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Working paper

Estimating intra- household inequality from time-use data

Estimating Intra-Household Inequality from Time-Use Data

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Abstract

Estimating intra-household sharing is crucial to understanding overall inequality. Standard measures of consumption inequality only account for inequality between, and not within, households, because expenditure surveys are generally available only at the household level. I develop a new approach to estimating intra-household sharing, which is both grounded in a collective household model, and simple to implement with widely available data. I propose using individual-level variation from time use data to identify the way households share resources between members. For UK working couples, my methodology reveals substantial intra-household inequality, and the poverty rate is 20.59% higher for women than men.

Keywords: Consumption inequality, Household bargaining, Collective model, Sharing rule, Time use

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1 Introduction

Individual-level consumption inequality is challenging to measure because expenditure surveys are typically collected at the household level. The simplest solution to this problem, which is widely used for official inequality statistics across the world, is to assume that there is no intra-household inequality, so that household-level expenditure, divided by the number of household members, directly provides estimates of individual-level consumption (the ‘per capita’ approach). A growing body of evidence suggests that the equal sharing assumption is unrealistic and that it is crucial to account for intra-household, as well as inter-household, inequality. Not doing so leads to inaccurate, generally downward-biased, estimates of the aggregate level of consumption inequality, such as the poverty rate. It also fails to appropriately capture key dimensions of inequality, such as gender and age, and their intersection (e.g. see Calvi (2020)). Therefore, standard measures may lead to incorrect conclusions on trends of inequality over time, and about the impact of specific policies. More accurate individual-level inequality measures are required to target public funding towards more effective policies, including policies specifically aimed at reducing intra-household inequalities.

I develop a new approach to estimating individual-level consumption, which is grounded in a collective household model with both private and public consumption, and both material goods and time use. I propose a two-step estimation procedure: first, I estimate the sharing rule with time use data, and then I apply my estimates to an expenditure survey to estimate consumption inequality. The sharing rule summarises how a household with specific characteristics assigns resources to members for their private consumption. In the collective model, the household agrees on time use and material consumption in the same bargaining problem. Therefore, the sharing rule can be identified from data on either material consumption or time use, as long as we observe individual consumption of one private good (the ‘assignable good’) for all household members. A key advantage of using time use surveys for identification is that they contain individual-level data, while expenditure data is typically recorded at the household level.

I propose using a novel assignable good which can be constructed from time use surveys: private leisure. This is time spent on leisure activities without other household members co-present, for instance reading a book alone or having a coffee with a friend.

The responsiveness of assignable good expenditure to household budget is informative about how that budget is shared between members. Together with an identifying assumption restricting preference heterogeneity, this yields point-identification of the sharing rule. The sharing rule can then be applied to expenditure data to estimate individual-level consumption. Similarly to Lise and Seitz (2011), I define this as the monetary market value of an individual’s consumption, i.e. the sum of (i) the household’s expenditure on public goods, and (ii) the individual’s estimated share of the household’s expenditure on private goods. This is a useful metric to calculate objective and policy-relevant measures of individual-level consumption inequality.

I estimate sharing from the UK Time-Use Survey (UKTUS). Women generally command a lower proportion of private expenditures than men, 45% on average, but this varies substantially between households. Characteristics affect resource shares in a manner consistent with bargaining theory, e.g. women with higher wages, or matched with less educated men, command a higher resource share. I then apply the sharing rule to a separate but comparable expenditure dataset, the Living Costs and Food Survey (LCF), allowing me to estimate individual-level material consumption. I find that, on average, men’s material consumption is 8.53% higher than women’s, with a wider gap for poorer households, so that the poverty rate is 20.59% higher for women than for men. These estimates suggest that policymakers should target policies to reduce female poverty in the UK, for instance by narrowing gender wage gaps. When I incorporate time use as well as material consumption, I estimate a wider average gender gap in ‘full’ consumption of 10.1%. This supports the increasingly popular view that time use is an important component of gender inequality.

These gender gaps are substantial, especially given the context: the UK is one of the most gender equal countries in the world.¹ Moreover, my application focuses on heterosexual working couples without cohabiting children, which are likely characterised by less gender inequality than other household compositions (e.g. see Bargain, Donni and Hentati (2022)). Therefore, we can think of this as an approximate lower bound for the level of intra-household inequality in the broader global population. This reinforces previous findings in the literature that equal sharing does not hold, and that it is important to estimate intra-household inequality instead of using a per capita approach.

¹United Nations Development Programme. (2022). Human development report 2021-22. <http://report.hdr.undp.org>

My results also shed light onto the apparently puzzling fact that women with higher wages tend to have less leisure, even though they have more bargaining power in the household. These facts are squared by noticing that *expenditure* on women’s leisure is higher for women with higher wages, even if their *quantity* of leisure is somewhat lower; and also that expenditure on material consumption increases in a way that compensates for lower leisure. Importantly, we can account for all this with a collective household model, with a single sharing rule which applies both to material goods and time use, because changes in wages have an income effect (both through the household budget and through bargaining) as well as a price effect (on the price of time).

1.1 Contributions to the literature

This paper builds on a large and growing literature on estimating intra-household sharing. A small number of papers estimate sharing directly from data on individual-level expenditure e.g. Cherchye, De Rock and Vermeulen (2012). However, as this type of data is rarely available in practice, most of the literature focuses on estimating individual-level consumption from household-level expenditure. Several papers have shown that this is theoretically possible under different versions of the collective household model, and with different restrictions (e.g. Chiappori (1992), Browning, Bourguignon et al. (1994), Blundell, Chiappori and Meghir (2005), Blundell, Chiappori, Magnac and Meghir (2007) and Chiappori and Ekeland (2009)).

A variety of papers have estimated intra-household sharing in different countries, both developing and developed, based on a range of approaches, with different underlying versions of the model, identifying assumptions, and estimation approaches (a summary of findings from different papers can be found in Almås et al. (2020)). For example, Cherchye, De Rock, Lewbel and Vermeulen (2015) draw on revealed preference techniques to estimate bounds on sharing. Other papers, including Browning, Chiappori and Lewbel (2013), Lewbel and Pendakur (2008), Bargain and Donni (2012) and Brown et al. (2021) point-identify the sharing rule from estimates of Engel curves of multiple goods combined with identifying assumptions restricting preference heterogeneity. Dunbar et al. (2013) shows that, in a setting with only non-public material consumption and no price variation, it is possible to identify the sharing rule from individual-level data for a single private good, known as the ‘assignable good’.

A similar approach is followed by Calvi (2020), Bargain, Donni and Hentati (2022) and Lechene et al. (2022). Lise and Seitz (2011) also estimates sharing from data on a single assignable good, but based on a different identifying assumption, restricting the bargaining process so that men and women with equal earnings potential share resources equally.

While several approaches in this literature involve complex estimation, recently there has been a shift towards simpler methods. In particular, Lechene et al. (2022) shows that, building on the identification result of Dunbar et al. (2013), it is possible to estimate resource shares by linear regression. I adapt these results to a setting with time use, price heterogeneity (which is required as the price of time are individual wages), and public consumption. I also propose a weaker identifying assumption restricting preference heterogeneity than those standardly used in related literature. To maintain tractability, I use a simpler functional form for utility: Cobb-Douglas rather than the Almost Ideal Demand System.² In this way, this paper is in keeping with the literature’s move towards increasingly tractable methods, while also reintroducing some important features of the general version of the underlying collective model.

1.1.1 Time-use, private leisure, and two-step estimation

Many papers in this literature focus on material consumption because time use creates additional challenges for the identification of individual-level consumption. However, as argued by Becker (1965), time use is a crucial component of household decision-making and well-being. Including time use in the model allows me to estimate ‘full’ individual-level inequality, inclusive of time use as well as material consumption. This paper is the first to provide such estimates. Additionally, recognising the endogeneity of time use is important to correctly defining the household budget as the full budget (how much the household could earn if all members worked all the time, in addition to any unearned income), rather than realised earnings, often used in other papers in this literature, and which are endogenous. Moreover, incorporating time use is necessary to use my proposed assignable good: private leisure.

The literature to date has been constrained in its choice of individual-level variation to identify the sharing rule from. This is because papers to date use household ex-

²It is possible to use the Almost Ideal Demand System in my setting, but it creates additional challenges discussed in appendix A.2.

penditure surveys both to (i) estimate the sharing rule, and (ii) apply the estimated household-specific shares to household expenditure, to obtain individual-level consumption. Household expenditure data contains very little individual-level variation, and for this reason most papers in the literature have used clothing as the assignable good, as it is often available split into men’s, women’s and children’s clothing.

However, clothing has limitations, as discussed in Lechene et al. (2022). Perhaps most concerning, clothing is a durable good, with a high proportion of 0s in expenditure surveys. In my UK data, 73.20% of households have zero recorded expenditure on at least one of male and female clothing. This is an issue both because it reduces the heterogeneity we can leverage for identification, and because most of the literature treats all observations as interior solutions, and when a large proportion of them are in fact corner solutions this can lead to inaccuracy and also bias towards equality because people with lower resource shares are more likely to hit the corner.

As alternatives to clothing, a small number of papers has attempted using individual-level food expenditure or the residual from usual hours worked (‘non-market-work’) as the assignable good. The former has been done for instance by Lechene et al. (2022) for Bangladesh, but this data is rarely available in practice. The latter has been done for example by Lise and Seitz (2011), and can be obtained as the residual by subtracting usual hours worked (which is often asked as a recall question in expenditure surveys) from the time endowment. It is a proxy for leisure which is often available in expenditure data. However, as acknowledged by authors who have used this assignable good, it is conceptually a good with substantial public components because it includes domestic work and leisure time spent jointly with other household members (‘joint leisure’). This is likely to bias estimates towards equal sharing.

To circumvent the limitations of individual-level variation in expenditure surveys, I propose a new approach: splitting the estimation of individual-level consumption into two phases. The first, estimating the sharing rule, can be conducted with time use data. In the second phase, the estimated sharing rule can then be applied to a separate but comparable household expenditure survey, to obtain individual-level consumption. This is advantageous because time use data is widely collected and recorded at the individual level, and hence contains individual-level variation which is challenging to find in expenditure surveys. Moreover, time use surveys typically record: (i) sufficiently detailed activity information to distinguish between domestic work and leisure time, and (ii) co-presence information to distinguish between time

spent with and without other household members. This makes it possible to define an assignable good, private leisure, which is both credibly private, unlike non-market-work, and has a large budget share, with few or no zeros, unlike clothing.

The main limitation of using private leisure as the assignable good is that its price is only known for those who work, for whom it coincides with the observed wage. For non-participants, the price of time is higher than their (unobserved) wage and we would have to estimate that in order to use time use data to identify sharing. In this paper, I avoid this complication by focusing on working couples without cohabiting children. This sample restriction is not unusual in the literature (for a discussion of this point, see Almås et al. (2020)). This sub-sample of the population is still of great interest, and in particular can shed light on gender inequalities and some of their drivers. Moreover, the identifying assumption is more credible for this sub-sample. The estimated sharing rule will be unbiased for the population of working heterosexual couples without cohabiting children, but care should be taken in extrapolating it to other household compositions. Extrapolation to households with non-participation may not be a bad approximation in the UK context, where non-participation in couples without cohabiting children is low, similar between genders, and generally due to reasonably exogenous drivers such as long-term illness or temporary unemployment. However, households with cohabiting children are likely characterised by more pronounced gender differences (e.g. see Bargain, Donni and Hentati (2022)).

1.1.2 Public consumption

Several papers in this literature, including Browning, Chiappori and Lewbel (2013), Dunbar et al. (2013) and Lechene et al. (2022), treat all goods as non-public and model household economies of scale through the shareable goods framework. This framework is very tractable, but it does not allow us to impose the restriction which is at the core of public consumption, i.e. the requirement that all household members consume the same quantity of a public good. For this reason, household optimisation under shareable goods and public goods generally yields different solutions. Since households spend a very large proportion of their budgets on public goods, e.g. housing, it is important to accurately capture economies of scale driven by public consumption.

In principle, this inclusion can make a difference at the stage of resource share estimation. However, in my application, my use of separable preferences and of a

further assumption, restricting preference heterogeneity on the private-public good split (‘private-public neutrality’), entail that the public good extension only really bites in the second stage, when I estimate individual-level consumption. At that stage, I apply the estimated sharing rule only to private expenditure, while I assign total public expenditure to each household member. This is because public goods are, by definition, non-rivalrous and consumed by all members in the same quantity, and hence the sharing rule should apply only to private expenditures. The inclusion of public goods matters substantially, even when it only bites in this stage of the analysis. I show that, if we behave as if all goods were non-public and apply sharing estimates to all expenditure (or exclude public expenditure), we substantially over-estimate intra-household inequality.

My approach to estimating individual-level consumption from the sharing rule also carefully takes into account (i) expenditure on durables, as well as expenditure on non-durables, (ii) goods with prices that vary substantially at a regional level, as well as goods with homogeneous prices in the sample, and (iii) goods that have substantial private and public components, as well as goods that are more clearly categorised as private or public. This allows me to incorporate large expenditures which are often excluded, such as housing and cars. Finally, this is the first paper to estimate individual-level inequality in ‘full’ consumption, including time use, as well as material consumption.

1.2 Structure of this paper

This paper is organised as follows. Section 2 sets out the structural model of the household. In section 3 I propose a new methodology to estimate intra-household sharing. Section 4 introduces the UK time use and expenditure datasets used in my application. Section 5 discusses the estimation of the sharing rule from time use data, the findings and their interpretation, empirical performance of the model and comparison to other approaches. In section 6, I estimate individual-level consumption by applying my estimated sharing rule to expenditure data. I conclude in section 7.

