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PAID AND UNPAID FEMALE WORK: SUBSTITUTES OR COMPLEMENTS? SOME EVIDENCE FROM BRITAIN[2]

Abstract

The article studies the time allocation patterns of working-age women in late 20th century Britain using diary data. It estimates the uncensored unpaid work and non-work functions with respect to age, wage, non-labor income, the number and ages of children, other adult housework contributions; and inserts the recovered coefficients in the mathematical expressions of a behavioral model structured around the maximization of a personal Cobb-Douglas utility function involving non-work and the consumption of goods and services. The adoption of a CES expression for consumption, comprising of purchased and domestically-produced goods and services (which are acquired via paid and unpaid work, respectively), introduces a substitution parameter. The econometric findings fit with the mathematical expressions when the substitution parameter is positive, which suggests that women view(ed) purchased and household-produced items as complements to each other. This is relatable to major policy initiatives regarding the enticement of women out of household into market production and from part-time to full-time employment.

Keywords: Time-Use, Time Budgets, Labor Supply, Household Production, Non-Work.
JEL-Codes: C24, D13, J16, J22.

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1. Introduction

The article explores the question of whether women view market and non-market work as substitutes or complements for each other. The aim is to contribute to the growing literature regarding the study of time allocation, and the ongoing discussion in Europe relating to the enticement of women out of household into market production and from part-time to full-time employment, in order to increase the level of employment and the GDP (e.g., Garibaldi and Wasmer, 2003; Pissarides et al., 2005; EU, 2010). Though relatable to major macroeconomic and social policy initiatives, to the best of our knowledge, the specific issue has not attracted much empirical analysis.

One explanation is that while the importance of human time as a fundamental economic resource is undisputed, for a long time its study was limited to its paid work component. Even though unpaid work has been considered an important *economic activity* in every sense of the word since the term's inception (Xenophon, circa 362/1 BC), practical reasons have made the collection of data pertaining to paid activities a great deal easier vis-à-vis the collection of data on unpaid work producing goods and services consumed within the household or bartered with neighbors. Indeed, paid work is recorded both regularly and in detail by employers, employees or the authorities and is evidenced easily through pay-checks, bonuses, income tax documents, contracts etc. On the other hand, unpaid work involves activities which are either not memorable or repetitive from day to day (involving ordinary household tasks such as cooking and cleaning, home repairs, etc.) that do not leave traces or proxies in the manner that paid work activities do. Consequently, unpaid work goes unmeasured or is poorly measured in the censuses and conventional employment or labor force surveys. In an attempt to rectify this situation and properly explore issues associated with unpaid work, as well as other time-uses, following the example of sociologists and psychologists, a number of economists have turned to the study of micro-data recovered through time-budgets (diaries).[3] (E.g., Kooreman and Kapteyn, 1987; Biddle and Hamermesh 1990; Juster and Stafford, 1991; Hamermesh et al., 1995; Hamermesh and Pfann, 2005). In Greece, calls to collect such data in order to improve the grasp of individual or household behavior in the labor market or at home have not borne fruit. As a result, indigenous researchers are constrained to explore issues through samples obtained from overseas.

The third component of time-use consists of non-work activities, such as leisure and personal care. These are no longer perceived as external

3. The use of time-budget data has advanced the study of paid work as well. Indeed, as diary surveys are more likely to log actual hours of paid work rather than contracted hours (as conventional surveys do), they may be extremely useful in empirical analyses of the labor supply insofar as the data they solicit exhibit higher responsiveness to wages compared to data solicited in labor force surveys (e.g. Klevmarken, 2005). In the present article, the diary data on other time-uses allow an empirical evaluation of the two most common *second generation* techniques employed in the estimation of the paid work equation.

to the economic system, and, in fact, are recognized as the time needed to consume the goods and services bought with the monetary income earned from paid-work and/or prepared by means of unpaid work (Himmelweit, 1991; Winston, 1991). In fact, Mincer (1962), Becker (1965), and Gronau (1977) have provided a unified theory regarding paid work and the other time-use components. This theory is at the heart of the analysis that follows.

In particular, we consider the time allocation choices of an individual (lone or family member) in the context of a utility maximization problem subject to income and time constraints, and explore the mathematical relationships deriving from the first order conditions of this theoretical model. Next we analyze female time-use data obtained via two British household surveys prior the adoption of the EU's 2000-2010 *Lisbon Strategy* on female employment and other economic, social, environmental objectives. More specifically, we will (a) estimate the effects of age, wage, non-labor income, the number and ages of children, and the unpaid work contributions of other household members on women's time allocations to paid (market) work, unpaid (domestic) work and non-work; and (b) apply the econometric findings on the aforementioned theoretical model. The intent is to infer women's disposition towards the substitutability/complementary of purchased and domestically-produced commodities and, hence, towards paid or/and unpaid work needed for their acquisition or production.

The rest of the paper is organized as follows: Section 2 sets up and works out the mathematical relationships of the theoretical model. Section 3 introduces the data and discusses the coefficients recovered from the time-use regressions. Section 4 explores the consistency of the model's first order condition relationships with the empirical findings, and Section 5 discusses the implications by furnishing a diagrammatical demonstration of both the model and the empirical results. Finally, Section 6 offers the main conclusions.

