assumed to be fully captured by a rational preference ordering over consumption and leisure bundles. Typically these preferences are assumed to be representable by a well-behaved utility function up to a monotonic transformation. Formally we could specify the household utility function of two working individuals A and B as[1]:

$$u = v(\mathbf{q}, q_0^A, q_0^B) \tag{3.1}$$

[1] See Vermeulen (2002) for a comprehensive survey of the unitary and household models presented in this chapter, as well as Apps and Rees (2009).

where $v(.)$ is an increasing, strongly quasi-concave and twice differentiable function. $\mathbf{q} = (q_1, ..., q_n)' \in \mathbb{R}^n_+$ is the household's consumption vector, and $(q_0^A, q_0^B) \in \mathbb{R}^n_+$ are the leisure demands. The individual's time is often assumed to be the sole income-generating commodity. Thus the budget constraint is given by:

$$\mathbf{p}'\mathbf{q} + w^A q_0^A + w^B q_0^B \leq y^A + y^B + y^H + w^A T + w^B T \tag{3.2}$$

where $\mathbf{p} = (p_1, ..., p_n)' \in \mathbb{R}^n_{++}$ is the price vector, $w^i \in \mathbb{R}^n_{++}$ is the wage rate and $y^i \in \mathbb{R}^n_+$ is the non-labour income of individual $i = (A, B)$ or personal wealth. y^H is typically referred to as household asset, government transfer or household non-labour income that cannot be attributed to a single individual and T is simply the total time endowment, naturally $(q_0^A, q_0^B) \in [0, T]$. The household thus solves the maximisation problem:

$$\max_{\widetilde{\mathbf{q}}} v(\widetilde{\mathbf{q}}) \tag{3.3}$$

subject to

$$\widetilde{\mathbf{p}}'\widetilde{\mathbf{q}} \leq y + w^A T + w^B T \tag{3.4}$$

where $\widetilde{\mathbf{q}} = (\mathbf{q}', q_0^A, q_0^B)'$ is the household consumption and leisure bundle, $\widetilde{\mathbf{p}} = (\mathbf{p}' w^A, w^B)'$is the combined price vector and $y = y^A + y^B + y^H$ is the total household non-labour income. The resulting $n + 2$ differentiable Marshallian commodity and leisure demand functions are given by:

$$\widetilde{\mathbf{q}} = \mathbf{g}(y + w^A T + w^B T, \widetilde{\mathbf{p}}) \tag{3.5}$$

Thus it follows from this model that any variation in leisure and consumption choices across individuals facing the same (net) wage rate and non-labour income can only be explained by variation in preferences alone. The assumptions of the theory including the exogeneity of prices, linearity of the budget constraint and characteristics of the utility function lead to a familiar set of testable implications for the commodity and leisure demand (or labour supply) functions. These restrictions are: (1) *Homogeneity of degree zero* in the price, wage rate and non-wage income, as multiplying all of these by the same scaler $k > 0$ does not alter the budget constraint or the consumption and leisure demands. i.e. $\mathbf{g}(k(y + w^A T + w^B T), k\widetilde{\mathbf{p}}) = \mathbf{g}(y + w^A T + w^B T, \widetilde{\mathbf{p}})$. (2) *Adding up* in the budget, i.e. $\widetilde{\mathbf{p}}'\mathbf{g}(y + w^A T + w^B T), \widetilde{\mathbf{p}}) = y + w^A T + w^B T$. This derives from the strictly increasing property (non-satiation) of the utility function in consumption and ensures that the budget constraint is satisfied as an equality. And finally, (3) *Symmetric and negative semidefinite Slutsky matrix.* Symmetry requires that $\mathbf{S} = \mathbf{S}'$, where $\mathbf{S} = \frac{\partial \mathbf{g}}{\partial \mathbf{p}'} + \frac{\partial \mathbf{g}}{\partial (y + w^A T + w^B T)} \widetilde{\mathbf{q}}'$. Hence $s_{\mathbf{q}w} = s_{q_0 \mathbf{p}}$ and $s_{q_0 w}, s_{\mathbf{qp}} \leq 0$, $s_{q_0 w} s_{\mathbf{qp}} - s_{q_0 \mathbf{p}} s_{\mathbf{q}w} \geq 0$ in matrix $\mathbf{S}$ below.

$$\mathbf{S} = \begin{bmatrix} s_{q_0 w} & s_{q_0 \mathbf{p}} \\ s_{\mathbf{q}w} & s_{\mathbf{qp}} \end{bmatrix}$$

However, this simplistic view raises many questions and there is strong evidence that the unitary model stands on weak grounds both in theoretical and empirical terms. From a theoretical perspective, the main criticism derives from the fact that neoclassical utility theory predominately applies to individuals and not to households. Thus we cannot expect a household demand function to obey the axioms of choice when classical results in the theory of aggregation strongly suggest that a group does not behave like a single individual. Prominent examples of this include Condorcet's 18th century paradox of majority cycles and Arrow's impossibility theorem (Arrow (1951)).

From an empirical perspective matters are not straightforward either. The primal concern being that the symmetry of the Slutsky matrix, i.e. the requirement that the effect of a change in the marginal compensated wage of two individuals in a household on each others labour supply be identical, is frequently rejected using household data. (Blundell, Pashardes, and Weber (1993); Browning and Meghir (1991)) Furthermore, in many cases choices cannot be rationalised as the outcome of a constrained maximisation problem with a single utility function. Finally, the "Income pooling" hypothesis in the unitary model implies that once total expenditure is controlled for, only total household income matters for allocation but not who earns the income. i.e. $\frac{\partial \mathbf{g}}{\partial y^A} = \frac{\partial \mathbf{g}}{\partial y^B} = \frac{\partial \mathbf{g}}{\partial y^H} = \frac{\partial \mathbf{g}}{\partial y}$. Yet this hypothesis has been strongly rejected by numerous studies such as Thomas (1990), Bourguignon, Browning, Chiappori, and Lechene (1993), Browning, Bourguignon, Chiappori, and Lechene (1994), Lundberg, Pollak, and Wales (1997), Fortin and Lacroix (1997) and indeed, the same conclusion is reached in this study. Furthermore, when analysing the effects of a tax reform, traditional economic models tend to focus solely on inter-household comparisons. However, as pointed out by Apps and Rees (1988), intra-household distribution of welfare cannot in general be ignored and unitary models are simply not equipped to analyse intra-household consumption and welfare changes. There is therefore strong rationale in this study to focus on household models.

3.2.2 Household models

There is an enormous literature on household models. One can crudely organise these into categories of *cooperative, non-cooperative* and *equilibrium* type models. Cooperative models include early works by Samuelson (1956) and Becker (1974, 1991). In order to collapse the household problem into a unitary one, Samuelson (1956) introduced the assumption of a weakly separable household utility function, within which each individual's utility function is embedded. Thus consensus is reached and a household behaves like a single individual. Similarly, Becker (1974) proposes the 'rotten kid theorem', which simplifies the problem into a unitary one by assuming an altruistic parent who aggregates the welfare of each member in the household. However, once again such rational aggregating of choice amongst household members raises questions with regard to the Arrow Impossibility Theorem. Secondly, by mimicking the unitary framework, again we are left unable to model variation in consumption and labour supply within the household.

Within cooperative models further progress has been made in bargaining and non-bargaining models. Examples of bargaining models include Alesina, Ichino, and Karabarbounis (2007); Chen and Woolley (2001); Lundberg and Pollak (1993); McElroy and Horney (1981); Manser and Brown (1980), while non-bargaining models include Apps and Rees (1988, 1997, 2009); Browning and Chiappori (1998); Chiappori (1988) and Chiappori (1992). Non-cooperative models tend to characterise the household allocation as the Nash equilibrium of a non-cooperative game. Examples include Ashworth and Ulph (1981); Konrad and Lommerud (1995, 2000); Leuthold (1968). A common criticism of non-cooperating models is that in many cases, non-Pareto efficient allocations could result. It is however important to note that both cooperative and non-cooperative models can lead to first best Pareto efficient equilibria. Finally, equilibrium type models differ from both cooperating and non-cooperating models in that household members do not coordinate in any strategic ways. Instead, each member makes his or her individual optimal decision subject to external constraints determined by competitive markets. Examples of equilibrium type models include the Walrasian exchange model of Apps (1981, 1982), marriage market models of Becker (1973) and marriage labour market model of Grossbard-Shechtman (1984). Equilibrium and bargaining models are similar in that external market conditions can have significant influence on equilibrium intra-household allocation. For the current study, the focus is on changes within the household, thus there is rationale to model the household in a cooperating and non-bargaining framework, hereafter referred to as the *collective approach.*

3.2.3 A general collective approach

The collective model was first proposed by Chiappori (1988, 1992) and Apps and Rees (1988), and was subsequently elaborated by Browning, Bourguignon, Chiappori, and Lechene (1994); Browning and Chiappori (1998) and Chiappori and Ekeland (2006). Extending the unitary model presented above, the household again consists of two individuals A and B who are both participating in the labour market. In contrast to the unitary framework, here each individual has a set of rational preferences which is defined over their leisure and consumption bundles. Following Chiappori (1988, 1992), the only assumption required is that intra-household decisions are Pareto efficient. This allows us to abstract from explicitly specifying or assuming the process by which agreement is reached in the household. All that is required is the basic assumption of stability, in other words, a stable relationship between the model, the economic environment and the chosen outcomes is assumed and hence, each household is characterised by a unique decision process. This does not necessarily amount to a deterministic relationship as randomisation is acceptable as long as it is stable.[2] Preferences are allowed to be very general and household externalities in consumption and leisure are permissible, commodities can also be privately or publicly consumed. This allows for a great deal of flexibility in modelling, making the inclusion of public goods, e.g. central heating, rent, and negative (or positive) externalities, e.g. smoke from spouse's cigarette or noise, possible. The household maximisation problem can be specified for a bundle $(\mathbf{q'^A}, \mathbf{q'^B}, q_0^A, q_0^B, \mathbf{Q'})'$ as:

$$\max_{\mathbf{q^A}, \mathbf{q^B}, q_0^A, q_0^B, \mathbf{Q}} v^A(\mathbf{q^A}, \mathbf{q^B}, q_0^A, q_0^B, \mathbf{Q}; \mathbf{a}) \tag{3.6}$$

[2]See Browning, Chiappori, and Weiss (2012) for a detailed discussion.

subject to

$$v^A(\mathbf{q^A}, \mathbf{q^B}, q_0^A, q_0^B, \mathbf{Q}; \mathbf{a}) \geq \bar{u}^B \tag{3.7}$$

$$\mathbf{p}'\mathbf{q} + w^A q_0^A + w^B q_0^B \leq y + (w^A + w^B)T \tag{3.8}$$

where $v(.)$ is a strongly concave and twice differentiable utility function and equation (3.8) is the household budget constraint. The preference factors are captured by $\mathbf{a}$ and is a vector of characteristics that affects preferences directly.[3] The consumption vectors are $\mathbf{q^A} = (q_1^A, ..., q_n^A)'$ and $\mathbf{q^B} = (q_1^B, ..., q_n^B)' \in \mathbb{R}_+^n$. Leisure is again given by q_0^A, q_0^B and are $\in \mathbb{R}_+^n$. A vector of household public goods is introduced, $\mathbf{Q} = (Q_1, ..., Q_n)' \in \mathbb{R}_+^n$. $\bar{u}^B$ is the required utility level for individual B. $y = y^A + y^B + y^H$ as before and $\mathbf{q} = \mathbf{q^A} + \mathbf{q^B} + \mathbf{Q}$. Note that $\frac{\partial v^i}{\partial \mathbf{q^i}} > 0$, $\frac{\partial v^i}{\partial q_0^i} > 0$ and $\frac{\partial v^i}{\partial \mathbf{Q}} > 0$ are assumed to hold, but due to the possibility of positive or negative externalities the sign on $\frac{\partial v^i}{\partial \mathbf{q^j}}$ and $\frac{\partial v^i}{\partial q_0^j}$, $j \neq i$, cannot be assumed a priori.

By maximising A's welfare subject to a given welfare level for B and the budget constraint, it is possible to trace out all the Pareto efficient allocations by varying $\bar{u}^B$; thus giving us the household possibility frontier, within which all the possible attainable allocations are captured. Given that individual utility functions are strongly concave and a convex set is defined by the budget constraint, the utility possibility set must be strictly convex. As shown by Dorfman (1975); Mas-Colell, Whinston, and Green (1995); Panzar and Willig (1976) and reiterated in Vermeulen (2002), this result allows all Pareto efficient allocations to be characterised as stationary points of a linear social welfare function for some positive welfare weights for both individuals. All utility pairs that grant the same total are perfect substitutes in the maximisation problem. However, it is important to note that we are not imposing the absence of inequality aversion in the

[3]Examples of preference factors include gender, age and education. Variables that are typically not considered as preference factors include relative wages of couples, local sex ratio and relative physical attributes; these are instead typically considered as distribution factors. See discussion below.

household decision process. The key point is that once household choices are observed, we can rationalise any household choices with a linear social welfare function, *as if* there is no inequality aversion. Hence, the household allocation problem above provides the unique solution to the following maximisation problem as shown in Browning and Chiappori (1998):

$$\max_{\mathbf{q^A},\mathbf{q^B},q_0^A,q_0^B,\mathbf{Q}} \mu(\mathbf{p},\mathbf{w},\mathbf{y})v^A(\mathbf{q^A},\mathbf{q^B},q_0^A,q_0^B,\mathbf{Q};\mathbf{a}) + [1-\mu(\mathbf{p},\mathbf{w},\mathbf{y})]v^B(\mathbf{q^A},\mathbf{q^B},q_0^A,q_0^B,\mathbf{Q};\mathbf{a}) \tag{3.9}$$

subject to

$$\mathbf{p}'\mathbf{q} + w^A q_0^A + w^B q_0^B \leq y + (w^A + w^B)T \tag{3.10}$$

where $\mathbf{w} = (w^A, w^B)'$ and $\mathbf{y} = (y^A, y^B, y^H)$. The resulting Marshallian labour supply equations are therefore:

$$L^A = l^A((\mathbf{p},\mathbf{w},\mathbf{y}), w^A) \tag{3.11}$$

$$L^B = l^B((\mathbf{p},\mathbf{w},\mathbf{y}), w^B) \tag{3.12}$$

The welfare weights on each individual $\mu(\mathbf{p},\mathbf{w},\mathbf{y})$ and $[1-\mu(\mathbf{p},\mathbf{w},\mathbf{y})]$ will clearly depend on the exogenous variables $\mathbf{p},\mathbf{w},\mathbf{y}$. One could interpret these weights as bargaining power of individuals in the household. This is in contrast to Samuelson's approach where weights on individuals are assumed to be independent of wages, prices and incomes. Here an increase in wages or non-labour income of an individual may shift household consumption and labour supply in their favour. In other words, in addition to the traditional income effect of increasing overall household consumption due to for example, a rise in non-labour income for one individual, the household may also change its consumption allocation shares. Other factors that affect the bargaining power function μ, but do not directly influence preferences and the household budget constraint are termed 'distribution factors' by Bourguignon, Browning, Chiappori, and Lechene (1993). Distribution factors are intricately linked with the sharing rule and will be examined in further detail in the next section.

3.2.4 Household expenditure and the sharing rule

Turning to the main theme of this paper, the above collective model can be extended to provide a basic framework for analysing household expenditure on for example, clothing and the sharing rule. Restricting our attention to private and public goods expenditures, if preferences are egotistic or caring[4], it can be shown that the household allocation problem collapses into a two-staged budgeting process. Assuming preferences are separable, individuals first divide total household income according to the sharing rule[5] $\phi(\mathbf{p}, \mathbf{y}, \mathbf{z})$, giving rise to an individual budget constraint, $\mathbf{p'q^i} \leq \phi^i(\mathbf{p}, \mathbf{y}, \mathbf{z})$, which each individual uses independently to generate their consumption allocation.[6] If we now focus on a specific private good, such as adult clothing, separability between clothing expenditure and other expenditures as well as separability between male and female clothing preferences are assumed, thus implying a household utility function of the following form:

$$U = \mu(y, \mathbf{a}, \mathbf{z})v^A(q_k^A, \mathbf{q_{-k}}) + [1 - \mu(y, \mathbf{a}, \mathbf{z})]v^B(q_k^B, \mathbf{q_{-k}}) \tag{3.13}$$

where q_k^i is clothing consumption for each individual, $i = A, B$ denoting female and male respectively, and $\mathbf{q_{-k}}$ denotes other goods which are not clothing but can include public goods. $\mathbf{z}$ is set of the distribution factor and $\mathbf{a}$ is a vector of characteristics that affect

[4]Egotistic preferences are of the form: $U^i = v^i(\mathbf{q^i}, q_0^i, \mathbf{Q})$, while caring preferences can be represented by $U^i = F^i(v^A(\mathbf{q^A}, q_0^A, \mathbf{Q}), v^A(\mathbf{q^B}, q_0^B, \mathbf{Q}))$, where $i = A, B$. Clearly "egotistic" is just a special case of caring preferences.

[5]The existence of a sharing rule has been shown in Browning, Bourguignon, Chiappori, and Lechene (1994).

[6]This is simply an application of the second fundamental theorem of welfare economics. Lump-sum transfers between household members will lead to Pareto efficient allocations at equilibrium.

preferences directly. Specifically, the utility functions for individual A and B are given by:

$$v^A(q_k^A, \mathbf{q_{-k}}) = \varphi^A(q_k^A) + \psi^A(\mathbf{q_{-k}}) \tag{3.14}$$

$$v^B(q_k^B, \mathbf{q_{-k}}) = \varphi^B(q_k^B) + \psi^B(\mathbf{q_{-k}}) \tag{3.15}$$

Maximising the household utility function (3.13) subject to the household budget constraint,

$$\mathbf{P}'(q_k^A + q_k^B + \mathbf{q_{-k}}) \leq y \tag{3.16}$$

yields the resulting household demand functions for private good k for person A and B:

$$q_k^A = \xi_k^A(\phi(x, \mathbf{z}), \mathbf{a}) \tag{3.17}$$

$$q_k^B = \xi_k^B(x - \phi(x, \mathbf{z}), \mathbf{a}) \tag{3.18}$$

where the functions $x^A = \phi^A(x, \mathbf{z}) = \phi(x, \mathbf{z})$ and $x^B = \phi^B(x, \mathbf{z}) = x - \phi(x, \mathbf{z})$ denote the proportion of total expenditure on private goods that each individual receives and is referred to as the 'sharing rule'. Thus the distribution factors, $\mathbf{z}$, despite not affecting the budget constraint, x, or preferences, $\mathbf{a}$, directly, can still influence the individual's demand via the sharing rule $\phi(.)$. The demand function is assumed to be continuous and twice differentiable. Moreover, restricting the set of distribution factors to one single variable could be done without the loss of generality.

Before we conclude the section on the sharing rule, it may be worth mentioning the close relationship between the sharing rule and the Pareto weight. Clearly they both reflect an individual's bargaining power in the relationship, and the sharing rule cannot be a function of the distribution factors unless the Pareto weight is. The sharing rule also depends on prices and income even if the Pareto weight does not. This could make the sharing rule slightly difficult to observe in practice as it is impossible to vary prices without varying the sharing rule simultaneously. Furthermore, the sharing rule does have its important advantage of being much easier to interpret than the Pareto weight as it avoids the need for cardinal representation of individual utilities. The interested reader should refer to Browning, Chiappori, and Weiss (2012) for a detailed discussion on this issue.

3.2.5 Characterising the demand functions

In order to quantify changes in relative demands, it is useful to focus on assignable private goods expenditures as we require the means to observe how much of each good each spouse is consuming. In other words, we require the ability to monitor assignable goods consumption within the household over time. Needless to say, this may not be trivial in terms of data requirement. Fortunately, for the UK, the Family Expenditure Survey provides detailed expenditure information on male, female and children clothing. As we can be reasonably confident about who is consuming each category of clothing, clothing expenditure is an ideal candidate for the task at hand.

As mentioned previously, under a collective framework the household optimisation problem for for example clothing expenditure can be represented by a two-staged budgeting framework. This means that in the first stage, the household decides how much total expenditure should go towards clothing versus other goods and services. Once the decision is made, the total clothing budget is divided into female, male and children clothing according to the sharing rule. Three demand equations are estimated and the dependent variables are female, male and children clothing expenditure shares respectively. Conceptually one could begin by considering the demands for the husband and wife. In the empirical section, we also allow for children clothing by adding a third equation. Using the demand equations (3.17)-(3.18) and taking the private good k to be clothing, one can define the total household clothing expenditure for clothing as:

$$x_k = P_k(q_k^A + q_k^B) = P_k[\xi_k^A(\phi(x, \mathbf{z}), \mathbf{a}) + \xi_k^B(x - \phi(x, \mathbf{z}), \mathbf{a})] \tag{3.19}$$

Now assuming that the function for total clothing expenditure is a strictly monotonic function, the above expression for total clothing expenditure can be inverted to give a function of total private goods expenditure as a function of clothing expenditure, the distributional and preference factors.

$$x_k = P_k(\xi_k^A + \xi_k^B)\{x, \mathbf{z}, \mathbf{a}\} \longmapsto x = \psi[x_k, \mathbf{z}, \mathbf{a}] \tag{3.20}$$

Hence clothing demands for each individual can be written as:

$$q_k^A = F_k^A(x_k, \mathbf{z}, \mathbf{a}) \tag{3.21}$$

$$q_k^B = F_k^B(x_k, \mathbf{z}, \mathbf{a}) = x_k - F_k^A(x_k, \mathbf{z}, \mathbf{a}) \tag{3.22}$$

Alternatively, one could express the demand equations as shares of the total clothing budget:

$$\omega_k^A = \frac{q_k^A}{x_k} = f_k^A(x_k, \mathbf{z}, \mathbf{a}) \tag{3.23}$$

where ω_k^i denotes the shares of total clothing budget each individual $i = A, B$ receives. In the empirical sections the results from estimating the above equation (3.23) are presented. In terms of the right-hand side variables, the primary interest centres on how clothing expenditures are affected by variables in $\mathbf{z}$ that are typically not included in demand equations. Essentially if $\frac{\partial \phi}{\partial z_j} = 0$ then it must be the case that $\frac{\partial F_k^A}{\partial z_j} = \frac{\partial f_k^A}{\partial z_j} = 0$. This means that the only channel distribution factors can affect clothing demand is via the sharing rule. Another implication is that once we condition on total clothing expenditure, x_k, individual incomes from the husband and wife should not enter the demand equation. Of course, one obvious objection of this separability assumption is that if certain occupations such as higher paid jobs require more expensive work clothing, then the individual incomes could enter the demand equations for clothing even after conditioning on total clothing expenditure, education or even occupation. However, after instrumenting for total clothing expenditure in the demand equations with the log of net income of the household and log of total household non-durable expenditure excluding clothing, $(x - x_k)$, the overidentifying restrictions are not rejected. This indicates that income variables are indeed not required in the demand equations once total clothing expenditure is controlled for.[7] It is important to remember that total household expenditure on clothing is endogenous in the model and is instrumented for with the log of net income of the household and log of total household non-durable expenditure excluding clothing, which also provides us with overidentification. Thus on the right-hand side we control for the log of total clothing expenditure, age of the wife, age gap and the squared terms of these, an interaction variable between the wife's age and a dummy for an older female spouse in the household, the school leaving age of the wife, the education gap, the number of children and number of children under the age of five, a time trend dummy and finally, a household power measure.

3.3 Using tax reform to generate a distribution factor

Typically 'power' in the household context refers to female household bargaining power[8]. This concept of power stems from the core of collective models as it is within the set of distribution factors that affect the sharing rule and consequently the proportion of total expenditure each individual receives, but do not affect the budget constraint directly. An

[7] Browning, Bourguignon, Chiappori, and Lechene (1994) examine clothing expenditure for Canadian couples with no children using income variables as instruments and reach the same conclusion.

[8] Although no specific bargaining process is assumed or required under the collective framework.

obvious candidate for the power measure is simply the the ratio between male and female incomes. The higher the female income relative to the male would suggest higher female bargaining power within the household. However, typically this ratio is fairly stable in households over time. For example, Browning, Bourguignon, Chiappori, and Lechene (1994) examine the gross income ratios of Canadian couples but find that the variation of this ratio over time was small, leading to weaker identification. Consequently, one main contribution of this paper is that by examining a period with an income taxation reform for couples, we are able to observe strong exogenous shifts in intra-household net income ratios across time, thereby enabling us to verify the effect of a change in relative spousal incomes on demands and achieve robust identification.

Now we turn to the discussion of the formal definition of power. As mentioned previously, one could simply take the ratio of female to male net earnings in the household. Ideally one would need to observe this ratio just before and after the reform in order to analyse any changes. However, one immediate question arises when one tries to define each spouse's net earnings under the pre-reform joint taxation system, as the concept of separate net incomes is not properly defined in this context. In order to overcome this obstacle one could instead define power in terms of the *Value Of Non-Participation*(Ξ) of the wife, where:

$$\Xi = \frac{\Psi^0(\mathbf{w}, \mathbf{y})}{\Psi^1(\mathbf{w}, \mathbf{y})} \tag{3.24}$$

where $\Psi(\mathbf{w}, \mathbf{y})$ is the household total net income, with the superscript equal to 1 when the wife's income is included and 0 when the wife's income is excluded. We define $Power(\varrho)$ as:

$$\varrho = 1 - \Xi \tag{3.25}$$

where $\varrho \in [0, 1]$ and $\Xi \in [0, 1]$. Under an independent taxation system, the above expression for Ξ is synonymous to the ratio of male net earnings to total household net earnings. But more crucially, under both tax systems, it represents the value of the wife's earnings to the household as a whole, and is well defined under both the joint and independent systems. For instance, if the wife earns the entire share of income in the household, the value of her non-participation would be zero, meaning that her non-participation and thus forgoing her earnings (also the household's entire income source) would be very undesirable for the household and thus her $Power(\varrho)$ in terms of relative net incomes would be equal to one. Alternatively, when $Power(\varrho)$ is zero, Ξ must be equal to one. This occurs when the wife has zero earning power in the household, most likely due to her non-participation in the labour force. In the empirical section, a discussion on the zero observations of *Power* and this selection effect is dealt with in more detail. It is worth stressing again that this measure of power nests within the wider set of distribution factors and is only one of the factors that could influence the division of resources within the household. The hypothesis is that the income taxation reform in 1990 led to an exogenous shift in women's '*Power*' in the household. This in turn has led to changes in observed intra-household outcomes. By exploiting the income taxation reform in 1990, we are therefore able to generate a unique distribution factor that is likely to have strong exogenous variation over time.

3.4 Structure of the data

The following subsections provide an overview of the dataset used for this study. Firstly, the choice of the dataset and its structure will be discussed. This is followed by the definition of cohort and the construction of the pseudo panel dataset. Section 3.4.3 provides an overview of the data and the main variables of interest.