2 The model

In keeping with the literature, I work within the static collective model of the household, which has several advantages relative to alternatives (see Browning, Chiappori and Weiss (2014)). No specific bargaining process is imposed on the household, but bargaining must be efficient.³ I work with a general version of the model, with both private and public goods and both material goods and time use. For simplicity of exposition, I focus only on the household composition that is relevant to my application: a heterosexual couple with both members participating in paid work.

Each household h is composed of two people, each with a ‘type’ t : a woman, indexed f , and a man, indexed m . Every individual of the same type has the same utility function u_t . The distribution of bargaining power within the household depends on a vector of characteristics z_h . This may include both (i) market variables such as wages of both members, and (ii) distribution factors, which enter the household’s optimisation problem only indirectly through the distribution of bargaining power, e.g. age and education of both members.

There are four types of goods: (i) private material goods, (ii) private time use, (iii) public material goods, and (iv) public time use. Each member consumes vector $\mathbf{c}_{t,h}$ of private material goods, such as food. The household purchases $\mathbf{c}_h = \mathbf{c}_{f,h} + \mathbf{c}_{m,h}$ at price vector $\mathbf{p}$. Private time use includes any leisure activities which are done without the other household member, such as reading a book alone, or going out for a coffee with a friend. I group all of these activities under the umbrella of private leisure $l_{t,h}$, with associated price $w_{t,h}$. Additionally, household members spend time on public time use, such as joint leisure time (which Fong and Zhang (2001) refer to as spousal leisure) and domestic work. These enter utility through unknown production functions, which we remain agnostic about. Finally, the household purchases public material goods, such as heating. The household’s overall vector of consumption of public goods (material and time use) is $\mathbf{Q}_h$, with price vector $\mathbf{R}_h$ ($\mathbf{R}_h$ varies at the household level since the price of public time depends on members’ wages). By definition, $\mathbf{Q}_h = \mathbf{Q}_{f,h} = \mathbf{Q}_{m,h}$.

This framework can incorporate partially public goods by appropriately defining goods e.g. splitting car fuel into car fuel used for holidays and car fuel used for work trips. It is possible to extend the model to additionally allow for ‘shareable’

³As opposed to models with specific bargaining solutions e.g. McElroy and Horney (1981).

goods through an ‘economies of scale’ matrix. These have been used as a more tractable alternative to public goods in Browning, Chiappori and Lewbel (2013), Dunbar et al. (2013) and Lechene et al. (2022). However, I do not explicitly do this as the identification approach in this paper, similarly to Dunbar et al. (2013) and Lechene et al. (2022), and unlike Browning, Chiappori and Lewbel (2013), would not allow recovering the ‘economies of scale’ matrix, and the rest of the methodology and results would remain unchanged.

Time is treated as continuous. While contractual hours cannot be chosen freely in many jobs, what is relevant to the model are *actual hours worked*, which can be chosen freely and are reasonably continuous in my UK time use data. The wage is assumed to be exogenous, and we can think of it being determined by an individual’s unobserved skills. Individuals choose, within the set of jobs available to them given their skills, whether to work in a longer-hour, higher-overall-pay job, or a shorter-hour, lower-overall-pay job. Within a main job, they can also work fewer or more actual hours, resulting in differential pay e.g. through bonuses, or through a side hustle with hourly pay.

Wage exogeneity is a general requirement of the static collective model (see e.g. Browning, Chiappori and Weiss (2014) section 4.4.2): since hourly pay generally affects bargaining power in the household, the household problem becomes inefficient if it is a choice variable. This is a strong assumption, which is made by all papers estimating individual-level consumption to date, as this literature is grounded in the collective model. This assumption is merely more salient in this paper because of the focus on time use. Modifying the model to allow for endogenous wages would greatly increase the complexity of the problem. It is encouraging to note that the collective model seems to provide a good empirical fit (see Browning, Chiappori and Weiss (2014)), so that the assumption of wage exogeneity may not be as problematic as it seems *prima facie*.

We normalise total time to unity, so that the household is endowed with the wage of both members plus any non-labour income:

$$y_h = w_{f,h} + y_{f,h}^{NL} + w_{m,h} + y_{m,h}^{NL}$$

This ‘full income’ is the household’s budget, which can be spent either on time use (reducing market income) or material goods purchased on the market.

2.1 The optimisation problem

The static collective household can be represented as maximising the weighted sum of members' utilities, where the weights are 'Pareto weights' $\mu_t(\mathbf{z}_h)$. The weights are normalised to sum to one within the household, and represent relative bargaining power. The same bargaining process applies to all households, so that we can think of a single function mapping household characteristics onto male and female bargaining weights. For the purpose of estimating individual-level consumption, it is useful to represent this problem in two stages. This representation clarifies the meaning of resource shares $\eta_{t,h}$, which are the key object to be estimated in order to estimate individual-level consumption measures.⁴

In the first stage, the household chooses expenditure on public goods $\mathbf{R}_h \mathbf{Q}_h$, and how to divide the remaining household budget into individual budgets for members:

$$\rho_{t,h} = (y_h - \mathbf{R}_h \mathbf{Q}_h) \eta_t(\mathbf{z}_h)$$

The sharing rule (or 'conditional sharing rule') determines the share of household budget net of public good expenditure assigned to each member. Each individual has a resource share $\eta_t(\mathbf{z}_h)$, which is a function of household characteristics. Shares sum to one within the household: $\eta_f(\mathbf{z}_h) + \eta_m(\mathbf{z}_h) = 1$. In the second stage, members decide how to allocate their individual budgets $\rho_{t,h}$ to private expenditure, i.e. private leisure and private material consumption. The optimisation problem is subject to the usual non-negativity constraints and budget constraints. This includes a time constraint, so that in the second stage the individual decides how to allocate their remaining time, net of joint leisure and domestic work, between private leisure and market work.

In general, second-stage demands depend on: (i) the individual's second-stage budget (determined by the sharing rule, household characteristics, and household budget net of public good expenditure), (ii) type-specific preference parameters, (iii) the prices of all private goods, including own-wage, and (iv) public good consumption as determined in the first stage (unless preferences are separable in private and public

⁴This representation is equivalent, and no further assumptions are required. Separability is often assumed when employing the two-stage representation of a collective model with public goods (e.g. Lise and Seitz (2011)), but that is so that second-stage demands do not depend on public good consumption.

goods). All of these are (potentially) observable with the exception of the sharing rule, which we wish to estimate, and preference parameters. If we observe individual-level second-stage demands for a private good (the assignable good) for both household members, and make an appropriate restriction on preference heterogeneity, we can typically identify the sharing rule.

3 Methodology

I propose a new method to estimate the sharing rule under the model set out in section 2, with (i) Cobb-Douglas preferences, (ii) private leisure as the assignable good, (iii) an identifying assumption restricting preference heterogeneity ('SRAT'), and (iv) an additional restriction on preference heterogeneity to simplify estimation ('private-public neutrality'). Under my assumptions, expenditure on private leisure takes the form:

$$w_{t,h}l_{t,h} = \alpha_t^l y_h (\eta_t^0 + \boldsymbol{\eta}_t^z (\mathbf{z}_h - \bar{\mathbf{z}}))$$

Where α_t^l is the Cobb-Douglas preference parameter for private leisure, η_t^0 and $\boldsymbol{\eta}_t^z$ are parameters in a linear approximation of the sharing rule (which is an unknown function of household characteristics), and y_h and $\mathbf{z}_h$ are observable household characteristics. Estimating this equation for both men and women allows me to identify the resource share parameters by using two facts: (i) under the 'SRAT' identifying assumption, $\frac{\alpha_t^l}{\alpha_t^m}$ is estimated from singles, and (ii) by definition, resource shares must sum to one within each household.

The methodology set out in this section can straightforwardly be applied to different assignable goods: in section 5.2, I compare my baseline results to findings from clothing and non-market-work. The methodology can also be adapted to different identifying assumptions, and alternative parametric specifications.

3.1 Parametric specification: Cobb-Douglas

Individuals have preferences which are Cobb-Douglas in: (i) private leisure $l_{t,h}$, (ii) a type-specific aggregate material private good $f_t^c(\mathbf{c}_{t,h})$, and (iii) a type-specific aggregate public good $f_t^Q(\mathbf{Q}_h)$:

$$u_{t,h} = \alpha_t^l \ln(l_{t,h}) + \alpha_t^c \ln(f_t^c(\mathbf{c}_{t,h})) + \alpha_t^Q \ln(f_t^Q(\mathbf{Q}_h))$$

Where the Cobb-Douglas preference parameters are normalised to sum to one. This functional form allows us to benefit from the tractability of Cobb-Douglas while imposing as few restrictions as possible on specific goods. For instance, homotheticity is imposed on private leisure, but not on food or clothing (which are part of the aggregate material private good). As discussed in section 5.1.3, I test homotheticity of private leisure using data on working singles, and cannot reject it (while, for instance, clothing appears to be a necessity good in my singles data). In section 5.1.3, I outline additional tests that suggest that the functional form assumption is not driving my results in my application to UK data.

The key advantage of Cobb-Douglas preferences is that they lead to parsimonious estimating equations. This enables estimation from realistic, widely available data, even when we have a rich vector of characteristics affecting sharing z_h . I note that small sample sizes are common in this literature, partly due to limitations of existing data, and partly by construction, because estimation must proceed separately for different household compositions.

As explained in supplemental appendix A, while it is possible to identify the sharing rule using more flexible functional forms than Cobb-Douglas, this often requires some other compromise. One option is to estimate a single average resource share for men and women, without estimating the impact of characteristics z_h . However, it may be that households with certain characteristics are both poorer and have more gendered sharing, so that estimating household-specific shares is important to accurately estimating consumption inequality measures, including poverty rates. Another alternative is to employ further linear approximations. For instance, a further linear approximation is required for Almost Ideal Demand System Engel curves to be estimated by OLS (similarly to Lechene et al. (2022)). This reduces the degree to which alternative preferences would better capture any non-linearities. Moreover, more flexible parametric forms often lead to practical issues for estimation because, in order to allow resource shares to depend on several characteristics z_h , estimation requires a large number of regressors, many of which are highly correlated with each other.

3.2 How time use can identify sharing of material goods

In the static collective model, all household decisions are made under a single, efficient bargaining problem. Under this assumption, it makes no difference if the assignable good is of a material or time use nature. On this basis, non-market-work has been used in the previous literature, and I use private leisure. However, one may worry that, in reality, household decision-making over time use is quite separate from decisions about material consumption, and that we cannot conceptualise a single resource share as applying to both types of goods. In that case, it would be problematic to use a time use assignable good to estimate a sharing rule to apply to material goods.

Reassuringly, Calvi et al. (2022) find that estimates of women’s resource shares, obtained using material assignable goods, are closely related to those women’s satisfaction with their availability of leisure time. This suggests that the collective model is right to conceptualise the same sharing rule being applied both to time use and material goods. Moreover, my resource share estimates, obtained from private leisure as the assignable good, are highly correlated to the wage ratio,⁵ a commonly used proxy for sharing.⁶

Furthermore, if we accept the collective representation of a single bargaining problem over time and material consumption, that does not force material consumption and leisure to always move in the same direction. For example, a woman’s leisure consumption may be lower-than-average while her material consumption is higher-than-average because she has a higher-than-average wage, corresponding both to a higher-than-average resource share and a higher-than-average opportunity cost of private leisure.

3.3 Identifying assumption: SRAT

Identification of the sharing rule from individual-level demand data for a single assignable good requires a strong identifying assumption. Assumptions could be made on the bargaining process, e.g. Lise and Seitz (2011) assume that women and men with the same potential earnings divide full income equally. Other papers have focused on restricting preference heterogeneity. For example, Lewbel and Pendakur

⁵Defined as the ratio of female wages to the sum of female and male wages.

⁶The correlation coefficient is 0.76.

(2008) and Bargain and Donni (2012) rely on the ‘SAT’ assumption (similarity across household types), that preferences for the assignable good are stable across household compositions, allowing for identification of the preference parameter from singles data. However, we may be concerned by findings that, at least in some contexts, preference stability across household composition is rejected empirically (see Hubner (2020)). Dunbar et al. (2013) and Lechene et al. (2022) use the alternative ‘SAP’ assumption (similarity across people) that women and men in the same household composition have the same preference parameter for the assignable good. However, there may well be gender differences in preferences, at least for some goods.

I suggest a new, somewhat weaker, alternative to ‘SAT’ and ‘SAP’, which I term ‘SRAT’ (similarity in ratios across household types). SAT requires *the level* of the assignable good preference parameter to be the same for a single woman (man) and a woman (man) in a couple. Instead, SRAT requires that this specific preference parameter changes similarly for men and women as they change household composition. This means that the ratio of a man’s to a woman’s assignable good preference parameter is the same for singles and for couples, and hence can be estimated from singles data. This seems realistic for people who transition between singlehood and being in a couple. There may be more scope for gender differences to emerge if there are children in the household, but as this paper focuses on working couples without cohabiting children this problem does not emerge here. SRAT is weaker than SAT in all cases. It coincides with SAP, with more of an evidence basis, if we are unable to reject that single men and women have the same preference parameter.

The interpretation of the SRAT identifying assumption depends on the functional form of preferences and the choice of assignable good. In this context, the ratio between men’s and women’s Cobb-Douglas preference parameters for private leisure remains the same regardless of whether they are single or in a couple.