2. The model

The model involves a family member's utility maximization (encompassing the special case of a lone individual), while taking into account her domestic production associated with unpaid work. More specifically, it employs a personal utility function of a Cobb-Douglas type, subject to income and time constraints:

$$U_i = (s_i C)^a L_i^b, \quad U_C \text{ and } U_L > 0, \tag{1}$$

where L_i stands for a person's own leisure, personal care and other non-work time allocation components, and C for a composite commodity purchased or produced in the household, a share (s_i) of which is consumed by person i. (The rest is consumed by other household mem-

bers.) The exponents are positive and reflect preferences over the two inputs.

C consists of goods and services that may be either purchased (C_1) or produced (C_2). We first discuss the features of C_1 and C_2 and then their relation to *C*:

- C_1 is acquired from the market at price, *P*. Its value cannot exceed the total available household income which consists of members' salaries ($\Sigma w_i H_i$), non-labor sources (v) and borrowing. However, for the sake of simplicity, we can take it to be equal to total earnings, i.e.,

$$C_1 \times P = \Sigma w_i H_i + v = \Sigma w_i (T_i - t_i - L_i) + v, \quad (2)$$

  with w_i standing for one's wage and T_i for the total number of weekly hours that one has at his or her disposal. T_i is allocated among paid work (H_i), unpaid work (t_i), and time spent in leisure and other non-work activities (L_i). That is, $T_i = H_i + t_i + L_i$, (3) where T_i = 7 days × 24 hours = 168 hours per week.
- C_2 refers to the sum of goods and services produced via the household members' production function. It depends on household technology, perhaps human capital, and requires time and effort in the form of unpaid or non-market work, t_i:[4] $C_2 = \Sigma h t_i^{d_i}$, (4) where *h* is positive and serves as a technology indicator, and $d_i \in (0,1)$ ensures positive productivity and diminishing returns.[5]

However, the goods and services purchased or produced domestically, though substitutes, may or may not constitute perfect substitutes to each other. As a result a simple linear relationship between the two, e.g., $C_1 + xC_2$, to replace *C*, is probably unwarranted. Similarly, a product arrangement of the sort $C_1 \times xC_2$ is also undesirable given that it presupposes that all households both earn income in the market and engage in domestic production in order to enjoy a positive utility. Instead, the standard Constant Elasticity of Substitution (CES) functional form allows both for convexity and perfect substitution between earned income and unpaid production:

$$C=[mC_1^{-q} + (1-m)\, C_2^{-q}]^{-1/q}, \text{ with } 0 < m < 1 \text{ and } -1 < q \neq 0, \quad (5)$$

where *m* captures the relative desire/need for monetary income (and

4. Household production may require the input of some portion of market goods and services. Yet, the exclusion of C_1 from the expression for C_2 simplifies the calculations and, in principle, allows production by those abstaining from the paid workforce.
5. See Chiang (1984) and Gronau (1986). The assumptions concerning *d* constitute a simplification of reality considering that there is no telling what pattern the returns may take in relation to a person's time and effort put in a project. For instance, in a well-known incident related by Vitruvius 9.10, Archimedes's negligible (mental) work returns were followed by a sudden breakthrough.

enters as the weight given to the consumption of goods acquired from the market compared to goods acquired via household production), and *q* is the substitution parameter. According to Chiang (1984), if it is positive the inputs are rather complementary to each other.

The incorporation of expressions (2) and (4) into (5), and the substitution of the latter in expression (1) transform the utility function of the hypothetical member of a two-person household of married or unmarried mates, adult siblings or other adult relatives,[6] into the following:

$$U_1 = s_i^a \left\{ \underbrace{m\left[(w_1/P)(T - L_1 - t_1) + (w_2 H_2 / P) + v/P\right]^{-q}}_{C_1} + \underbrace{(1-m)\left[ht_1^{d_1} + ht_2^{d_2}\right]^{-q}}_{C_2} \right\}^{-a/q} L_1^b \quad (6)$$

where C_1 and C_2 correspond to the first and second terms in brackets, on the right-hand side of (6).

This can also be expressed as $U_1 = s_j^a \Omega^{-a/q} L_1^b$, with Ω standing for the long term in braces. Solving the optimization problem yields the following first order conditions:

$$\text{First, with respect to } L_i\text{: } -s_i^a \frac{a}{q} \Omega^{\frac{-a}{q}-1} m(-q)\, C_1^{-q-1}\, (-w_1/P)\, L_1^b + s_i^a b \Omega^{\frac{-a}{q}} L_1^{b-1} = 0. \quad (7)$$

Division by $s_i^a L^{b-1} \Omega^{-(a+q)/q}$, which is positive, along with the elimination of *q* in the numerator and denominator of the first term, yields:

$$am\, C_1^{-q-1}\, w_1\, L_1/P = b\Omega \rightarrow m\, C_1^{-q-1}\, w_1/P = (b\Omega)/(aL_1). \quad (7a)$$

Second, with respect to t_1:

$$-\frac{a}{q}\, s_i^a\, \Omega^{\frac{-a}{q}-1} L_1^b \left[mqC_1^{-q-1}(w_1/P) - (1-m)q\, C_2^{-q-1} hd_1\, t_1^{d_1-1} \right]. \quad (8)$$

The outcome requires the long expression in brackets be equal to zero.