3.4.1 Family Expenditure Survey

To analyse how the UK income taxation reform in 1990 had shifted intra-household consumption patterns, we would require survey data that spans a long period covering both the period before and after the reform. For this purpose, a panel dataset, similar to the British Household Panel Survey(BHPS), would be ideal in principle as it would allow us to track the same individuals and households through the sample period. Regrettably, the BHPS only began in 1991, thus rendering it inadequate. The General Household Survey (GHS) was also considered but was rejected in favour of the Family Expenditure Survey(FES).

This study uses the UK Family Expenditure Survey (FES). The FES is a continuous survey of household expenditure and income that began in 1957. It is a voluntary annual survey of approximately 6,500 households in the UK and was first designed to provide weights for the Retail Price Index. The sample for Great Britain is drawn from the Post Office's list of addresses in 672 postal sectors, while the sample for Northern Ireland is drawn from the Valuation and Lands Agency list. Each individual aged 16 or over in the household is asked to keep a diary over 14 consecutive days in which all detailed expenditures are recorded. Other general expenditures and household characteristics such as rent and mortgage payments and household income are obtained from a household questionnaire via face-to-face interviews. In addition, each adult (aged 16 or over) in the household are asked to fill in an individual questionnaire providing demographic and income information. On the whole, the FES has the advantage of being a long running household survey giving rich information on individual and household characteristics including data on specific expenditures on goods and services.

For the purpose of this study, all monetary values are deflated by the UK retail price index and are expressed in 1987 prices. Since the aim is to analyse clothing expenditures of men, women and children living in the same household, attention is restricted to households with married couples with both individuals aged between 22 and 60 with children. Childless households are excluded due to potential non-comparable expenditure patterns against those with children. As the income tax reform occurred in 1990, the period 1986 to 1993 is taken as the sample period. It is also worth noting that the FES survey year changed from calendar to fiscal year from 1994 onwards. To maintain consistency with the tax system, all sample years were converted into fiscal years.

3.4.2 Constructing a pseudo panel dataset

In order to analyse the effect of the reform on household expenditures, a pseudo panel is compiled from the FES. Pseudo panel techniques were first introduced by Deaton (1985); Browning, Deaton, and Irish (1985) for the analysis of life-cycle labour supply and commodity demand. The basic idea behind pseudo panel is that by grouping individuals or households into for example, cohorts, one could follow the averages within these cohorts over time and treat the cohort averages as observations in a panel. In other words, a pseudo panel enables us to follow a representative sample of the same cohorts of individuals or households over time.

For the UK, there are no panel data on households for the period of the tax reform in 1990. However, the FES allows the tracking of cohorts through the time period concerned. For large enough cohorts, successive sampling of individuals in each of the cohorts generates a time series that can be used to analyse household choices and behaviour for the cohort as a whole as if panel data were available. This also means that panel techniques can be applied to the analysis of the data, for example to eliminate cohort fixed effects. Furthermore, this constant resampling of cohorts eliminates the problems caused by attrition in genuine panels.

By grouping individual observations into cohorts, one is assuming some (observable or unobservable) cohort homogeneity within the group. Thus cohorts should be defined based on some shared characteristics. Typically, cohorts are defined based on some time invariant characteristics such as the year of birth of the head of household, education levels, or geographic regions. The choice of the width of for example, the birth cohort is a trade off between the need to have a large number of observations per cohort and the desire to retain as much variation in the data as possible. For instance, the narrower the birth cohort, the greater number of birth cohorts and hence, the number of data points. However, this would imply a fewer number of observations per cohort, and hence, a greater potential error in estimating the cohort mean (Propper, Rees, and Green (2001)). For the purpose of this study, each 'cohort' is grouped based on the year of birth of the head of the household and the wife's education level (high or low). The birth cohort is defined in a five-year band. The pseudo panel covers 8 years from 1986-1993. The total number of cross-sectional observations came to 11,327 households, and the number of observations in pseudo panel were 124 from 8 birth cohorts.

3.4.3 Data description

There are 18 primary variables used in this study, a description of the variables are given in Table 4.1 below and the summary statistics are reported in Table 4.2. The FES has rich information on household and clothing expenditures. In particular, clothing expenditures can be broken down into female, male and children clothing expenditures. From these we can derive the respective clothing shares and the log of total clothing expenditure. Other key variables include demographic controls such as age, education level and the number of children in the household, as well as variables that are not typically included in demand equations, such as power, age age and education gap.

Figure 4.4 below shows the weekly gross earnings for the female and male spouses in the household from 1986 to 1993, and all figures are at 1987 prices. It is immediately apparent that as a whole, female earnings are much lower than their male counterparts. There is also a significant proportion of women earning zero income throughout this period. Despite this, female earnings experienced a gentle rise through the survey period, its dispersion also increased over time. Male gross earnings remained fairly stable over

Variable	Description
fclothshare	Female clothing expenditure share in the household
mclothshare	Male clothing expenditure share in the household
cclothshare	Children clothing expenditure share in the household
ltotalcloth	Log of total clothing expenditure in the household
power	Household power measure
powerzero	A dummy variable and is equal to one when power is zero for the household
lnyhh	Log of net income of household
ltotexpnetc	Log of total household non-durable expenditure excluding of clothing
fageleft	Female school-leaving age
numkids	Number of children in household
kidsu5	Number of children under the age of five in the household
edgap	Difference between female and male school-leaving age
agegap	Difference between female and male age
agegap2	Spousal age gap squared
agesp	Age of female spouse
agesp2	Age of female spouse squared
ageold	Interaction variable for female age and a dummy for an older female spouse
t	Time trend dummy

Table 3.1: Variables in the Dataset

Variable	Mean	Std. Dev	Min.	Max.	10%	25%	50%	75%
fclothshare	.435851	.37455	0	1	0	.0553191	.375	.7870519
mclothshare	.1966859	.2981579	0	1	0	0	0	.3359365
cclothshare	.3674631	.3723577	0	1	0	0	.2622236	.6923305
ltotalcloth	2.485576	1.256499	-3.186353	6.707314	.7533219	1.81064	2.67291	3.364192
power	.2612529	.323708	0	1	0	0	.1526289	.3521582
powerzero	.3240046	.4680224	0	1	0	0	0	1
fageleft	16.65693	2.145897	9	30	15	15	16	17
numkids	1.872076	.8299551	1	8	1	1	2	2
kidsu5	1.348989	.9773818	0	8	0	1	1	2
edgap	-.0979959	2.179343	-17	11	-2	-1	0	1
agegap	-2.351638	3.929073	-28	21	-7	-4	-2	0
agegap2	20.96645	46.81832	0	784	0	1	4	16
agesp	36.38483	7.059218	22	60	27	31	36	41
agesp2	1373.684	528.4945	484	3600	729	961	1296	1681
ageold	6.349342	14.60711	0	60	0	0	0	0
t	4.251788	2.266811	1	8	1	2	4	6
N		11327						

Table 3.2: Summary Statistics of FES Data

this period, with some moderate increases in median earnings and dispersion. However, the most important observation here is that there were no major breaks or jumps in gross incomes throughout this period, particularly for the period surrounding the reform in 1990. Because individual net incomes are not properly defined for the period before the reform, we instead examine the total household net annual income over the same period shown in Figure 4.5. Again these are at 1987 prices and the series is relatively smooth over time with some moderate increases in median net incomes and dispersion. Once again, there were no significant jumps in the series for the period surrounding the reform.

We now turn to examine the series for the household power measure in Figure 3.3. The power measure is bounded between zero and one, but up until 1991, the 25th percentile remained at zero[9], and from 1994 onwards, the 25th percentile rose comfortably above the zero threshold. The 75th percentile saw some gentle increase in and after 1990, but remained stable after 1993. However, the most crucial observation here is that although the series is once again relatively smooth both before and after 1990, there was a significant jump in 1990 when the reform came into force. The median alone rose by nearly 10 percentage points, the upper adjacent value[10] increased by approximately 12 percentage points.

The distribution of power also changes with age, cohort and education level. Figure 3.4 shows power against the age of the wife for different cohorts, the left (right) panel for low (high) education level. One would be tempted to interpret these plots as evidence for power to increase with age, with larger differences across cohorts for lower educational groups. However, caution is called for when interpreting these diagrams as it is impossible to disentangle the age, cohort and year effects and any movements in the series could be explained by a combination of two of the three effects. The same warning could be applied to the clothing share plots in Figures 3.8 to 3.10. The expenditure on

[9] See the next section on estimation for a discussion about zero observations in Power.
[10] The upper adjacent value is 1.5 times the upper interquartile range.

female clothing for high education women under 25 years old is also subject to small sample size issues and should be interpreted with caution.

Yet, what these clothing share figures do reveal is a systematic difference between the educational groups. To the best of my knowledge, this is the first time household clothing expenditures are presented graphically in this manner. Take the female clothing expenditure shares for example, for the low educational group, female clothing share starts very low and appears to increase steadily with age, but for the higher educational group, clothing demand starts off very high, but plunges sharply after the female's mid 20's and the profile remains fairly flat over the life-cycle. Female clothing demand also tends to dip after age 50 for both educational group. On the other hand, male clothing expenditures seem to have subtler changes over time or age. For both educational groups there is an upward trend in the series. Interestingly the series for children clothing expenditure seem to mirror those for the female spouse. There are also some differences across educational groups. Households with more educated women see children clothing expenditure peak when the wife is age 27 and remains high until the expenditures decrease sharply when the wife is at age 40. On the contrary, for households having women with lower education levels, expenditures tend to peak when the wife is age 25 and starts to fall consistently, with a steep fall at age 35. Despite the inability to separate the year, age and cohort effects, what we observe here is what we would expect in general, households tend to have very high children clothing expenditures at the beginning of the series (when the wife is younger), this then tails off as the couple gets older and as children leave the household later in the life cycle. Finally, a histogram of power in Figure 3.11 reveals a large number of zero observations and also a fair amount of bunching at the top. This will be examined in further detail later on in the paper as it has crucial implications for estimation.

In summary, this section provides a description of the structure of the data used for this study. The UK Family Expenditure Survey 1986-1993 is used to construct the pseudo panel for estimating changes in household clothing demand shares over this period. The pseudo panel includes variables for observable household characteristics that could affect clothing demand and preferences directly, as well as a set of distribution factors that influence the sharing rule, but not preferences directly. Clothing demands for female, male and children all seem to vary quite significantly across the life-cycle, educational groups also seem to matter. The examination of changes in power over this period reveals a sharp increase in the series in the year 1990, which was when the reform in income taxation of couples came into force.

3.5 Empirical results

3.5.1 Methodology

There are a number of different ways one could estimate the model for clothing demand. For illustrative purposes we could take a simpler example:

$$y_{it} = \alpha + x_{it}'\beta + a_i + u_{it} \tag{3.26}$$

where $i = 1...N$, $t = 1...T$, x_{it} is some observable individual characteristics that varies across time, a_i is some unobservable individual characteristic that does not vary across time, u_{it} is the disturbance term. The simplest method would consist of pooling all pseudo panel observations and estimating the model by OLS, treating it as a cross sectional regression. If no time dummies are included, the implicit assumption would be that coefficients simply do not change over time. Needless to say this is a rather strong assumption. On the contrary, if we allow a full set of time dummies for all coefficients, it would be synonymous to estimating T different equations. However, there are other more serious drawbacks with a pooled OLS strategy. By pooling observations across time and estimating the model as a static model, we would be implicitly assuming that errors are independent across observations, as well as time. This is clearly a strong assumption. In addition, the pooled OLS estimator will only be consistent under a random effects model and would yield inconsistent estimates under a fixed effect model when there are unobservable individual time non-varying effects that are correlated with the explanatory variables, i.e. $v_{it} = (a_i + u_{it})$, where v_{it} is now a composite error term and $E(x_i v_{it}) \neq 0$ as $E(x_{it} a_i) \neq 0$, this is often termed heterogeneity bias and is caused by essentially omitting the time invariant variable in the regression.

This provides motivation for exploiting the panel structure of the data. The main advantage of using panel data is its ability to allow for unobservable individual time non-varying effects such as a_i to be correlated with the explanatory variable. Two obvious estimators that could deal with fixed effects models are the first difference(FD) and within group(WG) estimators. These two methods are similar in that they both involve transforming the existing model in some ways to remove the individual fixed effect. The FD estimator does this by taking the first difference thereby removing any time non-varying component in the process, while the WG estimator transforms the model in the following manner:

$$(y_{it} - \bar{y_i}) = (x_{it} - \bar{x_i})\beta + (u_{it} - \bar{u_i}) \tag{3.27}$$

where a bar indicates the mean value in each case. With both estimators we will lose the ability to identify any non-time varying coefficients. The FD estimator assumes autocorrelation of errors within individuals and requires weak exogeneity, while the WG estimator requires strong exogeneity as the transformation requires errors from all periods to be in the current period equation. In principle, one could choose the suitable estimator based on the dynamics of the error term. For example, when estimating an Euler equation, it may be preferable to use the FD estimator due to the dynamics of the error term. However, for this study, there is no reason to expect the error term to have a particular dynamic structure, hence it is not immediately clear which estimator is better suited for the task. In terms of efficiency, as only within group variation is used in the WG estimator, the standard errors are likely to be larger. Despite this, the WG estimator is frequently chosen over the FD estimator. This is probably due to its ease of implementation, especially even in the presence of an unbalanced panel. For the purpose of this study, both estimator were tested and yielded very similar results, consequently, the WG estimator was chosen for its ease of implementation. In addition, the software package Stata further transforms the WG estimator such that the model becomes:

$$(y_{it} - \bar{y_i} + \bar{\bar{y}}) = \alpha + (x_{it} - \bar{x_i} + \bar{\bar{x}})\beta + (u_{it} - \bar{u_i} + \bar{\bar{u}}) \tag{3.28}$$

where the double bar indicates the grand mean of the variable, for example, $\bar{\bar{y}} = \frac{1}{N}\bar{y_i}$, $\bar{\bar{x}} = \frac{1}{N}\bar{x_i}$ and $\bar{\bar{u}} = \frac{1}{N}\bar{u_i}$. α, the intercept, gives the average of individual effects α_i, while yielding the same slope β from the standard WG model. Finally, by using robust standard errors[11] we can relax the assumption that after controlling for α_i that u_{it} is i.i.d, provided that the observations are independent over i as $N \to \infty$.

3.5.2 Estimation

As mentioned previously, by following the averages within cohorts over time, one could treat the cohort averages as observations in a panel. Thus allowing the application of typical panel techniques to a pseudo panel. Following Section 3.2.5 closely, the model for clothing demand can be specified as:

$$\omega_{cti} = \alpha_{ci} + \beta_i log x_{ct} + \gamma_i \mathbf{a}_{ct} + \phi_i \mathbf{z_{ct}} + \delta_i \varrho_{ct} + \theta_i T_t + \epsilon_{cti} \tag{3.29}$$

[11]This is equivalent to cluster robust standard errors.

where c is an indicator for the cohort, $c = 1, 2, ..., N$, t is the year indicator. $i = 1, 2, 3$ and it indicates female, male and children respectively. ω_{cti} are observed outcomes of clothing shares. α_{ci} is the intercept, x_{ct} is the total household clothing expenditure, T_t is a time trend dummy. $\mathbf{a}_{ct}$ is a set of observable household characteristics such as age of the wife, age squared, female school leaving age, the number of children, number of children under the age of five. These are factors that could directly affect preferences. $\mathbf{z_{ct}}$ is a set of distribution factors including age gap, age gap squared, an interaction variable between the wife's age and a dummy for an older female spouse in the household and the education gap, but excluding *Power*. *Power* is denoted by ϱ_{ct}. As discussed in Section 3.2.5, total household expenditure on clothing is endogenous in the model and is instrumented for with the log of net income of the household and log of total household non-durable expenditure excluding clothing.

3.5.3 Results

Before we move onto the instrumental variable and fixed effects estimates, it is worth examining the results from a baseline Seemingly Unrelated Regression(SUR) specification for comparison. SUR suffers from the same drawbacks as OLS which were mentioned in Section 3.5.1, but SUR was chosen over OLS as the baseline model for its superior efficiency. As the disturbances for the three clothing demand equations (Female, Male, Children) are likely to be correlated with one another, even in the absence of heterogenity biases and dependency of the disturbances across time, OLS would not yield efficient estimators for such a system. Table 3.3 gives the SUR baseline results for the model of clothing demand. These results should be interpreted with caution as this specification does not allow for the endogeneity of total clothing expenditure. However, there are a few interesting observations that could be noted for comparison later.

First of all, the log of total clothing expenditure is highly significant in all equations as expected. Interestingly, male and children clothing shares increase with total expenditure

SUR Regression of Pseudo Panel Model			
	Female	Male	Children
ltotalcloth	-0.147***	0.087***	0.060***
	(0.02)	(0.01)	(0.02)
power	0.226	-0.198*	-0.028
	(0.13)	(0.08)	(0.12)
powerzero	-0.014	-0.091	0.104
	(0.09)	(0.06)	(0.09)
fageleft	0.015**	-0.004	-0.011*
	(0.01)	(0.00)	(0.01)
numkids	-0.210***	-0.015	0.225***
	(0.06)	(0.04)	(0.05)
kidsu5	0.071	-0.002	-0.069
	(0.05)	(0.03)	(0.05)
edgap	-0.046***	0.010	0.036**
	(0.01)	(0.01)	(0.01)
agegap	-0.058***	0.009	0.049***
	(0.02)	(0.01)	(0.01)
agegap2	-0.316***	0.060	0.256***
	(0.08)	(0.06)	(0.08)
agesp	0.005	-0.028*	0.023
	(0.02)	(0.01)	(0.02)
agesp2	-0.010	0.042**	-0.032
	(0.02)	(0.01)	(0.02)
ageold	0.018***	-0.002	-0.016***
	(0.00)	(0.00)	(0.00)
t	-0.011***	0.007***	0.004
	(0.00)	(0.00)	(0.00)
cons	0.618	0.593*	-0.211
	(0.37)	(0.25)	(0.35)
R^2	0.607	0.649	0.675
$\chi^2(13)$	191.534	229.606	257.894
p-value	0.000	0.000	0.000

Table 3.3: SUR Regressions of Female, Male and Children Clothing Expenditures. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level. The variables *agegap*2 and *agesp*2 have been divided by 100 for more meaningful comparison.

Instrumental Variable Regressions						
	Cross-sectional			Pseudo Panel		
	Female	Male	Children	Female	Male	Children
ltotalcloth	-0.100***	0.103***	-0.004	-0.040	0.152***	-0.112
	(0.03)	(0.03)	(0.03)	(0.06)	(0.04)	(0.06)
power	0.330*	-0.161	-0.169	0.389*	-0.248*	-0.141
	(0.15)	(0.19)	(0.17)	(0.16)	(0.10)	(0.17)
powerzero	0.016	-0.080	0.064	0.139	-0.160*	0.021
	(0.10)	(0.10)	(0.11)	(0.12)	(0.07)	(0.12)
fageleft	0.014*	-0.004	-0.009	0.063*	0.022	-0.084**
	(0.01)	(0.01)	(0.01)	(0.03)	(0.02)	(0.03)
numkids	-0.194***	-0.009	0.203***	-0.184	0.096	0.088
	(0.06)	(0.04)	(0.06)	(0.10)	(0.06)	(0.10)
kidsu5	0.072	-0.002	-0.070	0.156	-0.066	-0.090
	(0.06)	(0.04)	(0.05)	(0.09)	(0.05)	(0.09)
edgap	-0.043*	0.011	0.032*	-0.032	0.009	0.023
	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)
agegap	-0.058*	0.009	0.049*	-0.034	-0.034	0.068
	(0.02)	(0.01)	(0.02)	(0.04)	(0.02)	(0.04)
agegap2	-0.320**	0.059	0.261*	-0.254*	0.057	0.197
	(0.12)	(0.07)	(0.12)	(0.10)	(0.06)	(0.10)
agesp	-0.007	-0.032	0.039	-0.074	-0.031	0.105*
	(0.03)	(0.02)	(0.03)	(0.05)	(0.03)	(0.05)
agesp2	0.004	0.046*	-0.050	0.057	0.100**	-0.158**
	(0.04)	(0.02)	(0.03)	(0.05)	(0.03)	(0.05)
ageold	0.018**	-0.002	-0.016*	0.016**	-0.001	-0.015**
	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)	(0.01)
t	-0.012***	0.007*	0.005	0.008	-0.032	0.024
	(0.00)	(0.00)	(0.00)	(0.03)	(0.02)	(0.03)
cons	0.689	0.618	-0.307	1.244	-0.852	0.608
	(0.52)	(0.32)	(0.52)	(1.35)	(0.83)	(1.36)
R^2	0.588	0.645	0.642			
F or χ^2	47.69	17.93	30.43	4202.873	2638.125	2258.106
p-value	0.000	0.000	0.000	0.000	0.000	0.000

Table 3.4: FE IV Regressions of Female, Male and Children Clothing Expenditures. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level. The variables *agegap*2 and *agesp*2 have been divided by 100 for more meaningful comparison.

but the female share falls. *Power* is positive and significant at 10% level in the female equation but negative for both the male (significant at 5% level) and children clothing equations, which could lend support to the argument that increasing the power of the female in the household could increase her relative resources in the household. We observe that *Powerzero* is not significant in any of the three equations, however this does not in anyway signify the unimportance of this variable; indeed, a more detailed discussion on the importance of this variable is provided later in this section. The number of children also seems very important for explaining female and children shares in clothing, as one may expect, female clothing share decreases sharply with more children, while children clothing share increases. Having younger children in the household does not appear to be important for explaining clothing expenditure.

We now turn to examine the sharing rule variables which would not otherwise be included in a standard demand equation. It is clear that these variables appear significant in the analysis and this is contrary to the unitary framework but consistent with the collective approach. Educational gap between the husband and wife is highly significant and indicates that the more educated the wife relative to her spouse, the less is spent on her clothing and more is spent on her children instead. Age gap is also very significant which suggests that the older the wife is relative to her spouse, the less the household spends on her clothing and once again more is spent on her children. This age gap effect is also non-linear and the effect is accentuated as the age gap grows wider. Finally with the interaction variable *ageold*, it is interesting to see that it is not just the age of the wife that matters, but also whether she is the older spouse in the couple. The time dummy t is partially picking up relative price effects as well as year effects. The R^2 statistic summarises the goodness-of-fit for each equation, in each case the R^2 statistic is above 0.60. A test for joint significant of all regressors in each equation(excluding the intercept) is given by the $\chi^2_{(13)}$ statistic (13 regressors in total) and the respective p-value obtained from the $\chi^2_{(13)}$ distribution is reported below it. The regressors are jointly significant in each equation.

Yet there is one remaining issue to address. In the data, we observe a large number of zero observations in *Power*. This is mainly due to the fact that many women have reported zero earnings in the sample period. Although we could treat the zeros as occurring at random, this is unlikely to be appropriate, as households with wives not participating in the labour force may be systematically different from households with a working female. In the literature, many methods have been suggested to counter this type of problem, but considering the limits of our small pseudo panel dataset, this paper takes a simple approach by including a variable, *Powerzero*, that is set to one when a household has zero power.

This is important for two main reasons. First of all, it allows for a systematic distinction between the zero and non-zero observations. This ensures that the variable *Power* is well defined and its coefficient measures the effect of female power on household decisions without contamination from the participation effects. Secondly, the difference between the coefficients on the variable *Powerzero* and *Power* captures the shift in preferences when a woman switches from non-participation to participation and vice versa. For example, when a woman decides to join the labour force, one may expect more expensive clothing to be required for their job; this is reflected in the estimation results, as female clothing expenditure share is found to increase when earnings turn positive i.e. when *Power* is non-zero. In terms of understanding the variable *Power*, one possible interpretation is that the increase from zero to an infinitesimal positive amount ϵ, could be seen as a preference shifting effect. Any increase from ϵ to 1 could be interpreted as a change in the wife's relative power. Hence the introduction of the variable *Powerzero* allows for better identification of the wife's bargaining power. As we will see in Table 3.4, an increase in power from zero to one would increase female clothing share by around 40 percent, while male clothing share decreases by approximately 25 percent, these are both statistically significant.

We now turn to examine an intermediate specification that allows for endogeneity of total clothing expenditure but not fixed effects. In the meantime, we can restrict our attention to the cross-sectional IV specification in the first three columns of Table 3.4. As discussed in Section 3.2.5, for instruments the variables the log of net income of the household and log of total household non-durable expenditure excluding clothing are used. As frequently encountered with the instrumental variable approach, the standard errors have in many cases more than doubled. However, the signs and coefficients on most variables have remained comparable to the previous SUR specification. Consistent with previous results, the log of total clothing expenditure continues to be statistically significant. $Powerzero$ is again not significant in all three equations, but the coefficient of $Power$ has increased to about 0.33 in the female equation. The coefficients on the rest of the coefficients such as female school leaving age, number of children, age gap and education gap are almost unchanged.

In the last three columns of Table 3.4 the results from the final specification is presented. This is the only specification that exploits the panel structure of the data and therefore, the assumption of independence of errors across time is relaxed. In addition, it allows for any unobserved individual time non-varying effects that are correlated with the explanatory variables via the WG transformation as discussed in Section 3.5.1. Once again, as often encountered with this kind of analysis, the standard errors have in many cases doubled or even quadrupled. Compared to the previous specification, the coefficients in the male equation have seen more adjustments, while both the female and children clothing equations remain roughly comparable to the previous results, with the exception of female school leaving age.

Turning to specifics in the results, the variable $Power$ is now significant in both the female and male equations. In particular, there is a positive and significant relationship between $Power$ and female clothing share, with a coefficient of about 0.40. The opposite is true for male, with a coefficient of -0.25. This means that when $Power$ is positive, a change from close to zero to a value of 1 is associated with an increase in approximately 40 percent in female clothing, and a decrease of about 25 percent in male clothing share. Once again an increase in total clothing expenditure is associated with a fall in the female clothing share, but significant increases in the male clothing share. As discussed above, the inclusion of the variable *Powerzero* captures the preference shifting effects associated with labour market participation and thus, the effect of *Power* is less likely to be contaminated by the preference for female non-participation or zero earnings and therefore enabling better identification of *Power*. The school-leaving age of the wife appears to be important for female and children clothing expenditures, higher educated mothers are associated with lower children clothing shares but higher female clothing shares. For instance, an extra year of female education is associated with around a 6 percent increase in her clothing share, while children clothing share falls by around 8 percent. The number of children in the female equation is now marginally insignificant due to an inflated standard error, but the coefficient remains negative and comparable to previous results, an extra child is associated with a fall of 18 percent in female clothing share. Educational gap is now marginally insignificant in the female equation but is still comfortably significant at 10 percent level. Once again the presence of young children does not appear to matter.[12] However, the interaction variable *ageold* is once again very significant in both the female and children equations, and the coefficients are again consistent with previous results. This is interesting, as while the age gap between spouses has become less important, the actual age of the wife when she is older than her spouse matters much more. The effects are estimated at around 2 percent in each direction, indicating that when the wife is relatively older than her husband, every extra year in her age brings about a two percent increase in clothing expenditure share for the wife and this increase is taken almost entirely from the children's clothing budget.