3.4 Additional restriction : private-public neutrality

The second-stage demand for assignable goods is conditional on public good expenditure (even when preferences are separable) because the resource share enters multiplicatively with the household budget *net of public good expenditure*. This presents two challenges. Firstly, it entails the substantial data requirement of having high-quality data both on time use and material expenditure to construct overall expenditure on

public goods, including domestic time and joint leisure as well as material goods. The second challenge is correctly constructing the budget net of public expenditure. The main difficulty is handling data on durables within a static framework. In section 6 I explain how I tackle these challenges for the purpose of applying my estimated sharing rule to estimate individual-level consumption. A similar approach could be taken at this stage too, but any inaccuracies arising from it would enter estimates twice, and affect the accuracy of sharing rule estimates as well as consumption inequality measures.

To circumvent the challenges presented by estimating household budget *net of public good expenditure*, one can impose an additional preference restriction that total expenditure on public goods does not vary with the distribution of bargaining power in the household (‘private-public neutrality’). Under this assumption, bargaining power still affects the composition of public good (and private good) expenditure; it simply does not affect the *overall* split between private and public expenditure. For example, female empowerment could lead to more spending on housing and less on television subscriptions.

If using private leisure as the assignable good, private-public neutrality makes it possible to estimate the sharing rule from time use data alone. Alternatively, if using a material assignable good, it is possible to account for time use as well as material goods, and still estimate the sharing rule from expenditure data alone. This assumption is not strictly speaking an identifying assumption in that it is not required if we instead choose to use combined time use and expenditure data (to obtain household budget net of public good expenditure) to estimate the sharing rule.

Private-public neutrality may seem too strong because some papers have found gender differences in investment in children (e.g. see Doepke and Tertilt (2019)), which is often thought of as a public good in the household. However, evidence on this point is mixed (e.g. see Gitter and Barham (2008)). Moreover, it would be possible for female empowerment to increase investment in children without increasing overall public expenditure. Either way, investment in children is not a concern in this paper as I focus on couples without cohabiting children. The private-public neutrality assumption appears to be consistent with the data in the context of this paper’s application, as discussed in section 5.1.2.

With the preferences outlined in section 3.1, private-public neutrality amounts to the

restriction that:

$$\alpha_t^Q \ln \left(f_t^Q (\mathbf{Q}_h) \right) = \sum_j \alpha_t^{Qj} \ln (Q_h^j)$$

Where $\sum_j \alpha_t^{Qj} = \alpha_t^Q$ and $\alpha_f^Q = \alpha_m^Q$. This entails leaning into the Cobb-Douglas assumption further for public goods, and requiring the sum of all Cobb-Douglas preference parameters on public goods to be the same for men and women, while specific preferences for specific public goods remain heterogeneous.⁷ Note that, since preference parameters are normalised to sum to 1, this implies that $\alpha_f^l + \alpha_f^c = \alpha_f^m + \alpha_f^m$.

For the purpose of estimating the sharing rule, this assumption allows us to proceed as if all goods were private, though in a manner that is theory-consistent with the presence of public goods. Under private-public neutrality, the inclusion of public goods only really bites when it comes to using the estimated sharing rule to estimate individual-level consumption. Even so, the inclusion of public goods makes a substantive difference to individual-level inequality estimates (see section 6).

3.5 Linear approximation of resource shares

The sharing rule $\eta_t(\mathbf{z}_h)$ is an unknown function of household characteristics. To estimate the sharing rule by linear regression, I linearly approximate it as:

$$\eta_t(\mathbf{z}_h) = \eta_t^0 + \boldsymbol{\eta}_t^z (\mathbf{z}_h - \bar{\mathbf{z}})$$

- The average resource share is η_f^0 for women, and $\eta_m^0 = 1 - \eta_f^0$ for men.
- $\boldsymbol{\eta}_t^z$ is the vector of marginal effects on sharing of household characteristics deviating from the sample average $(\mathbf{z}_h - \bar{\mathbf{z}})$. For instance, a woman with a higher-than-average wage will have a higher-than-average share. Since resource shares must sum to one within the household, her partner will correspondingly have a lower-than-average share: $\boldsymbol{\eta}_m^z = -\boldsymbol{\eta}_f^z$.

⁷An alternative interpretation would be that: $\alpha_t^Q \ln \left(f_t^Q (\mathbf{Q}_h) \right) = \alpha^Q \ln (f^Q (\mathbf{Q}_h))$. In this case, we do not need to lean into the Cobb-Douglas assumption further, but we shut down preference heterogeneity on public goods more fully.

3.6 A structural approach to the error term

To proceed to estimation, we must consider the source of any error terms. Firstly, there will be some error due to our linear approximation of the sharing rule based only on observable characteristics. By definition, the shocks sum to zero within each household, implying a correlation of -1 between the error terms for men and women. Secondly, there may be some optimisation error in the first stage of the household problem. This means that a member's individual budget will deviate relative to the optimal budget. These errors needn't sum to zero across household members' individual budgets since there is also scope for error in public good expenditure. The errors will be negatively correlated across household members, with a correlation weakly smaller in magnitude than -1. Thirdly, there may be some optimisation errors in the second stage of the household problem. This means that private leisure expenditure may deviate from optimum. These errors are likely uncorrelated between members. Taking these three sources of error, the final model can be written as:

$$w_{t,h}l_{t,h} = \alpha_t^l y_h (\eta_t^0 + \boldsymbol{\eta}_t^z (\mathbf{z}_h - \bar{\mathbf{z}})) + \epsilon_{t,h}$$

Under standard assumptions, $\epsilon_{t,h}$ is mean-zero and uncorrelated with other regressors. The errors have a correlation between -1 and 0 within household, so that a SURE estimation approach is recommended.

3.7 Estimation

This framework yields a linear and parsimonious system of structural estimating equations:

1. Equation for women: $w_{f,h}l_{f,h} = \beta_f^0 y_h + \boldsymbol{\beta}_f^z y_h (\mathbf{z}_h - \bar{\mathbf{z}}) + \epsilon_{f,h}$
2. Equation for men: $w_{m,h}l_{m,h} = \beta_m^0 y_h + \boldsymbol{\beta}_m^z y_h (\mathbf{z}_h - \bar{\mathbf{z}}) + \epsilon_{m,h}$

where $\beta_t^0 = \alpha_t^l \eta_t^0$ and $\boldsymbol{\beta}_t^z = \alpha_t^l \boldsymbol{\eta}_t^z$

Estimation follows these steps:

1. Use singles data to estimate $\Delta^l = \frac{\alpha_f^l}{\alpha_m^l}$. It is best to focus just on singles who are working for a few reasons. Firstly, this allows us to define the budget in the

same way, using wages. Secondly, we may worry about involuntary leisure for the unemployed complicating the estimation of preferences for leisure.

- (a) Run a regression for single working women: $w_h l_h = \alpha_{f,s}^l y_h$
 - (b) Run a regression for single working men: $w_h l_h = \alpha_{m,s}^l y_h$
 - (c) Under the SRAT assumption, estimate the ratio Δ^l from singles: $\Delta^l = \frac{\alpha_{f,s}^l}{\alpha_{m,s}^l}$
2. Run linear SURE regressions of the estimating equations, one for men and one for women, with the restriction that $\beta_f^z + \Delta^l \beta_m^z = \mathbf{0}$.
- (a) $\beta_f^z + \Delta^l \beta_m^z = \alpha_f^l \eta_f^z + \Delta^l \alpha_m^l \eta_m^z$
 - (b) Under SRAT, $\beta_f^z + \Delta^l \beta_m^z = \alpha_f^l (\eta_f^z + \eta_m^z)$
 - (c) By definition, $\eta_f^z + \eta_m^z = \mathbf{0}$
3. Estimate the average female share as $\hat{\eta}_f^0 = \frac{\hat{\beta}_f^0}{\hat{\beta}_f^0 + \Delta^l \hat{\beta}_m^0}$. This is because:
- (a) $\frac{\beta_f^0}{\beta_f^0 + \Delta^l \beta_m^0} = \frac{\alpha_f^l \eta_f^0}{\alpha_f^l \eta_f^0 + \Delta^l \alpha_m^l \eta_m^0}$
 - (b) Under SRAT, the preference parameters cancel out
 - (c) Since $\eta_f^0 + \eta_m^0 = 1$, the denominator sums to one
4. The average male share is $\hat{\eta}_m^0 = 1 - \hat{\eta}_f^0$
5. The preference parameter on leisure is $\hat{\alpha}_f^l = \frac{\hat{\beta}_f^0}{\hat{\eta}_f^0}$ for women and $\hat{\alpha}_m^l = \frac{\hat{\beta}_m^0}{\hat{\eta}_m^0}$ for men
6. The marginal impact of characteristics is $\hat{\eta}_f^z = \frac{\hat{\beta}_f^z}{\hat{\alpha}_f^l}$ and $\hat{\eta}_m^z = -\hat{\eta}_f^z$

Armed with the estimated sharing rule parameters, one can estimate household-specific resource shares in the dataset used for estimation (time use data): $\eta_{t,h}^{\hat{}} = \hat{\eta}_t^0 + \hat{\eta}_t^z (z_h - \bar{z})$. Moreover, one can apply the sharing rule to other comparable datasets (e.g. expenditure data, to estimate consumption) and estimate household-specific resource shares there. When applying the sharing rule to separate datasets, the relevant vector of average characteristics $\bar{z}$ remains the one from the estimating dataset.

3.7.1 Intuition for identification

The identification problem we face is that the man’s expenditure on private leisure may be more (less) responsive than the woman’s to changes in the household budget for one of two reasons, or a combination of them. The first possibility is that the man receives a larger (smaller) proportion of the household budget net of public good expenditure, i.e. he has a higher (lower) resource share than the woman. The second possibility is that the man’s preference for private leisure is stronger (weaker) relative to the woman’s, so that he spends a larger (smaller) proportion of his individual budget on private leisure. In order to disentangle these two channels, I employ my identifying assumption to pin down the impact of the preference channel, allowing me to then identify the sharing rule.

Empirically, identification of the levels of resource shares, and the marginal effects of different characteristics on them, is driven by different sources of variation in the data. For example, *ceteris paribus*, a higher wage for the man will reduce his leisure demand through a price effect, but increase it through a twofold income effect: (i) increased overall household budget, and (ii) increased own-resource share.⁸ Therefore, the leisure patterns of two similar couples that differ in the man’s wage help identify both the effect of male wage on sharing, and, by increasing the overall household budget, the levels of resource shares. Similarly, couples which are identical in characteristics apart from the age gap, and have different leisure patterns, help identify the effect of intra-couple age gaps on sharing.

Finally, it is important to note that, while this approach allows us to infer the split of overall resources from individual-level demands for a single good, it does not entail how other particular private goods are split between members. That depends not only on the resource split but also on unknown preference parameters for those goods.

⁸Browning and Gørtz (2012) find that the ‘unitary effect’, that leisure demand falls as its price increases, dominates the ‘collective effect’ of the individual’s bargaining power increasing in own-wage.

4 Data

4.1 Time use data: UKTUS

The UK Time-Use Survey (UKTUS 2000, 2014),⁹ is a high-quality cross-sectional time use survey that has been used in the economics literature (e.g. Kalenkoski et al. (2005)) but never before with the goal of estimating intra-household inequality. It is a national household-based study composed of: (i) a household questionnaire, (ii) an individual questionnaire, and (iii) individual time diaries. A household representative answered the household questionnaire, which includes information on household composition and location. The other components were answered by the relevant individual. The individual questionnaire asks about individual characteristics including age, educational attainment and earnings. Each member completed a weekday and weekend time diary identifying primary and secondary activities for each 10-minute interval over the two days. The time use data includes very detailed activities, location, and co-presence of others (distinguishing between household and non-household members). This enables me to define private leisure very precisely, as time spent doing leisure activities without other household members co-present. For a list of activities, and the ones I categorise as leisure, see supplemental appendix B. The time diaries are constructed carefully to minimise measurement error, for instance with the possibility of writing a simple sign to signify the same activity for multiple time intervals. The quality of the data is very high, with approximately 95% of observations having more than 5 distinct activities recorded in a day, and less than 90 minutes of unrecorded time.

I narrow the sample to heterosexual working couples without cohabiting children. This includes both couples who have never had children, and couples who have adult children who are no longer cohabiting with them.¹⁰ After cleaning the data, the final pooled (2000 and 2014) sample comprises 711 households (1,422 individuals). While the sample size is not particularly large, it is of a good size relative to this literature.¹¹

⁹Office for National Statistics. (2019b). United Kingdom Time Use Survey [data series] 2nd Release. <https://doi.org/http://doi.org/10.5255/UKDA-Series-2000054>

¹⁰Results are similar for younger individuals, who likely have never had children if they do not have cohabiting children in the home. Female shares for this group are somewhat higher on average, possibly driven by generational shifts towards more gender-equal views, and by gender differences in the ease of finding a new partner at an older age.

¹¹e.g. Cherchye, De Rock and Vermeulen (2012) estimate a closely related model on a sample

Summary statistics for some of the key variables are reported in table 1. Hourly pay is obtained by dividing labour income by actual hours worked, rather than contractual hours.¹² Women on average are more qualified, but command lower hourly wages than men. Couples generally form with an older, higher-earning man and a younger, lower-earning woman. Household budget is full income: the sum of the labour endowment of members (hourly wage multiplied by 24 hours).¹³

		UKTUS sample					LCF sample				
		mean	sd	p25	p50	p75	mean	sd	p25	p50	p75
Hourly pay (2020 GBP)	female	9.87	5.58	6.6	8.61	11.6	10.5	5.39	7.51	9.37	12.2
	male	11.6	8.74	7.51	9.78	13.1	12.2	7.61	7.79	10.4	14.3
Age (years)	female	41.9	13	30	43	53	42.1	13.6	29	43	55
	male	44	13.1	31	46	55	44	13.6	30	44	57
Qualification (levels 0,1,2) ¹⁴	female	.864	.824	0	1	2	1.04	.871	0	1	2
	male	.816	.813	0	1	2	.956	.857	0	1	2

Table 1: Summary statistics

4.2 Expenditure data: LCF

The LCF (Living Costs and Food Survey, previously Family Expenditure Survey, FES)¹⁵ is a UK survey containing information on individual and household characteristics, individual labour supply, detailed income data, and very detailed expenditure data. It is a repeated cross-section available yearly since 1961. It is a high-quality, nationally representative, large-scale survey that is used to estimate official government statistics. LCF/FES has been widely used both for policy applications and academic studies, including Bargain, Donni and Hentati (2022) and Lise and Seitz (2011).