Dividing each of its two components by *q* yields:

$$mC_1^{-q-1} w_1/P = (1-m)C_2^{-q-1} hd_1\, t_1^{d_1-1}. \quad (8a)$$

6. In the two British samples considered in this paper, all adult cohabitants happen to be either spouses or blood relatives. Nothing in the model precludes the absence of a second person (i.e., the existence of a lone person) or the presence of an additional person or people, the effect of whom may be captured by additional terms, w_3H_3, $ht_3^{d_3}$, much like w_2H_2 and $ht_2^{d_2}$ in expression (6).

Manipulation of the latter yields: $C_1^{-q-1} = C_1^{-(q+1)} = \dfrac{(1-m)C_2^{-q-1}hd_1t_1^{d_1-1}}{mw_1/P}$,

hence $$C_1 = (1-m)^{\frac{-1}{q+1}} C_2 \, (hd_1)^{\frac{-1}{q+1}} \, t_1^{\frac{-(d_1-1)}{q+1}} (mw_1/P)^{\frac{1}{q+1}} . \qquad (9)$$

Equating the right-hand sides of expressions (7a) and (8a) yields:

$$b\Omega / aL_1 = (1-m)C_2^{-q-1}hd_1t_1^{d_1-1} \rightarrow b\Omega = aL_1(1-m)C_2^{-q-1}hd_1t_1^{d_1-1}. \qquad (10)$$

But Ω stands for a collection of terms, namely the collection of terms between braces in expression (6). Substituting these terms in expression (10) yields:

$$b\left[mc_1^{-q} + (1-m)c_2^{-q}\right] = aL_1(1-m)c_2^{-(q+1)}hd_1t_1^{d_1-1}. \qquad (10a)$$

Replacing C_1 with the expression provided in (9), yields:

$$b\left[m\left((1\text{-}m)^{\frac{q}{q+1}}C_2^{-q}(hd_1)^{\frac{q}{q+1}}t_1^{\frac{q(d_1-1)}{q+1}}(mw_1/P)^{\frac{-q}{q+1}}\right) + (1-m)C_2^{-q}\right] =$$

$$aL_1(1-m)C_2^{-(q+1)}hd_1t_1^{d_1-1}.$$

Division by $(1-m)C_2^{(q+1)}hd_1t_1^{d_1-1}$, transforms this to:

$$b\left[mm^{\frac{-q}{q+1}}(1\text{-}m)^{\frac{q}{q+1}-1}C_2(hd_1)^{\frac{q}{q+1}-1}t_1^{\frac{q(d_1-1)}{q+1}-(d_1-1)}(w_1/P)^{\frac{-q}{q+1}} + C_2(hd_1)^{-1}t_1^{-(d_1-1)}\right] \qquad (11)$$

$$\rightarrow L_1 = \frac{b}{a}\left[m^{\frac{1}{q+1}}(1\text{-}m)^{\frac{-1}{q+1}}C_2(hd_1)^{\frac{-1}{q+1}}t_1^{\frac{-(d_1-1)}{q+1}}(w_1/P)^{\frac{-q}{q+1}} + C_2(hd_1)^{-1}t_1^{-(d_1-1)}\right]$$

$$\rightarrow L_1 = \frac{b}{a}C_2\left[(m)^{\frac{1}{q+1}}(1\text{-}m)^{\frac{-1}{q+1}}(hd_1)^{\frac{-1}{q+1}}t_1^{\frac{1-d_1}{q+1}}(w_1/P)^{\frac{-q}{q+1}} + (hd_1)^{-1}t_1^{1-d_1}\right].$$

And for $C_2 = h(t_1^{d_1} + t_2^{d_2}) \geq 0$, which is given in expression (4), we get:

$$L_1 = \frac{b}{a} h \underbrace{\left(t_1^{d_1} + t_2^{d_2}\right)}_{C_2} \left[\underbrace{(m)^{\frac{1}{q+1}} (1\text{-}m)^{\frac{-1}{q+1}} (hd_1)^{\frac{-1}{q+1}} t_1^{\overset{Y}{\overbrace{\frac{1-d_1}{q+1}}}}}_{R} (w_1/P)^{\frac{-q}{q+1}} + \underbrace{(hd_1)^{-1} t_1^{1-d_1}}_{S} \right]$$

In short, L_1 depends on combinations of t_1, t_2, w_1, and the values of a, b, d_1, d_2, m, h, q, P:

$$L_1 = \frac{b}{a} C_2 \left(R t_1^Y \ (w_1/P)^{\frac{-q}{q+1}} + S t_1^{1-d_1} \right), \tag{11a}$$

where $R = (m)^{\frac{1}{q+1}} (1-m)^{\frac{-1}{q+1}} (hd_1)^{\frac{-1}{q+1}} > 0$, $\quad Y = \frac{1-d_1}{q+1} > 0$, $\quad S = (hd_1)^{-1} > 0$.