The non-linear effects in female age and age gap are once again significant. Again

[12] A further test of joint significance between *numkids* and *kidsu*5 confirms this. See Appendix Table 3.12 for details.

the time dummy t is partially picking up relative price effects as well as year effects, but after the panel dimension of the data is controlled for, the time trend is no longer significant. The R^2 statistic for the cross-sectional model summarises the goodness-of-fit for each equation, in each case the R^2 statistic is again around 0.60. A test for joint significance of all regressors in each equation (excluding the intercept) is given by the appropriate $F(13, 110)$ or $\chi^2_{(13)}$ statistic (13 regressors in total, 124 pseudo panel observations) and the respective p-value obtained from the $F(13, 110)$ or $\chi^2_{(13)}$ distribution is reported below it. The regressors are jointly significant in each equation. On the whole, all three models yield concurring results with corresponding signs. There is also evidence to support the importance of the principal variable $Power$ for explaining clothing expenditures. A joint test between $Power$ and $Powerzero$ also reveals their joint significance for both the Female and Male equations. Furthermore, a joint test for other distribution factors, $edgap, agegap, agegap2, ageold$ confirm their strong joint significance in all three equations. The importance of these distribution factor variables could be interpreted as another piece of evidence against the unitary model in favour of the collective approach, and the sharing rule interpretation of how households make decisions in practice. The detailed results are reported in Tables 3.10 and 3.11 in the Appendix.

3.6 Specification checks

A battery of tests were run to ascertain the robustness of the results. In this section, the results from three misspecification tests are reported: 1) Overidentifying restrictions(OIR) tests for instrument exogeneity, 2) Test for weak instruments, 3) Test for underidentification, 4) Hausman test for fixed effects, and 5) Including a full set of time dummies. The misspecification tests in this section lend strong support to the model specification. There is also strong evidence that the instruments are valid in all cases considered. Furthermore, adding a full set of time dummies do not appear to change the results significantly.

3.6.1 Test for overidentifying restrictions(OIR)

If a set of instruments is to be used, the instruments must be exogenous for the estimates to be consistent. For overidentified models a test for exogeneity of instruments is possible. The OIR is distributed as $\chi^2_{(r-K)}$ under H_0, where $(r-K)$ is the number of overidentifying restrictions. In this case, each clothing share equation involves one endogenous variable and two instruments, thus leaving one over-identification restriction per equation. If the OIR statistic is large then the moment conditions are rejected and the instruments are endogenous, or it could also be evidence of model misspecification. In either case, rejection indicates serious problems for the IV estimator. The Sargan-Hansen statistics are reported in Table 3.5 below, in all cases H_0 of instrument exogeneity cannot be rejected.

Overidentifying Restrictions Test						
	Cross-sectional			Pseudo Panel		
	Female	Male	Children	Female	Male	Children
Sargan-Hansen statistic	0.119	1.144	0.517	0.647	0.294	0.235
$\chi^2(1)$ p-value	0.7298	0.2848	0.4722	0.4115	0.5875	0.6278
N	124	124	124	124	124	124

Table 3.5: OIR Test

3.6.2 Test for weak instruments

If the correlation between the instrument and the endogenous variable being instrumented is very weak, the estimated model will be weakly identified. This could lead to a large loss in efficiency and this loss of precision will be concentrated on the endogenous variable. The test results from the Stock and Yogo (2002) test of weak instruments are reported below. As there is only one endogenous variable in our model, the test statistic in this case is the F statistic for joint significance of the instruments used in the first stage regression. The null hypothesis is that the instruments are weak and under the alternative they are strong. The Cragg-Donald Wald F statistic and Kleibergen-Paap rk Wald F statistic are computed and compared against the Stock-Yogo weak identification test critical values. The degrees of freedom adjustment for the rk statistic is (N-L)/L1, where N is the number of observations, L is the number of instruments and L1 is the number of excluded instruments. The test statistics are reported in Table 3.6 below. Clearly, the null hypothesis of weak instruments is rejected in all cases.

Weak Identification Test	
Cragg-Donald Wald F statistic	31.572
Kleibergen-Paap rk Wald F-Statistic	28.576
Stock-Yogo weak ID test critical values:	
10% maximal LIML size	19.93
15% maximal LIML size	11.59
20% maximal LIML size	8.75
25% maximal LIML size	7.25

Table 3.6: Weak Identification Test

3.6.3 Test for underidentification

The underidentification test is a Lagrange multiplier test of whether the regression equation is identified. This test is carried out on the first stage regression and is distributed as χ^2_2. Under the null hypothesis that the equation is underidentified, and a rejection of the null indicates that the matrix is of full column rank, i.e., the model is identified. The test results are reported in Table 3.7 below. The LM test clearly rejects the null hypothesis of underidentification.

Underidentification Test	
Kleibergen-Paap LM statistic	8.684
Chi-sq P-value	0.0130

Table 3.7: Underidentification Test For Cross-sectional Model with IV

3.6.4 Hausman test for fixed effects

The choice between fixed and random effects models is an important one. If one believes that the individual effects are fixed, the pooled OLS, SUR or random effects estimators will be inconsistent, and thus, fixed effects estimators should be used. On the other hand, if effects are found to be random, it is generally sensible not to use the within group estimator, as exploiting within group variation only leads to inefficient estimates. Furthermore, within estimators do not allow the estimation of coefficients of time invariant regressors; this means that whether or not the individual effects are fixed or random is potentially an important question that should be verified. The Hausman test is a straightforward way to test this. Under the null hypothesis, individual effects are random, and thus both the fixed and random effects estimators should yield similar outcomes. Under the alternative, these estimators are significantly different. The results from the Hausman test are reported in Table 3.8 below. The strong rejection of the null hypothesis of consistent estimates under the random effects model indicates a strong case for a fixed effects estimator.

Hausman Test for Specification			
	Female	Male	Children
chi2(13)	36.83	93.90	38.24
Prob>chi2	0.0004	0.0000	0.0003
N	124	124	124

Table 3.8: Hausman Test for Fixed Effects

3.6.5 Including a full set of time dummies

The inclusion of controls for each time period ensures that any year-specific effects are controlled for. However, the choice of instrument to achieve this may be a matter of taste. In this paper, a simple time dummy that indicates the time period is considered, but this is also compared against a specification with a full set of time dummies, one for each period. Our results appear to be relatively insensitive to the choice of time controls. To demonstrate this, the results for the FE IV regressions with a full set of time dummies are presented in Table 3.9 below. It is clear that *Power* is still very statistically significant and the patterns are similar to the results presented in Table 3.4 in the previous section. *Power* continues to have a positive and significant effect on female clothing share and a negative and significant effect on male clothing share. Overall the pattern and magnitude of the coefficients have remained very similar to the original results. This suggests that the effect of household *Power* on clothing expenditures cannot be simply explained by year specific effects in addition to the set of explanatory variables.

FE IV Regressions With Full Time Dummies			
ltotalcloth	-0.037	0.182***	-0.145
	(0.08)	(0.05)	(0.08)
power	0.440*	-0.238*	-0.202
	(0.18)	(0.11)	(0.19)
powerzero	0.154	-0.185*	0.031
	(0.13)	(0.08)	(0.13)
fageleft	0.060	0.041	-0.102**
	(0.04)	(0.02)	(0.04)
numkids	-0.195*	0.083	0.113
	(0.10)	(0.06)	(0.10)
kidsu5	0.160	-0.041	-0.119
	(0.09)	(0.05)	(0.09)
edgap	-0.036*	0.017	0.019
	(0.02)	(0.01)	(0.02)
agegap	-0.038	-0.059*	0.097*
	(0.05)	(0.03)	(0.05)
agegap2	-0.263*	-0.008	0.271*
	(0.12)	(0.07)	(0.12)
agesp	-0.081	-0.046	0.127*
	(0.05)	(0.03)	(0.05)
agesp2	0.066	0.131***	-0.197**
	(0.06)	(0.04)	(0.06)
ageold	0.018**	0.004	-0.022**
	(0.01)	(0.00)	(0.01)
T2	-0.047	0.295*	-0.248
	(0.24)	(0.15)	(0.25)
T3	-0.062	0.244	-0.182
	(0.21)	(0.12)	(0.21)
T4	-0.052	0.184	-0.133
	(0.17)	(0.11)	(0.18)
T5	-0.037	0.164	-0.127
	(0.14)	(0.09)	(0.15)
T6	-0.039	0.147*	-0.109
	(0.12)	(0.07)	(0.12)
T7	-0.048	0.059	-0.011
	(0.07)	(0.04)	(0.07)
T8	-0.011	0.019	-0.008
	(0.04)	(0.03)	(0.04)
_cons	1.459	-1.521	1.062
	(1.76)	(1.07)	(1.82)
chi2	3972.604	2565.203	2029.793
p	0.000	0.000	0.000

Table 3.9: FE IV Regressions of Female, Male and Children Clothing Expenditures for time period with a full set of time dummies. Standard errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level. The variables *agegap*2 and *agesp*2 have been divided by 100 for more meaningful comparison.

3.7 Conclusion

The analysis of this paper shows that an exogenous increase in women's income relative to their spouse could significantly and substantially increase female clothing expenditure and decrease male clothing expenditure, holding total household expenditure on clothing constant. This finding is largely in line with existing studies such as, Browning, Bourguignon, Chiappori, and Lechene (1994) and Lundberg, Pollak, and Wales (1997), in that exogenous income shifts in spousal incomes can have significant effects on family expenditure patterns.

Although the original government intention behind the UK tax reform in 1990 was solely to improve the 'privacy and independence' of married women, the results from this study suggest that for the group of women who were positively affected by the reform, there was also likely to have been a positive effect on their welfare in terms of household clothing expenditure. Even though this study only focuses on clothing due to data limitations, it is reasonable to expect that women also saw improvements in other areas of household consumption with clothing being one example.

Another important finding of this paper is that distribution factors, such as relative power, age gap, education gap, and whether or not the wife is the older spouse, were highly significant, despite the fact that these variables do not impact on preferences or on budgets directly. Once again this leads to the firm rejection of the unitary framework in favour of the collective approach and the sharing rule interpretation of how households make decisions in practice. The results are also robust to various misspecification tests.

Perhaps it is also worth mentioning that in contrast to Lundberg, Pollak, and Wales (1997), this study finds that the effect of the reform on children clothing expenditure is less apparent and could even be negative. One possible explanation is that when the exogenous income shift stems from child-related subsidies such as child benefit transfers, mothers may feel more obliged to increase expenditure on their children as this is what the transfer was intended for originally. In contrast, when the exogenous income shift is caused by a general subsidy or transfer for wives, such as a fall in taxation on female labour earnings, there is less obligation on the mothers to increase children specific expenditures; instead there is more justification to increase expenditure on themselves. Therefore, although an increase in relative female earnings could raise the level of expenditure on children, it may not necessarily mean that children will do better relatively as one may be tempted to conclude from Lundberg, Pollak, and Wales (1997). The final outcome could depend on the type of transfer in question.

In this study, many simplifying assumptions were made and in particular, we have assumed that children matter for household decisions only through the utility their parents derive from their well-being, but children themselves cannot influence household choices directly. This is clearly a strong assumption as the power of children to influence household decisions can depend on many different factors such as parents' age, education, occupation, income, relationship between spouses etc. Nevertheless, in the context of clothing this assumption may be acceptable as parents do tend to make the final decisions when purchasing clothing for their children. One other issue discussed was the lack of panel data for the sample period, thus a pseudo panel was constructed for analysis instead. Aside from losing information from individual observations, this approach requires non-trivial assumptions about the data. Because homogeneity is assumed within a cohort, the unobserved fixed effect within cohorts is assumed to be constant, while heterogeneity across cohorts is allowed. Though this requirement is fairly strong, our specification tests do not reject our model, perhaps suggesting that homogeneity within cohorts may not be an entirely invalid assumption in this case.

Another important issue that we examined was on the treatment of total clothing expenditure as endogenous. By instrumenting total clothing expenditure with net household income and non-durable expenditure excluding clothing, we are implicitly assuming that the utility function is separable between labour supply (or leisure) and clothing.

As mentioned before, this assumption could fail if there is non-separability in the utility functions. An example would be where certain occupations require more expensive work clothing; if this is the case, individual incomes could enter the demand equations for clothing, even after conditioning on total clothing expenditure, education or even occupation. However, after instrumenting for total clothing expenditure in the demand equations with the log of net income of the household and log of total household non-durable expenditure excluding clothing, the overidentifying restrictions are not rejected, thus indicating that in this case the assumptions may be acceptable and therefore we choose to follow this common methodology used in the literature.

Finally, one may be tempted to interpret the results in the context of marriage and divorce. On one hand, the reform in the taxation of couples did alleviate problems such as the marriage penalty, thus potentially encouraging marriage. On the other hand, it also exogenously increased women's income relative to their husbands. This could have had the effect of increasing women's independence and bargaining power, which could have potentially led to changes in spousal marriage dynamics. In addition, the resulting rise in female net wage rate from the reform would also encourage female labour force participation. This could have also had wide-ranging repercussions for the household. Hence without a thorough analysis it is difficult to ascertain the overall effect of this reform on marriage and divorce propensities, and this could be an interesting area for future research.

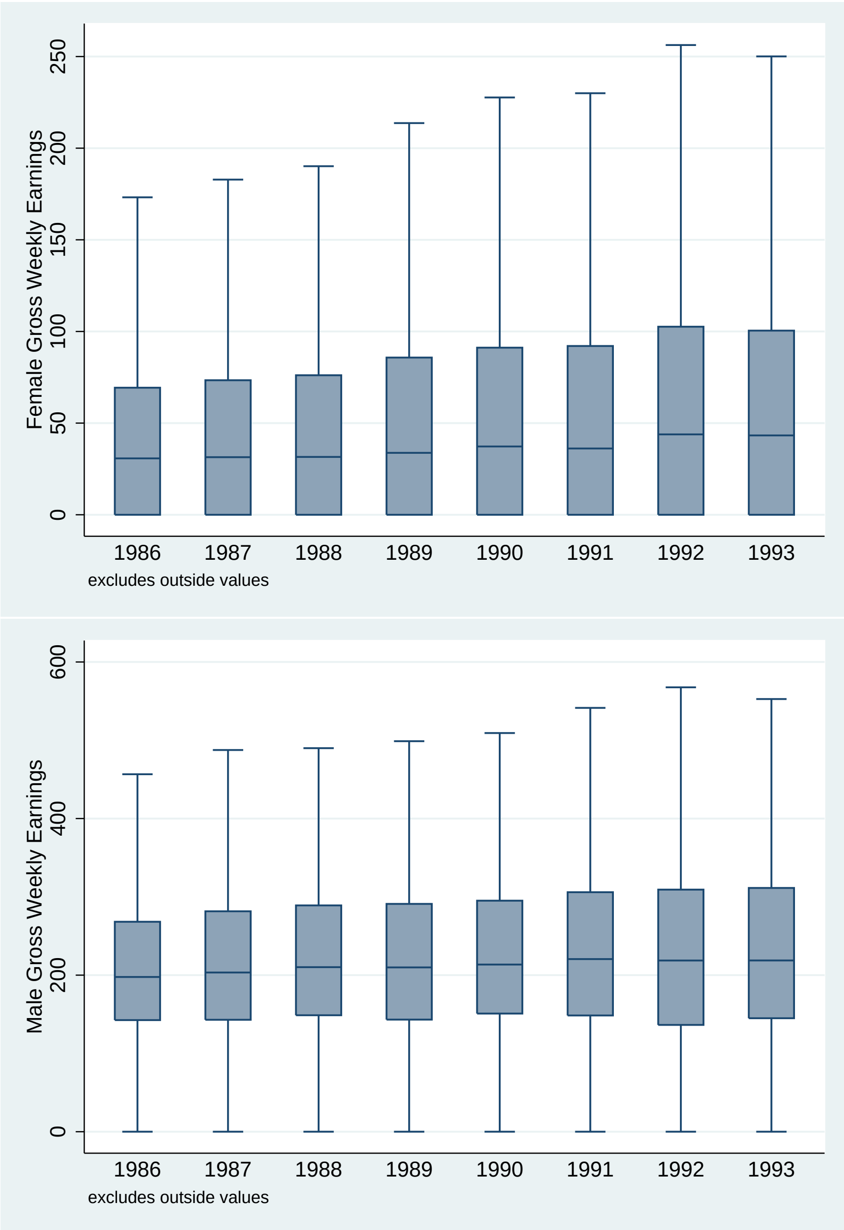


Figure 3.1: Female and Male Gross Weekly Earnings (1986 - 1993)

Figure 3.2: Household Net Annual Income (1986 - 1993)

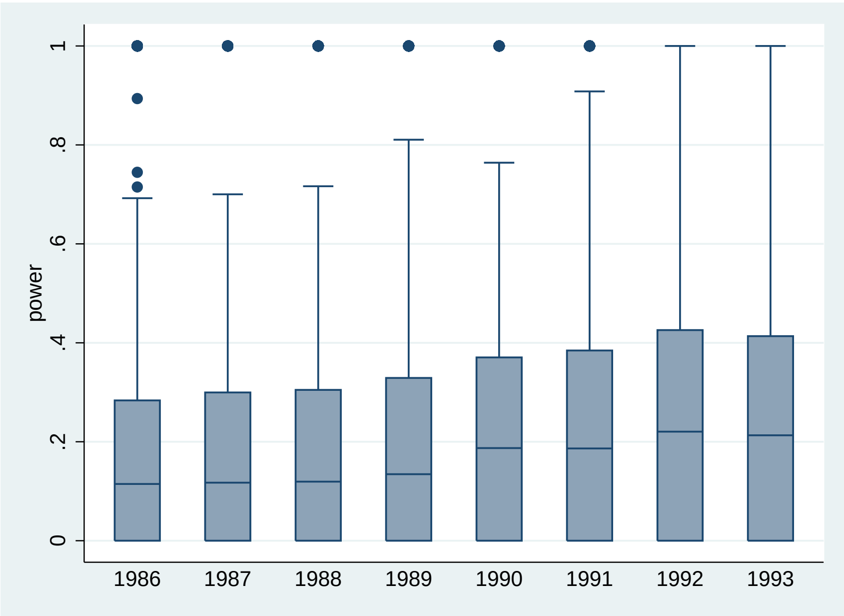


Figure 3.3: Household Power Measure (1986 - 1993)

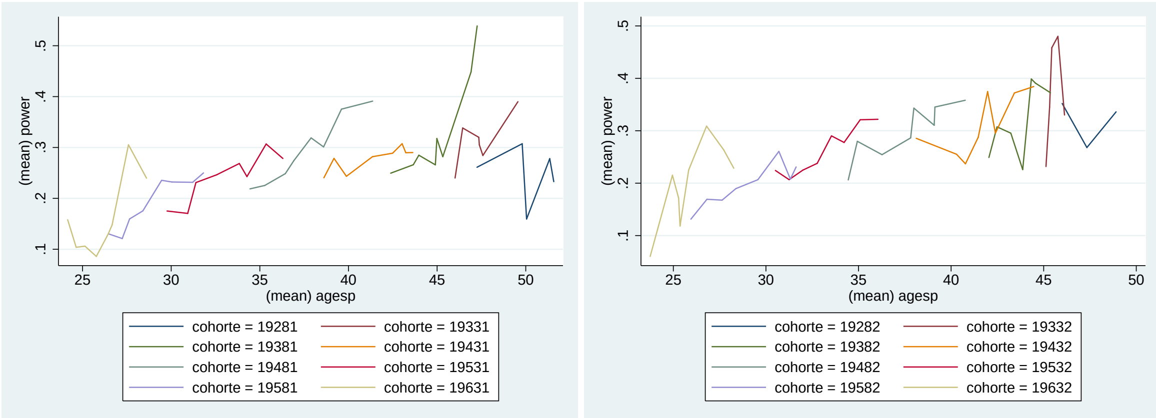


Figure 3.4: Power against Age of Wife by Cohort and Education Level. Low Education Level (Left) and High Education Level (Right)

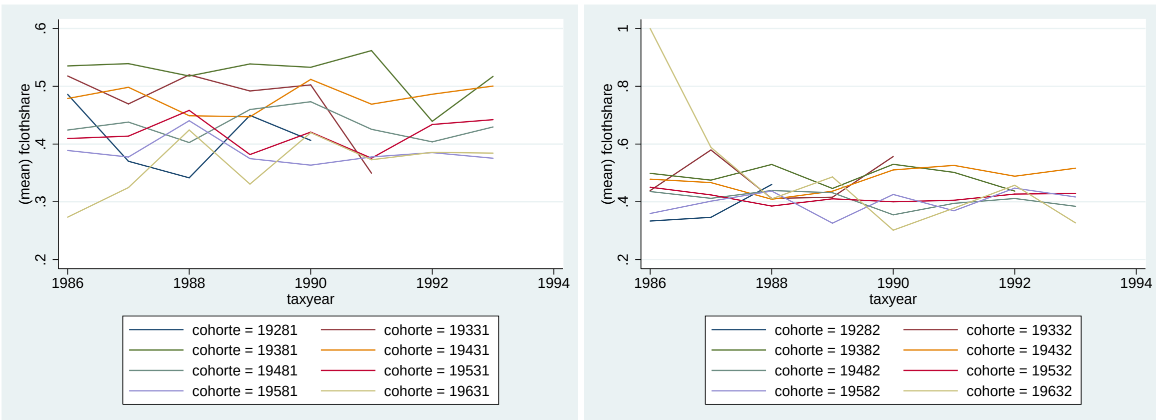


Figure 3.5: Female Clothing Expenditure Share against Tax Year by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right)

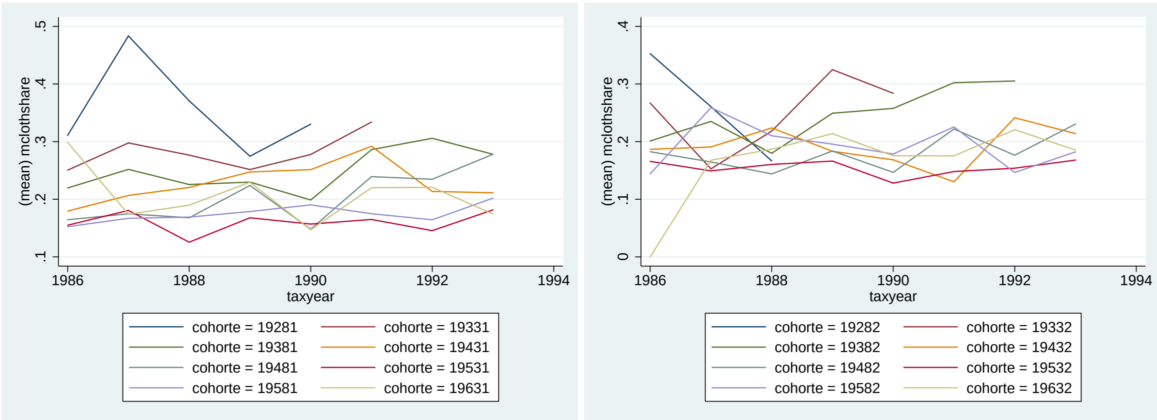


Figure 3.6: Male Clothing Expenditure Share against Tax Year by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right)

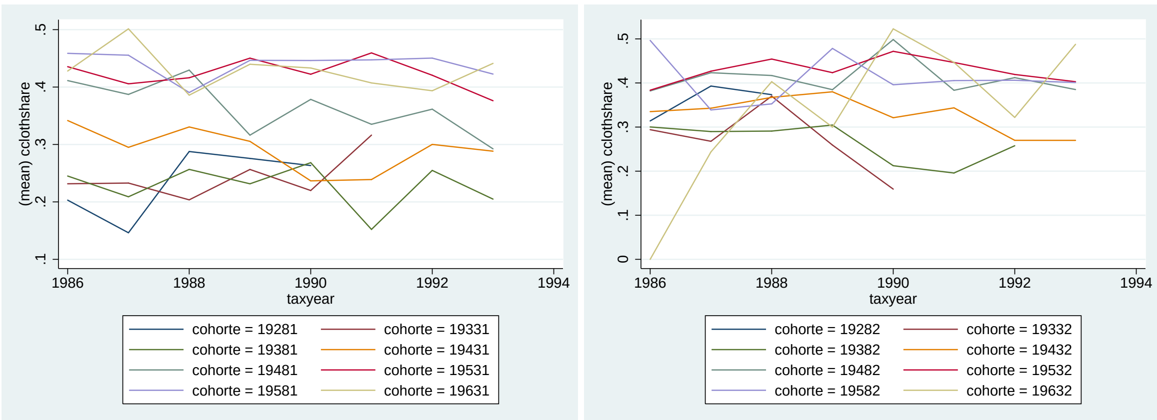


Figure 3.7: Children Clothing Expenditure Share against Tax Year by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right)

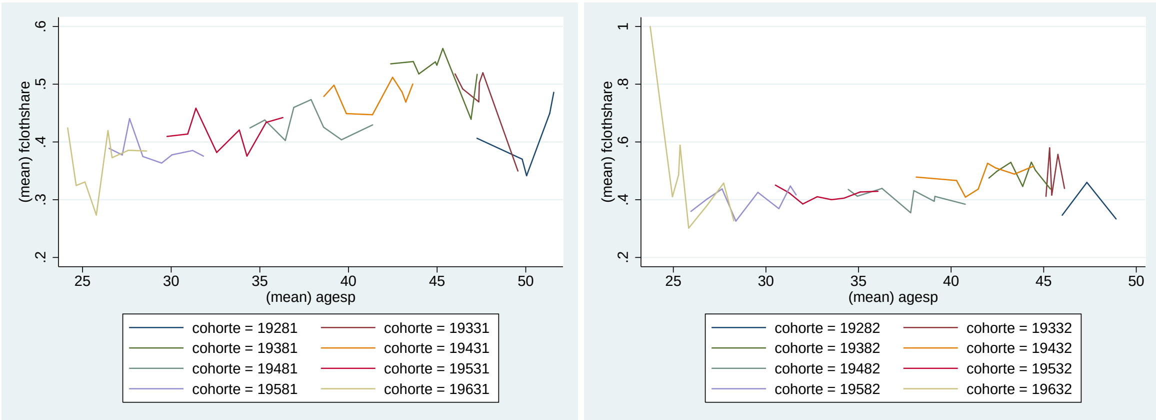


Figure 3.8: Female Clothing Expenditure Share against Age of Wife by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right)