The survey has multiple components: (i) a household survey recording household of 212 Dutch households. Small sample sizes are to some extent inevitable in applications where different household compositions are analysed separately.

¹²This, together with self-employed labour, explains the lower end of hourly wages (which are sometimes lower than the official minimum hourly wage).

¹³Accurate non-labour income data is not available in UKTUS.

¹⁴Highest qualification obtained, simplified into three categories. Category 2 is equivalent to an undergraduate degree or higher. Category 1 is equivalent to end-of-school diplomas e.g. A levels, IBDP, or equivalent technical qualifications. Category 0 is anything less than that, including lower technical qualifications and school diplomas obtained before the end of school e.g. GCSEs.

¹⁵Office for National Statistics. (2019a). Living Costs and Food Survey [data series] 3rd Release. <http://doi.org/10.5255/UKDA-Series-2000028>

characteristics and retrospective questions on infrequent expenses (rent, vehicles...); (ii) an individual questionnaire with individual characteristics, including demographic characteristics, hours worked and sources of income;¹⁶ and (iii) a detailed two-week expenditure diary for all members. The household questionnaire is answered by the reference person either alone, or together with other household members. Individual surveys, and expenditure diaries, are answered by the relevant person. The expenditure diaries are kept for two weeks by all household members older than 7.

The expenditure diary records the type of good in detail, and receipts are attached. Clothing and footwear are divided into male, female, and children. Household expenditure is obtained by summing outflows over all members.¹⁷ Additional information on expenditure on large infrequent expenses, such as house repairs, and regular expenses, such as rent, is obtained from the household survey. These expenditures are transformed to an equivalent weekly value to make them comparable to other categories.

I use data for the year 2014,¹⁸ and focus on the sub-sample of heterosexual working couples without cohabiting children. After cleaning the data, the final sample comprises 583 households (i.e. 1,166 individuals). Key variables are summarised in table 1.

5 Estimating the sharing rule

First, I estimate the ratio of the female-to-male preference parameter on private leisure from the sample of working singles in UKTUS. I find the preference parameters are approximately equal: $\hat{\alpha}_{m,s}^l \simeq \hat{\alpha}_{f,s}^l \simeq 0.6$.¹⁹ I test the null hypothesis that $\alpha_{m,s}^l = \alpha_{f,s}^l$

¹⁶In rare instances, income is top-coded. I adjust top-coded values using data on after-tax income percentiles from HM Revenue & Customs. HM Revenue & Customs. (2023). Percentile points from 1 to 99 for total income before and after tax. <https://www.gov.uk/government/statistics/percentile-points-from-1-to-99-for-total-income-before-and-after-tax>

¹⁷Note that any particular good may be purchased by a household member but consumed by any combination of them and/or other members, so personal expenditures do not measure personal consumption.

¹⁸The sharing rule was estimated using data from 2000 and 2014. I do not additionally analyse LCF data from 2000 as there were substantial changes in the dataset which undermine the feasibility of accurately pooling the 2000 and 2014 LCF datasets.

¹⁹Not only are these preference parameters similar to each other but, comfortably, they are higher than the estimated preference parameter for private leisure for working couples, which is 0.44. Since joint leisure is not an option for singles, and as preference parameters are normalised to one for

and cannot reject that the coefficients are the same at any of the usual significance levels. Therefore, the ratio of preference parameters is $\Delta^l = 1$. In this instance, SRAT coincides with an evidence-driven version of the SAP assumption.

Turning to the sample of working couples in UKTUS, I estimate the sharing rule. I allow resource shares to depend on the following characteristics: the hourly pay and educational attainment of both members, the age gap and average age of the couple,²⁰ and regional wealth in the household's region. The results are reported in table 2. I find that households do not share resources equally: the mean resource share for women is 0.45 and 0.55 for men (the medians are 0.44 and 0.56). Confidence intervals are reported in table 4, and I strongly reject equal sharing.

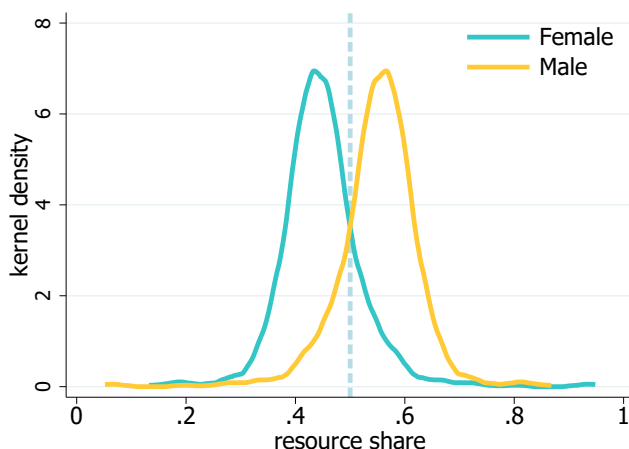


Figure 1: Baseline results, UKTUS. The distribution of male resource shares is a reflection of the distribution of female resource shares in the equal sharing (dotted) line. This is because each household's shares must sum to one.

The marginal effect of different characteristics on sharing is summarised in table 3. The direction of estimated marginal effects is consistent both with bargaining theory and with previous findings in the literature. Women's resource shares are higher in households with high female hourly pay and low male hourly pay. The impact of the former outweighs the latter, so that women in households with higher household budgets have higher resource shares, as shown in table 4. Note that in the model specification used in this paper, resource shares are equal to Pareto weights. As wages have a statistically significant effect on resource shares, this implies that Pareto

everyone, it seems reasonable for singles to have a higher parameter for private leisure.

²⁰The age gap is the difference in years between the man and the woman

Dependent variable	leisure expenditure	
Equation	male	female
Budget	0.243*** (0.00262)	0.198*** (0.00236)
Budget * dev. fem. hourly pay	-0.00559*** (0.000198)	0.00559*** (0.000198)
Budget * dev. mal. hourly pay	0.00215*** (6.87e-05)	-0.00215*** (6.87e-05)
Budget * dev. fem. qualification	-0.00295 (0.00253)	0.00295 (0.00253)
Budget * dev. mal. qualification	0.0154*** (0.00237)	-0.0154*** (0.00237)
Budget * dev. average age	0.000905*** (0.000151)	-0.000905*** (0.000151)
Budget * dev. age gap	0.000481 (0.000338)	-0.000481 (0.000338)
Budget * dev. regional wealth p.c.	-5.44e-07** (2.19e-07)	5.44e-07** (2.19e-07)
Observations (households)	711	711
R-squared	0.937	0.931

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2: Regression results, baseline specification, UKTUS. The symmetry of coefficients on the interaction terms is imposed as a constraint during SUR estimation. Budget * dev. variable = budget * (household-specific value of variable - sample average of variable)

weights are not determined exclusively by distribution factors. This is inconsistent with the unitary model and can be interpreted as evidence for the collective model. This finding is in keeping with several other findings in the household economics literature (see Cherchye, De Rock and Vermeulen (2012)).

Older couples (either because they are older or belong to more traditional generations) and couples with a larger age gap (older man relative to the woman) are characterised by a higher fraction of resources going to the man, although the latter effect is not statistically significant. Women have higher resource shares in regions with higher wealth per capita, potentially because of better outside options for women in wealthier regions, or due to wealthier regions proxying more gender progressive regions.

is often used as a proxy for sharing in the household. The model appears to fit the data well. Results are stable, and change in the theoretically consistent direction, when performing various robustness checks, including:

- Different definitions of private leisure, e.g. defining leisure in a much narrower way, excluding time spent sleeping, eating, and work breaks.
- Estimation on different samples, e.g. excluding outliers with particularly low or high wages, and estimating the sharing rule separately on 2000 and 2014 data.
- Running alternative regression specifications, e.g. substituting the gap between male and female qualification for the levels of male and female qualification, and excluding the age gap and regional wealth as determinants of bargaining power.

Moreover, the model imposes testable restrictions on estimates, which are satisfied. Mostly importantly, all resource shares fall within the unit interval.²² Additionally, in conformity to the way noise was incorporated in the model (see section 3.6), residuals are negatively correlated within the household, with a correlation coefficient of -0.09.²³

During estimation, I imposed the restriction that all coefficients apart from that on household budget sum to zero across equations. I run unconstrained SURE regressions and find the magnitudes of coefficients are similar across the two equations, and the signs are opposites of each other (though some of the estimated coefficients are statistically significantly different from each other). This suggests that imposing the restriction that these coefficients sum to zero across the equations is not far off from correct, and is not strong-arming the results.

5.1.1 Empirical evidence for the identifying assumption

Under my SRAT assumption, I estimate that the ratio between women's and men's preference parameter on private leisure is one. As a sense-check, I look at high-level patterns in the data on UK couples without cohabiting children. If men and women have the same preference for private leisure, then the proportion of household budget

²²I note that this is very much not mechanical: when I repeat my analysis using clothing and non-market-work, several estimates fall outside of the unit interval.

²³A statistical test of cross-equation independence rejects at the 5% significance level

spent on overall private leisure (the sum of expenditure on female private leisure and expenditure on male private leisure) should not vary with the distribution of bargaining power. This is consistent with UKTUS data: the budget share spent on private leisure is mildly, and not statistically significantly, correlated with my estimated resource shares. I repeat the same check with the wage ratio, a frequently used proxy for bargaining power, yielding similar results.

5.1.2 Testing private-public neutrality

I test whether the Cobb-Douglas preference parameters over all public goods sum to the same quantity for men and women $\sum_j \alpha_t^{Qj} = \alpha^Q$. I test this with LCF data for working singles. For singles there isn't a distinction between private and public goods in practice, but we can still distinguish theoretically between goods which are non-rivalrous and those that aren't, categorising goods in the same way for singles and couples. I regress aggregate material private goods expenditure on the budget for men and women. I cannot reject equality of coefficients at any of the usual significance levels. Having already tested that private leisure preferences are the same for single men and women, this entails that single men and women spend the same share of their budget on private goods. Since the remaining share is spent on public goods, it follows that, for singles, $\alpha_f^Q = \alpha_m^Q$. Hence, the result of this test is supportive of the private-public neutrality assumption for working couples.

I perform an additional high-level check using data on couples. If private-public neutrality holds, then the share of household budget devoted to private goods should be independent of the distribution of bargaining power. I have already checked that this holds for private leisure. I additionally use the LCF data for working couples to check that the share of household budget devoted to private material goods is independent of the distribution of bargaining power. The proportion of budget spent on private material goods is mildly, and not statistically significantly, correlated with my estimated resource shares. As a further check, I also repeat this exercise with the ratio of female-to-male wages as a commonly used proxy for household sharing. Again, the correlation is mild and not significant, suggesting that private-public neutrality is a reasonable simplification in the context of this paper's application.

5.1.3 Testing homotheticity

I test homotheticity of private leisure by estimating singles' private leisure expenditure separately for higher and lower income singles. I cannot reject equality of coefficients at any of the usual significance levels. Similarly, for singles, the correlation between the budget share of private leisure and their budget is mild and not significant. As a further check, I estimate resource shares separately for higher and lower budget couples. Parameter estimates are broadly similar to the baseline, and the resulting estimated resource shares are highly correlated (correlation of 0.85) with the baseline estimates.²⁴ Finally, I relax the homotheticity assumption by estimating the sharing rule under the assumption of Stone-Geary preferences.²⁵ Comparing the results to the baseline estimates, the direction of marginal effects is the same, and the estimated resource shares are very highly correlated (correlation of 0.97) with baseline estimates. Overall, it appears that, in this context, assuming homotheticity is not strong-arming results.

5.1.4 Back-of-the-envelope impact on utility

In Appendix D, I set out a back-of-the-envelope method to check that the estimated sharing rule parameters are quantitatively, as well as qualitatively, consistent with bargaining theory. I find that own utility is increasing in own wage under my estimated parameters. This is what we would expect since increased own wage improves one's outside option.

5.2 Alternative assignable goods

I re-estimate resource shares using two alternative assignable goods which are available in the LCF expenditure data: (i) non-market-work time, and (ii) clothing, and compare the findings. I construct non-market-work from a recall question on usual hours worked. For clothing, I observe expenditure on female clothing and expenditure on male clothing separately.

²⁴This is for the sample excluding outliers. The correlation coefficient including outliers is still high but falls to 0.75 as each of the two sub-samples only contains outliers in one direction.

²⁵In order to avoid colinearity issues due to the lack of accurate non-labour income data, this version is grounded in a version of the model where all goods are private and where the subsistence levels for private leisure are equal to zero.