As mentioned in the introduction, at this point we turn to two datasets in order to match these relationships with some actual numbers from Britain.

3. Some diary evidence and empirical results

Most British time-budget datasets (from surveys conducted in 1937, 1961, 1974-75 and 1984) lack continuity and are not easily comparable to each other due to differences in the activity-classifications, the underlying statistical assumptions, the methods of selecting samples, and the parts of the week surveyed (Gershuny, 1983, 1995). However, the two time-use surveys considered hereinafter solicited similar information. This is not coincidental. In fact, it reflects a conscious attempt by Gershuny, who oversaw the second of the two surveys.

The earliest of the two surveys was part of the Social Change and Economic Life Initiative (SCELI) directed by Gallie (1991) and was conducted between March and July of 1987, among (a) 1,816 working-age individuals (aged 18-60) located in six travel-to-work areas, and (b) the other residents of their households. The second survey was undertaken by the Institute for Social and Economic Research (ISER) and was conducted between October 1998 and February 1999, among people of all ages from a random national sample of 998 households. For the sake of comparability, we focus on respondents aged 18-60. In both surveys, the time-diary booklets were distributed to individuals with instructions to record their activities in 15-minute segments in the course of a week. Once the diaries were returned, the researchers coded the sequential accounts into detailed time-use categories. For the purposes of the present paper, we grouped the coded primary activities into paid work, unpaid work, and non-work,[7] and matched their personal and household information.

7. *Paid work* captures the time spent in work both outside and inside the home in one or more paid formal jobs and in informal income-earning activities. Travelling

We concentrate on households of which adult members' time-uses are well-documented, with all diaries returned and rather complete: accounting for over 160 hours out of a maximum of 168 hours per week. Much like Bloemen and Stancanelli (2008), we drop households in which a diary is not filled. This leaves a sample of 265 working-age women from the SCELI set and 247 from the ISER set, averaging 164.6 and 166.4 hours per week, respectively.[8] Their profiles in terms of average age, family composition and unpaid help at home turn out to be very similar (see Table 1).

TABLE 1
The SCELI'87 and ISER'99 sample averages

	Mean Values	
	1987	1999
Age	38.0	40.1
Number of children		
• Aged 0-2	0.1	0.1
• Aged 3-5	0.2	0.1
• Aged 6-9	0.2	0.2
• Aged 10-12	0.1	0.2
• Aged 13-18	0.2	0.3
Unpaid work supplied by other adults		
• Spouse	13.0	10.0
• Other	1.2	2.9
Wage	2.3	4.8
Non-labor income	N/A	65.9
Non-selection hazard	0.4	0.4

Source: Own calculations based on the SCELI and ISER datasets.

to work and job-seeking activities are also classified into this category. *Unpaid work* measures the time spent in domestic activities, such as food preparation, cooking, cleaning the house, washing and tidying clothes, ironing, sewing, and related housework; taking care of household dependants or accompanying them, doing odd jobs about the home (including do-it-yourself activities), gardening, shopping, child caring etc., down to posting a letter. *Non-work* consists of personal care, sleep, leisure, and education. *Personal care* refers to meals and snacks, sleeps and naps, bathing, dressing and toilet, medical or other personal services. *Leisure* includes outdoor activities (such as travelling, excursions, sports, watching sports, religious practices or joining activities of civic organizations), out of home activities (going to the cinema or theatre, dances and parties, clubs, pubs, restaurants, visiting friends), passive leisure (watching television, listening to the radio, records and so on), and studying, reading books and magazines, relaxing at home, conversing, entertaining friends at home, pastimes and hobbies, or doing nothing. This activity classification convention has been developed by sociologists researching time-use, e.g., Gershuny (1995), who provided it to us. On the other hand, however reasonable, consistent, and generally acceptable this typology may be, it is conceivable that alternative activity-groupings might also be considered as acceptable by a substantial part of the population who view, for example, gardening, cooking, caring for and interacting with one's children, as leisure-activities, rather than unpaid work.

8. Hence, some 3.4 and 1.6 weekly hours (i.e., about 2% and 1%, of total time) are unaccounted in the SCELI and ISER diaries, respectively. As all three time-use regressions are estimated on the basis of recorded time, they may not add up to the aggregate of 168 weekly hours.

On average, the women surveyed in 1999 appear to (a) be slightly older (by 2 years) than the women surveyed in 1987, (b) enjoy lower unpaid (domestic) work contributions by their spouses (about 3 hours per week) and slightly higher unpaid work contributions by other adults (of 1.7 hours per week), (c) earn a modestly higher nominal wage (by £2.5 per hour), which may reflect the impact of inflation among other things. Additionally, the average number of children aged 13-18 in the ISER set corresponds to the average number of children aged 0-5 in the SCELI set surveyed 12 years earlier.