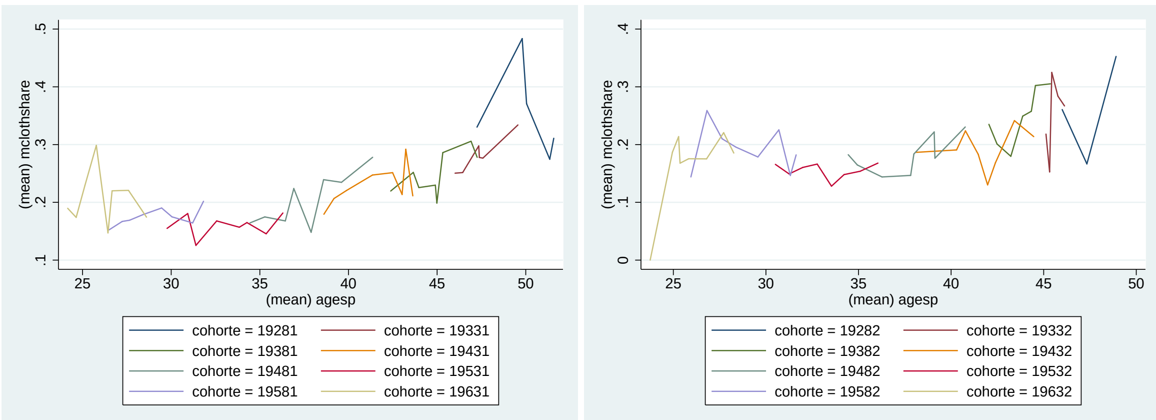


Figure 3.9: Male Clothing Expenditure Share against Age of Wife by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right)

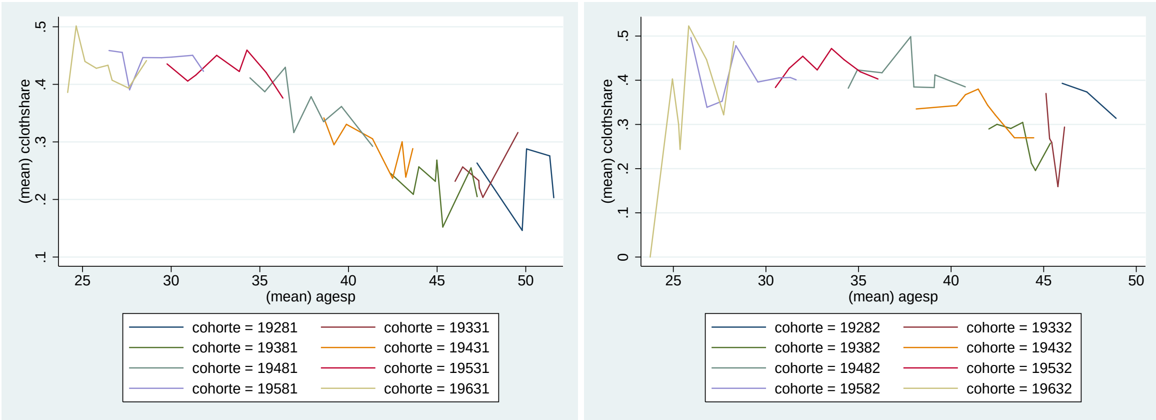


Figure 3.10: Children Clothing Expenditure Share against Age of Wife by Education Level by Cohort and Education level. Low Education Level (Left), High Education Level (Right)

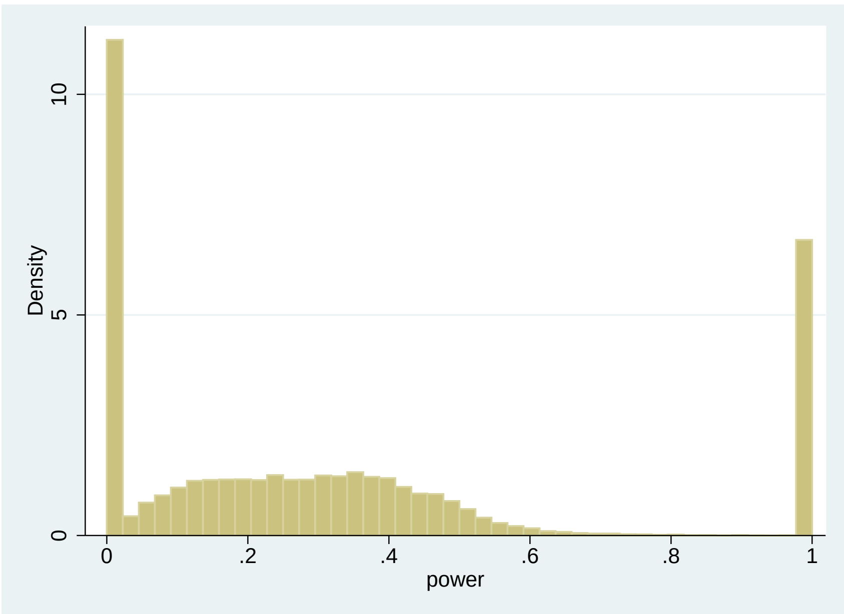


Figure 3.11: Histogram for Power Measure

3.8 Appendix

3.8.1 Joint Test of significance for *Power* and *Powerzero*

The joint significance of two variables *Power* and *Powerzero* are tested and the results are reported below. The χ^2 statistic for the male equation is clearly significant, while the statistic for the female equation is borderline significant, on the whole indicating that *Power* and *Powerzero* are jointly significant for both the male and female equations but not for the children equation.

Joint Test of Significance			
	Female	Male	Children
chi2(2)	6.15	8.65	1.86
Prob>chi2	0.0461	0.0132	0.3754
N	124	124	124

Table 3.10: Joint test of significance for *Power* and *Powerzero*

3.8.2 Joint test of significance for other distribution factors

The joint significance of other distribution factors, $edgap, agegap, agegap2, ageold$ are tested. This can be seen as a test to verify the importance of distribution factors, which should be insignificant if the unitary framework was to be valid. The results are reported below. Clearly the null hypothesis of joint insignificance is rejected for all three equations. The importance of distribution factors could be interpreted as another piece of evidence against the unitary framework in favour of the collective approach and the sharing rule interpretation of how households make decisions in practice.

3.8.3 Joint test of significance for *numkids* and $kidsu5$

As mentioned previously, the variable *numkids* has been found to be significant in a number of cases, but the variable for young children, $kidsu5$, has been found to be

Joint Test of Significance			
	Female	Male	Children
chi2(4)	17.68	9.82	12.61
Prob>chi2	0.0014	0.0436	0.0134
N	124	124	124

Table 3.11: Joint test of significance for the set of distribution factors

consistently insignificant. Here the joint significance of the two variables for children, *numkids* and *kidsu*5, are tested. The results are reported below and in all three equations, the null hypothesis of joint insignificance cannot be rejected for all three equations. Thus there is further evidence to suggest a minor role of young children in the decision making of clothing expenditure for this study.

Joint Test of Significance			
	Female	Male	Children
chi2(2)	4.25	2.97	1.26
Prob>chi2	0.1194	0.2269	1.5314
N	124	124	124

Table 3.12: Joint test of significance for *numkids* and *kidsu*5

Chapter 4

Taxation and Labour Supply of Married Couples

Abstract

Across countries, there is a large variation in the tax treatment of couples. Over the last three decades, many countries have undergone reforms in their tax systems, some have moved from joint to independent taxation, some from independent to joint, while others have begun the practice of allowing couples to choose the system they prefer. In 1990, the UK moved from a system of joint taxation of couples to a system of independent taxation. This paper aims to examine the effects of this reform with particular emphasis on female labour supply.

There are five main findings that are of particular interest. First of all, we highlight the serious problems surrounding the definition of a spouse's net income before 1990. This issue has rarely been examined in depth in the literature. We propose a method of clarifying the concept of a spouse's individual net income under a joint tax regime. Second, we follow the methodology of Blundell et al (2007), we estimate the labour supply elasticities for both male and female and find that our results are similar in magnitude and patterns. Third, we extend the methodology of Blundell et al to include children in our model and find that both the number of children and their age are highly significant for women's labour supply and to a smaller extent also for men. Fourth, testing the income pooling hypothesis, we find that we are unable to reject the unitary model. However, we strongly reject the hypothesis that distribution factors have no effect on labour supply.

Finally, our results suggest that for the group of women affected, the reform generated two opposing effects on their labour supply. There was a positive effect from an increase in net wage, but also a negative effect from possibly an increase in bargaining power. The overall impact of the reform will depend on the relative magnitudes of these two opposing forces. On balance, we find that a typical female affected by the reform decreased her labour supply by approximately 2.6 hours per week, yet she still experienced a 22 percent increase in her net income.

4.1 Introduction

Across countries, there is a large variation in the tax treatment of couples. Over the last three decades, many countries have undergone reforms in their tax systems, some have moved from joint to independent taxation, some from independent to joint, while others have begun the practice of allowing couples to choose the system they prefer. In 1990, the UK moved from a system of joint taxation of couples to a system of independent taxation. This chapter aims to examine the effects of this reform with particular emphasis on female labour supply.

There exists a vast literature on labour supply and women's labour supply. A comprehensive survey could be found in for example, Blundell and MaCurdy (1999). Several papers have used policy changes to quantify the economic effects of taxation and the labour supply of married women. Eissa (1995) analyses the US Tax Reform Act 1986 as a natural experiment. The tax reform reduced the number of tax brackets from 14 to five, and this was accompanied by a fall in the top marginal tax rate from 50 to 28 percent. Using a difference-in-difference approach and concentrating on women with high income husbands, she finds that the reform significantly increased the labour supply of women with high income husbands relative to the control group of women with lower income husbands. In a different study, Eissa (1996) uses the US Economic Recovery Tax Act in 1981 to study the labour supply responses of married women. The policy change lowered the top marginal tax rate from 70 to 50 percent. For the second earner in the household, a reduction by 23 percent in the marginal tax rate is estimated within each tax bracket. Using data from 1981 and 1985, she estimates the labour response of women using both difference-in-difference and standard labour supply methods and finds weak evidence of labour force participation responses in upper-income women. Furthermore, she finds no significant evidence of an increase in annual working hours in this group of women.

The literature specifically on the effects of joint taxation is relatively limited and more emphasis has been placed on the theoretical perspective. As discussed in Chapter 2 of this thesis, several papers such as Piggott and Whalley (1996), Apps and Rees (1999), Goutfried and Richter (1999) and Kleven and Kreiner (2007) debate the relative merits of a joint versus independent taxation regime in a formal theoretical context. There seems to be a broad agreement that in reality, distortions in the second earner's marginal tax rate and restricted commodity taxation would mean that independent taxation would typically dominate joint taxation.

Empirically, few papers have focused specifically on the economic effects of joint taxation. In a recent paper, Crossley and Jeon (2007) follow a similar approach to Eissa (1995) and apply a difference-in-difference estimation method to the Canadian federal tax reform of 1988. The reform replaced a system of spousal tax exemption with a non-refundable tax credit and they argue that this reduced the 'jointness' of the tax system. Their study finds a significant increase in labour force participation among married women with higher-income husbands. LaLumia (2008) examines the US tax reform in 1948. Again using a difference-in-difference estimation strategy, she exploits the differences in tax treatment of property law across states. She finds that joint taxation lowered the marginal tax rates of husbands and raised that of the wives. Her results show that joint taxation is associated with a decline of approximately two percentage points in employment rate of married women. Gustafsson (1992) examines the labour supply of Swedish and German women facing independent and joint taxation respectively. Using tax simulations and regression analysis, he finds a significant difference in the behaviour of German and Swedish women. In addition, he estimates that the participation rates of Swedish married women would fall from 80% to 60% if the German system of joint taxation was adopted. His study also highlights the importance of children for German women's labour force participation but less so for Swedish women. Besides employment and participation effects, a reform may also affect how couples allocate their assets for taxation. Stephens Jr and Ward-Batts (2004) is the only study to date that examines the UK tax reform in 1990. They investigate asset ownership shares between spouses and found significant evidence of tax avoidance following the reform by shifting investment income to the spouse with lower earnings.

Many of the studies above have employed a difference-in-difference framework, this approach has the advantage of allowing the estimation of labour supply responses without explicit modelling of the budget sets. However, the use of the difference-in-difference estimation method in this context has been criticised heavily in the literature by for example, Heckman (1996), Blundell, Duncan, and Meghir (1998) and Blundell and MaCurdy (1999). The foremost criticism centres around the construction of the grouping variable, from which women are assigned to treatment or control groups.

For the difference-in-difference methodology to be valid, we require an exogenous grouping variable that could separate the control group (women not affected by the tax reform) from the treatment group (women affected by the tax reform). Studies tend to treat the husband's income as an exogenous grouping variable and sort women according to their husband's income. The rationale is that women with higher income husbands are more likely to be affected by this type of reform. However, a primary concern is that the husband's income may in fact be endogenous, as it could itself respond to the tax reform. This concern is particular apparent in the context of joint taxation. Furthermore, some women could move from one group to another as a result of the reform. These failures to separate the treatment and control groups will lead to biased labour supply estimates for the tax reform. Due to these serious concerns, in this paper we shall follow a standard labour supply framework and attempt to model labour supply in a collective setting instead.

In the next section of this chapter we shall begin by reviewing some of the theoretical models in the literature. This is followed by a discussion on how different types of tax systems could be built into existing theoretical frameworks. We then move onto the empirical aspects of the paper. In section 5, we provide a definition of net income under different tax regimes and discuss the difficulties in constructing a well defined notion of net income under joint taxation. An overview of the structure of the data is presented in section 6, followed by a review of our estimation strategy in section 7. Finally, the results from our estimation are presented in section 8 with further discussions on testable implications and model diagnostics. The conclusion is given in Section 9.

4.2 Theory

We begin the paper by critically reviewing the unitary model which assumes that there is a single household utility function that guides choices of labour supply and consumption subject to a household budget constraint.

4.2.1 Unitary model

The classical or unitary approach treats the household as a single decision making unit. All labour and non-labour incomes are pooled, and decisions about consumption, leisure and labour supplies are made centrally. Labour supply is modelled as a trade off between consumption and leisure. Individuals derive utility from consumption and leisure. Leisure is simply the amount of time not spent working, and consumption can be purchased with labour income and non-labour income. Starting from a stripped down model without household production, the household utility function can be written as $U(h_m, h_f, c_m, c_f)$, with h_m, h_f denoting the individuals' labour supply (with $0 \leq h_i \leq T$, $i = m, f$, denoting male and female respectively) and taking a model in which all consumption is private, c_m, c_f denote the private consumptions of each individual. Let w_m, w_f, y denote real wage rates for the male, female members and household non-labour income respectively. In the absence of taxation, this would lead to the following optimisation problem:

$$\max_{c_m, c_f, h_m, h_f} \quad U(c_m, c_f, 1-h_m, 1-h_f) \tag{4.1}$$

$$s.t. \;\; c_m + c_f \leq w_m h_m + w_f h_f + y \tag{4.2}$$

Assuming that the hours of work and consumption are non-negative, $h_i \geq 0, c_i \geq 0$, where $i = m, f$, the Lagrange problem is therefore:

$$L = U(c_m, c_f, 1-h_m, 1-h_f) - \lambda[c_m + c_f - w_m h_m - w_f h_f - y] \tag{4.3}$$

The first order conditions:

$$\begin{aligned}
\frac{\partial L}{\partial c_m} &= U_{c_m} - \lambda = 0 \\
\frac{\partial L}{\partial c_f} &= U_{c_f} - \lambda = 0 \\
\frac{\partial L}{\partial h_m} &= -U_{h_m} + \lambda w_m \leq 0 \\
\frac{\partial L}{\partial h_f} &= -U_{h_f} + \lambda w_f \leq 0 \\
\frac{\partial L}{\partial \lambda} &= c_m + c_f - w_m h_m - w_f h_f - y = 0
\end{aligned}$$

At the optimum, the marginal rates of substitution are:

$$
\begin{aligned}
MRS_{h_m,c_m} &= \frac{U_{h_m}}{U_{c_m}} = w_m \\
MRS_{h_f,c_f} &= \frac{U_{h_f}}{U_{c_f}} = w_f \\
MRS_{h_m,c_f} &= \frac{U_{h_m}}{U_{c_f}} = w_m \\
MRS_{h_f,c_m} &= \frac{U_{h_f}}{U_{c_m}} = w_f \\
MRS_{h_f,h_m} &= \frac{U_{h_f}}{U_{h_m}} = \frac{w_f}{w_m}
\end{aligned}
$$

Solving for Marshallian Demands:

$$c_m = C_m(w_m, w_f, y) \tag{4.4}$$

$$c_f = C_f(w_m, w_f, y) \tag{4.5}$$

$$h_m = H_m(w_m, w_f, y) \leq 1 \tag{4.6}$$

$$h_f = H_f(w_m, w_f, y) \leq 1 \tag{4.7}$$

Although the unitary model has the advantage of being analytically simple, the impact of policies could affect each individual in the household differentially. These cannot be correctly assessed in the unitary model, and its use will lead to erroneous welfare inferences (see Vermeulen (2002) for a more detailed discussion). Furthermore, another study by Laisney and Beninger (2002) compares the collective and unitary models using simulated data with income taxation, distinguishing between cases of joint and individual taxation. They find evidence of substantial difference between the two models and evidence of distortions with unitary estimates. These all suggest that a unitary framework may not be sufficient for the purposes of this study.

4.2.2 Collective model

Now we turn to examine the collective model of labour supply. Again we focus on the baseline specification without household production. We assume that each individual has their own utility function. Although the mechanism of bargaining is not assumed, intra-household allocations are assumed to be Pareto efficient. Labour supply is modelled as a trade off between consumption and leisure. Individuals derive utility from consumption and leisure. Leisure is simply the amount of time not spent working, and consumption can be purchased with labour and non-labour income.

The dynamics of a couple are slightly more complex than two independent singles, as there is the additional dimension of the division of labour and non-labour income between the two individuals. The pooling and redistribution of resources means that in most cases, the final labour supply and consumption allocations are likely to be very different from the case where the two people were single independent individuals. In addition, the results from a collective model may also differ from that of a unitary model, as we shall examine shortly. The Pareto weight and sharing rule in the collective model add a further dimension to the dynamics of couples. This simple model generates many important implications and is a useful way to develop our analysis for a married couple. Assuming egoistic preferences, one could rewrite the maximisation problem as a decentralised problem consisting of a sharing stage, followed by a consumption stage. The resulting allocation will be efficient no matter how the total income is divided, as long as the individuals maximise their utility in the final consumption stage. (See Chiappori (1992) for a formal proof.) In the absence of income taxation, the household budget optimisation problem is given by:

$$\max_{c_m, c_f, h_m, h_f} \quad U_m(c_m, l_m) + \mu(w_m, w_f, y, z) U_f(c_f, l_f) \tag{4.8}$$

$$s.t. \quad c_m + c_f + w_m l_m + w_f l_f = w_m + w_f + y \equiv M$$

Where $\mu \geq 0$, is the utility weight for the female member, given by some non-negative function, z is the set of distribution factors, which are variables that could influence the sharing rule, but do not directly impact upon preferences or the household budget constraint. These could include factors such as age gap or earnings differences, $\mu = f(w_m, w_f, y, z)$, this is equivalent to the sharing rule. M is the 'full income' of the household. Depending on the availability of data, empirically the researcher may only observe the household consumption, $c = c_m + c_f$, instead of the individual consumption quantities. Given the usual convexity assumptions with independent agents (separable preferences) in the absence of externalities, the Second Fundamental Theorem of Welfare Economics would imply that any efficient outcome can be decentralised for a set of chosen prices and a re(distribution) of total income between members can be achieved without sacrificing efficiency (see e.g. Mas-Colell, Whinston, and Green (1995)). The decentralised program is presented below. The intuition is that, the household first decides on the allocation of non-labour income, and then each individual subsequently chooses their level of labour supply and private consumption. The amount of income share the husband receives is given by the following:

$$y - \gamma(w_m, w_f, y, z) \tag{4.9}$$

The function $\gamma(w_m, w_f, y, z)$ is defined as the sharing rule and is the wife's share of unearned income. It therefore governs the proportion of non-labour income each individual receives from the total household non-labour income, y. In general, γ is assumed to be continuous differentiable. It is worth noting that γ may be negative or greater than y, depending on the household. Thus it is possible for an individual to receive a lump sum transfer from their spouse or vice versa, be asked to pay a lump sum amount out of their own earnings. The key feature is that, in general individuals are likely to attain an income allocation which is different from their personal non-labour income contribution.

The exact allocation they receive will depend on wages, income and distribution factors. The important observation here is that spouse's wage can only have an effect through the sharing rule. In addition, an implicit assumption is that γ should not depend on the individuals' total labour income, $w_i h_i$, where $i = m, f$, as the choice of hours of work is endogenous. Indeed Basu (2006) has shown that such a circular link would in effect act as a subsidy and distort the price of leisure for the agent. This is because an increase in the hours of work would now not only increase the total household income and subsequently change the household budget constraint, but it would also have the effect of shifting the individual's bargaining power in the household. This endogenous feedback creates a distorted incentive to over supply labour.

In the present case, the husband's income share is allocated according to his own optimisation problem given by:

$$\max_{c_m, h_m} \quad U_m(c_m, 1 - h_m) \tag{4.10}$$
$$s.t. \;\; c_m \leq w_m h_m + (y - \gamma(w_m, w_f, y, z))$$

The Marshallian Demands:

$$c_m = C_m(w_m, y - \gamma(w_m, w_f, y, z)) \tag{4.11}$$
$$c_f = C_f(w_f, \gamma(w_m, w_f, y, z)) \tag{4.12}$$
$$h_m = H_m(w_m, y - \gamma(w_m, w_f, y, z)) \leq 1 \tag{4.13}$$
$$h_f = H_f(w_f, \gamma(w_m, w_f, y, z)) \leq 1 \tag{4.14}$$

The position of the final outcome on the Pareto frontier would thus depend on all of the parameters w_m, w_f, y, z. It should now be clear that the unitary model is just a special case of the collective model, with the Pareto weight assumed to be constant, and as a result, distribution factors have no effect on household behaviour.

Results from Chiappori (1988), Chiappori (1992) and Chiappori, Fortin, and Lacroix (2002) have demonstrated that the observation of the Marshallian labour supply equations (4.13) and (4.14) allows for the identification of the sharing rule up to an additive constant. As this result is of central importance for the identification of the collective model, a review of its main implications are presented below. We begin by generating cross equation restrictions by differentiating the Marshallian labour supply equations with respect to w, y, z.

Differentiating f's Marshallian labour supply with respect to (w_m, y, z) yields,

$$\frac{\partial h_f}{\partial w_m} = \frac{\partial H_f}{\partial \gamma}\frac{\partial \gamma}{\partial w_m} \tag{4.15}$$

$$\frac{\partial h_f}{\partial y} = \frac{\partial H_f}{\partial \gamma}\frac{\partial \gamma}{\partial y} \tag{4.16}$$

$$\frac{\partial h_f}{\partial z} = \frac{\partial H_f}{\partial \gamma}\frac{\partial \gamma}{\partial z} \tag{4.17}$$

Assuming $\frac{\partial h_f}{\partial y} \neq 0$,

$$\frac{\partial h_f/\partial z}{\partial h_f/\partial y} = \frac{\partial \gamma/\partial z}{\partial \gamma/\partial y} \tag{4.18}$$

Deriving the equivalent conditions for m,

$$\frac{\partial h_m}{\partial w_f} = -\frac{\partial H_m}{\partial \gamma}\frac{\partial \gamma}{\partial w_f} \tag{4.19}$$

$$\frac{\partial h_m}{\partial y} = \frac{\partial H_m}{\partial \gamma}\left(1 - \frac{\partial \gamma}{\partial y}\right) \tag{4.20}$$

$$\frac{\partial h_m}{\partial z} = -\frac{\partial H_m}{\partial \gamma}\frac{\partial \gamma}{\partial z} \tag{4.21}$$

Thus yielding similar results for m,

$$\frac{\partial h_m/\partial z}{\partial h_m/\partial y} = -\frac{\partial \gamma/\partial z}{1 - \partial \gamma/\partial y} \tag{4.22}$$

Following the notations in Browning, Chiappori, and Weiss (2012), we let $F_i = \frac{\partial h_i/\partial z}{\partial h_i/\partial y}$, where $i = m, f$. Equations (4.18) and (4.22) can then be solved simultaneously as long as $F_m \neq F_f$.

$$\frac{\partial \gamma}{\partial y} = \frac{F_m}{F_m - F_f} \tag{4.23}$$

$$\frac{\partial \gamma}{\partial z} = \frac{F_m F_f}{F_m - F_f} \tag{4.24}$$

The function F_i can be observed or estimated empirically as a function of (w_m, w_f, y, z). The requirement that $F_m \neq F_f$ is almost always satisfied. This can be shown by analysing the effect of a change in non-labour income, we could infer that both $\frac{\partial \gamma}{\partial y}$ and $1 - \frac{\partial \gamma}{\partial y}$ must be positive, as individuals must be better off when non-labour income increases. It follows that F_m and F_f will in general have opposite signs, unless they are both zero. As this would imply that the distribution factor has no effect on labour supply, which simply means that we require at least one meaningful distribution factor. Similarly one could derive the partial derivatives of the sharing rule with respect to w_m, w_f as shown below in (4.25) and (4.26) to fully recover the complete set of partial derivatives of the sharing rule.

$$\frac{\partial \gamma}{\partial w_m} = \frac{\partial h_f/\partial w_m}{\partial H_f/\partial \gamma} = \frac{\partial h_f/\partial w_m}{\partial h_f/\partial y}\frac{\partial \gamma}{\partial y} = \frac{\partial h_f/\partial w_m}{\partial h_f/\partial y}\frac{F_m}{F_m - F_f} \tag{4.25}$$

$$\frac{\partial \gamma}{\partial w_f} = -\frac{\partial h_m/\partial w_f}{\partial H_m/\partial \gamma} = -\frac{\partial h_m/\partial w_f}{\partial h_m/\partial y}\left(1 - \frac{\partial \gamma}{\partial y}\right) = \frac{\partial h_m/\partial w_f}{\partial h_m/\partial y}\frac{F_f}{F_m - F_f} \tag{4.26}$$

Once again, the ability to observe the two labour supply functions provide the key to recovering the sharing rule. The main insight is that the partial derivatives of the sharing rule are all fully identified and recovered. (Browning, Chiappori, and Weiss (2012)) These results are important as they allow for the recovery of the partial derivative of the sharing rule, and thus the sharing rule itself, up to an additive constant. It can also be shown that the individual consumption of Hicksian commodities c_m, c_f can be recovered up to the same additive constant. However, the constant is irrelevant for welfare analysis, as variation in the constant will not affect the resulting comparative statics. These strong identification results allow for meaningful empirical predictions, such as how much an individual's share in non-labour income would change following a one percent increase in his or her wage. Such results are generally not available under a unitary approach[1] and thus, renders it less favourable when dealing with welfare analysis. In addition, the cross equation restrictions generated from the collective model can provide additional testable predictions. Considering the only key assumptions required are restrictions on the individual preferences (e.g. egoistic) and that household allocation are Pareto efficient, these identification results are remarkable.