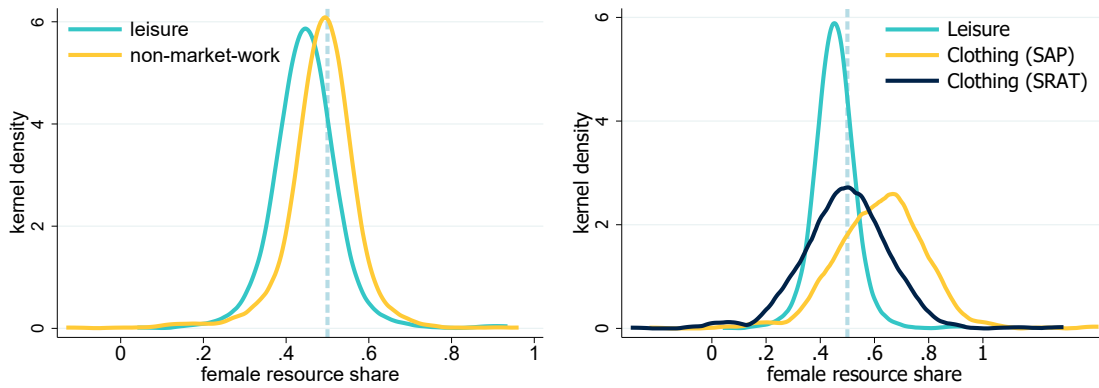


Figure 2: Estimated female shares using different assignable goods

Using singles LCF data, I find that women’s preference parameter for clothing is approximately 1.77 times larger than men’s, and equality is rejected at the 5% significance level. As a further check, I also estimate clothing preference parameters *for couples*, by running structural regressions of clothing expenditure on estimated individual budget computed using my baseline sharing estimates. This also yields a similarly larger female preference parameter for clothing. Turning to couples data, I estimate resource shares. The average for women and men is 0.50. While in the case of private leisure SRAT and SAP estimates coincide, for clothing this is very much not the case. As shown in figure 2, under the SAP assumption the whole distribution of female shares from clothing is shifted to the right, and the average is 0.63. The impact of characteristics on sharing is the opposite of what we would expect from bargaining theory. Estimates are very noisy and negatively correlated with my baseline estimates. However, since clothing is non-homothetic, these clothing estimates are to be taken with a pinch of salt.

I repeat a similar analysis for non-market-work. Women’s preference parameter for non-market-work is approximately 1.07 times larger than men’s, and equality is very strongly rejected. As can be seen in figure 2, the whole distribution is shifted towards equal sharing relative to my baseline estimates, and the average share is 0.47 for women and 0.53 for men. The difference between the non-market-work average female share is statistically significantly different from my baseline estimate. Characteristics have similar qualitative impact on shares, and the estimates are highly correlated with my baseline results (the correlation coefficient is 0.76). This difference is consistent with non-market-work including some public time use as well as

private leisure, biasing estimates towards equal sharing. This bias may be larger in applications with cohabiting children, where women spend substantially more time than men on childcare and domestic work.

5.3 Comparison to other papers with UK applications

My paper is closely related to two papers which also focus on the UK context: Bargain, Donni and Hentati (2022) and Lise and Seitz (2011). Lise and Seitz (2011) use non-market-work as the assignable good, and their framework differs from this paper in several respects, including parametric specification, identifying assumption,²⁶ and estimation approach. The last cohort in their data, born in the 1960s, has an average female share of 44.2%, though this includes couples with non-participation, who may have lower female shares.

Bargain, Donni and Hentati (2022) also estimate sharing in the UK. They use clothing as the assignable good, and their approach differs both from this paper and from Lise and Seitz (2011) in several respects, including the choice of identifying assumption, parametric specification, and estimation approach. They find the average resource share for women in heterosexual couples without children (including non-participants) in 1978-2007 is 51.7%. They find an upward trend in female shares over time, implying a higher estimate for 2000-14. Bargain, Donni and Hentati (2022) is not the only paper to have found higher average shares for women than men (see Almås et al. (2020)). However, even in a country like the UK, which is comparatively gender progressive, it would be somewhat surprising if women had higher shares than men, given still prevalent patriarchal tradition and norms.

6 Estimating individual-level inequality

Applying the sharing estimates to LCF expenditure data, I find substantial gender gaps between men's and women's material consumption, 'consumption' for short. I also estimate gender gaps in 'full' consumption, including time use.

²⁶The 'symmetry' of bargaining assumption in Lise and Seitz (2011) is not consistent with my findings: in my setting, a woman with an hourly wage equal to the average male wage in the sample is estimated to have only a 47% share, substantially below the average male share of 55%.

6.1 Methodology for individual-level material consumption

I define individual-level consumption as the monetary market value of an individual's consumption. This is calculated as the sum of household material public expenditure and the individual's share of the household's material private expenditure. An alternative approach would additionally consider individual Lindahl prices for public goods, to adjust consumption of public goods by the individual's enjoyment of them. An example of this is the Money Metric Welfare Index (MMWI) of Chiappori, Meghir and Okuyama (2024). With this type of measure, someone who is objectively consuming less than someone else may be considered just as well off if they are compensated by deriving more utility from their partner's consumption. This is of interest for other applications, but in the context of measuring individual-level consumption inequality, including poverty rates, it is more natural to focus on the objective (preference-independent) value of material consumption.

Using the detailed expenditure data in LCF, which is divided into very granular categories (COICOP codes), I split household expenditures into public and private expenditures. I exclude some outflows which are incompatible with the static nature of the model (e.g. saving, insurance and investments). While several papers in the literature exclude housing and cars, these are the largest expenditures in my UK data. Moreover, housing is the biggest component of public consumption and household economies of scale. It is therefore desirable to take housing and vehicles into account, but doing so is complicated because of: (i) the way these goods are purchased, (ii) regional variations in house prices, and (iii) the partially private and partially public nature of cars. I propose an approach that tackles these difficulties in a simple manner, drawing on information included in the LCF on the number of vehicles owned, and the characteristics of the home the family lives in (number of bedrooms, area type, region...).

Firstly, I impute rents for homes and leases for cars. This tackles the infrequency problem for homes that are owned outright, and allows for comparability between homes which have similar characteristics but are owned outright, purchased with a mortgage (the interest on which varies vastly by year and credit score of the purchasing party), rented privately, and rented publicly (e.g. council housing provided as a benefit). Secondly, I propose standardising imputed rents for homes across UK regions. This is because the monetary market value of an individual's material con-

sumption is the correct metric to measure consumption inequality only when prices of goods are reasonably similar for people in the sample. For material goods, individuals in the same country generally face similar market prices for the same goods (although the composition of consumption varies between individuals).²⁷ The exception is housing, which in a country like the UK is priced very differently across regions. That price heterogeneity is relevant for the purpose of estimating wealth inequality, but should be abstracted from in estimating consumption inequality. For instance, someone living in London may receive a higher salary than someone living in Manchester, spend a larger proportion of that salary on a home of the same underlying quality, and spend the same amount on other consumption. Then the person living in London would have higher wealth (if they own the home) but the same level of consumption as the person living in Manchester. Finally, I draw on separate car usage data to estimate the degree to which cars are public goods, and to which degree they are private. Further methodological details are provided in supplemental appendix C.

In order to apply my estimated sharing rule to LCF data, I construct all of the variables which my sharing rule depends on from the detailed information contained in LCF on individual and household characteristics. As shown in table 1, the LCF sample is characterised by somewhat higher wages and education than the UKTUS sample. Hence, female shares are slightly higher in LCF than UKTUS, although the mean female share remains 45%.

To calculate individual-level consumption, I sum the household’s public material expenditure and the individual’s estimated proportion of private material expenditure. In general, that proportion is given by:

$$\frac{\alpha_t^c \eta_{t,h}}{\alpha_f^c \eta_{f,h} + \alpha_m^c \eta_{m,h}}$$

If I had found that $\alpha_f^l \neq \alpha_m^l$, I would have had to further estimate α_f^c and α_f^m to implement this. However, given private-public neutrality and my finding that $\alpha_f^l = \alpha_m^l$, it must be that $\alpha_f^c = \alpha_m^c$ in my application, and hence this adjusted share simplifies to $\eta_{t,h}$. In this case, individual-level material consumption is obtained by summing (i) public good expenditure and (ii) private good expenditure weighted by

²⁷For instance, see DellaVigna and Gentzkow (2019) on uniform pricing across the U.S.

the individual's resource share:

$$C\hat{C}_{t,h} = \eta_{t,h} \left(\sum_j p^j c_h^j \right) + \left(\sum_j r^j X_h^j \right)$$

Note that this discussion would be the same regardless of the assignable good used to estimate the sharing rule in the first place. The estimated resource shares summarise how total private expenditure, on both private material goods and private leisure time, is split between members. In a model with time use, when assigning expenditure only on private material goods, the shares must be adjusted if men and women are believed to have different preferences for private leisure relative to material consumption.

6.2 Findings for individual-level material consumption

For heterosexual working couples without cohabiting children, the average gender gap in consumption is 8.53%.²⁸ This substantial gap would go undetected under the standard ‘per capita’ approach because it is fully driven by intra-household inequality. The reason this gap is smaller than the average gender gap in resource shares is that the sharing rule only applies to private expenditures, while consumption is also inclusive of public expenditure. The Gini coefficient is 0.21, and 6.43% of the group live in relative poverty (consuming less than 60% of the median individual-level consumption). Since women have lower resource shares than men, especially in lower income households, the poverty rate is higher for women (7.03%) than for men (5.83%); a gender gap of 20.59%.²⁹ These measures of inequality would likely be higher for the broader UK population than for my sample of working couples without cohabiting children.

Even though the inclusion of public goods only really bites at this stage of my proposed approach, rather than at the stage of estimating the sharing rule, it still makes a substantial difference. If I modify my approach to only consider private consumption, or to treat public expenditures as private, this substantially overestimates inequality. This is especially true for absolute measures of poverty, as these mechanically increase

²⁸This gap is defined as the difference between mean male consumption and mean female consumption, divided by mean male consumption.

²⁹Defined as the female poverty rate minus the male poverty rate, divided by the male poverty rate

if some expenditures are excluded. Excluding public expenditure, the Gini coefficient increases to 0.30 and the poverty rate to 15.95%. When treating public expenditure as private (similarly to the approach in Lechene et al. (2022)), the Gini coefficient increases to 0.24 and the poverty rate to 9.01%.

6.3 Individual-level ‘full’ consumption (including time use)

We may be interested in the monetary value of individual-level consumption including time use. Following Becker (1965) and Lise and Seitz (2011) I term this ‘full’ consumption. Here, I take this to mean the sum of individual-level material consumption and private leisure.³⁰ It is possible to estimate ‘full’ consumption even when time use and expenditure datasets are separate, as long as we observe hours worked $m_{t,h}$ and hourly wage $w_{t,h}$ in the expenditure data. Then, in the expenditure data, we can estimate $w_{t,h}l_{t,h} = \hat{\alpha}_t^l y_h \eta_{t,h}$ using estimates of $\eta_{t,h}$ and $\hat{\alpha}_t^l$ from the time use data.

I find that the average gender gap in individual-level consumption is higher (11.3%) when taking time use into account. Since the price of time varies at the individual level, time-inclusive measures of individual-level consumption are harder to interpret at face value. I re-estimate individual-level consumption using the average wage, instead of own-wage, as the price of time. This lowers the average gender gap because men’s wages are higher than women’s on average. However, the gender gap estimated in this manner (10.1%) is still higher than the measure excluding time use.³¹

7 Conclusion

In this paper, I have proposed a novel way of estimating individual-level consumption via a two-step approach. First, using time use data to estimate the intra-household sharing rule, and then applying this estimated rule to an expenditure survey to estimate individual-level consumption. While the method is structural, under my proposed simplifying assumptions it yields very tractable resource share estimating equations

³⁰In order to take joint leisure and domestic work, one would first need to develop an approach to carefully disentangling between the two. This is sometimes challenging, e.g. in situations where one member of the household reports joint leisure as they were watching TV in the same room as their partner, who reports domestic work because they were ironing while watching TV.

³¹Note that this does not contradict the finding that men and women spend the same share of their individual budget on leisure - the inequality arises from men having larger individual budgets.

that can be estimated from data that is relatively easy to collect. I also contribute to the literature on how to estimate individual-level consumption from household-level expenditure data and estimates of resource shares. In particular, I show the importance of carefully distinguishing between private and public consumption at this stage. Moreover, this paper is the first to provide estimates of ‘full’ individual-level consumption inequality. These are supportive of the widely held view that gender inequality may be underestimated when only considering material consumption.

My empirical finding of substantial gender inequality within households, even in the context of the UK, one of the most gender equal countries in the world, strongly suggests that the widely used equal sharing assumption is not fit for purpose. It is important for policy to be guided by measures of consumption inequality that account for unequal sharing within households. For instance, one of the United Nations’ Sustainable Development Goals for 2030 is the eradication of extreme poverty. In order to accurately track progress towards this goal, and evaluate which policies are most impactful, it is crucial to have accurate estimates of poverty. To tackle inequality within households, it may be important to employ different policies than to reduce inequality between households, e.g. targeting women with in-cash transfers, provision of free sanitary products and contraceptives, and measures to narrow gender pay gaps.

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Supplemental Appendix

A Identification in a more general setting

In this appendix, I sketch out how identification of the resource share works in a more general setting. The linear approximation of the sharing rule is semi-parametrically point-identified under an identifying assumption restricting preference heterogeneity. First, a composite coefficient is identified by linear regression. This step relies on standard assumptions for linear regression. Then, the sharing rule parameters are identified from the composite coefficient by imposing an identifying assumption restricting preference heterogeneity. I prove the identification result with an argument by construction. This discussion builds on the identification result in Dunbar et al. (2013) and the estimation framework of Lechene et al. (2022), extending them to a setting with (i) public goods instead of shareable goods, (ii) time use as well as material consumption, and (iii) price-variation (which is necessary to model time use, as the price of time is not constant across the sample).

A.1 Identification result

Theorem A.1. *The linear approximation of the sharing rule $\eta_t^0 + \sum_z \eta_t^z (z_h - \bar{z})$ is fully identified if (i) for each household member we observe a function of demand for assignable good $c_{t,h}^a$:*

$$f(c_{t,h}^a) = f(c_t^a(p, w_{t,h}, Q_h, (y_h - R_h Q_h) \eta_{t,h}))$$

and (ii) the following Assumptions hold.