A concise description of these women's time allocation patterns is provided in Table 2. According to it, the women of the earlier survey allocated between 0 and 71.2 weekly hours in paid work, between 2.7 and 77 weekly

TABLE 2
Female time-use according to the primary activities reported in the two samples

Dataset	*Sample Statistics*	*Weekly hours spent in activities of*			
		Paid Work	*Unpaid Work*	*Non-Work*	*Total*
SCELI'87	*range*	0 - 71.25	2.75 - 77.00	78.25-150.00	
(265 women)	*mean*	16.3	34.7	113.5	164.6
	standard deviation	18.0	14.4	13.5	
	share of recorded diary time	9.9%	21.0%	68.9%	100%
ISER'99	*range*	0 - 76.00	1.00 – 96.63	70.50 - 167.00	
(247 women)	*mean*	21.8	29.9	114.6	166.4
	standard deviation	20.7	18.3	18.3	
	share of recorded diary time	13.1%	18.0%	68.8%	100%

Source: As in Table 1.

hours in unpaid work, and between 78.2 and 150.5 weekly hours in non-work activities, averaging 16.3, 34.7, and 113.5 weekly hours in the respective activities (or 9.9%, 21.0% and 68.9% in terms of total recorded time). Similarly, the subjects of the second survey allocated between 0 and 76 weekly hours in paid work, between 1 and 96.9 weekly hours in unpaid work, and between 70.5 and 167 weekly hours in non-work activities, averaging 21.8, 29.9, and 114.6 weekly hours in the respective activities (or 13.1%, 18.0%, 68.8% in terms of total recorded time).

Allocation to non-work and unpaid work fluctuated the least, reflecting inflexible components such as sleep (in the case of non-work), and some attachment to traditional homemaking roles.[9] On the other hand, allocation to paid work exhibited relatively higher fluctuation, often taking the value of zero (i.e., being censored) among homemakers. Indeed, one third of the women considered did not engage in paid work or earn

9. We are mindful that Biddle and Hamermesh (1990) suggest that time allocation to sleep is not entirely stationary.

a wage.[10] This is consistent with the 62-65% female paid work participation rate reported in the UK during the second half of the 1990s and throughout the 2000s. It also means that the estimation of the labor supply has to rely on the subset of paid work participants. However, the error terms of this subset may not be zero-mean even if originating from a population with zero-mean errors. Hence, unless one adopts so-called *second generation* techniques the regression may lead to biased estimates.

To correct the problem, we avoid the common OLS regressions (first generation techniques). Instead, we will endeavor to consider the heterogeneity of the workforce participants vis-à-vis the remaining observations and add a bias-correction measure (namely, the non-selection hazard) for each observation.[11] In doing so, we note in Table 3 that the paid work estimates of the conventional Tobit and Heckit or Selection-Bias Corrected (SBC) functions diverge somewhat. This is not very surprising considering that the two procedures vary.[12] On the other hand, the proximity of the SBC coefficients to the *residual* expression of the uncensored unpaid work and non-work OLS regressions intimates that the SBC (Tobit) labor supply coefficients are implicitly more consistent (inconsistent) with the unpaid work and non-work OLS coefficients.[13] We flag this observation for other empirical labor supply researchers with the understanding that it is partly explained by the reliance of the uncensored unpaid work and non-work functions on the same (different) non-selection hazard. At the same time, we wish to clarify that the recovery of two sets of coefficients for the censored labor supply regression has no direct effect on the discussion regarding our theoretical model, for we choose to rely on the coefficients of the two uncensored OLS regressions which are estimated from the full set of ob-

10. Or so is reported. Paid work takes the value of zero in 94 cases out of 265 in the SCELI sample (35.4%), and in 84 out of 249 in the ISER sample (33.7%).
11. The non-selection hazard reflects the probability of abstention from paid work, and is estimated (Prodromidis, 2003, 2005) from the regression of the probability of participation in paid work on age, family composition, home-ownership, non-labor income information, attitudinal and regional variables, in conjunction with past job and residence information (which is available in the SCELI data) or health (which is available in the ISER data). In the analysis that follows, it turns out to have an adverse effect on paid work, a positive effect on non-work, and an ambivalent effect on unpaid work: negative in case of the ISER equation, positive in the case of the SCELI equation.
12. The former of the two procedures assumes that the regressors that predict people's choice between participation and non-participation in paid work (i.e., the initial stage of a *second generation* analysis) also predict the hours of paid work performed (i.e., the final stage of a *second generation* analysis), whereas the SBC procedure allows for the regressors employed in the two stages to differ.
13. Indeed, six out of the ten SCELI coefficients estimated via the SBC procedure and eight out of the eleven ISER coefficients estimated via the SBC procedure are closer to the corresponding *residual* coefficients than their Tobit counterparts; and, in eight out of the nine cases in which both the SBC and Tobit estimated coefficients are simultaneously statistically significant at the 90% level of confidence, the SBC coefficients are closer to their *residual* counterparts than the Tobit coefficients.

servations. This allows for more degrees of freedom and the use of more information compared to the conventional labor supply regressions.[14] In fact, we conduct the econometric analysis on the basis of the unpaid work and non-work functions alone,[15] and by-and-large deduce the shape of the paid work expression from their complement (*residual*).