We now turn to consider the identification of the model. Turning back to the general collective model, the observable and structural Marshallian labour supply equations for the two individuals are as follows:

$$h_m = \hat{H}_m(w_m, w_f, y, z) = \tilde{H}_m(w_m, w_f, y, \mu(w_m, w_f, y, z)) \tag{4.27}$$

$$h_f = \hat{H}_f(w_m, w_f, y, z) = \tilde{H}_f(w_m, w_f, y, \mu(w_m, w_f, y, z)) \tag{4.28}$$

Where $\hat{H}_i(w_m, w_f, y, z)$ and $\tilde{H}_m(w_m, w_f, y, \mu(w_m, w_f, y, z))$, $i = m, f$, denote the observable and structural labour supply for male and female respectively. We can differentiate each individual's labour supply with respect to their own wage rate, their partner's wage

[1]e.g. when the unitary approach has a general household utility function that is not the weighted sum of individual utilities.

rate, household non-labour income and distribution factors. For the female individual we have:

$$\frac{\partial h_f}{\partial w_m} = \underbrace{\frac{\partial \hat{H}_f}{\partial w_m}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_f}{\partial w_m}\bigg|_{\bar{\mu}} + \frac{\partial \tilde{H}_f}{\partial \mu}\frac{\partial \mu}{\partial w_m}}_{\text{Structural}} \tag{4.29}$$

$$\frac{\partial h_f}{\partial w_f} = \underbrace{\frac{\partial \hat{H}_f}{\partial w_f}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_f}{\partial w_f}\bigg|_{\bar{\mu}} + \frac{\partial \tilde{H}_f}{\partial \mu}\frac{\partial \mu}{\partial w_f}}_{\text{Structural}} \tag{4.30}$$

$$\frac{\partial h_f}{\partial y} = \underbrace{\frac{\partial \hat{H}_f}{\partial y}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_f}{\partial y}\bigg|_{\bar{\mu}} + \frac{\partial \tilde{H}_f}{\partial \mu}\frac{\partial \mu}{\partial y}}_{\text{Structural}} \tag{4.31}$$

$$\frac{\partial h_f}{\partial z} = \underbrace{\frac{\partial \hat{H}_f}{\partial z}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_f}{\partial \mu}\frac{\partial \mu}{\partial z}}_{\text{Structural}} \tag{4.32}$$

Similarly, for the male individual we have:

$$\frac{\partial h_m}{\partial w_m} = \underbrace{\frac{\partial \hat{H}_m}{\partial w_m}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_m}{\partial w_m}\bigg|_{\bar{\mu}} + \frac{\partial \tilde{H}_m}{\partial \mu}\frac{\partial \mu}{\partial w_m}}_{\text{Structural}} \tag{4.33}$$

$$\frac{\partial h_m}{\partial w_f} = \underbrace{\frac{\partial \hat{H}_m}{\partial w_f}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_m}{\partial w_f}\bigg|_{\bar{\mu}} + \frac{\partial \tilde{H}_m}{\partial \mu}\frac{\partial \mu}{\partial w_f}}_{\text{Structural}} \tag{4.34}$$

$$\frac{\partial h_m}{\partial y} = \underbrace{\frac{\partial \hat{H}_m}{\partial y}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_m}{\partial y}\bigg|_{\bar{\mu}} + \frac{\partial \tilde{H}_m}{\partial \mu}\frac{\partial \mu}{\partial y}}_{\text{Structural}} \tag{4.35}$$

$$\frac{\partial h_m}{\partial z} = \underbrace{\frac{\partial \hat{H}_m}{\partial z}}_{\text{Observable}} = \underbrace{\frac{\partial \tilde{H}_m}{\partial \mu}\frac{\partial \mu}{\partial z}}_{\text{Structural}} \tag{4.36}$$

In each of the eight equations above, the term in the middle is what the econometrician can observe empirically; while the final element on the right is derived from the structural model. These can be written in terms of the sharing rule, γ, as there is a one-to-one mapping between the two. $\left(\frac{\partial \mu}{\partial w_m}, \frac{\partial \mu}{\partial w_f}, \frac{\partial \mu}{\partial y}, \frac{\partial \mu}{\partial z}\right)$ are the collective effects. For each of the observable partial derivatives, one could further break these down into the conventional substitution and income effects. Another interesting implication that emerges from the above model relates to the individuals' elasticities. Following Blundell, Chiappori, Magnac, and Meghir (2007), we can infer the following if both spouses are working:

$$\frac{h_{f,w_m}}{h_{f,y}} = \frac{\partial h_f/\partial w_m}{\partial h_f/\partial y} = \frac{\gamma_{w_m}}{\gamma_y} = A(w_m, w_f, y) \tag{4.37}$$

$$\frac{h_{m,w_f}}{h_{f,y}} = \frac{\partial h_m/\partial w_f}{\partial h_m/\partial y} = \frac{1-\gamma_{w_f}}{1-\gamma_y} \tag{4.38}$$

Theory would predict the term $\frac{\partial h_f}{\partial y}$ to be negative due to the normal good assumption for leisure. However, the overall sign of A also depends on $\frac{\partial h_f}{\partial w_m}$. Turning to γ_{w_m}, we can rewrite this as:

$$\frac{\partial \gamma}{\partial w_m} = \frac{\partial \gamma}{\partial w_m}\Big|_{\bar{z}} + \frac{\partial \gamma}{\partial z}\frac{\partial z}{\partial w_m} \tag{4.39}$$

Equation (4.39) describes the effects of a change in the husband's wage on the sharing rule. An implication of the model is that the spouse's wage can only affect an individual's demand through the sharing rule. The precise effect would depend firstly on, how the spouse's wage rate enters the sharing rule directly, and secondly how (if at all) it enters as a distribution factor within the sharing rule. Nonetheless it is important to understand that any such effects will effectively be an income effect, as these are channeled through the sharing rule. To distinguish these two effects, we can perhaps consider the first component as a direct income effect, whilst the second component we label as the 'collective effect'. A convenient example of how w_m can play the role of a distribution factor is if we take $\frac{w_f}{w_m}$ as a distribution factor. It is frequently demonstrated in the literature that it is the relative earnings that matters for intrahousehold allocation (For a detailed summary, see Browning, Chiappori, and Weiss (2012)). The intuition here is that if male relative wage increases, the ratio $\frac{w_f}{w_m}$ falls and this is likely to lead to a corresponding fall in female consumption share γ. The sign on the second component of equation (4.39) would therefore be negative in this example. However, the overall sign of $\frac{\partial \gamma}{\partial w_m}$ will depend on the relative magnitudes of the direct income effect and what we label as the 'collective effect'. In the absence of unobserved heterogeneity in preferences, the function h_f and therefore the functions on the left hand side of (4.37) and the ratio A are empirically observable; hence providing the first restriction on γ.

Finally, the derivations above for the collective model has implicitly assumed a single distribution factor. The argument remains valid when there are additional distribution factors, but would require additional proportionality restrictions on the distribution factors. (See Appendix and Browning, Chiappori, and Weiss (2012) for more details on this issue.)

4.2.3 Household utility: Prices, income and distribution factors

In a unitary framework, when economic variables like prices or total household income change, the only effect on the household is on the shape of its utility possibility frontier (UPF). The Pareto weight μ stays constant when prices and income change (an implicit unitary assumption) and the household simply shifts to a new bundle at which point the tangent is parallel to the old tangent at the original bundle. However, in a collective model even when ignoring distribution factors, there is an additional effect which stems from the fact that the Pareto weight is now allowed to change with prices and income. In addition to the unitary UPF augmenting effect described above, the collective effect acts by causing the optimal bundle to pivot around the UPF as μ changes with income and prices. It is however, important not to confound the effect from prices and income with other distribution factors, z. By definition, changes in the distribution factors can only act through the Pareto weight leading to the pivoting effect on the UPF. In contrast, while prices and income can affect the Pareto weight μ like other distribution factors, it also has the additional effect of augmenting the shape of the UPF. In the case of a tax reform which changes net income, this is the effect we anticipate. Hence, the precise impact of a change in prices or total income is likely to be more difficult to asses than a change in a distribution factor.

4.2.4 Sharing rule and the Pareto weight

Clearly the sharing rule and the Pareto Weight are intricately linked in the collective model. They both reflect the individual's relative power in the household, which is important in the sharing stage of the model. The Pareto weight is a function of distribution factors; this would imply that the sharing rule must also be a function of the distribution factors if the Pareto weight is. Thus in general, both the sharing rule and the Pareto weight would be functions of (w_m, w_f, y, z). In fact, under strong assumptions of strictly concave utility functions, a one-to-one increasing mapping could be shown. However, there are also situations when this may not be true. For example, we could take a special case when the Pareto weight does not vary with income or prices, in essence this could simply be a unitary model. In this case, even though the Pareto weight is fixed, the sharing rule can still depend on prices and total expenditure.

One key advantage of the sharing rule is that it avoids the need of cardinal representation of individual utilities and is therefore much simpler to interpret than the Pareto weight. There are however, two potential drawbacks as well. Firstly, the sharing rule is only valid when all goods are privately consumed, although it could to some extent be generalised to public goods. Secondly, despite it possessing a structural form, the sharing rule cannot in general be observed because it is not possible to vary prices without also changing the sharing rule. The interested reader should refer to Browning, Chiappori, and Weiss (2012) for an in-depth discussion on this issue.

4.3 Unitary model and Income taxation

In this section, we illustrate how the two different forms of taxation could affect the budget constraints of households. We begin with a baseline unitary model.

4.3.1 Independent taxation with private consumption goods

If couples are now taxed independently, following the unitary approach we the have the following optimisation problem:

$$\max_{c_m,c_f,h_m,h_f} \quad U_m(c_m, 1-h_m) + \mu U_f(c_f, 1-h_f) \tag{4.40}$$
$$s.t. \;\; c_m + c_f = g_m(w_m h_m) + g_f(w_f h_f) + y$$

The Lagrange problem is therefore,

$$L = U_m(c_m, 1-h_m) + \mu U_f(c_f, 1-h_f) - \lambda[c_m + c_f - g_m(w_m h_m) - g_f(w_f h_f) - y] \tag{4.41}$$

The first order conditions,

$$\frac{\partial L}{\partial c_m} = \frac{\partial U_m(c_m, 1-h_m)}{\partial c_m} - \lambda = 0$$
$$\frac{\partial L}{\partial c_f} = \frac{\mu \partial U_f(c_f, 1-h_f)}{\partial c_f} - \lambda = 0$$
$$\frac{\partial L}{\partial h_m} = -\frac{\partial U_m(c_m, 1-h_m)}{\partial h_m} + \lambda g_m'(w_m h_m) w_m \leq 0$$
$$\frac{\partial L}{\partial h_f} = -\frac{\mu \partial U_f(c_f, 1-h_f)}{\partial h_f} + \lambda g_f'(w_f h_f) w_f \leq 0$$
$$\frac{\partial L}{\partial \lambda} = c_m + c_f - g_m(w_m h_m) - g_f(w_f h_f) - y = 0$$

At the optimum, the marginal rates of substitution are:

$$MRS_{h_m,c_m} = \frac{U_{h_m}}{U_{c_m}} = g'_m(w_m h_m) w_m \tag{4.42}$$

$$MRS_{h_f,c_f} = \frac{U_{h_f}}{U_{c_f}} = g'_f(w_f h_f) w_f \tag{4.43}$$

$$MRS_{h_m,c_f} = \frac{U_{h_m}}{\mu U_{c_f}} = g'_m(w_m h_m) w_m \tag{4.44}$$

$$MRS_{h_f,c_m} = \frac{\mu U_{h_f}}{U_{c_m}} = g'_f(w_f h_f) w_f \tag{4.45}$$

$$MRS_{h_f,h_m} = \frac{\mu U_{h_f}}{U_{h_m}} = \frac{g'_f(w_f h_f) w_f}{g'_m(w_m h_m) w_m} \tag{4.46}$$

Solving for the Marshallian demands:

$$c_m = C(w_m, w_f, y, \mu) \tag{4.47}$$

$$c_f = C(w_m, w_f, y, \mu) \tag{4.48}$$

$$h_m = H_m(w_m, w_f, y, \mu) \leq 1 \tag{4.49}$$

$$h_f = H_f(w_m, w_f, y, \mu) \leq 1 \tag{4.50}$$

4.3.2 Joint taxation with private consumption goods

We assume that the household maximises a single utility function, $U(c_m, c_f, 1-h_m, 1-h_f)$, household incomes are pooled centrally and the household behaves as a single decision making unit. To model a joint taxation regime, we can modify the household optimisation problem in (4.1) as follows[2]:

$$\max_{c_m,c_f,h_m,h_f} \quad U_m(c_m, 1-h_m) + \mu U_f(c_f, 1-h_f) \tag{4.51}$$

$$s.t. \quad c_m + c_f = g(w_m h_m + w_f h_f) + y$$

[2]Here the Pareto weight is a constant. For simplicity, the preferences of the individuals are assumed to be separable.

The Lagrange problem is therefore,

$$L = U_m(c_m, 1-h_m) + \mu U_f(c_f, 1-h_f) - \lambda[c_m + c_f - g(w_m h_m + w_f h_f) - y] \tag{4.52}$$

The first order conditions,

$$\begin{aligned}
\frac{\partial L}{\partial c_m} &= \frac{\partial U_m(c_m, 1-h_m)}{\partial c_m} - \lambda = 0 \\
\frac{\partial L}{\partial c_f} &= \frac{\mu \partial U_f(c_f, 1-h_f)}{\partial c_f} - \lambda = 0 \\
\frac{\partial L}{\partial h_m} &= -\frac{\partial U_m(c_m, 1-h_m)}{\partial h_m} + \lambda g'(w_m h_m + w_f h_f) w_m \leq 0 \\
\frac{\partial L}{\partial h_f} &= -\frac{\mu \partial U_f(c_f, 1-h_f)}{\partial h_f} + \lambda g'(w_m h_m + w_f h_f) w_f \leq 0 \\
\frac{\partial L}{\partial \lambda} &= c_m + c_f - g(w_m h_m + w_f h_f) - y = 0
\end{aligned}$$

At the optimum, the marginal rates of substitution are:

$$MRS_{h_m, c_m} = \frac{U_{h_m}}{U_{c_m}} = g'(w_m h_m + w_f h_f) w_m \tag{4.53}$$

$$MRS_{h_f, c_f} = \frac{U_{h_f}}{U_{c_f}} = g'(w_m h_m + w_f h_f) w_f \tag{4.54}$$

$$MRS_{h_f, c_m} = \frac{\mu U_{h_f}}{U_{c_m}} = g'(w_m h_m + w_f h_f) w_f \tag{4.55}$$

$$MRS_{h_m, c_f} = \frac{U_{h_m}}{\mu U_{c_f}} = g'(w_m h_m + w_f h_f) w_f \tag{4.56}$$

$$MRS_{h_f, h_m} = \frac{\mu U_{h_f}}{U_{h_m}} = \frac{g'(w_m h_m + w_f h_f) w_f}{g'(w_m h_m + w_f h_f) w_m} = \frac{w_f}{w_m} \tag{4.57}$$

Assuming interior solutions exist, solving for the Marshallian demands yields:

$$c_m = C_m(w_m, w_f, y, \mu) \tag{4.58}$$

$$c_f = C_f(w_m, w_f, y, \mu) \tag{4.59}$$

$$h_m = H_m(w_m, w_f, y, \mu) \leq 1 \tag{4.60}$$

$$h_f = H_f(w_m, w_f, y, \mu) \leq 1 \tag{4.61}$$

Comparing the above to the results obtained from independent taxation earlier, we observe some systematic similarities. In contrast to a situation without taxation, here regardless of the tax regime, the MRS between consumption and labour supply for each individual depends on their individual net wage. However, when individuals are taxed jointly, their net wage would also depend on their spouse's behaviour. This is because the applicable marginal tax rate is determined by the couple jointly. Hence even in the absence of a collective framework, joint taxation introduces added dependency between the spouses through the tax system.

4.4 Collective model and Income taxation

In this section, we explore how the two different forms of taxation could affect the budget constraints of households in a collective model.

4.4.1 Independent taxation

With independent taxation each member is subject to their own tax schedule and marginal tax rates. The household optimisation problem can be written as:

$$\max_{c_m, c_f, h_m, h_f} \quad U = U_m + \mu U_f \tag{4.62}$$

$$s.t. \;\; c_m + c_f \leq g(w_m h_m) + g(w_f h_f) + y$$

Under this framework, decentralisation in the conventional manner is potentially problematic because full income in the normal sense may not be well defined in the presence of income taxation. Thus the decentralisation has to be modelled in a different way. Under independent taxation one possible way to address this issue is to think of the household redistributing resources via non-labour income.

Decentralisation and the optimisation problem for each member of the household are given below, first for the husband:

$$\begin{aligned} Max \;\; U_m(c_m, 1-h_m) \\ s.t. \;\; c_m \leq g(w_m h_m) + (y - y_f) \end{aligned} \tag{4.63}$$

And for the wife:

$$\begin{aligned} Max \;\; U_f(c_f, 1-h_f) \\ s.t. \;\; c_f \leq g(w_f h_f) + y_f \end{aligned} \tag{4.64}$$

The sharing rule is defined by

$$y_f \equiv \hat{c}_f - \hat{g}(w_f \hat{h}_f) \tag{4.65}$$

y_f is defined as the difference between the wife's consumption and her earned income. It is worth noting that because y_f is the transfer between couples it can be positive or negative. $\hat{h}_m$ and $\hat{h}_f$ are the labour supply functions derived from the direct maximisation problem and can be linked to the decentralised solutions:

$$\hat{h}_m(w_m, w_f, y) = H_m(w_m, y - y_f(w_m, w_f, y)) \leq 1 \tag{4.66}$$

$$\hat{h}_f(w_m, w_f, y) = H_f(w_f, y_f(w_m, w_f, y)) \leq 1 \tag{4.67}$$

$$\hat{c}_m(w_m, w_f, y) = C_m(w_m, y - y_f(w_m, w_f, y)) \tag{4.68}$$

$$\hat{c}_f(w_m, w_f, y) = C_f(w_m, y_f(w_m, w_f, y)) \tag{4.69}$$

4.4.2 Joint taxation

In this case the conventional method of decentralisation is not possible under general circumstances. This is because the net wage rate of each individual would now depend on the behaviour of the other. In other words, the usual two stages of sharing/bargaining and optimisation can no longer be separated in a simple way. An exception, however, is when we have a simple case where the tax schedule is linear. If this is the case we can decentralise the household problem as before. We start by examining the general case, and in the next subsection we discuss the linear joint tax case. A household facing a general joint taxation schedule would face the following optimisation problem:

$$\max_{c_m, h_m, c_f, h_f} \quad U = U_m + \mu U_f \tag{4.70}$$

$$s.t. \quad c_m + c_f = g(w_m h_m + w_f h_f) + y$$

We follow Blundell, Chiappori, Magnac, and Meghir (2007) in modelling male labour supply as discrete and can only take the values zero or one. This assumption is strongly supported by the data, as empirically we observe male labour supply to be essentially dichotomous. Assuming the male individual is working, his labour supply is fixed, $h_m =$

$\bar{h}_m$. Thus the female individual's optimisation problem becomes:

$$\max_{c_f, h_f} \quad U_f(c_f, h_f) \tag{4.71}$$
$$s.t. \quad c_f = g(w_f h_f + w_m h_m) + y - c_m$$

where $(y - c_m)$ is simply the wife's share of non-labour income, y_a. Similar to the standard collective model, this term can be positive or negative depending on the household. The female member chooses her optimal labour supply such that $h_f = \tilde{H}_f(w_f, w_m h_m, y_a)$. Thus the Marshallian Demands in this case will be:

$$c_m = \tilde{C}_m(w_m, y - \gamma(w_m, w_f, y, z)) \tag{4.72}$$
$$c_f = \tilde{C}_f(w_f, \gamma(w_m, w_f, y, z)) \tag{4.73}$$
$$h_m = \tilde{H}_m(w_m, y - \gamma(w_m, w_f, y, z)) \leq 1 \tag{4.74}$$
$$h_f = \tilde{H}_f(w_f, \gamma(w_m, w_f, y, z)) \leq 1 \tag{4.75}$$

Joint taxation & Linear tax schedule

If the joint tax schedule $g(.)$ is a linear function, the problem essentially unravels. This is because in effect the spousal net incomes could be isolated and the household budget constraint becomes:

$$c_m + c_f + (1-t)(w_m L_m + w_f L_f) = (1-t)(w_m + w_f) + y \equiv M \tag{4.76}$$

We can rewrite the problem as a decentralised optimisation problem. The husband chooses his optimal labour supply and private consumption according to the following:

$$\max_{c_m, h_m} \quad U_m(c_m, 1 - h_m) \tag{4.77}$$

$$s.t. \;\; c_m \leq w_m(1-t)h_m + (y - \gamma(w_m, w_f, y, z, t))$$

The Marshallian Demands:

$$c_m = C_m((1-t)w_m, y - \gamma(w_m, w_f, y, z, t)) \tag{4.78}$$

$$c_f = C_f((1-t)w_f, \gamma(w_m, w_f, y, z, t)) \tag{4.79}$$

$$h_m = H_m((1-t)w_m, y - \gamma(w_m, w_f, y, z, t)) \tag{4.80}$$

$$h_f = H_f((1-t)w_f, \gamma(w_m, w_f, y, z, t)) \tag{4.81}$$

Hence yielding similar solutions to a unitary case, but now the linear tax rate t is embedded in the sharing rule. Since the tax schedule is linear in this case, the tax rate is in effect fixed, each member's net wage rate is therefore independent of the other member's behaviour, in fact, it is also independent of their own behaviour. In other words, we can define a net wage that is independent of labour supply if the tax system is linear. Thus in essence this case is much more similar to independent taxation or even a situation without taxation.

Examining the labour conditions and Marshallian demands for each of the four scenarios above, it is apparent that no matter which approach we take, unitary or collective, a reform from joint to independent taxation will have a significant impact on the household budget constraint and hence, repercussions for the household.

4.5 Definition of net income

In the simplest terms, the net income of an individual is the remaining amount from their gross income after taxes have been deducted. This concept is of great importance to this study because to examine how an individual has been affected by a change in taxation, we are primarily interested in the changes in their net income. In this case, we are interested in how a change from joint to individual taxation has affected the net income of married women.

At first glance, this may appear to be a relatively straightforward problem; one could simply examine how the net income of married women has changed over this period. Depending on whether a significant change is observed, we may be able to draw conclusions about the impact of the tax reform. Unfortunately, even such a simple experiment is fraught with difficulties. The most problematic issue relates to the concept of an individual's net income when they are married. Under an independent tax system, it is simple to assess an individual's net income. Each individual is entitled to their own tax allowances and the relevant tax brackets are applied to their taxable income. The resulting sum left over is defined as the individual's net income. However, for the UK prior to 1990 under joint taxation, the gross incomes of couples were aggregated and taxed jointly. In addition, upon marriage a woman was given a non-transferrable tax allowance, while her husband would gain the 'married man allowance'. This was not equivalent to the simple summing of the two single persons allowances. The husband was also eligible to claim this irrespective of whether the wife worked or not. A result of this is that for an individual, their net income did not only depend on their own behaviour, but also on their spouse's. For a typical woman, her marginal tax rate would therefore depend directly on her spouse's gross earnings. The resulting household net income is a product of both spouses' contributions, hence when trying to retrieve one individual's net income, it is not immediately clear how one should think of the net income of the wife or husband individually, as their marginal tax rates and allowances would depend on one another.

This issue has received very little attention in the literature. Even though our approach is largely based upon the Blundell, Chiappori, Magnac, and Meghir (2007) labour supply study, the study does not appear to take into account the tax system over its sample period. It is likely that gross earnings was used for the analysis. Other studies tend to take the net income reported in datasets such as the FES or GHS as given. However, it is not immediately clear how an individual's net income was calculated in the surveys pre-1990 under joint taxation, as the concept was simply not well defined.

Within our sample, around 84 percent of women earn less than their husbands do[3]. Even when both spouses are working, the mean gross earnings of the wife is on average around 39 percent of that of her husband[4]. Hence in the majority of cases, the husband is considered the main earner of the household, while the wife could be viewed as the secondary earner, providing supplementary income for the household. If we accept this as the basic earning structure of a typical household, we can begin to formulate the notion of an individual's net income prior to the reform. The fundamental question is: How much does each spouse contribute to the household in post-tax terms? In particular, how much does the wife contribute? For the majority of households, the husband participates in the labour market regardless of the behaviour of the wife. This is in contrast to female labour supply, which is usually much more elastic and sensitive to individual and household characteristics. Taking the husband as the primary earner and using information on the gross incomes of the husband and wife, we subsequently calculate what the net household income would be if the wife 'participates' (by including her gross income in the total household gross income) and alternatively, if she does not 'participate' (excluding her gross income).

We can express this algebraically. First, we write down the net household income

[3]Pre-reform: 85%. Post-reform: 83%.

[4]Pre-reform: 38%. Post-reform: 41%.

when both the husband and wife contribute to household income:

$$I_1 = g(e_m + e_f) \tag{4.82}$$

Where I_j is the net household income, and $j = 1, 0$ indicates if the wife contributes or not respectively. $g(.)$ is the joint tax schedule, and e_i is the individual gross earnings, $i = m, f$ indicates male and female respectively. Now we can write down what the household net income would be without the wife's contribution. Excluding the wife's gross income from our calculations, we have:

$$I_0 = g(e_m) \tag{4.83}$$

The expression in (4.83) we define as the husband's net income under joint taxation. The difference between the two measures above, $(I_1 - I_0)$, is considered to be the wife's net contribution to the household. This is the amount of net income the household would gain if she decides to participate given her husband's behaviour. We define this as her net income under the joint taxation regime.

4.6 Structure of the data

The data for this study is drawn from the UK Family Expenditure Survey (FES) from April 1986 to March 1994 inclusive, giving us eight complete tax years[5]. As the focus of the study is a tax reform which was targeted at married couples, we restrict our attention to households consisting of married couples, where both the male and the female members are over 22 and not older than 60. We also choose to focus on households with children as this represents the most typical family formation for married couples in our data. Prices are deflated using the UK retail price index and are expressed in 1987

[5]The UK tax year begins in April of each year.

prices. Our sample excludes cohabiting couples and singles. Self-employed individuals are also excluded as their hours of work are not recorded. In addition, those who report leaving full-time education before the age of 10, and individuals with asset income above 1000 a week in real terms are excluded to eliminate extreme outliers.

The FES is a continuous survey of household expenditure and income. According to the FES documentation, it is a voluntary annual survey of approximately 6,500 households in the UK and was first designed to provide weights for the retail price index. The sample for Great Britain is drawn from the Post Office's list of addresses in 672 postal sectors, while the Northern Ireland sample is drawn from the Valuation and Lands Agency list. Each individual aged 16 or over in the household is asked to keep a diary over 14 consecutive days in which all detailed expenditures are recorded. Other general expenditures and household characteristics such as rent and mortgage payments and household income are obtained from a household questionnaire via face-to-face interviews. In addition, each adult (aged 16 or over) in the household is asked to fill in an individual questionnaire providing demographic and income information. On the whole, the FES has the advantage of being a long running household survey giving rich information on individual and household characteristics including data on specific expenditures on goods and services.