Assumption A.1.1. Linearity in resource shares.

$f(c_{t,h}^a)$ can be decomposed into a component $f_t^0 \eta_{t,h}$ which is linear in the resource share:

$$f(c_{t,h}^a) = \sum_{\varphi} f_t^{\varphi}(p, w_{t,h}, Q_h, (y_h - R_h Q_h) \eta_{t,h}) + f_t^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h) \eta_{t,h})$$

This assumption imposes that the assignable good demand functions (or some func-

tion of demand) have a *component* which is linear in the individual's second-stage budget. Roy's identity can be used to check whether a specific indirect utility function is consistent or not with this requirement. Some functional forms that are consistent with this assumption are: (i) the Linear Expenditure System (Cobb-Douglas or Stone-Geary, see Stone (1954) and Geary (1950)), (ii) Price-Independent Generalised Linear (PIGL) (indirect utility functions that are a function of $\rho_{t,h}^k, k > 0$, see Muellbauer (1976)) and (iii) Price-Independent Generalised Logarithmic (PIGLOG) (indirect utility functions that are a function of $\ln \rho_{t,h}$ e.g. the Almost Ideal Demand System, see Muellbauer (1976) and Deaton and Muellbauer (1980)).³² The category of functional forms that satisfy this assumption include those used in Lechene et al. (2022), which requires that Engel curves be of the Almost Ideal Demand System, and those used in Dunbar et al. (2013), which require that budget share functions are linear in functions of expenditure. These are both examples of functions of demand that have a component which is linear in the resource share.

Assumption A.1.2. *Linearity in unknowns.*

Part A. The vectors of unknown resource share parameters η_t and preference parameters α_t enter $f(c_{t,h}^a)$ linearly in the sense that:

$$f(c_{t,h}^a) = a_t + \sum_{\varphi} b_t^{\varphi} g^{\varphi}(p, w_{t,h}, Q_h, (y_h - R_h Q_h), (y_h - R_h Q_h)(z_h - \bar{z})) \\ + \gamma_t \left(\eta_t^0 + \sum_z \eta_t^z (z_h - \bar{z}) \right) g^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h))$$

Where: (i) $a_t(\alpha_t, \eta_t)$ and $b_t^{\varphi}(\alpha_t, \eta_t)$ are unknown constants which may be (potentially composite) preference parameters, or composite parameters composed of preference parameters and resource share parameters, (ii) $\gamma_t(\alpha_t)$ is a potentially composite preference parameter and (iii) g^{φ} and g^0 are observed in the data.

Part B. The functions $a_t(\alpha_t, \eta_t)$ and $b_t^{\varphi}(\alpha_t, \eta_t)$ are linear in the vector of resource

³²Weaker parametric assumptions are also consistent with this assumption. For instance, preferences may be represented as Cobb-Douglas over the assignable good, an aggregate private and an aggregate public good (instead of Cobb-Douglas over each granular good). Alternatively, demand for the assignable good may be modelled as being linear in the budget without restricting the functional form of demands for other goods, and only requiring them to be jointly consistent with rational preferences.

share parameters η_t .

The assumption that unknowns enter linearly is required so that the estimating equations can be estimated by linear regression. If the resource share is modelled as a type-specific constant η_t^0 , with no vector of characteristics affecting sharing, z_h , then Part A of this assumption is sufficient. Then, we have:

$$f(c_{t,h}^a) = a_t(\alpha_t, \eta_t^0) + \sum_{\varphi} b_t^{\varphi}(\alpha_t, \eta_t^0) g^{\varphi}(p, w_{t,h}, Q_h, (y_h - R_h Q_h)) \\ + \gamma_t \eta_t^0 g^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h))$$

In this case, the identification result holds exactly for a broad families of preferences, including the Almost Ideal Demand System.

If instead we wish to allow sharing to depend on a vector of household characteristics, z_h , then we additionally require Part B of this assumption. In this case, the identification result holds exactly for fewer parametric forms, such as the Linear Expenditure System. Where Part B does not hold, it is possible to relax it by linearising whichever components of $f(c_{t,h}^a)$ are problematic. For instance, Lechene et al. (2022) linearise part of the Almost Ideal Demand System Engel curves to estimate sharing with covariates by OLS.

Assumption A.1.3. Rank condition.

No component of $g^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h))$ or $(z_h - \bar{z}) g^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h))$ is co-linear with any other component of $f(c_{t,h}^a)$

Noting that $\beta_t^0 = \gamma_t \eta_t^0$ and $\beta_t^z = \gamma_t \eta_t^z$, we can write the estimating equations (with covariates z_h) as:

$$f(c_{t,h}^a) = a_t + \sum_{\varphi} b_t^{\varphi} g^{\varphi}(p, w_{t,h}, Q_h, (y_h - R_h Q_h), (y_h - R_h Q_h)(z_h - \bar{z})) \\ + \beta_t^0 g^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h)) + \sum_z \beta_t^z (z_h - \bar{z}) g^0(p, w_{t,h}, Q_h, (y_h - R_h Q_h))$$

We can see that the rank condition is required so that coefficients β_t^0 and β_t^z can be identified separately from other coefficients in $f(c_{t,h}^a)$. This is necessary because we

will identify η_t^0 and η_t^z from β_t^0 and β_t^z . Depending on the functional form of choice, this assumption can imply restrictions on which variables z_h influence the resource share. A related assumption which is often made in the literature is that resource shares are invariant to expenditure (see Dunbar et al. (2013) for a discussion of why this assumption is reasonably non-restrictive both theoretically and empirically).

Assumption A.1.4. *Invertibility condition.*

$$\gamma_t \neq 0, \forall t$$

Depending on the chosen functional form specification, parts of the general form of $f(c_{t,h}^a)$ may be absent, e.g. there may be no constant term a_t . However, the component which is linear in the resource share must be present for identification to work. The interpretation of this assumption depends on the functional form used in implementation. With Cobb-Douglas preferences, we can think of this as a requirement that the assignable good does not command a very small budget share. If using the Almost Ideal Demand System, then this assumption is equivalent to the requirement in Lechene et al. (2022) that the slope of the Engel curves for the assignable good isn't too close to zero.

Assumption A.1.5. *Regression.*

Any noise in the observed data is uncorrelated with the right-hand-side variables. The variables have non-zero variance.

As discussed in section 3.6, there are multiple sources of possible noise in our estimating equations. In order to identify the coefficients of interest by linear regression, this noise must be uncorrelated with right-hand-side variables and have non-zero-variance.

Assumption A.1.6. *SAP, SAT or SRAT.*

Assume a suitable restriction on preference heterogeneity on parameter γ_t .

A.1.1 Identification proof

Proof. Firstly, by assumptions A.1.1 - A.1.5 and the usual arguments for identification from linear regression, the constants a_t and β_t^0 , and the vectors b_t^φ and β_t^z can be estimated by OLS (one for each person type) and hence are identified.

Secondly, resource share parameters η_t are identified from the β coefficients by assumption A.1.6. Intuitively, the resource share parameters η_t enter into the β coefficients multiplicatively with the (composite) preference parameter γ_t , so we require an identifying assumption to separately identify the resource share parameters. The proof is outlined separately for each of the three candidate identifying assumptions:

- Under SAT, the preference parameter γ_t is identified from singles data, so that $\gamma_t = \gamma_{t,single} = \gamma_t$ is known. Therefore, we compute: $\eta_t^0 = \frac{\beta_t^0}{\gamma_t}$ and $\eta_t^z = \frac{\beta_t^z}{\gamma_t}$.
- Under SAP, the average resource share of each type is identified by $\eta_t^0 = \frac{\beta_t^0}{\beta_f^0 + \beta_m^0}$. This is because under SAP $\frac{\beta_t^0}{\beta_f^0 + \beta_m^0} = \frac{\gamma_t \eta_t^0}{\gamma_t \eta_f^0 + \gamma_t \eta_m^0} = \frac{\eta_t^0}{\eta_f^0 + \eta_m^0} = \eta_t^0$ since, by definition, resource shares sum to one within the household. The marginal impact of characteristic z is identified by $\eta_t^z = \frac{\beta_t^z}{\beta_t^0} \eta_t^0$. This is because under SAP $\frac{\beta_t^z}{\beta_t^0} \eta_t^0 = \frac{\gamma_t \eta_t^z}{\gamma_t \eta_t^0} \eta_t^0 = \eta_t^z$.
- Under SRAT, the proof is similar to SAP with the difference that we identify $\frac{\gamma_f}{\gamma_m} = \frac{\gamma_{f,single}}{\gamma_{m,single}} = \Delta$ from singles data and then identify the average resource share of each type as $\eta_f^0 = \frac{\beta_f^0}{\beta_f^0 + \Delta \beta_m^0}$ and $\eta_m^0 = 1 - \eta_f^0$. As for SAP, the marginal impact of characteristic z is identified by $\frac{\beta_t^z}{\beta_t^0} \eta_t^0 = \eta_t^z$.

□

A.2 Example with the Almost Ideal Demand System

Consider preferences which are separable in public and private goods, and where the private good sub-utility corresponds to the Almost Ideal Demand System (Deaton and Muellbauer (1980)).³³ Then Engel curves for the assignable good take the form:

³³This is an extension of the set-up in Lechene et al. (2022) to public goods, but without shareable goods. If also wishing to incorporate the shareable goods framework, this can be done as in Lechene et al. (2022), with their assumption that A is block-diagonal so that there are no cross-good complementarities relating to the assignable good $A = \begin{pmatrix} A^X & 0 \\ 0 & A^c \end{pmatrix}$. This assumption ensures that the assignable good Engel curves have the usual form, instead of the more complex form which would result from cross-good complementarities with other goods.

$$\frac{p_{t,h}^a c_{t,h}^a}{\rho_{t,h}} = \alpha_t + \sum_j \gamma_t^j \ln p_{t,h}^j + \beta_t \ln \rho_{t,h} - \beta_t \left(\alpha_t^0 + \sum_j \alpha_t^j \ln p_{t,h}^j + \frac{1}{2} \sum_j \sum_k \gamma_{kj} \ln p_{t,h}^k \ln p_{t,h}^j \right)$$

Here the notation for material private goods is used to also include private leisure, so that $p_{t,h}^l = w_{t,h}$. Hence, the t subscript on prices. There is also an h subscript as the prices of some material goods may vary between households e.g. due to regional variations.

We re-write the Engel curves in terms of observables and the object of interest, remembering that $\rho_{t,h} = \eta_{t,h}(y_h - R_h Q_h)$ and multiplying through by the resource share:

$$\begin{aligned} \frac{p_{t,h}^a c_{t,h}^a}{y_h - R_h Q_h} &= \eta_{t,h} (\alpha_t - \beta_t \alpha_t^0) + \eta_{t,h} \sum_j ((\gamma_t^j - \beta_t \alpha_t^j) \ln p_{t,h}^j) \\ &\quad - \eta_{t,h} \beta_t \frac{1}{2} \sum_j \sum_k \gamma_{kj} \ln p_{t,h}^k \ln p_{t,h}^j + \eta_{t,h} \beta_t \ln \eta_{t,h} + \eta_{t,h} \beta_t \ln (y_h - R_h Q_h) \end{aligned}$$

The prices of public goods R_h are indexed by h both because of potential regional variation and because of the price of public time use depending on the wages of household members.

- As required by assumption A.1.1, the estimating equation has a component which is linear in the resource share. In fact, it has multiple such components. The most natural one to identify the sharing rule from is $\eta_{t,h} \beta_t \ln (y_h - R_h Q_h)$.
- As required by part A of assumption A.1.2, the estimating equation is linear in unknowns if we consider resource shares to be type-specific constants. Even though $\eta_{t,h}$ enters non-linearly through the $\eta_{t,h} \beta_t \ln \eta_{t,h}$ term, when $\eta_{t,h} = \eta_t^0$, this term becomes $\eta_t^0 \beta_t \ln \eta_t^0$ and hence becomes part of the constant term.
- However, part B of assumption A.1.2 is not satisfied because of the non-linear $\eta_{t,h} \beta_t \ln \eta_{t,h}$ term. Hence, if we are interested in household-specific resource

shares varying with z_h we need to linearly approximate the $\eta_{t,h}\beta_t \ln \eta_{t,h}$ term (similarly to Lechene et al. (2022)):

- We can linearly approximate $\beta_t \ln \eta_{t,h}$ as $\kappa_t^0 + \sum_{\omega} \kappa_t^z \omega_h$, where ω_h could coincide with the characteristics z_h used in the resource share approximation, or be transformations of z_h . Substituting this in and rearranging we obtain:

$$\begin{aligned} \frac{p_{t,h}^a c_{t,h}^a}{y_h - R_h Q_h} &= \eta_{t,h} (\alpha_t - \beta_t \alpha_t^0 + \kappa_t^0) + \eta_{t,h} \sum_j ((\gamma_t^j - \beta_t \alpha_t^j) \ln p_{t,h}^j) \\ &- \eta_{t,h} \beta_t \frac{1}{2} \sum_j \sum_k \gamma_{kj} \ln p_{t,h}^k \ln p_{t,h}^j + \eta_{t,h} \left(\sum_{\omega} \kappa_t^z \omega_h \right) + \eta_{t,h} \beta_t \ln (y_h - R_h Q_h) \end{aligned}$$

- The rank condition is satisfied if
 - We are interested in estimating resource shares as type-specific constants, and $\ln (y_h - R_h Q_h)$ is not colinear with the other observables i.e. $\sum_j (\ln p_{t,h}^j)$ and $\sum_j \sum_k \ln p_{t,h}^k \ln p_{t,h}^j$. These terms are not colinear if more than one household member works.
 - We are interested in estimating household-specific resource shares (with covariates), and $(y_h - R_h Q_h)$ is not an element of z_h or ω_h . A related assumption in Lechene et al. (2022) is that resource shares don't depend on the household budget.
- The invertibility assumption requires that assignable good Engel curves are sufficiently responsive to household budget net of public expenditure.