In particular, we regress the two time-use components on the same set of explanatory variables, namely, age, number of children, other adult contributions of unpaid work, the wage,[16] and the non-selection hazard. In the case of the somewhat richer ISER sample, these variables are complemented by a vector of proxies for non-paid work household income before taxes, which are calculated from the midpoints of 14 weekly income-ranges provided in the questionnaire (i.e., £0-24, £25-39, etc.). With one exception (see fn.17), these regressors are common in labor supply functions (e.g., Pencavel, 1986; Killingsworth and Heckman, 1986; Merz, 1990; Flood and Gråsjö, 1998; Connelly et al., 2001; Blau and Kahn, 2005; Amin and Suran, 2009). As the possession of labor-saving domestic appliances and use of hired help may constitute (not explanatory but) explained variables of people's time-use choices, they will not be included among the regressors. The econometric results are provided in Table 3: Those regarding unpaid work in columns 1-2, those regarding non-work in columns 3-4, those regarding their residual components (i.e., their complements) in columns i and ii, those regard-

14. The censoring that occurs in the paid work expression is taken into account (to some or considerable extent) by means of the sample selection correction variable that captures the heterogeneity of paid work participants vis-à-vis the non-participants.
15. These are estimated separately as is often the case in the voluminous labor supply literature and in the fledging literature on domestic work and non-work (e.g., Stafford and Duncan, 1980; Jenkins and O'Leary, 1995; Ramos, 2005; Amin and Suran, 2009; Merz and Osberg, 2009). The alternative joint estimation of all three time-use functions within a seemingly unrelated regression framework restricts the data to the number of uncensored observations directly involved in the estimation of the Tobit and the second stage of the SBC paid work function.
16. The ISER and SCELI wage vectors are imputed from people's usual salary and usual weekly hours of paid work, on the basis of their education, maternity information, and the non-selection hazard; in conjunction with (a) the place of origin and past job-history information in the case of the SCELI data, and (b) age, health, regional variables, and some computer literacy information in the case of the ISER data. The explicit wage-offer formulas are provided by Prodromidis (2003, 2005).
17. The exception refers to the explanatory role of the unpaid work contributions of other household members, considering that the time allocations of the women in question and the time allocations of the other adult members in their households may be jointly determined. On the other hand, it is not unusual to devise a model in which a person's time allocation decisions takes other household members' behavior (paid or unpaid work contributions) as given. (E.g., the *male chauvinist model* in Killingsworth, 1983; the time-use regressions of Deding and Lausten, 2006, or Bonke, 2010.) In the model under consideration, the inclusion of other unpaid work contributions is essential (see expression 11a) and facilitates our analysis (expression 13).

ing the SBC labor supply in columns 5 and 7, and those regarding the Tobit labor supply in columns 6 and 8.

TABLE 3
The estimates of the time-use regressions from 265 women of the SCELI'87 sample and 247 women of the ISER'99 sample (in weekly hours)

Explanatory Variables	*The Activities (Dependent Variables)*									
	Unpaid Work		*Non Work*		*Paid Work '87 set*			*Paid Work '99 set*		
	'87	*'99*	*'87*	*'99*	*Resid.*[a]	*SBC*	*Tobit*	*Resid.*[a]	*SBC*	*Tobit*
	(1)	*(2)*	*(3)*	*(4)*	*(i)*	*(5)*	*(6)*	*(ii)*	*(7)*	*(8)*
1. Constant	13.7	10.9	123.1	113.6	27.7	38.5	27.7	40.8	54.6	1.6
2. Age	0.3	0.4	0.1	-0.2	-0.5	-0.6	-0.9	-0.1	-0.2	-0.7
Number of children:										
None (reference)										
3. Aged 0-2	19.3	17.4	-4.8	-12.3	-14.5	-20.1	-28.7	-5.1	-0.6	-10.7
4. Aged 3-5	6.0	17.5	0.3	-7.6	-6.4	-11.1	-16.5	-9.8	-12.8	-14.1
5. Aged 6-9	6.3	8.6	-0.3	-2.6	-5.9	-5.7	-7.8	-5.9	-6.0	-6.7
6. Aged 10-12	4.8	7.2	-0.9	-7.6	-3.9	-1.8	-7.9	0.3	-0.5	1.0
7. Aged 13-18	1.4	2.2	-1.7	-2.6	0.3	2.0	0.8	0.4	0.7	0.7
Average unpaid work contributions by other household adults										
No adult (reference)										
8. Spouse (hrs/week)	0.1	0.0	-0.1	-0.1	0.0	0.1	0.1	0.0	-0.0	0.2
9. Other (hrs/week)	-0.1	-0.2	0.0	0.3	0.1	0.0	0.1	-0.1	-0.2	-0.0
10. Hourly wage (£) [b]	-1.3	-0.9	-5.9	0.6	7.3	5.0	11.8	0.3	0.0	9.4
11. Weekly non-labor income (£)	-0.0			0.0				-0.0	-0.0	-0.0
12. Non-selection hazard	0.9	-6.5	5.1	35.8	-6.0	0.5		-29.3	-32.9	

Additional equation information per column:

(1) F(10,254)=16.6; Prob>F=0.0; adj.R^2=37.2%. t_1=3.2; t_2=4.4; t_3=8.2; t_4=2.7; t_5=4.2; t_6=2.2; t_7=0.9; t_8=2.5; t_9=-0.9; t_{10}=-1.0; t_{12}=0.4.