Table 4.1 shows a list of the main variables used in this study. Most of the variables have straightforward definitions. The variables $w1, w2wk$ are the net weekly earnings for male and female respectively. These are derived by taking the gross earnings of the spouses and applying the relevant tax schedule to their earnings. As discussed in the previous section, the interpretation of an individual's net income before the reform poses some difficulties. For the purpose of this study, the net income of each spouse under joint taxation is defined according to the definition given in Section 5. Non-labour income, y, is defined as the difference between consumption and total household earnings. A more detailed discussion on the definition and its practical implementation are presented in the next section.

The summary statistics for the main variables are reported in Table 4.2. In Figure 4.1 we see that male participation has shown a consistent decline over the period, while female participation has shown an upward trend. Another important observation from Figure 4.2 is that the majority of men work more than 36 hours per week, but the hours for women are more variable and generally much lower. There is also a substantial proportion of female non-participation. These properties will prove important for our analysis in later sections. Figure 4.3 shows the labour force participation of men over their life cycle. We observe a clear downward trend over the life cycle. In contrast, women tend to increase participation quite steeply over their life cycle, with their participation rate peaking at over 80% just after age 40.

One possible explanation for this may be that younger women tend to focus on childbirth and childcare responsibilities, but as the children get older, they are able to devote more time to their careers. Figure 4.4 shows the weekly gross earnings for the male and female spouses. All monetary values are expressed in 1987 prices. It is immediately apparent that female earnings are in general much lower than their male counterparts. We also observe a substantial proportion of zero earnings throughout the sample period. Despite this, female gross earnings have seen a gentle increase over the survey period, with its dispersion also increasing over time. We also see a similar rise in median male earnings over this period, rising from around 220 in 1986 to around 300 in 1991, and once again, this is accompanied by an increase in dispersion over this period. However, the most important observation here is that there are no significant breaks or jumps in gross incomes throughout the survey years for both male and female, particularly for the period surrounding the reform in 1990. From Figure 4.5 we see that the net earnings for male remain largely stable over the sample period, but in contrast, we observe a clear rise in female net weekly earnings after the reform in 1990.

Variable	Description
part1	Male Participation
part2	Female Participation
hours1	Labour supply of male per week (Hours)
hours2	Labour supply of female per week (Hours)
w1	Net weekly earnings for male
w2wk	Net weekly earnings for female
y	Net weekly other household (non-labour) income
mage	Age of the male
fage	Age of the female
meduc	Age left full-time education male
feduc	Age left full-time education female
childu5	Number of children under the age of five
childo5	Number of children aged five and over
agegap	Difference in age between female and male age centred on mean
agegap2	Spousal age gap squared
edgap	Difference between female and male school leaving age
T	Time dummies

Table 4.1: Main Variables

Variable	Mean	Std. Dev	Min.	Max.	10%	25%	50%	75%
part1	.8750569	.3306732	0	1	0	1	1	1
part2	.7025057	.4571819	0	1	0	0	1	1
hours1	36.168	15.77	0	99	0	37	39	40
hours2	16.04055	14.42415	0	99	0	0	15	27
w1	238.1195	154.6591	0	1443.735	0	162.2356	227.3047	307.5918
w2wk	61.70496	75.20223	0	625.1369	0	0	38.46	92.61955
y	-2.134603	1.194192	-6.175261	10.34659	-3.896034	-2.840024	-1.916972	-1.308776
mage	38.94362	7.266062	23	60	29	34	39	44
fage	36.66572	6.850509	23	60	28	31	37	42
meduc	16.94624	2.645915	10	33	15	15	16	18
feduc	16.83747	2.211946	10	30	15	15	16	18
childu5	.5061503	.700891	0	3	0	0	0	1
childo5	1.333713	.9613929	0	6	0	1	1	2
agegap	0.00000	3.832016	-24.7221	20.2779	-4.722095	-1.722096	.2779043	2.277904
agegap2	14.68268	34.42031	.0772308	611.182	.0772308	.5214223	5.188848	10.74466
edgap	-.1087699	2.258878	-17	10	-3	-1	0	1
N		8780						

Table 4.2: Summary statistics

Source: UK Family Expenditure Survey 1986 - 1994

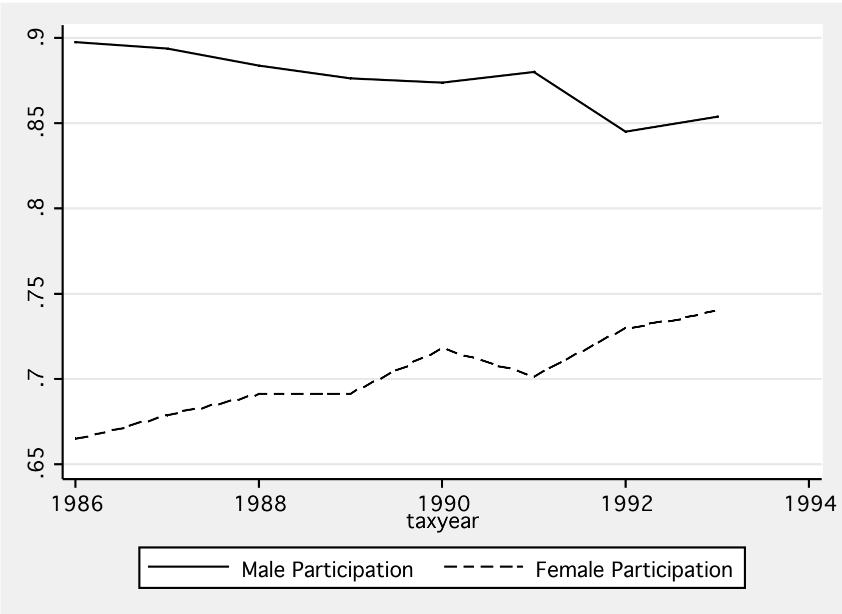


Figure 4.1: Labour Force Participation Rates (1986 - 1993)

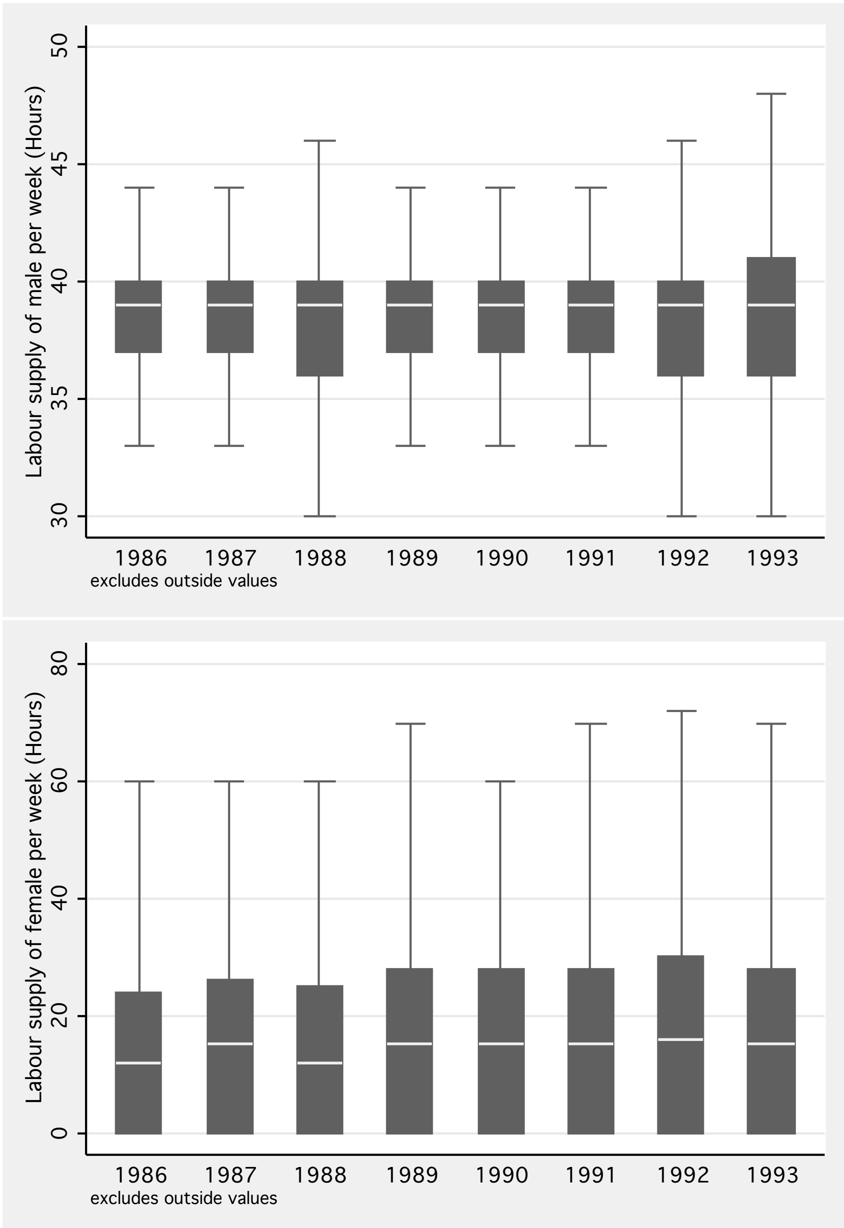


Figure 4.2: Male and Female Labour Supply Per Week (1986 - 1993)

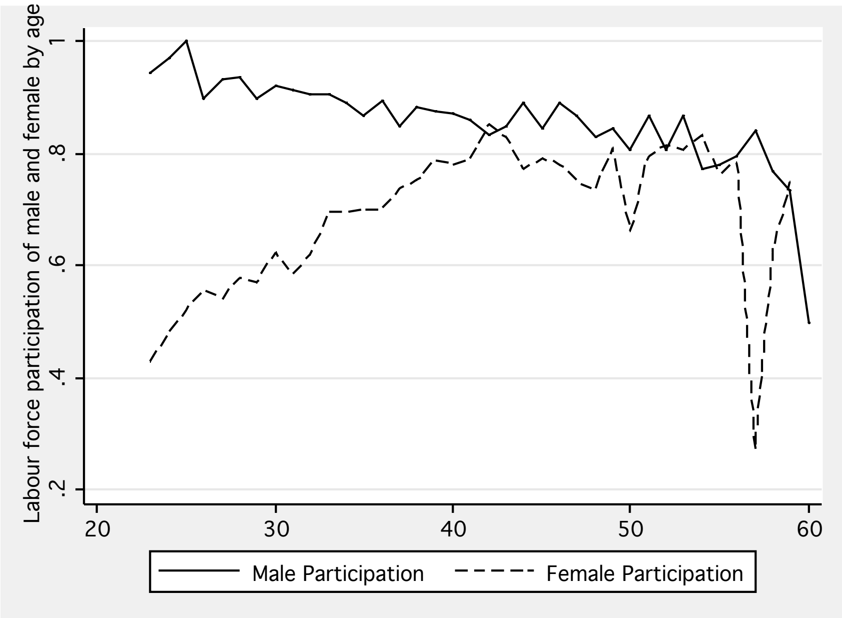


Figure 4.3: Labour Force Participation Rates by Age (1986 - 1993)

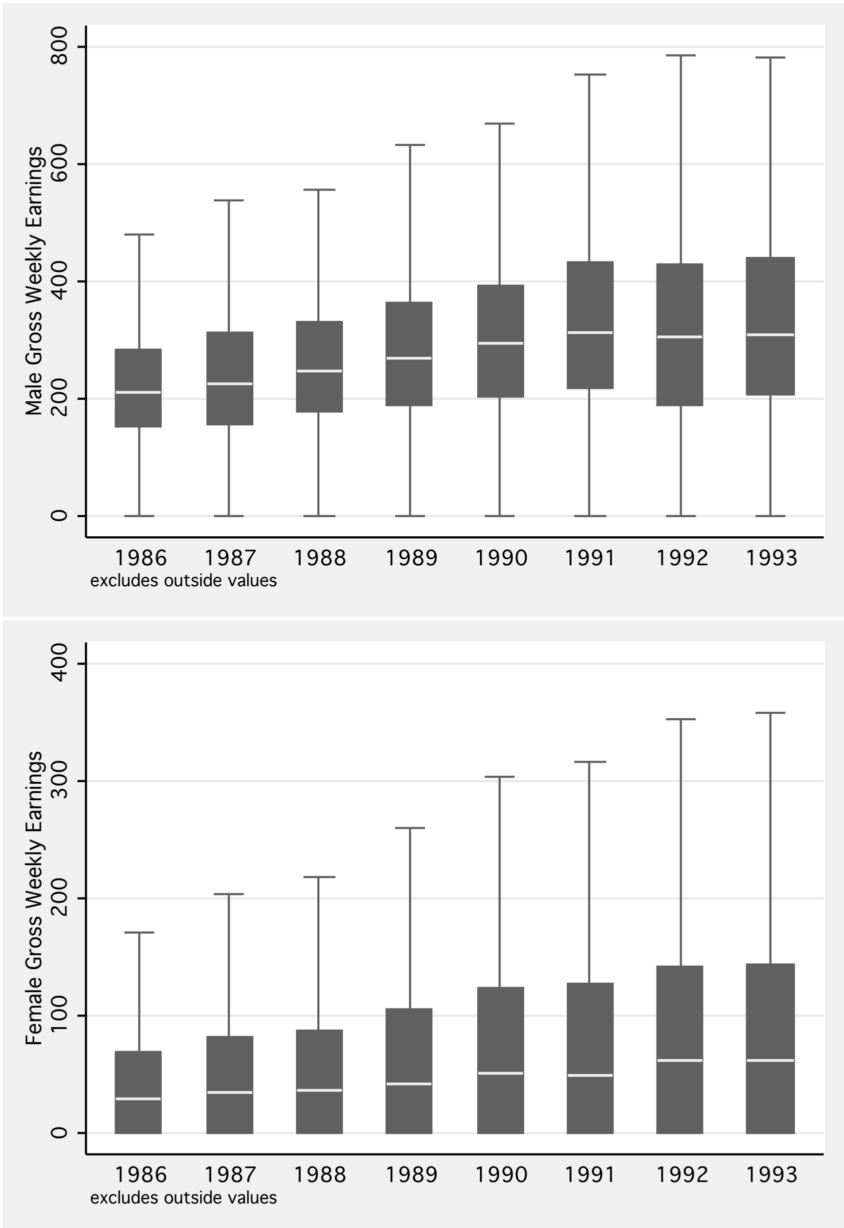


Figure 4.4: Male and Female Gross Weekly Earnings (1986 - 1993)

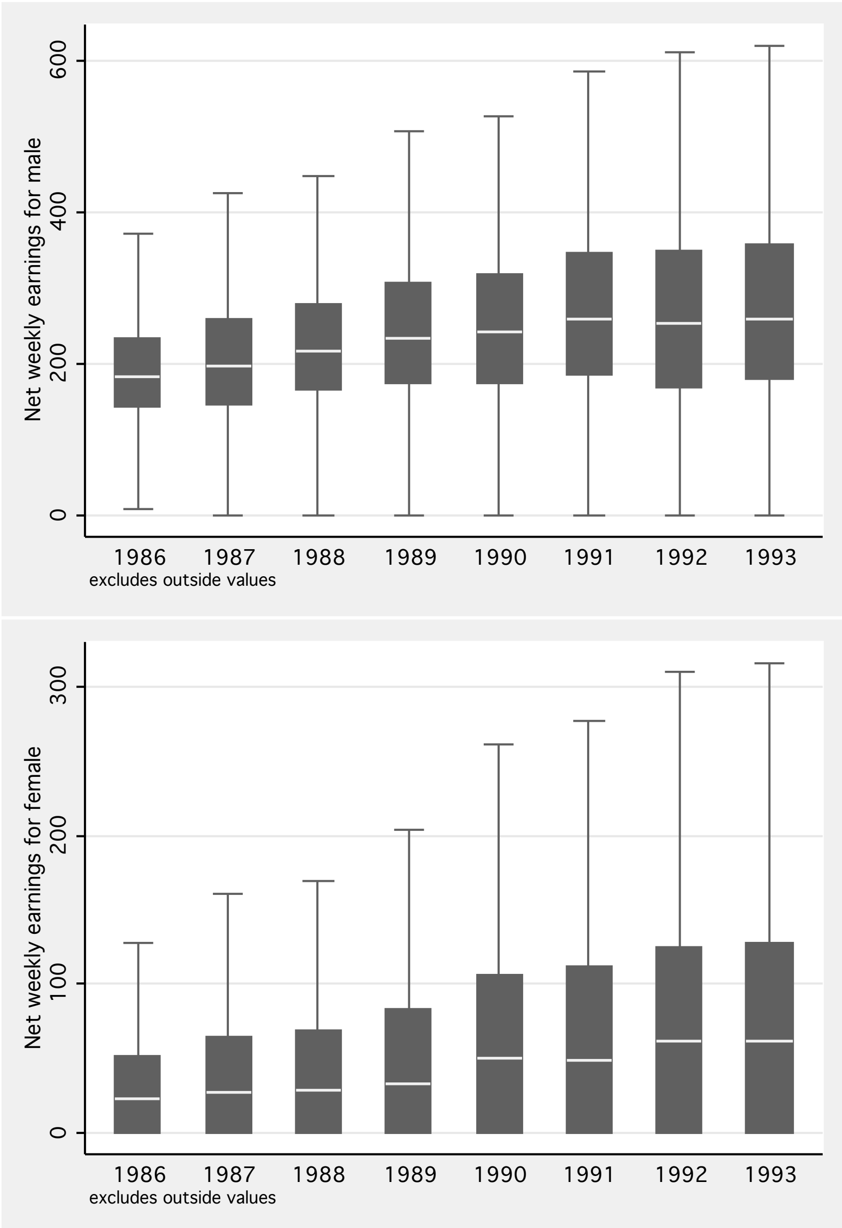


Figure 4.5: Male and Female Net Weekly Earnings (1986 - 1993)

4.7 Estimation

This paper follows the 'semi structural' approach of Blundell, Chiappori, Magnac, and Meghir (2007), where the sharing rule is written in terms of a function of (endogenous) wages, income and other exogenous variables. This model builds on the existing labour supply literature (Blundell and MaCurdy (1999)) and has the advantage of being parsimonious yet allowing for rich structural identification and interpretation. The labour supply functions take a semi-log linear form and are additive in the heterogeneity terms. This empirical specification is particularly attractive for this study because it can be used in a Tobit formulation to handle non-participation with ease, as well as zero or negative values for non-labour income. With this specification, it is natural to introduce heterogeneity in the error term, with the vector of random term assumed to be multivariate normal. We also assume that all error terms are jointly conditionally normal with constant variance and independent of the other covariates, education, age, other income and the time dummies.

As mentioned earlier, the observed labour supply of men in our sample is essentially dichotomous. In contrast, the labour supply of women is largely continuous but as is frequently observed empirically, there is a significant proportion of non-participation. Thus when constructing the model for this study, we are guided by these fundamental patterns observed in the data. In the model that follows, the husband's labour supply decision is assumed to be discrete (he can choose to work or not work), while the wife's labour supply is allowed to vary continuously. We also take into consideration the importance of female non-participation and whether her husband is participating in the labour market. We follow the estimation methodology outlined by Blundell, Chiappori, Magnac, and Meghir (2007) which involves four stages: the reduced form participation equations, the female and male wage equations, the reduced-form non-labour income equation, and finally, the female hours and male structural participation equations.

4.7.1 Non-participation and sample selection bias

Labour supply theories provide a good framework for us to analyse individuals decisions to participate in the labour market. Usually, theoretical predictions are made based on the wage individuals would earn if they participate in the labour market. Unfortunately, this data is generally not available to the econometrician. Surveys typically only record the earnings of those who are actually in work during the survey period. Rarely are individuals who had voluntarily chosen not to work asked about their reservation wage or what they think they would earn per hour if they do decide to work. And even if such data exists, it is unclear how reliable such reports would be. Thus the econometrician only observes wage data for individuals who choose to work, this is just the classical self-selection problem.

In fact, this is also similar to an omitted variable problem, but instead of certain explanatory variables being missing, here some data are missing for the dependent variable of a regression. If ignored, this will lead to estimates of the coefficients in the labour supply equations to be biased. In effect, the resulting regression coefficients confound the meaningful structural parameters with the parameters of the function that determines the probability of an observation entering the sample in a non-random manner. This of course is the classical selection bias problem described in the seminal paper by Heckman (1979). Heckman's proposed method not only rectifies the selection problem[6] by reformulating it as an ordinary omitted explanatory variable problem, but it also enables us to fully utilise the entire sample and to extract information about non-participating individuals to estimate the parameters that underlie their labour supply and work decision equations. In the following section I will describe the model and its methodology as it is directly relevant to this study.

[6] In this case, the inability to observe wages for women who are not working.

The first step involves writing down the structural labour supply equation:

$$h_i{}^* = \delta_0 + \delta_1 w_i + \delta_2 Z_i + \eta_i \tag{4.84}$$

where h_i^* is the desired hours of work, w_i is the wage rate, Z_i includes non-labour income and other taste variables such as the number of children, education levels, the age of the individual and their spouse. η_i can be thought of as an idiosyncratic unobserved individual taste for work which generates the observed variation in hours worked for two otherwise observationally identical individuals.

Next, we can write down the wage equation. We are only able to use samples which we are able to observe their wages:

$$w_i = \beta_0 + \beta_1 X_i + u_i \tag{4.85}$$

where X_i are the observed productivity and human capital variables such as age, age squared and education for individuals $i = 1...N$. We can label this the structural wage equations. u_i includes all unobserved determinants of wages.

As mentioned earlier, if we were to estimate these two structural equations with OLS directly, our results will be biased and inconsistent. This is because for equation (4.84), the sample we observe will only consist of individuals with positive desired hours. Equation (4.85) on the other hand, consists only of samples with wages above their reservation wage. In addition, data on wages is only available if hours are positive, there are no observations on wages otherwise. We proceed by substituting the wage equation into the hours equation, which yields:

$$\begin{aligned} h_i^* =& \delta_0 + \delta_1[\beta_0 + \beta_1 X_i + u_i] + \delta_2 Z_i + \eta_i \\ h_i^* =& \alpha_0 + \alpha_1 X_i + \alpha_2 Z_i + \epsilon_i \end{aligned} \tag{4.86}$$

where $\alpha_0 = \delta_0 + \delta_1\beta_0; \alpha_1 = \delta_1\beta_1; \alpha_2 = \delta_2; \epsilon_i = \eta_i + \delta_1 u_i$. Equation (4.86) can be thought of as the reduced form hour equation. To see the implications of the selection problem more clearly, we can write down for the general case:

$$E(w_i|X_i, h_i^* \geq 0) = \beta_0 + \beta_1 X_i + E(u_i|\epsilon_i \geq -\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i) \tag{4.87}$$

Except in special cases of independence between u_i and ϵ_i, for instance when data on wages are missing randomly, the final term in equation (4.87) will in general be non-zero. This result highlights the fact that selected sample regression estimators of the parameters of equation (4.85) will in general omit the final term in equation (4.87). Thus the bias arising from a non-randomly selected sample is in essence similar to an ordinary omitted variable bias problem[7].

$$\begin{aligned}
E(u_i|h_i^* \geq 0) =& E(u_i|\epsilon_i \geq -\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i) && (4.88)\\
=& \frac{\sigma_{u\epsilon}}{\sigma_\epsilon^2} E(\epsilon_i|\epsilon_i \geq -\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i)\\
=& \frac{\sigma_{u\epsilon}}{\sigma_\epsilon} \frac{\phi\left(\frac{-\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i}{\sigma_\epsilon}\right)}{1 - \Phi\left(\frac{-\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i}{\sigma_\epsilon}\right)}\\
=& \frac{\sigma_{u\epsilon}}{\sigma_\epsilon} \lambda_i && (4.89)
\end{aligned}$$

where ϕ is just the standard normal density function and Φ is the standard normal c.d.f. The first term in equation (4.89) is constant across observations. The second

[7]Similarly,

$$\begin{aligned}
E(\epsilon_i|h_i^* \geq 0) =& E(\epsilon_i|\epsilon_i \geq -\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i)\\
=& \frac{\sigma_\epsilon^2}{\sigma_\epsilon} \frac{\phi\left(\frac{-\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i}{\sigma_\epsilon}\right)}{1 - \Phi\left(\frac{-\alpha_0 - \alpha_1 X_i - \alpha_2 Z_i}{\sigma_\epsilon}\right)}\\
=& \sigma_\epsilon \lambda_i
\end{aligned}$$

term is the inverse Mills ratio, derived from standard properties of the standard Normal distribution. It is a monotone decreasing function of the probability that an observation is selected into the sample and thus, varies across individual observations. The usual approach to overcome this self-selection bias is to first add an explicit selection equation to the model. We run a probit model of participation using all observations in the data. One could write down a structural participation equation for individuals:

$$p_i = \gamma_0 + \gamma_1 Z_i + v_i \tag{4.90}$$

where p_i is a binary variable that indicates if an individual participates in the labour market, it is defined as $p_i = 1$ if the individual works and $p_i = 0$ otherwise. The estimates of the coefficients from this probit model are used to construct consistent estimates of the inverse Mills ratio. The Heckman model requires three core assumptions. Firstly, we require the error terms from the probit and the wage equations to be jointly normal, $(u_i, v_i) \sim N(0, 0, \sigma_u^2, \sigma_v^2, \rho_{uv})$. Secondly, we need (u_i, v_i) to be independent of both X_i and Z_i. These two are fairly strong requirements. Finally, we have the standard normalisation for the probit selection equation, $var(v_i) = \sigma_u^2 = 1$.

$$w_i = \beta_0 + \beta_1 X_i + \theta\lambda_i + u_i \tag{4.91}$$

The wage equation above includes the inverse Mills ratio and is estimated by ordinary least squares for the uncensored observations. It gives consistent and asymptotically normal estimators for β and θ. Therefore the data on λ_i makes it possible to eliminate the bias in the wage equation using just the non-censored subsample.

4.7.2 Empirical specification

Regression model

As discussed at the beginning of this section, this paper follows the fundamental framework of Blundell, Chiappori, Magnac, and Meghir (2007) which builds on the empirical labour supply literature (Blundell and MaCurdy (1999)). Because the focus of this paper is on the behaviour of married couples, in addition to the basic framework of Blundell et al (2007), we also include children and at a later stage distribution factors in our analysis.