The Almost Ideal Demand System Engel curves are not very tractable if all prices vary in the sample. This is both because it becomes highly multi-dimensional and because estimating it requires high-quality, detailed price data. As a result, Dunbar et al. (2013) and Lechene et al. (2022) assume no price variation and drop the price index terms into the constant. This was possible because time use was not modelled in those papers. In a model with time use, there will be some price variation in the form of individual-level wages, even if we can assume all other prices to be constant in the sample.³⁴ If this is the case, we can simplify the estimating equations to:

³⁴To avoid dealing with this, if the assignable good is material, we could assume preferences that are separable in material goods and time use.

$$\frac{p_{t,h}^a c_{t,h}^a}{y_h - R_h Q_h} = a_t^0 \eta_{t,h} + a_t^1 \eta_{t,h} \ln w_{t,h} + a_t^2 \eta_{t,h} (\ln w_{t,h})^2 + \sum_{\omega} a_t^{\omega} \omega_h \eta_{t,h} + \eta_{t,h} \beta_t \ln (y_h - R_h Q_h)$$

Even so, as soon as we add covariates affecting intra-household bargaining, z_h , this exponentially increases the number of regressors because of the interaction between ω and η , which both depend on these covariates. Many of these regressors will be highly correlated. Without yet more approximation, this is not a tractable specification, especially for estimation with small samples, which are common in this literature.

B Time use data

I provide the list of activities in UKTUS 2014 (where the name of the activity is very long, I abbreviate it and indicate this with an ellipsis in square brackets). The list is very similar, with minor differences, for UKTUS 2000. I indicate which activities are included in my baseline definition of leisure.

I also conduct robustness analyses removing some of the activities which are borderline between leisure and domestic work, such as gardening, and activities which, like sleep, may be more likely to have externalities on other family members. Both in my baseline and robustness checks, I focus only on leisure time which was spent ‘NOT with other household members’ (there are several binary variables coding co-presence information), with the exception of sleep, where I allow other household members to be co-present.

Activity list from UKTUS 2014	Leisure?
Unspecified personal care	Y
Visiting and receiving visitors	Y
Correspondence	
Unspecified organisational work	
Other specified ball games	Y
Gymnastics	Y
Visiting a wildlife site	Y

Activity list from UKTUS 2014	Leisure?
Celebrations	Y
Work for an organisation	
Fitness	Y
Unspecified TV video or DVD watching	Y
Watching a film on TV	Y
Telephone conversation	
Unspecified childcare as help to other households	
Other specified or unspecified arts and hobbies	Y
Volunteer work through an organisation	
Unspecified water sports	Y
Other specified TV watching	Y
Unspecified food management	
Watching a film on video	Y
Watching sport on video	Y
Other specified water sports	Y
Other specified video watching	Y
Food preparation and baking	
Disposal of waste	
Other specified physical exercise	Y
Physical care and supervision of own child [...]	
Study: Unspecified activities [...]	
Unspecified productive exercise	
Dish washing	
Study: Classes and lectures	
Information searching on the internet	
Hunting and fishing	
Preserving	
Other specified social life	Y
Other specified information by computing	
Study: Homework	
Communication on the internet	Y
Main job: unspecified main job	
Unspecified entertainment and culture	Y

Activity list from UKTUS 2014	Leisure?
Other specified communication by computing	Y
Unspecified other computing	
Skype or other video call	Y
Travel escorting to/ from education	
Main job: Working time in main job	
Cinema	Y
Other specified computing	
Second job: Working time in second job	
Travel related to household care	
Main job: Coffee and other breaks in main job	Y
Unspecified theatre or concerts	Y
Plays musicals or pantomimes	Y
Opera operetta or light opera	Y
Concerts or other performances of classical music	Y
Unspecified informal help to other households	
Dance performances	Y
Unspecified listening to radio and music	Y
Other specified theatre or concerts	Y
Sleep	Y
Sleep: In bed not asleep	Y
Food management as help to other households	
Other specified food management	
Listening to music on the radio	Y
Sleep: Sick in bed	
Borrowing [...] from a library	
Reference to books and other [...] within a library	
Using internet in the library	
Household upkeep as help to other households	
Reading newspapers in a library	Y
Other specified radio listening	Y
Unspecified household upkeep	
Other specified library activities	
Sports events	Y

Activity list from UKTUS 2014	Leisure?
Unspecified games	Y
Gardening and pet care as help to other households	
Cleaning dwelling	
Travel related to voluntary work and meetings	
Study: other specified activities [...]	
Construction and repairs as help to other households	
Other specified productive exercise	
Cleaning yard	
Unspecified games and play with others	Y
Billiards pool snooker or petanque	Y
Shopping and services as help to other households	
Heating and water	
Other specified parlour games and play	Y
Free time study	
Swimming	Y
Travel escorting a child other than education	
Unspecified sports related activities	Y
Activities related to sports	Y
Arranging household goods and materials	
Unspecified video watching	Y
Other unspecified entertainment and culture	Y
Visiting a historical site	Y
Gambling	Y
Visiting a botanical site	Y
Visiting a leisure park	Y
[...] supervision of child as help to other household	
Teaching non-coresident child	
Reading playing & talking to non-coresident child	
Accompanying non-coresident child	
Other or unspecified entertainment or culture	Y
Reading playing & talking to own non-coresident child	
Accompanying own non-coresident child	
Other specified childcare as help to other household	

Activity list from UKTUS 2014	Leisure?
Travel related to organisational work	
[...] supervision of an adult as help to another household	
Accompanying an adult as help to another household	
Other specified help to an adult member of another household	
Unspecified help to an adult of another household	
Resting - Time out	Y
Other specified informal help to another household	
Other specified informal help	
Second job: Coffee and other breaks in second job	Y
Outdoor team games	Y
Travel related to informal help to other households	
Unspecified participatory activities	Y
Eating	Y
Meetings	
Other or unspecified household upkeep	
Other specified games	Y
Religious activities	
Unspecified making and care for textiles	
Laundry	
Ironing	
Handicraft and producing textiles	
Travel related to religious activities	
Activities related to employment: Unspecified [...]	
Travel to visit friends/relatives in their homes [...]	
Activities related to employment: Lunch break	Y
Travel related to other social activities	
Other personal care: Unspecified other personal care	Y
Visiting an urban park playground designated play area	
Travel related to entertainment and culture	
Other personal care: Wash and dress	Y
Computing - programming	
Other specified making and care for textiles	
Travel related to participatory activities [...]	

Activity list from UKTUS 2014	Leisure?
Gardening	Y
Tending domestic animals	
Caring for pets	
[...] Other specified activities related to employment	
[...] Activities related to job seeking	
Walking the dog	
Unspecified information by computing	
[...] Other unspecified activities related to employment	
Travel related to other leisure	
Other personal care: Other specified personal care	Y
Travel related to physical exercise	
Travel escorting an adult other than education	
Travel related to hunting & fishing	
Travel related to productive exercise [...]	
Other specified gardening and pet care	
Unspecified construction and repairs	
Unspecified communication by computer	Y
House construction and renovation	
Repairs of dwelling	
Travel to work from home and back only	
Picking berries mushroom and herbs	
Making repairing and maintaining equipment	
Woodcraft metalcraft sculpture and pottery	Y
Other specified making repairing and maintaining equipment	
Vehicle maintenance	
Travel related to gambling	
Travel related to hobbies other than gambling	
Other specified construction and repairs	
Unspecified shopping and services	
Unspecified shopping	
Shopping mainly for food	
Shopping mainly for clothing	
Shopping mainly related to accommodation	

Activity list from UKTUS 2014	Leisure?
Shopping or browsing at car boot sales or antique fairs	
Window shopping or other shopping as leisure	Y
Other specified shopping	
Commercial and administrative services	
Personal services	
Other specified organisational work	
Travel related to changing locality	
Unspecified household and family care	
Travel to holiday base	
Travel for day trip/just walk	Y
Other specified shopping and services	
Live music other than classical concerts opera and musicals	Y
Household management not using the internet	
Shopping for and ordering clothing via the internet	
Unspecified household management using the internet	
Shopping [...] via the internet	
Shopping for and ordering food via the internet	
Shopping for [...] accommodation via the internet	
Shopping for and ordering mass media via the internet	
Shopping for and ordering entertainment via the internet	
Banking and bill paying via the internet	
Other specified household management using the internet	
Art exhibitions and museums	Y
Other specified travel	
Unspecified radio listening	Y
Unspecified library	
Punctuating activity	
Unknown: at home	
Unspecified childcare	
Filling in the time use diary	
Study: Unspecified study school or university	
Unspecified physical care & supervision of a child	
Feeding the child	

Activity list from UKTUS 2014	Leisure?
Other specified participatory activities	Y
No main activity no idea what it might be	
Using computers in the library other than internet use	
Other and unspecified physical care & supervision of a child	
Teaching the child	
No main activity some idea what it might be	
Reading playing and talking with child	
Illegible activity	
Accompanying child	
Listening to recordings	
Unspecified time use	
Queryable	
Other specified performing arts	Y
Listening to sport on the radio	Y
Travel related to unspecified time use	
Other or unspecified childcare	
Travel related to personal business	
Travel related to services	
Unspecified mass media	Y
Unspecified help to a non-dependent [...]	
Physical care of a non-dependent [...]	
Accompanying a non-dependent [...]	
Other specified help to a non-dependent [...]	
Unspecified help to a dependent adult [...]	
Physical care of a dependent adult [...]	
Accompanying a dependent adult [...]	
Solo games and play	Y
Unspecified hobbies games and computing	Y
Other specified help to a dependent adult [...]	
Watching sport on TV	Y
Travel related to shopping	
Unspecified sports and outdoor activities	Y
Unspecified employment	

Activity list from UKTUS 2014	Leisure?
Unspecified social life and entertainment	Y
Travel to/from work	
Travel in the course of work	
Chess and bridge	Y
Unspecified volunteer work and meetings	
Unspecified reading	Y
Travel to work from a place other than home	
Reading periodicals	Y
Reading books	Y
Unspecified arts	Y
Unspecified visual arts	Y
Painting drawing or other graphic arts	Y
Making videos taking photographs or related photographic activities	Y
Not applicable	
Computer games	Y
Other specified visual arts	Y
Unspecified performing arts	Y
Singing or other musical activities	Y
Unspecified physical exercise	Y
Help to other households in employment and farming	
Literary arts	Y
Walking and hiking	Y
Taking a walk or hike that lasts at least miles or 1 hour	Y
Other specified arts	Y
Other walk or hike	Y
Jogging and running	Y
Unspecified social life	Y
Unspecified hobbies	Y
Activities related to productive exercise	
Biking skiing and skating	Y
Biking	Y
Skiing or skating	Y
Indoor team games	Y

Activity list from UKTUS 2014	Leisure?
Socialising with family	
Collecting	Y
Travel related to education	
Unspecified ball games	Y
Indoor pairs or doubles games	Y
Other specified reading	Y
Outdoor pairs or doubles games	Y

C Methodological details on consumption estimation

C.1 Excluded categories

I exclude expenditure categories which have almost no immediate consumption value and cannot easily be squared with the static model underlying the methodology in this paper. This includes: savings, insurance, investments, major house works including renovation (minor repairs are included), financial gifts, bets, gambling and expenditure on education (the latter is minor for working couples without cohabiting children).

Sometimes expenditures are partly funded by the government and this is visible in the expenditure data for some goods. Where this is the case, I do not detract any subsidies or refunds from expenditure, since these still contribute to material well-being.³⁵

C.2 Private vs public consumption

Based on the detailed COICOP plus codes into which expenditure is divided in the LCF, I divide expenditure between private and public. While it would be possible to categorise expenditure based on less granular data, the granularity aids accuracy. For

³⁵For other applications, e.g. to estimate what proportion of the population has access to a minimal standard of living, we might not consider the consumption of ‘bads’ to contribute to that standard of living, and hence also exclude those.

instance, most house-cleaning products are categorised as public (as they contribute to the public cleanliness of the house) but washing powders are categorised as private as more is needed to wash the clothes of more members. In some cases, it might be possible to use other data (e.g. data on car occupancy) to estimate to what degree a good (e.g. cars) is public and to what degree it is private. We can think of car-related expenditures (insurance, fuel, etc.) as separate goods depending on the type of trip, where some of them are private and some of them are public. A car and related expenses could be purely public if everyone in the household only used it together (e.g. to drive to a holiday home). Alternatively, it could be purely private if only one household member used it to drive to work. As discussed in more detail below, I approximate the economies of scale of car-related expenditures using UK car occupancy data.

C.3 Homes and vehicles

For less expensive durables such as clothing and phones, I use the LCF expenditure data without adjustments. While for any specific category this is likely to lead either to over-estimates or under-estimates, the overall expenditure across categories is likely to be a reasonably accurate estimate of usual expenditure. For very large expenses (buying a home or a vehicle), a different approach is needed, since the magnitude of these expenditures dwarves regular weekly purchases. Moreover, these expenditures are often diluted over some periods of time, with a mortgage or loan, with repayments depending not only on the quality of the good being purchased but also on factors which are not directly relevant to material well-being, such as macroeconomic conditions at the time of purchase and individual credit score. Keeping in mind the goal of measuring material well-being, we wish to estimate the value of the good being consumed (e.g. a home in a certain area with a certain number of rooms) while abstracting from extraneous considerations (e.g. whether the home is owned or rented). Of course, the household may financially benefit from owning outright instead of renting, through decreased monthly expenditures on housing. However, this will translate into increased expenditures on other goods, and hence will still be accounted for insofar as it affects material well-being.