(2) F(11,235)=11.9; Prob>F=0.0; adj.R^2=32.7%. t_1=1.6; t_2=3.8; t_3=5.6; t_4=5.8; t_5=4.1; t_6=3.2; t_7=1.3; t_8=0.5; t_9=-1.9; t_{10}=-1.0; t_{11}=-0.4; t_{12}=-1.6.

(3) F(10,254)=6.4; Prob>F=0.0; adj.R^2=17.0%. t_1=26.6; t_2=1.5; t_3=-1.9; t_4=0.1; t_5=-0.2; t_6=-0.4; t_7=-1.1; t_8=-3.1; t_9=0.3; t_{10}=-4.3; t_{12}=2.1.

(4) F(11,235)=28.0; Prob>F=0.0; adj.R^2=54.7%. t_1=20.3; t_2=-3.0; t_3=-4.8; t_4=-3.0; t_5=-1.5; t_6=-4.1; t_7=-1.9; t_8=-1.6; t_9=3.4; t_{10}=0.8; t_{11}=2.5; t_{12}=10.9.

(5) 94 censored observations; F(10,160)=6.2; Prob>F=0.0; adj.R^2=23.6%. t_1=6.2; t_2=-4.3; t_3=-4.9; t_4=-2.7; t_5=-2.5; t_6=-0.5; t_7=0.8; t_8=1.4; t_9=0.1; t_{10}=2.7; t_{12}=0.1.

(6) Log Likelihood=-818.7; LR X^2(9)=117.8; Prob>X^2=0.0; PseudoR^2=6.71%. t_1=3.6; t_2=-6.7; t_3=-6.9; t_4=-4.6; t_5=-2.8; t_6=-1.9; t_7=0.3; t_8=1.0; t_9=0.4; t_{10}=5.2; ancillary parameter 19.7 with std.errors 1.1.

(7) 84 censored observations; F(11,151)=7.7; Prob>F=0.0; adj.R^2=31.5%. t_1=7.0; t_2=-1.7; t_3=-0.1; t_4=-3.3; t_5=-2.5; t_6=-0.1; t_7=0.4; t_8=-0.3; t_9=-1.3; t_{10}=0.0; t_{11}=-1.2; t_{12}=-5.4.

(8) Log Likelihood=-819.4; LR X^2(10)=76.1; Prob>X^2=0.0; PseudoR^2=4.44%. t_1=0.1; t_2=-3.7; t_3=-1.9; t_4=-2.6; t_5=-1.8; t_6=0.2; t_7=0.2; t_8=1.4; t_9=-0.3; t_{10}=7.2; t_{11}=-1.3; ancillary parameter 24.5 with std.errors 1.4.

Notes:

(a) The Residual expression captures what is not explained by the Unpaid Work and Non-Work functions, i.e., Paid Work and some unaccounted diary time (see fn. 8). So, the constant in column (i) accounts for the difference between the average recorded time of the SCELI'87 set and the sum of the constants in columns (1) and (3): 164.6-(13.7+123.1))≈27.7, and the age coefficient in column (i) offsets the sum of the age coefficients in columns (1) and (3): 0-(0.3+0.1)≈ -0.5.

(b) The Wage variable corresponds to the vector of imputed offer-wages from the wage function of wage earners, as described in fn. 16.

(c) The Non-selection hazard is described in fn. 11.

The underlines in columns 1-4, 5, 6, 7 and 8 denote the rejection of the hypothesis of each coefficient's equality to zero. The double, single, and dotted underlines reflect 95%, 90%, and 85% confidence, respectively. (See also fn. 18) The underlines in the residual functions (columns i and ii) reflect the confidence of the corresponding t-statistics from the uncensored regressions. In other words, the first double underline in column (i) is consistent with the high t-statistics (and the respective double underlines) obtained in both the corresponding Unpaid Work and Non-Work intercepts of columns (1) and (3); similarly for the other underlines.

We note that the autonomous effects are positive. Additionally, age has a positive effect on women's unpaid work, a negative effect on paid work, a positive effect on non-work in the case of the SCELI sample and a negative effect in the case of its ISER counterpart. At the same time, the presence of a newborn (and, in the ISER sample, the presence of an older preschooler) stimulates 17-19 weekly hours of additional unpaid female work at the expense of non-work and (often) paid work; whereas an older child stimulates smaller, yet additional, domestic involvement, thus, typically reducing female time allocation to other uses. There are, however, some exceptions: the presence of a child aged 3-5 seems to allow for a small non-work respite in the SCELI sample, the presence of a of child aged 10-12 years may be associated with a small increment in female paid work in the ISER sample (according to the Tobit procedure), and the presence of a teenager is associated with similar increases of female paid work in both samples (according to both the Tobit and SBC procedures).