The female hours of work labour supply is written in semi-log specification form[8]. This specification was chosen over a linear specification as it does not impose the same sign on the wage response throughout and does not impose restrictive quasi-homothetic preference. The semi-log specification grants non-linear curvature in the wage response and permits the wage elasticity to decline with hours yet retaining its positive sign, while also maintaining linearity in income. Moreover, as discussed in the previous section, this formulation can handle non-participation very well. It is also useful when there may be measurement error or endogeneity issues in wages and income. This formulation is typical for British data and works well with the FES data. We can separate the women in our sample into two groups, the first group consists of only women whose husbands are working, and the second group consists of women with non-working husbands. For the first group of women, the female hours equation in this case is just,

[8] Semi-log labour supply specification:

$$H = \alpha lnW + \theta Y + \rho$$

Restrictions summarised by the specification of the indirect utility function:

$$v(W, Y; X) = \frac{exp(\theta W)}{\theta}(\theta Y + \rho + \alpha \log W) - \frac{\alpha}{\theta}\int_{\theta W} \frac{exp(\theta W)}{\theta W} d(\theta W)$$

$$h_{it}^f = A_{0t}^f + A_m w_{it}^m + A_f \log w_{it}^f + A_y y_{it} + A_4 educ_{it}^f + A_5 age_{it}^f \tag{4.92}$$
$$+ A_6 educ_{it}^m + A_7 age_{it}^m + A_8 childu5_{it} + A_9 childo5_{it} + u_{1it}$$

where f and m denote female and male respectively, w_{it}^f denotes the hourly wage rate for the female, and w_{it}^m denotes the weekly earning for the male, y_{it} denotes other non-labour household income. One advantage of Blundell et al's approach of using the level of male earnings rather than log is that we can nest the income pooling hypothesis in the model by testing $A_m = A_y$. Individual and household characteristics are controlled for by $educ_{it}$, age_{it}, $childu5_{it}$ and $childo5_{it}$, which are the age an individual left full time education, their age, the number of children under the age of five, and the number of children aged five and over in the household. Time effects are allowed in this model and are expressed by the inclusion of A_{0t}^f. Depending on whether the husband participates in the labour market or not, one would expect the parameters of the labour supply function for women to change. It is therefore important to examine these two groups of women separately. We can write the female hours equation for women with non-working husbands as,

$$h_{it}^f = a_{0t}^f + a_m w_{it}^m + a_f \log w_{it}^f + a_y y_{it} + a_4 educ_{it}^f + a_5 age_{it}^f \tag{4.93}$$
$$+ a_6 educ_{it}^m + a_7 age_{it}^m + a_8 childu5_{it} + a_9 childo5_{it} + u_{0it}$$

As discussed in the earlier sections of this paper, male labour supply is observed to be essentially dichotomous. Once again, we follow the framework of Blundell et al closely, but we also include variables controlling for the number of children and their age. We can therefore write the male participation equation as,

$$p_{it}^{m} = b_{0t} + b_m w_{it}^{m} + b_f \log w_{it}^{f} + b_y y_{it} + b_4 educ_{it}^{f} + b_5 age_{it}^{f} \qquad (4.94)$$
$$+ b_6 educ_{it}^{m} + b_7 age_{it}^{m} + b_8 childu5_{it} + b_9 childo5_{it} + u_{it}^{m}$$

where p_{it}^{m} indicates whether a male is participating, it is equal to one when he participates and zero otherwise. Once again, we have assumed a semi-log linear specification for male participation.

Estimation procedure

To tackle the empirical issues stemming from non-participation and selective bias as discussed at the beginning of the section, we utilise the standard Heckman approach. The estimation involves four stages: the reduced form participation equations, the female and male wage equations, the reduced-form non-labour income equation, and finally, the female hours and male structural participation equations. The first stage involves estimating the two reduced form participation equations, one for each of the male and female individuals respectively. We obtain these two reduced form participation equations by substituting the wages from the structural participation equations using the wage equations (4.96) and (4.97).

$$p_{it}^{k} = \beta_{0t}^{k} + \beta_{1t}^{k} educ_{it}^{f} + \beta_{2t}^{k} age_{it}^{f} + \beta_{3t}^{k} (age_{it}^{f})^2 + \beta_{4t}^{k} educ_{it}^{m} + \beta_{5t}^{k} age_{it}^{m} \qquad (4.95)$$
$$+ \beta_{6t}^{k} (age_{it}^{m})^2 + \beta_{7t}^{k} childu5_{it} + \beta_{8t}^{k} childo5_{it} + \beta_{9t}^{k} y_{it} + v_{it}^{k}$$

Where $k = m, f$, indicating the male and female individual respectively. In addition to variables that determine participation such as age, education and non-labour income, variables relevant for the determination of wages are also included in this reduced form participation equation for male and female. Consistent with the wage equations, coefficients are allowed to change over time. Although strictly speaking the model does not require the coefficient on non-labour income to vary over time, we follow the spirit of the original approach in Blundell et al; this also has the advantage of granting an extra degree of flexibility. Using the above reduced form participation equation for female, we can estimate the inverse Mills ratio for women. The next step is to estimate the own wage equations for both male and female. We estimate the female log-hourly wage equation and male weekly earnings equation, including the inverse Mills ratio for females. This allows us to obtain predictions of the wages for the entire sample. We can write down the wage equations for each individual,

$$w_{it}^m = \alpha_{0t}^m + \alpha_{1t}^m educ_{it}^m + \alpha_{2t}^m age_{it}^m + \alpha_{3t}^m (age_{it}^m)^2 + u_{wit}^m \tag{4.96}$$

$$\log w_{it}^f = \alpha_{0t}^f + \alpha_{1t}^f educ_{it}^f + \alpha_{2t}^f age_{it}^f + \alpha_{3t}^f (age_{it}^f)^2 + u_{wit}^f \tag{4.97}$$

The above wage equations are equivalent to the structural wage equation (4.85). We take a standard human capital approach, and as such, wages do not depend on spouse's characteristics or other non-human capital factors. Relative prices of each component of human capital is allowed to change over time, this is indicated by the time component on each of the coefficients above. Identification for the wage equations is achieved by excluding factors that do not directly impact upon an individual's accumulated human capital. The exclusion restrictions are discussed in further details in the following section.

The next step is to provide a clear definition for non-labour income. In a static model, non-labour income is often thought of as the sum of asset income and other unearned income. We follow a standard approach in the literature and define non-labour income as the difference between consumption and total household earnings: $y_{it} = c_{it} - w_{it}^f h_{it}^f - w_{it}^m p_{it}^m$. (See MaCurdy (1983), Blundell, Duncan, and Meghir (1998) p.833, Blundell and MaCurdy (1999) p.1625 and Blundell, Chiappori, Magnac, and

Meghir (2007)). This formulation has the advantages of being easy to measure using the available data and reduces measurement error by accounting for other sources of income which are not observed explicitly in the data. As consistent with Blundell et al's approach, this measure of non-labour income is treated as endogenous and instead, we use predictions derived from the reduced form equation,

$$y_i t = \alpha^y_{0t} + \alpha^y_{1t} educ^m_{it} + \alpha^y_{2t} age^m_{it} + \alpha^y_{3t}(age^m_{it})^2 + \alpha^y_{4t} educ^f_{it} + \alpha^y_{5t} age^f_{it} + \alpha^y_{6t}(age^f_{it})^2$$
$$+\alpha^y_{7t}\mu_{it} + \alpha^y_{8t}\mu^2_{it} + \alpha^y_{9t}\mu^3_{it} + \sum_{k=1}^{6} \alpha^y_{9+k} 1(\mu_{it} - s_k > 0)(\mu_{it} - s_k)^3 + \alpha^y_{16} 1(\mu_{it} > 0) + u_{yit} \tag{4.98}$$

where μ_{it} is household asset income excluding government transfers and welfare payments. To maintain maximum comparability, we follow Blundell et al's approach in using asset income, education and age interacted with time as instruments. Spline terms and an indicator for non-zero asset income are introduced to improve fit. Cubic spline bases are used instead of quadratic bases to allow for more flexibility in fitting peaks and troughs in the data.

The placement of knots for the cubic spline regression requires a little more thought. One must select the number of knots and decide the position of each knot along the range of x in the data. Unfortunately, visual examinations of the scatterplots are usually not immensely helpful for this purpose. For example, the scatterplot between household non-labour income and asset income reveals little about the optimal positioning of knots for spline estimation. The standard practice is to place knots at evenly spaced intervals in the data. This makes sure that there is enough data within each interval of x to generate a smooth fit.

In general, the number of knots used would affect the amount of smoothing applied to the data as this changes the number of piecewise fits. A higher number of piecewise fits, would allow for more flexibility and less bias. On the other hand, the more knots implemented, the fewer data points are available per piecewise function. This may lead to increased variability in the fit and overfitting. If only a small number of knots are implemented, the spline estimate may produce an unsatisfactory fit and lead to biases. Therefore there is a tradeoff between the two. Most statistical software packages place knots at either quantiles of quintiles in the data by default. In general, for larger sample sizes such as the one used in this study, five to six knots would typically yield a good compromise. Hence we follow the standard approach by placing six knots at evenly spaced intervals in the data. Indeed, this seems to be the general approach taken by Blundell et al in their paper. At any rate, we find that our results are very insensitive to changes in the number and positioning of knots.

Finally, we then estimate the female hours equations (4.92)-(4.93) and the male structural participation equation (4.94) using the predicted wages and non-labour income obtained from stage 2 and 3.

4.7.3 Identification and exclusion restrictions

To achieve identification we need to make some assumptions about the model. As mentioned previously, the Heckman methodology requires some strong assumptions about the error terms to achieve identification. Specifically we assume that all error terms $(u^f_{1it}, u^f_{0it}, u^m_{it}, u^m_{wit}, u_{yit})$ are jointly conditionally normal with constant variance and are independent of the explanatory variables (education, age, non-labour income, and time dummies). For the wage equation, we take a standard human capital approach. Identification for the wage equations is achieved by excluding factors that do not directly impact on an individual's accumulated human capital. The excluded variables include spousal characteristics, other household characteristics and household non-labour income.

In the female labour supply equation, due to the potential endogeneity of wage arising from unobserved characteristics affecting both wage and hours simultaneously or measurement error, it is necessary to utilise instrumental-variable techniques in order to achieve identification. Similar to the approach in Blundell, Chiappori, Magnac, and Meghir (2007), education-time and age-time interactions are excluded from the labour supply equations. For these exclusion restrictions to be valid, we require that differences in the preferences and the sharing rule across education groups remain constant over time. Thus we do not need to exclude education in order to achieve identification of labour supply, but instead one has to rely on how the returns to education have changed over time. In their paper, Blundell et al further discuss the rank condition required for identification in this case, the crucial requirement is that wages have changed differently across educational groups over time. To achieve this, one might be tempted to separate the sample into taxpayers and non-taxpayers; however this will in general be invalid, as the composition of these groups are likely to change over time in a non-random way.

Examining the returns to education across groups for the UK, we see strong evidence of differing returns across educational groups in numerous studies (see for example Blundell, Chiappori, Magnac, and Meghir (2007), Blundell, Duncan, and Meghir (1998)). In addition, further evidence is documented by Gosling, Machin, and Meghir (2000), which is particularly important for the sample period (1986-1994) used in this study. They estimate that a third of the wage dispersion during the period from the late seventies to mid-nineties can be attributed to increases in educational differentials, with another third arising from cohort effects, thus supporting the suitability of this methodology for our sample period. See Gosling, Machin, and Meghir (2000) and Blundell, Duncan, and Meghir (1998) for further discussions on this issue.

Another important identifying assumption we require is that there were no other institutional changes that could have affected households differently across education groups. To address this concern, we have narrowed down our sample period to focus on the tax reform of interest only, allowing for sufficient time periods before and after the reform, but avoiding excessive sample periods in order to keep additional noise from other potential institutional changes to a minimum. Nevertheless, there were some noteworthy changes in the benefit system which spans our sample period.

In 1971, an intended temporary measure called the Family Income Supplement(FIS) was introduced to help alleviate poverty and assist lone parents especially those with children. This was a means tested benefit for adults working at least 24 hours a week. In 1988, the FIS was renamed the Family Credit(FC) with some structural changes. Like its predecessor, this system of in-work benefit gave individuals in households with children tax credits when their working hours exceeded 24 hours per week and if their overall income fell below a specified threshold. Calculations were made based on the number and age of children in the household. The credit was progressively withdrawn at the reduction rate of 70% as income rises. In 1992, the FC hours requirement was relaxed from 24 to 16. Subsequently the FC was replaced by the Working Families Tax Credit in 1999. Overall, the FC scheme had a lower level of credits (especially for younger children), a lower income eligibility threshold (families lose eligibility at a lower level of earnings) and a higher benefit reduction (withdrawal or taper) rate than the WFTC, resulting in a higher take-up rate with the latter. According to estimates by Dilnot and McCrae (1999) and Adam and Brewer (2005), the initial take-up rate for the FIS and FC was rather low but grew over the 1970s and 1980s. A major driving force behind this increased take-up was thought to be due to the significant rise in the number of single parents. More relevant for this study, however, is the take-up rate for couples. Their estimates imply an approximately 3% take-up rate for couples with children at the introduction in 1988, this rose to about 6% in 1995 (administrative figures). The WFTC also replaced the childcare disregard in the FC, which also suffered from very low levels of take-up.

On the whole, the FC was undoubtedly important for some families and could have had a large impact on low income households. However, given its low levels of initial take-up in the 1980s and early 1990s, its relatively limited extent of benefits and that its most important adjustment occurred in 1992, two years after the reform in joint taxation, it is unclear that the FC could have sufficiently shifted preferences differentially across groups to invalidate our analysis. One may also question if the adjustments in the income tax system and national insurance contributions over our sample period were part of the government's plan to tailor taxation in order to exploit the increased returns to education. If this is the case, the differences in net earnings between high and low educational groups would fall, thereby reducing the explanatory power of our instruments. Yet over this period, the income tax structure was greatly simplified such that the the top rate was brought down and the number of brackets was reduced substantially. The national insurance system went through similar simplifications over the period, with the number of brackets falling from three to two and the lower earning limit rate falling from 5% to 2% in 1989 (HMRC (2000)). Hence one would instead expect the combined effects of these policies to mildly increase the disparity in returns to education across groups.

Nonetheless, it is important to take note of these potential issues when assessing the results and to proceed with caution. Another related institutional change may be the reform in the divorce laws for couples, as it could have implications for the sharing rule. This came into force in 1969, 18 years before the start of our data. Although this reform had a large impact on households at the time, it is unlikely that it would have a significant impact on our sample period. Finally, there has been no earnings-related unemployment insurance in the UK since 1980. Nevertheless, we still require the assumption that other institutional changes, such as the ones discussed above, have not influenced preferences and sharing rules differentially across education groups over our sample period. It is important to distinguish this from general time and age effects, as well as differences across educational groups, which are controlled for in the model.

4.8 Results

4.8.1 Model diagnostics

For the probit model, we can test the assumption of homoskedasticity by comparing our restricted model with an alternative using maximum likelihood. The likelihood-ratio test has a p-value of 38% ($\chi^2_1 = 0.76$). Thus generalising the model does not yield statistically significant improvements in the model. The key assumptions of the tobit model of normality and homoskedasticity can also be tested. However, due to the censored nature of the data, we are unable to apply ordinary linear regression diagnostic tests. This is because the fitted values and residuals from a censored model have different properties to their ordinary regression counterparts. We use generalised residuals for our diagnostic tests. (Please refer to Cameron and Trivedi (2005) (ch.18.7.2) for a more detailed discussion on the construction of residuals for a censored regression.) We construct Lagrange multiplier(score) tests for heteroskedasticity and non-normality for our model. These tests have the advantage of being simple to use, as they only require estimation of the models under the hypothesis of homoskedasticity and normality. When testing for normality, it is however important to bear in mind the potential issues with this test, as using the asymptotic distribution introduces non-trivial size distortions. To overcome this problem, we follow the approach in Drukker (2002) in using a parametric bootstrap to correct the size distortion. The normality test for the tobit model has a p-value of around 6% (conditional moment estimate = 7.58). Thus we are unable to reject the null hypothesis of normality at 5% level, but can do so at 10% level. However, the results from the test for homoskedasticity strongly rejects the null hypothesis of homoskedasticity. This could suggest a possible weakness in our model and could potentially cause our results to be inconsistent. Lastly, we also record a low value of R^2 for each regression, thus on balance, these may suggest room for improvement in terms of fit and modelling.

4.8.2 Baseline results

We estimate the participation and hours equations with maximum likelihood. Standard errors are computed using bootstrap. It is not necessary to opt for robust standard errors, as using the robust sandwich form for the variance-covariance matrix of the estimator provides no clear advantage in the case of probit models if observations are independent over i and $F(x'\beta)$ is correctly specified.[9] The estimates for male participation and female labour supply are presented in Table 4.5. Similar to Blundell, Chiappori, Magnac, and Meghir (2007), we find that the correlation between the three equations were very low and insignificant. We have therefore imposed zero correlation between the male participation equation and the two female labour supply equations (corresponding to whether the male individual participates). Doing so also allows our results to be directly comparable to the restricted labour supply estimates in Blundell et al (2007). In fact, their restricted and unrestricted results are almost virtually identical, further suggesting that the restrictions had little impact on the results.

Examining the results starting from the male participation equation, we find that our estimates are very similar to the results in Blundell et al's (2007) study both in terms of signs and magnitudes. Male participation appears to be negatively related to female wages as well as non-labour income. There also appears to be a positive own wage effect, but in both studies the estimate for male is not precisely determined. In addition, his age also contributes negatively to his participation, but factors such as spousal educational levels seem less relevant for male participation. Next we turn to the female labour supply equation when the husband is not working, we find that our baseline results are again very much in line with Blundell et al's study. The only exception being the sign on the age of the male, but in both of our studies the age of male was imprecisely determined and insignificant for female labour supply. They also

[9]The default standard errors derived in these cases are restricted to be $Var(y|x) = F(x'\beta)(1-F(x'\beta))$, which is automatically satisfied for binary outcome models in the form of $p(1-p)$. For a further discussion of this, please refer to Cameron and Trivedi (2005).

found a slightly higher coefficient on female wage; however when we interpret our results in terms of labour supply elasticities we find that our result of 0.46 for women with working husbands are again very similar to their estimate of 0.33 for the same group of women. (See Table 4.8 for elasticities estimates.) One possible reason for our slightly higher elasticity estimate may be due to the difference in our samples. Their study only included couples without children[10] which could explain the lower elasticity of their female labour supply estimate. In addition, their data period also spanned a much wider period as they were not focusing on the tax reform.

This brings us to a natural point of departure from Blundell et al's approach. Because this study aims to examine how the 1990 tax reform had affected an average married couple, we have chosen to allow children in our study.[11] We include controls for younger and older children in our regressions and found them to be highly significant and substantial for women, and to a lesser extent also for men. We find that the presence of children affect the labour supply of women significantly, irrespective of whether her husband is working. The age of the children also matters. For women, labour supply is substantially reduced when there are children under the age of five in the household. Children over the age of five also have a significant negative effect but the impact is reduced considerably. In fact, for women whose husbands are not participating, the characteristics of her children and her age become the most important determinants of her labour supply. Men are also affected by the presence of children, but to a much smaller extent. Interestingly for men, the presence of older children has a negative impact but not younger children.

As an extension to our baseline model, distribution factors are included to the regressions. Distribution factors are variables that could influence the sharing rule, but do

[10] Or cases where the older children have already left home.

[11] Children could be endogenously determined with labour supply, however, excluding married couples with children from our sample would be highly restrictive. Alternatively, if we include all married couples with or without children but exclude variables controlling for children, our results could be seriously biased.

not directly impact upon preferences or the household budget constraint. The variables age gap, age gap squared and education gap are added to the baseline specification as distribution factors. Under the unitary framework, one would not expect these variables to be significant once individual age and education levels are controlled for, as they do not influence preferences or the household budget constraint directly. The results are reported in Table 4.6. Our baseline results are insensitive to the adding of distribution factors. However, variables such as age gap squared and education gap are found to be significant for women. In particular, a larger age gap (compared to the sample mean) in the relationship and a more educated female relative to her spouse are both associated with higher female labour supply. The significance of these variables could be seen as evidence in support of a collective interpretation of the household.

4.8.3 Estimating the effect of the tax reform

One of the core aims of this paper is to study the impact of the 1990 tax reform on married women. One way to achieve this is to examine how their net incomes have changed over this period. Not all women were equally affected by the reform. In fact, the group of women we are primarily interested in have two distinctive characteristics. First of all, for the reform to matter at all these women must be married to men in a different income tax bracket to themselves. Secondly, we are interested in women whose husbands are in the medium or higher tax brackets. In this section, we shall discuss the methodology in more details.

To capture the effect of the reform, the variable 'Reform' was created. It is formed from two dummy variables (gap and highmale). 'gap' is equal to one when the difference between the husband's tax bracket and the wife's tax bracket is positive, it is zero otherwise. This variable therefore excludes couples who are in the same tax bracket, and in very rare cases when the wife earns more than her husband. Clearly, couples who are earning very similar incomes will not be very much affected by the reform.

The second dummy variable, ‘highmale’, is equal to one when the husband is earning above the basic tax bracket for the relevant tax year, it is zero otherwise. The primary purpose of this variable is to exclude women who are not participating or are earning zero income and are married to low income men. This is due to the fact that for these women, their ‘gap’ indicator will be positive by default, as long as their husbands are working. However, these women are *not* the ones most affected by the reform. This is because no matter which tax system they are under (joint or independent), their marginal tax rate will not be affected by their husband, as he is also a low income earner. Therefore, to capture the true effect of the reform, we have isolated the women who are most affected by the reform. And these are women who are in a lower tax bracket than their husbands, and their husbands cannot be low tax bracket earners themselves. In our sample, approximately 20 percent of couples after the reform would fall under this category. The variable ‘Reform’ was created by interacting the two variables above. The nature of the joint tax system was such that before the reform, all women were taxed at the same rate as their husbands, thus the ‘Reform’ dummy is zero automatically before the reform. After 1990, the reform meant that women were no longer taxed at their husbands rate, and couples each had their own marginal tax rates. The ‘Reform’ variable therefore attempts to capture this decoupling effect of the reform.

Frequencies pre-reform		
	highmale	
gap	0	1
0	3912	504
1	0	0
N	3912	504

Table 4.3: Frequencies for dummy variables ‘gap’ and ‘highmale’

If one is to believe that the only effect of the reform was to change the net income of individuals, then we should not expect the variable ‘Reform’ to be significant at all, as the effect on net wage should be captured by the male and female wage variables

Frequencies post-reform		
	highmale	
gap	0	1
0	1816	9
1	1900	639
N	3716	648

Table 4.4: Frequencies for dummy variables 'gap' and 'highmale'

(what1 and what2). We include the 'Reform' dummy in our regression, the female hours equation when her husband is working now takes the form of:

$$h_{it}^{f} = A_{0t}^{f} + A_m w_{it}^{m} + A_f \log w_{it}^{f} + A_y y_{it} + A_4 educ_{it}^{f} + A_5 age_{it}^{f} + A_6 educ_{it}^{m} + A_7 age_{it}^{m}$$
$$+ A_8 childu5_{it} + A_9 childo5_{it} + A_{10} agegap_{it} + A_{11} agegap2_{it} + A_{12} edgap_{it} + A_{13} reform + u_{1it} \tag{4.99}$$

The results are reported in Table 4.7. The coefficient on the 'Reform' variable is around -7.21 and is highly significant. One may argue that perhaps there is a spillover net wage effect that was not completely captured by the wage variables (what1 and what2). However, if this is indeed the case, we should expect the coefficient to be positive, working in the same direction as the own wage effect. This observation of a negative coefficient on the 'Reform' dummy is in fact consistent with the prediction from a collective model. This suggests that the 'Reform' dummy has a separate effect after controlling for the effect working through wages. Although the reform did increase net wages for some women (which is captured by what2), one could argue that it also shifted power in the household in favour of the wife as it raised her potential earning power. This in turn gives her more bargaining power and improves her outcome. Therefore the reform had two opposing effects on the hours of work for the women affected, a positive effect from net wages, and a negative effect from increased power. When interpreting the relative magnitudes of the two opposing effects, one should be cautious as in a non-linear model like the tobit specification here, marginal effect and elasticities are more informative than the coefficients, these are reported in Table 4.8.

In order to make a more meaningful comparison, we could set up a numerical example using the estimates. Take the case of a hypothetical couple in 1989, the husband is a high income earner and as a consequence the household is in the higher income tax bracket of 40 percent. The wife is earning a much lower income but is also taxed at 40 percent before the reform. Now the reform comes into effect, and the two spouses are taxed separately. The husband retains the 40 percent marginal tax rate, but the wife now faces the lower 20 percent marginal tax rate. If the wife is working 30 hours per week at a gross wage of £10 per hour, ignoring tax allowances as they are irrelevant here, her net wage before the reform would be £6 per hour, giving her a net income of £180 per week. Under independent taxation, her new net wage is £8 per hour, giving her a net income of £240 per week. This is a 33 percent increase in her net income if her labour supply remains at 30 hours. Using the female labour supply elasticity estimate of 0.46 from our model, a 33 percent rise in her net wage is associated with a 15.3 percent increase in hours. This translates to an increase of approximately 4.6 hours per week. Turning to the effect from bargaining which is measured by the reform dummy, the marginal effect is around -7.2 hours. The two opposing effects therefore generates a net decrease of 2.6 hours per week. In net earnings terms, the wife was earning £180 per week before the reform. After the reform, taking into account the two opposing effects on her hours, her net hours falls to 27.4, which gives her a net income of approximately £219 per week. Thus her net income has risen by about 22 percent despite a fall of labour supply by approximately 2.6 hours per week. This is only a crude illustration, but it does tend to support the view that the reform from joint to independent taxation had improved the welfare of this group of married women.

It is worth mentioning that this result may also be consistent with a model in which households agree on a shared total net income target for the spouses. In such a model, when the wife's marginal tax rate is reduced, one would expect her to adjust her labour supply downwards accordingly. This type of dynamics is not captured by the semi-log form labour supply model used in this paper.

4.8.4 Testing the restrictions of the unitary model

The unitary model imposes certain restrictions that we can test for. One advantage of using the level of male income rather than the log in our analysis is that we can test for the income pooling hypothesis directly in our model. Formally, we can first test the hypothesis that $A_m = A_y$ in equation (4.92). The test has a p-value of 26% ($\chi^2_1 = 6.33$), which does not reject the unitary model. This is in fact very similar to the findings in Blundell, Chiappori, Magnac, and Meghir (2007). Recall in the theory section for the collective model, we differentiated the labour supply of each individual with respect to their own wage, their partner's wage, household income and distribution factors. (See equations (4.29)-(4.36)) The unitary model further imposes the restriction that $\frac{\partial\mu}{\partial w_m} = \frac{\partial\mu}{\partial w_f} = \frac{\partial\mu}{\partial y} = \frac{\partial\mu}{\partial z} = 0$ in each of these equations. We can directly test for the hypothesis that $\frac{\partial\mu}{\partial z} = 0$ using our data. From Table 4.6 we can see that individually, the distribution factors agegap2 and edgap are significant only for women. A joint test for all three distribution factors(agegap, agegap2, edgap) is carried out and the unitary restriction of zero effect is not rejected for men ($\chi^2_3 = 0.55$, p-value of 91%), but is strongly rejected for women both when her husband is working($\chi^2_3 = 37.95$, p-value of 0%) and when her husband is not working ($\chi^2_3 = 14.49$, p-value of 0%). For completeness we also test for the effect of the husband's wage on the wife's labour supply when he is not working. In Blundell et al's study, they find a positive but statistically insignificant effect and interprets this as an increase in his potential wage and bargaining power. Similar to their findings, for our sample we are also unable to reject the hypothesis of zero effect when the husband is not working.