Imputed rents for homes Housing is a particularly complex good from the viewpoint of measuring inequality in the UK. The prices of homes with similar attributes in different regions differs vastly, but households generally have limited choice as to their location, especially in the short run (due to jobs, relationships, and coordination between members). While it is approximately true that goods like food are similarly priced across the UK, assuming price homogeneity for homes across the UK would be too unrealistic (e.g. homes in the London area command a very large premium). Another source of difficulty is that homes are sometimes owned outright, sometimes they are purchased with a mortgage (the interest on which varies vastly by year and credit score of the purchasing party), sometimes they are rented privately, and sometimes publicly (e.g. council housing provided as a benefit). To avoid both the issue of infrequency and the problem of comparability between renters, outright owners, and owners paying back a mortgage, I impute a weekly standardised rental price. This price increases in the quality of the home (as measured by the number of bedrooms, centrality of location, etc.) but is standardised across different purchasing conditions, as well as for regional house price differences (the latter being mostly something that affects the investment value of the property rather than reflecting the underlying quality of the home).

I suggest the following approach:

- Using data on private renters, I regress rent expenditure on
 1. Number of bedrooms. This is the best proxy for home size available in the data.
 2. Area type. The 2011 Area Classification for Output Areas (OAC) categorises postcodes into types e.g. areas dominated by ‘urban professional and families’. Using granular OAC codes, I define four aggregated area types: rural, more desirable urban, less desirable urban, and suburban.
 3. Council tax band. Council tax bands are available for homes in England, Wales, and Scotland (I impute them for Northern Ireland). Council tax bands are based on legacy valuations of homes, and provide a good signal of the quality of the home.
 4. Region (Wales, Scotland, Northern Ireland, and the nine regions of England). There are substantial regional disparities in the prices of homes in the UK.

- I impute the rent for all households in the data (including those who own, rather than rent) based on these characteristics.
- Next, I standardise imputed rents across regions by indexing them to the region with the lowest median imputed rent (the North East of England). I deflate the imputed rents for homes in other regions by the ratio of the median imputed rent in their region to the median imputed rent in the North East of England. This procedure can be thought of as uncovering the fundamental quality of the consumption obtained from the house, disentangling it from other considerations like investment value of property. I also note that households often cannot move region (at least in the short run), but can choose the specific location of their home (with different associated OAC code), its size (proxied by the number of bedrooms) and broader quality (proxied by council tax band).
- For each household I record the standardised imputed rent.
- A small number of households have a second home, but the LFS data contains no information on the second home. Where this is the case, I double the standardised imputed rent of the main home, since the value of the main home is the best available signal in the data of the likely value of the second home.
- I add the standardised imputed rents to public household expenses.

Imputed lease price for vehicles Car purchases are the second largest expenditure items after homes for many UK households. For this reason, it is important not to exclude this expenditure. Following a principle similar to the one outlined above for housing, I propose a rental approach to vehicles (cars, vans and motorcycles):

- I calculate the median weekly lease price paid by households that lease a vehicle.
- For each household, I observe how many vehicles they own, and estimate their vehicle lease expenditure by multiplying the average lease price by the number of vehicles owned.
- I add 54% of this imputed lease to private expenditures and the remaining 46% to public expenditures. This approximation is based on data from the National

Travel Survey³⁶ on the proportion of car trips by purpose, and data on the occupancy rate of cars by trip purpose.³⁷ This method aims to capture the likely economies of scale of cars, although of course further granularity could be achieved if the data contained information on how the household uses cars. We can think of this as dividing car-related expenditures into multiple goods, some of which are private (e.g. car trips for solo work trips) and some of which are public (e.g. car trips for family holidays).³⁸

D Back-of-the-envelope check

In order to check that the magnitudes (as well as signs) of sharing rule parameter estimates are consistent with bargaining theory, I substitute estimated parameters into indirect utility functions and check whether an increase in own-wage implies an increase in own-utility.

Wage changes impact utility through multiple channels:

1. A price effect on own private leisure. This tends to lower utility through decreased private leisure.
2. An income effect through overall household budget. This tends to increase utility through increased overall consumption.
3. An income effect through sharing. This tends to increase utility through increased overall consumption.
4. A price effect on joint leisure and domestic work. This tends to lower utility through decreased public time use.
5. Increased weight on own preferences in the composition of the aggregate public good. This tends to increase utility as the budget share devoted to public goods

³⁶Department for Transport. (2021). National Travel Survey: 2020. <https://www.gov.uk/government/statistics/national-travel-survey-2020/national-travel-survey-2020#trends-in-car-trips>

³⁷Department for Transport. (2022). Car or van occupancy and lone driver rate by trip purpose, England: 2002 onwards. <https://www.gov.uk/government/statistical-data-sets/nts09-vehicle-mileage-and-occupancy>

³⁸I do not attempt to adjust this split based on the numbers of vehicles owned as I am not aware of data that would enable such an adjustment.

is increasingly assigned to specific public goods one has a stronger preference for.

Because I do not estimate the whole model, I cannot compute exact utility changes. Instead, I conduct a back-of-the-envelope calculation by assuming away the last two effects. I consider the average household, allowing only the female wage to vary. I show that female utility is increasing in female wage for reasonable initial values of the female wage (due to linear approximation, the sharing rule is best applied to wage counterfactuals that are not extreme). I then repeat the same exercise for male utility and the male wage, obtaining the same result.

Female utility is:

$$u_f = 0.44 \ln\left(\frac{0.44\eta_f(w_f + w_m)}{w_f}\right) + \alpha^Q \ln\left(\frac{\alpha^Q(w_f + w_m)}{r}\right) + (1 - \alpha^Q - 0.44) \ln\left(\frac{\eta_f(1 - \alpha^Q - 0.44)(w_f + w_m)}{p_f}\right)$$

This equation relies on the fact that, for working couples, the estimated preference parameter on leisure is 0.44 (for both men and women). Moreover, as a back-of-the-envelope simplification, I defined the aggregate public good (private material good) as total expenditure on public goods (private material goods) divided by a fixed constant price r (p_f).

The derivative with respect to female wage is:

$$\frac{du_f}{dw_f} = \frac{1}{w_f + w_m} + \frac{1 - \alpha^Q}{\eta_f} \frac{d\eta_f}{dw_f} - \frac{0.44}{w_f}$$

Substituting in the estimated sharing rule $\eta_f = 0.45 + 0.01(w_f - 9.87)$ and the fact that, for an average household, the male wage is $w_m = 11.6$ we obtain:

$$\frac{du_f}{dw_f} = \frac{1}{w_f + 11.6} + 0.01 \frac{1 - \alpha^Q}{0.45 + 0.01(w_f - 9.87)} - \frac{0.44}{w_f}$$

The estimated parameters are theory-consistent if $\frac{du_f}{dw_f} > 0$. I evaluate this for three options of w_f : (i) the lower quartile of the female wage (£6.6), (ii) the mean female wage (£9.87), and (iii) the upper quartile of the female wage (£11.6).

For a woman with a lower quartile wage:

$$\frac{du_f}{dw_f} = \frac{1}{18.2} + \frac{1 - \alpha^Q}{41.73} - \frac{2.2}{33}$$

$\frac{du_f}{dw_f} > 0$ if $\alpha^Q < 0.51$. This is very likely to include the true parameter value since $\alpha^l + \alpha^c + \alpha^Q = 1$ and $\alpha^l = 0.44$, so that if $\alpha^Q > 0.51$ the parameter on private material goods would have to be less than 0.05, which is very low.

For a woman with the mean wage:

$$\frac{du_f}{dw_f} = \frac{1}{21.47} + \frac{1 - \alpha^Q}{45} - \frac{0.44}{9.87}$$

$\frac{du_f}{dw_f} > 0$ if $\alpha^Q < 1.09$, which is definitionally the case.

For a woman with an upper quartile wage:

$$\frac{du_f}{dw_f} = \frac{1}{23.2} + \frac{1 - \alpha^Q}{46.73} - \frac{0.44}{11.6}$$

$\frac{du_f}{dw_f} > 0$ if $\alpha^Q < 1.24$, which is definitionally the case.

Repeating the same exercise for men:

$$\frac{du_m}{dw_m} = \frac{1}{9.87 + w_m} + 0.005 \frac{1 - \alpha^Q}{0.55 + 0.005(w_m - 11.6)} - \frac{0.44}{w_m}$$

For a man with a lower quartile wage of £7.51, consistency with bargaining theory requires:

$$\frac{1}{17.38} + \frac{1 - \alpha^Q}{105.91} - \frac{0.44}{7.51} > 0$$

This entails that $\alpha^Q < 0.89$, which is definitionally the case since $\alpha^l + \alpha^c + \alpha^Q = 1$ and $\alpha^l = 0.44$.

For a man with a mean wage of £11.6, consistency with bargaining theory requires:

$$\frac{1}{21.47} + \frac{1 - \alpha^Q}{110} - \frac{0.44}{11.6} > 0$$

This entails that $\alpha^Q < 1.95$, which is definitionally the case.

For a man with an upper quartile wage of £13.1, consistency with bargaining theory requires:

$$\frac{1}{22.97} + \frac{1 - \alpha^Q}{111.5} - \frac{0.44}{13.1} > 0$$

This entails that $\alpha^Q < 2.11$, which is definitionally the case.

Hence, for both men and women, for reasonable variations of wages and keeping other characteristics at the sample-average values, own-utility is increasing in own-wage, consistently with bargaining theory.

E Estimation and hypothesis testing

Under standard assumptions, the regression coefficients (β_f^0, β_m^0) are consistent estimators of their population counterparts, i.e.

$$N \rightarrow \infty : (\beta_f^0, \beta_m^0) \rightarrow (\mu_{\beta 0f}, \mu_{\beta 0m})$$

The average female share is estimated as a function of these objects:

$$\eta_f^0(\mu_{\beta 0f}, \mu_{\beta 0m}) = \frac{\mu_{\beta 0f}}{\mu_{\beta 0f} + \Delta^l \mu_{\beta 0m}}$$

By the Continuous Mapping Theorem:

$$N \rightarrow \infty : \eta_f^0(\beta_f^0, \beta_m^0) \rightarrow \eta_f^0(\mu_{\beta 0f}, \mu_{\beta 0m})$$

The asymptotic distribution of the regression coefficients (β_f^0, β_m^0) is found by the Central Limit Theorem:

$$\sqrt{N} \begin{bmatrix} \beta_f^0 - \mu_{\beta 0f} \\ \beta_m^0 - \mu_{\beta 0m} \end{bmatrix} \xrightarrow{D} \mathcal{N}(0, \Sigma)$$

Where N is the sample size and $\Sigma = \begin{bmatrix} \sigma_{\beta 0f}^2 & \sigma_{\beta 0fm}^2 \\ \sigma_{\beta 0fm}^2 & \sigma_{\beta 0m}^2 \end{bmatrix}$

As long as the first two moments of this distribution are finite, and the Jacobian of the resource share as a function of the regression coefficients exists and is non-zero valued, we can apply the delta method to find the asymptotic distribution of the estimated resource share:

$$\eta_f^0(\beta_f^0, \beta_m^0) \xrightarrow{D} \mathcal{N}\left(\eta_f^0(\mu_{\beta 0f}, \mu_{\beta 0m}), \frac{\delta \Sigma \delta'}{N}\right)$$

Where:

$$\delta = \begin{bmatrix} \frac{\delta \eta_f^0(x,y)}{\delta x} \Big|_{x=\mu_{\beta 0f}, y=\mu_{\beta 0m}} & \frac{\delta \eta_f^0(x,y)}{\delta y} \Big|_{x=\mu_{\beta 0f}, y=\mu_{\beta 0m}} \end{bmatrix} = \begin{bmatrix} \frac{\Delta^l \mu_{\beta 0m}}{(\mu_{\beta 0f} + \mu_{\beta 0m})^2} & \frac{-\Delta^l \mu_{\beta 0f}}{(\mu_{\beta 0f} + \mu_{\beta 0m})^2} \end{bmatrix}$$

We can construct the confidence interval as:

$$\left[\eta_f^0(\mu_{\beta 0f}, \mu_{\beta 0m}) \pm c \sqrt{\frac{\delta \Sigma \delta'}{N}} \right]$$

Since we do not know the population parameters of the distributions, we substitute consistent estimators for the parameters in the δ vector and in the variance-covariance matrix. Hence, we use the following estimates to construct the confidence interval:

$$\hat{\delta} = \begin{bmatrix} \frac{\delta \eta_f^0(x,y)}{\delta x} \Big|_{x=\beta_f^0, y=\beta_m^0} & \frac{\delta \eta_f^0(x,y)}{\delta y} \Big|_{x=\beta_f^0, y=\beta_m^0} \end{bmatrix} = \begin{bmatrix} \frac{\Delta^l \hat{\beta}_m^0}{(\beta_f^0 + \hat{\beta}_m^0)^2} & \frac{-\Delta^l \hat{\beta}_f^0}{(\beta_f^0 + \hat{\beta}_m^0)^2} \end{bmatrix}$$

And we use the variance-covariance matrix for our regression coefficients:

$$\frac{\hat{\Sigma}}{N} = \begin{bmatrix} \sigma_{\beta 0f}^2 & \sigma_{\beta 0fm}^2 \\ \sigma_{\beta 0fm}^2 & \sigma_{\beta 0m}^2 \end{bmatrix}$$

In Stata, confidence intervals can be obtained using the command nlcom.