4.9 Conclusion

The objective of this paper is to examine the effects of the 1990 UK tax reform from a system of joint taxation of spouses to a system of independent taxation. There are five main findings that are of particular interest. First of all, we have highlighted the serious problems surrounding the definition of a spouse's net income before 1990. This issue has rarely been examined in depth in the literature. In this paper, we propose a method of clarifying this notion and provide a practical definition of a spouse's individual net income even under a joint taxation regime. Second, when estimating the baseline labour supply for couples, we follow closely the methodology of Blundell, Chiappori, Magnac, and Meghir (2007). We find that our results are similar in magnitude and patterns. Our elasticity estimate for women (0.46) is slightly higher than their estimate (0.33), but this is most likely due to our inclusion of women with children. We also have a much shorter sample period in comparison. Third, as an extension to Blundell et al's methodology, we include children in our model and find that both the number of children and their age are highly significant for women's labour supply. Children have a negative impact on the labour supply of women, but for men, the results suggest a slightly different picture. The participation of men is insensitive to the presence of young children, but the presence of older children has a significant negative impact on his labour supply decision. One possible explanation may be that mothers tend to be the more involved parent when the children are very young, but fathers gradually increase their caring responsibilities when the children are older. Fourth, we are able to test for unitary restrictions in our model. Consistent with Blundell et al's findings, we are unable to reject the income pooling hypothesis, and hence the unitary model. However, when examining the structural estimates for women, we strongly reject the hypothesis that distribution factors have no effect on labour supply. The reform dummy could be interpreted as another distribution factor and its significance could be seen as further evidence against the unitary model.

Finally, this brings us to the central finding of this paper. We attempt to isolate the effects of the reform by including a reform dummy in the model. Our results suggest that for the group of women affected, the reform generated two opposing effects on their labour supply. There was a positive effect from an increase in net wage, but also a negative effect from possibly an increase in bargaining power. The overall impact of the reform will depend on the relative magnitudes of these two opposing forces. On balance, we find that a typical female affected by the reform decreased her labour supply by approximately 2.6 hours per week, yet she still experienced a 22 percent increase in her net income. Although a broad-brush approach, our findings would tend to support the view that the reform from joint to independent taxation had improved the welfare of this group of married women. However, in order to assess the welfare of these women, we would require a framework that allows for housework and home production. In our model, any time not spent in market work is considered leisure, but in practice these women could be spending the extra time they gained after the reform for housework or childcare. In order to carefully assess these changes in intra-household welfare, we require a more sophisticated framework that could model home production and childcare choices. This could be a potential direction for future research. In conclusion, although our results do suggest that the 1990 income taxation reform did have a significant positive effect on a group of married women, caution should be exercised when extrapolating these results for policy inference.

Labour Supply Estimates			
	Male	Female Male Working	Female Male Not Working
what1	0.025	-0.783**	-0.140
	(0.03)	(0.30)	(0.67)
what2	-0.295*	4.862*	-4.659
	(0.15)	(2.12)	(3.14)
uninco	-0.106***	-0.830*	-0.544
	(0.02)	(0.35)	(0.55)
agehd	-0.012**	0.027	-0.002
	(0.00)	(0.07)	(0.10)
agesp	-0.002	-0.081	-0.033
	(0.01)	(0.07)	(0.10)
mageleft	0.008	-0.894***	-0.315
	(0.01)	(0.15)	(0.25)
fageleft	-0.009	1.000***	1.060***
	(0.01)	(0.22)	(0.28)
childu5	0.071	-12.438***	-4.812***
	(0.04)	(0.68)	(0.83)
childo5	-0.052*	-2.816***	-1.457**
	(0.02)	(0.38)	(0.47)
T2	-0.037	1.408	-0.710
	(0.07)	(0.91)	(1.61)
T3	-0.109	0.233	-0.784
	(0.08)	(1.10)	(1.33)
T4	-0.143	0.954	2.328
	(0.09)	(1.21)	(2.20)
T5	-0.112	0.447	3.211
	(0.11)	(1.42)	(2.33)
T6	-0.152	0.190	1.402
	(0.12)	(1.67)	(2.54)
T7	-0.275*	1.144	4.340
	(0.12)	(1.54)	(2.58)
T8	-0.207	1.160	3.586
	(0.13)	(1.54)	(2.66)
_cons	1.821***	18.859***	17.656***
	(0.23)	(3.39)	(5.34)
χ^2	162.592	610.122	107.082
p	0.000	0.000	0.000
N	8780	7683	1097

Table 4.5: Baseline labour supply estimates. what1 and what2 are the predicted weekly earnings for males and log hourly wage for females. uninco is the predicted non-labour income of the household. Definitions of the other variables are given in Table. 4.1. Bootstrapped errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level.

Labour Supply Estimates with Distribution Factors			
	Male	Female Male Working	Female Male Not Working
what1	0.025	-0.742*	-0.107
	(0.03)	(0.36)	(0.63)
what2	-0.295*	4.972*	-4.822
	(0.13)	(2.11)	(2.80)
uninco	-0.106***	-0.817*	-0.554
	(0.03)	(0.37)	(0.69)
agehd	-0.014***	-0.067	-0.041
	(0.00)	(0.05)	(0.07)
agegap	-0.001	-0.040	-0.009
	(0.01)	(0.07)	(0.11)
agegap2	0.000	0.017*	0.009
	(0.00)	(0.01)	(0.01)
mageleft	-0.001	0.087	0.744*
	(0.01)	(0.20)	(0.31)
edgap	-0.009	0.994***	1.068***
	(0.01)	(0.21)	(0.27)
childu5	0.071	-12.500***	-4.841***
	(0.04)	(0.65)	(0.94)
childo5	-0.052*	-2.818***	-1.449**
	(0.02)	(0.38)	(0.47)
T2	-0.038	1.351	-0.710
	(0.08)	(0.84)	(1.73)
T3	-0.109	0.167	-0.774
	(0.07)	(1.05)	(1.64)
T4	-0.143	0.874	2.301
	(0.08)	(1.11)	(1.88)
T5	-0.112	0.285	3.257
	(0.11)	(1.66)	(2.55)
T6	-0.153	0.001	1.370
	(0.11)	(1.69)	(2.44)
T7	-0.275*	0.985	4.381
	(0.11)	(1.78)	(2.61)
T8	-0.208	0.978	3.588
	(0.13)	(1.83)	(3.01)
_cons	1.826***	19.373***	17.718***
	(0.26)	(3.28)	(5.15)
χ^2	320.064	928.083	72.195
p	0.000	0.000	0.000
N	8780	7683	1097

Table 4.6: Labour supply estimates with distribution factors included. what1 and what2 are the predicted weekly earnings for males and log hourly wage for females. uninco is the predicted non-labour income of the household. Definitions of the other variables are given in Table. 4.1. Bootstrapped errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level.

Female Labour Supply Estimates (Male Working)		
	Baseline	With Distribution Factors
what1	-0.570	-0.530
	(0.40)	(0.36)
what2	4.274*	4.382*
	(1.87)	(1.99)
uninco	-0.933*	-0.920**
	(0.37)	(0.29)
agehd	0.027	-0.045
	(0.06)	(0.05)
agesp	-0.060	
	(0.07)	
fageleft	1.071***	
	(0.17)	
mageleft	-0.845***	0.207
	(0.16)	(0.21)
agegap		-0.020
		(0.09)
agegap2		0.017*
		(0.01)
edgap		1.064***
		(0.21)
childu5	-12.338***	-12.398***
	(0.61)	(0.52)
childo5	-2.748***	-2.750***
	(0.36)	(0.32)
T2	1.319	1.265
	(0.85)	(0.96)
T3	0.051	-0.012
	(0.98)	(1.02)
T4	0.680	0.604
	(0.96)	(1.16)
T5	1.402	1.241
	(1.34)	(1.63)
T6	0.911	0.726
	(1.55)	(1.64)
T7	2.002	1.845
	(1.60)	(1.75)
T8	1.957	1.778
	(1.83)	(1.71)
reform	-7.206***	-7.180***
	(0.82)	(1.09)
_cons	15.094***	15.561***
	(3.54)	(3.97)
χ^2	1168.044	1701.287
p	0.000	0.000
N	7683	7683

Table 4.7: Female labour supply estimates with 'Reform' dummy. what1 and what2 are the predicted weekly earnings for males and log hourly wage for females. uninco is the predicted non-labour income of the household. Definitions of the other variables are given in Table. 4.1. Bootstrapped errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level.

Labour Supply Elasticities	
	Female (Male Working)
what1	-0.339
	(0.21)
what2	0.412*
	(0.19)
uninco	0.186*
	(0.08)
agehd	-0.162
	(0.22)
agegap	-0.000
	(0.00)
agegap2	0.023*
	(0.01)
mageleft	0.330
	(0.35)
edgap	-0.014***
	(0.00)
childu5	-0.614***
	(0.03)
childo5	-0.338***
	(0.04)
reform	-7.180***
	(1.04)

Table 4.8: Elasticities in the form of $\frac{\partial lny}{\partial lnx}$, except for the 'Reform' dummy where the marginal effect is the effect on the conditional mean of the dependent variable for a discrete change of the dummy variable from 0 to 1. what1 and what2 are the predicted weekly earnings for males and log hourly wage for females. uninco is the predicted non-labour income of the household. Definitions of the other variables are given in Table. 4.1. Bootstrapped errors in parenthesis. * indicates significance at the 5% level, ** indicates significance at the 1% level and *** indicates significance at the 0.1% level.

4.10 Appendix

4.10.1 Proportionality Property of Distribution Factors

This section outlines the general proportionality property of distribution factors. The observable and structural household demand equation can be written as:

$$\hat{\mathbf{g}}(\mathbf{p}, x, \mathbf{z}) = \tilde{\mathbf{g}}(\mathbf{p}, x, \mu(\mathbf{p}, x, \mathbf{z})) \tag{4.100}$$

where $\mathbf{p}$ is a vector of prices, x is the budget constraint, z is the set of distribution factors, and μ is the Pareto weight. Differentiating (4.100) to obtain the marginal impact of a change in distribution factor z_k on the collective demand for commodity i we obtain:

$$\frac{\partial \hat{g}_i}{\partial x_k} = \frac{\partial \tilde{g}_i}{\partial \mu} \frac{\partial \mu}{\partial z_k}$$

We could take two different distribution factors, z_k and z_l, assuming that $\frac{\partial g_i}{\partial z_l} \neq 0$, then:

$$\frac{\partial \hat{g}_i / \partial z_k}{\partial \hat{g}_i / \partial z_l} = \frac{\partial \mu / \partial z_k}{\partial \mu / \partial z_l} \tag{4.101}$$

Since the right hand side of equation (4.101) is independent of the good being considered, the ratio of derivatives with respect to two sharing factors is the same for all goods. We can rewrite this as,

$$\frac{\partial \hat{g}_i}{\partial z_k} = \frac{\partial \mu / \partial z_k}{\partial \mu / \partial z_l} \frac{\partial \hat{g}_i}{\partial z_i} \tag{4.102}$$

Thus if the effect of z_k on good i is double that of z_l, this must also be true for all goods. This is referred to as the proportionality property of distribution factors. The interested reader should refer to Browning, Chiappori, and Weiss (2012) for more details.

Bibliography

Adam, S., and M. Brewer (2005): *Take-up of family credit and working families' tax credit: final report*. HM Revenue and Customs, Crown Copyright.

Alesina, A., A. Ichino, and L. Karabarbounis (2007): "Gender based taxation and the division of family chores," *NBER working paper*, 13638.

Alm, J., S. Dickert-Conlin, and L. Whittington (1999): "Policy watch: The marriage penalty," *The Journal of Economic Perspectives*, 13(3), 193–204.

Alm, J., and M. Melnik (2004): "Taxing the "family" in the individual income tax," *Andrew Young School of Policy Studies*, 7.

Apps, P. (1981): *A theory of inequality and taxation*. CUP Archive.

——— (1982): "Institutional inequality and tax incidence," *Journal of Public Economics*, 18(2), 217–242.

Apps, P., and R. Rees (1988): "Taxation and the Household," *Journal of Public Economics*, 35(3), 355–369.

——— (1997): "Collective labor supply and household production," *Journal of Political Economy*, 105(1), 178–190.

——— (1999): "Individual versus joint taxation in models with household production," *Journal of Political Economy*, 107(2), 393–403.

Apps, P., and R. Rees (2009): *Public economics and the household*. Cambridge University Press.

Arrow, K. (1951): "Alternative approaches to the theory of choice in risk-taking situations," *Econometrica: Journal of the Econometric Society*, pp. 404–437.

Ashworth, J., and D. Ulph (1981): "Household models," *Taxation and Labour Supply, London, George Allen & Unwin*, pp. 117–133.

Attanasio, O., and V. Lechene (2002): "Tests of income pooling in household decisions," *Review of economic dynamics*, 5(4), 720–748.

Basu, K. (2006): "Gender and Say: a Model of Household Behaviour with Endogenously Determined Balance of Power," *The Economic Journal*, 116(511), 558–580.

Becker, G. (1965): "A Theory of the Allocation of Time," *The economic journal*, 75(299), 493–517.

——— (1973): "A theory of marriage," *Journal of Political Economy*, 81(4), 813–846.

Becker, G. (1974): "'A theory of social interactions'," *Journal of Political Economy*, 82(6), 1063–1093.

Becker, G. (1991): *A Treatise on the Family*. Harvard University Press.

Becker, G. S. (1981): "Altruism in the Family and Selfishness in the Market Place," *Economica*, 48(189), pp. 1–15.

Blundell, R., P. Chiappori, P.A., T. Magnac, and C. Meghir (2007): "Collective Labour Supply: Heterogeneity and Non-Participation," *Review of Economic Studies*, 74(2), 417–445.

Blundell, R., A. Duncan, and C. Meghir (1998): "Estimating labor supply responses using tax reforms," *Econometrica*, pp. 827–861.

BLUNDELL, R., AND T. MACURDY (1999): "Labor supply: A review of alternative approaches," *Handbooks in Economics*, 5(3 PART A), 1559–1696.

BLUNDELL, R., P. PASHARDES, AND G. WEBER (1993): "What do we learn about consumer demand patterns from micro data?," *The American Economic Review*, 83(3), 570–597.

BOSKIN, M., AND E. SHESHINSKI (1983): "Optimal tax treatment of the family: Married couples," *Journal of Public Economics*, 20(3), 281–297.

BOUIS, H., AND L. HADDAD (1992): "Are estimates of calorie-income fxelasticities too high?: A recalibration of the plausible range," *Journal of Development Economics*, 39(2), 333–364.

BOURGUIGNON, F., M. BROWNING, P. CHIAPPORI, AND V. LECHENE (1993): "Intra household allocation of consumption: a model and some evidence from French data," *Annales d'Economie et de Statistique*, pp. 137–156.

BOURGUIGNON, F., C. O'DONOGHUE, J. SASTRE-DESCALS, A. SPADARO, AND F. UTILI (1997): "Eur 3: A Prototype European Tax-Benefit Model," *DELTA Working Papers*.

BROWNING, M. (1995): "Saving and the intra-household distribution of income: an empirical investigation," *Ricerche Economiche*, 49(3), 277–292.

BROWNING, M., F. BOURGUIGNON, P. CHIAPPORI, AND V. LECHENE (1994): "Income and Outcomes: A Structural Model of Intrahousehold Allocation," *Journal of Political Economy*, 102(6), 1067.

BROWNING, M., AND P. CHIAPPORI (1998): "Efficient intra-household allocations: A general characterization and empirical tests," *Econometrica*, pp. 1241–1278.

Browning, M., P. Chiappori, and Y. Weiss (2012): *The Economics of the Family*. Cambridge University Press.

Browning, M., A. Deaton, and M. Irish (1985): "A profitable approach to labor supply and commodity demands over the life-cycle," *Econometrica: Journal of the Econometric Society*, 53(3), 503–543.

Browning, M., and M. Gørtz (2006): "Spending time and money within the household," *Department of Economics Discussion Paper*, 288.

Browning, M., and C. Meghir (1991): "The effects of male and female labor supply on commodity demands," *Econometrica: Journal of the Econometric Society*, 59(4), 925–951.

Cameron, A., and P. Trivedi (2005): *Microeconometrics: methods and applications*. Cambridge Univ Press.

Chen, Z., and F. Woolley (2001): "A Cournot-Nash model of family decision making," *Economic Journal*, 111(474), 722–748.

Chiappori, P. (1988): "Rational household labor supply," *Econometrica: Journal of the Econometric Society*, 56(1), 63–90.

——— (1992): "Collective labor supply and welfare," *Journal of Political Economy*, 100(3), 437–467.

Chiappori, P., and I. Ekeland (2006): "The micro economics of group behavior: general characterization," *Journal of Economic Theory*, 130(1), 1–26.

Chiappori, P., B. Fortin, and G. Lacroix (2002): "Marriage market, divorce legislation, and household labor supply," *Journal of political Economy*, 110(1), 37–72.

Commission of the European Communities (1984): "Memorandum On Income Taxation And Equal Treatment For Men And Women," *Commision of the European Communities*, COM(84) 695.

Connelly, R., and J. Kimmel (2009): "Spousal influences on parents' non-market time choices," *Review of Economics of the Household*, 7, 361–394.

Cremer, H., J. Lozachmeur, and P. Pestieau (2012): "Income taxation of couples and the tax unit choice," *Journal of Population Economics*, pp. 1–16.

Crossley, T., and S. Jeon (2007): "Joint Taxation and the Labour Supply of Married Women: Evidence from the Canadian Tax Reform of 1988*," *Fiscal Studies*, 28(3), 343–365.

Deaton, A. (1985): "Panel data from time series of cross-sections," *Journal of Econometrics*, 30(1-2), 109–126.

——— (1997): *The analysis of household surveys: a microeconomic approach to development policy*. Johns Hopkins University Press.

Dilnot, A., and J. McCrae (1999): "Family credit and the working families' tax credit," in *Paper presented at OECD workshop on Making Work Pay*, vol. 10, p. 11. IFS.

Dorfman, R. (1975): "Note on a common mistake in welfare economics," *The Journal of Political Economy*, 83(4).

Drukker, D. (2002): "Bootstrapping a conditional moments test for normality after tobit estimation," *Stata Journal*, 2(2), 125–139.

Eissa, N. (1995): "Taxation and labor supply of married women: the Tax Reform Act of 1986 as a natural experiment," *NBER working paper*.

——— (1996): "Labor Supply and the Economic Recovery Tax Act of 1981," in *Empirical foundations of household taxation*, ed. by J. M. P. M. Feldstein, p. 5. University Of Chicago Press.

European Communities Legislation (1975): "The principle of equal pay for men and women," *European Communities Offical Journal*, 18(L45).

——— (1976): "The implementation of the principle of equal treatment for men and women as regards access to employment, vocational training and promotion, and working conditions," *European Communities Offical Journal*, 19(L39).

——— (1979): "The progressive implementation of the principle of equal treatment for men and women in matters of social security," *European Communities Offical Journal*, 22(L6).

European Parliment Committee of Enquiry (1984): *Taxation: Special Problems Encountered by Women*. European Parliament Committee of Enquiry.

Feenberg, D., and H. Rosen (1995): "Recent developments in the marriage tax," Discussion paper, National Bureau of Economic Research.

Fortin, B., and G. Lacroix (1997): "A test of the unitary and collective models of household labour supply," *The economic journal*, 107(443), 933–955.

Gosling, A., S. Machin, and C. Meghir (2000): "The changing distribution of male wages in the UK," *The Review of Economic Studies*, 67(4), 635–666.

Goutfried, P., and W. Richter (1999): "The Tax Unit and Household Production Comment," *Journal of Political Economy*, 107(2), 404–409.

Gronau, R. (1977): "Leisure, home production, and work–the theory of the allocation of time revisited," *The Journal of Political Economy*, 85(6), 1099–1123.

GROSSBARD-SHECHTMAN, A. (1984): "A theory of allocation of time in markets for labour and marriage," *The Economic Journal*, 94(376), 863–882.

GUSTAFSSON, S. (1992): "Separate taxation and married women's labor supply," *Journal of Population Economics*, 5(1), 61–85.

HALLBERG, D. (2003): "Synchronous leisure, jointness and household labor supply," *Labour Economics*, 10(2), 185–203.

HAMERMESH, D. (2000): "Togetherness: SpousesSynchronous Leisure, and the Impact of Children," *NBER working paper*.

HECKMAN, J. (1979): "Sample Selection Bias as a Specification Error," *Econometrica*, 47(1), 153–162.

HECKMAN, J. (1996): "Comment on N. Eissa Labor supply and the Economic Recovery Tax Reform of 1981," in *Empirical foundations of household taxation*, ed. by J. M. P. M. Feldstein. University Of Chicago Press.

HMRC (1994): *Inland Revenue Statistics*. Crown Copyright.

——— (2000): *TA.4A Main Features of NICS*. Crown Copyright.

——— (2011): *Survey of Personal Incomes*. Crown Copyright.

JENKINS, S., AND L. OSBERG (2005): "Nobody to play with? The implications of leisure coordination," in *The Economics of Time Use*, ed. by D. Hamermesh, and G. E. Pfann. Elsevier.

KALMIJN, M., AND W. BERNASCO (2004): "Joint and separated lifestyles in couple relationships," *Journal of Marriage and Family*, 63(3), 639–654.

KLEVEN, H., AND C. KREINER (2007): "Optimal taxation of married couples with household production," *FinanzArchiv: Public Finance Analysis*, 63(4), 498–518.

Kleven, H. J., C. T. Kreiner, and E. Saez (2008): "The Optimal Income Taxation of Couples," *Econometrica Forthcoming.*

Konrad, K., and K. Lommerud (1995): "Family policy with non-cooperative families," *The Scandinavian Journal of Economics*, 97(4), 581–601.

——— (2000): "The bargaining family revisited," *Canadian Journal of Economics*, 33(2), 471–487.

Laisney, F., and D. Beninger (2002): "Comparison between unitary and collective models of household labor supply with taxation," *ZEW Discussion Papers.*

LaLumia, S. (2008): "The effects of joint taxation of married couples on labor supply and non-wage income," *Journal of Public Economics*, 92(7), 1698–1719.

Leuthold, J. (1968): "An empirical study of formula income transfers and the work decision of the poor," *Journal of Human Resources*, 3(3), 312–323.

Lundberg, S., and R. Pollak (1993): "Separate spheres bargaining and the marriage market," *Journal of Political Economy*, 101(6).

Lundberg, S., R. Pollak, and T. Wales (1997): "Do husbands and wives pool their resources? Evidence from the United Kingdom Child Benefit," *Journal of Human Resources*, 32(3), 463–480.

MaCurdy, T. (1983): "A simple scheme for estimating an intertemporal model of labor supply and consumption in the presence of taxes and uncertainty," *International Economic Review*, 24(2), 265–289.

Manser, M., and M. Brown (1980): "Marriage and household decision-making: A bargaining analysis," *International Economic Review*, 21(1), 31–44.

Mas-Colell, A., M. Whinston, and J. Green (1995): *Microeconomic theory.* Oxford university press New York.

McElroy, M., and M. Horney (1981): "Nash-bargained household decisions: Toward a generalization of the theory of demand," *International Economic Review*, 22(2), 333–349.

Messere, K. (1998): *The tax system in industrialized countries.* Oxford University Press, USA.

Milardo, R. (1987): "Changes in Social Networks of Women and Men Following Divorce A Review," *Journal of Family Issues*, 8(1), 78–96.

Mirrlees, J. (1971): "An exploration in the theory of optimum income taxation," *The Review of Economic Studies*, 38(2), 175–208.

OECD (2005): *OECD Tax Policy Studies Taxing Working Families: A Distributional Analysis*, OECD tax policy studies. OECD.

Panzar, J., and R. Willig (1976): "Vindication of a" Common Mistake" in Welfare Economics," *The Journal of Political Economy*, 84(6).

Piggott, J., and J. Whalley (1996): "The tax unit and household production," *Journal of Political Economy*, 104(2), 398–418.

Propper, C., H. Rees, and K. Green (2001): "The demand for private medical insurance in the UK: a cohort analysis," *The Economic Journal*, 111(471), 180–200.

Prowse, V. (2004): "Estimating labor supply functions under rationing," *University of Oxford Department of Economics Discussion Paper*, 209.

Rosen, H. (1977): "Is It Time to Abandon Joint Filing?," *National Tax Journal*, 30(4), 423–428.

Rosen, H. (1988): "The marriage tax is down but not out," *NBER working paper*, (2231).

RUUSKANEN, O. (2004): *An econometric analysis of time use in Finnish households.* Research Institute of the Finnish Economy (ETLA).

SAMUELSON, P. (1956): "Social indifference curves," *The Quarterly Journal of Economics*, 70(1), 1–22.

SHORT, S. (2006): *Review of the UK 2000 Time Use Survey.* Office for National Statistics.

SOLBERG, E., AND D. WONG (1992): "Family time use: Leisure, home production, market work, and work related travel," *The Journal of Human Resources*, 27(3), 485–510.

STEPHENS JR, M., AND J. WARD-BATTS (2004): "The impact of separate taxation on the intra-household allocation of assets: evidence from the UK," *Journal of Public Economics*, 88(9-10), 1989–2007.

STOCK, J., AND M. YOGO (2002): "Testing for weak instruments in linear IV regression," Discussion paper, National Bureau of Economic Research.

SULLIVAN, O. (1996): "Time co-ordination, the domestic division of labour and affective relations: Time use and the enjoyment of activities within couples," *Sociology*, 30(1), 79.

THOMAS, D. (1990): "Intra-household resource allocation: An inferential approach," *Journal of Human Resources*, 25(4), 635–664.

VERMEULEN, F. (2002): "Collective household models: principles and main results," *Journal of Economic Surveys*, 16(4), 533–564.

WARD-BATTS, J. (2000): "Out of the wallet and into the purse: modeling family expenditures to test income pooling," *Population Studies Center Research Report 00-466.*

Wooldridge, J. (2002): *Econometric analysis of cross section and panel data*. The MIT press.

Zabriskie, R., and B. McCormick (2004): "The Influences of Family Leisure Patterns on Perceptions of Family Functioning*," *Family Relations*, 50(3), 281–289.