Another finding concerns the impact of a husband's (or male partner's) unpaid work involvement. It seems that his domestic contribution of a weekly hour gives rise to a 2-8 minute increment of female unpaid work and a 7-11 minute reduction in female leisure and personal care. This probably means that either the man's marginal unpaid work contribution is not essential and has virtually no impact on female time-use or that it may create slightly more female work such as cleaning up, etc. (Alternatively, it may induce the wife to emulate or spend more time with him by collaborating (thus, engaging in more unpaid work), or worrying her to the degree to cause her to linger about in order to monitor him.) By contrast, other adult contributions of one hour of unpaid work appear to have a miniscule positive impact on female non-work (especially in the ISER sample) by increasing leisure and personal care by 3-23 minutes, while reducing a woman's domestic involvement by 3-15 minutes and having a trivial positive effect on her paid work.

Turning to the wage coefficients, we note that the ISER estimates are smaller in size compared to their SCELI counterparts. On average, a wage increment of £1 induces female engagement in paid work by 5 or 11.8 weekly hours in the SCELI sample (according to the SBC and Tobit results, respectively), and by 0 or 9.4 hours in the ISER sample, while reducing unpaid work in both instances by 59–78 minutes. The reduction of the normal good leisure by 5.9 hours in the SCELI sample is very much consistent with the dominance of the conventional substitution effect, whereas the recovery of a trivial increment in leisure (by 0.6 hours) in the ISER expression reflects the dominance of the income effect. This would be consistent with the recovery of a negligible, yet positive, non-labor income effect on female leisure, at the expense of both types of work, in the same sample.

Moreover it appears that despite differences in (sub)regional sampling and the passage of time between the two surveys, the estimated coefficients exhibit a close correspondence in terms of signs (for eighteen out of the twenty-two unpaid work and non-work coefficients), and a modest similarity in terms of values recovered. That is, fourteen out of the twenty-two estimated unpaid work and non-work SCELI coefficients diverge by less than three weekly hours from their ISER counterparts. Additionally, in considering the estimates with high or modest t-statistics that exceed the 85% confidence interval,[18] we observe the following: (a) In unpaid work, the constants, the age effect, and the effects of children aged 0-12 turn out to be positive. (b) In non-work, the constants are positive and large (which is consistent with the presence of substantial stationary components such as sleep), whereas the newborn children and spousal-contribution effects are negative.

However, there also exist variations: More specifically, it seems that the adult women of the ISER sample exhibited a reduced autonomous involvement in non-work activities (by 9.5 hours) when compared to their counterparts in the SCELI sample. Additionally, female engagement in non-work activities generally increased with age up to the age of sixty in the SCELI sample. In the ISER sample the pattern appears reversed as engagement in non-work activities generally declined with age up until the time of retirement.[19] The negative effect of a newborn child and near-zero effect of a child aged 3-5 or a child aged 10-12 years in the non-work SCELI function reappear reduced by about 7 to 8 hours in the ISER function. The positive effect of a child aged 3-5 in the unpaid work ISER function is nearly three times bigger compared to its (positive) SCELI counterpart (a difference of 11.5 weekly hours). Additionally, the probability of non-participation in paid work activities (as captured by the non-selection haz-

18. The statistical significance of estimated coefficients may be traced at the 90, 95% and 99% probability levels as well. The consideration of this modest level of confidence brings to light a couple more possible similarities and one dissimilarity in the non-work expressions of the two samples.
19. At the same time, engagement in unpaid work activities waxed with age and engagement in paid work activities waned, in both samples.

ard) had a positive effect on non-work, with the ISER effect exceeding its SCELI counterpart by 30.7 hours. Essentially, the two groups responded differently to certain factors, which suggests that they operated in different environments/realities or were different or both.

Moving on from the similarities and differences of the coefficients of two populations we note that the estimated coefficients can offer additional insights if matched against the outcomes of the theoretical time-use model developed in Section 2, so we turn to their examination.

4. The model's relationships and the econometric results

For the model to be consistent with the recovered coefficients of the unpaid work (L_1) and non-work regressions (t_1), it has to be the case that v (in expression 2) enters expression (11a) concerning L_1 via (or in conjunction with the manner it enters) t_1,

$$\frac{dL_1}{dv} = \frac{dL_1}{dt_1}\frac{dt_1}{dv}, \tag{12}$$

whereas t_2 (or some t_3, t_4 etc. offered by other household members) enters the same expression (11a) both directly as part of C_2 and indirectly through its connection to t_1:

$$\frac{dL_1}{dt_2} = \left[\frac{b}{a}\left(Rt_1^{Y}(w_1/P)^{\frac{-q}{q+1}} + St_1^{1-d_1}\right)\frac{dC_2}{dt_2}\right] + \frac{dL_1}{dt_1}\frac{dt_1}{dt_2} \tag{13}$$

The next step is to insert the numerical values of the recovered coefficients into these two equations and into equation (14) which is supplied below. For the sake of convenience we bring together the values of the estimated coefficients in Table 4.

First, we consider a few ISER results:

- In the last line, $dL_1/dv \approx 0.014$ and $dt_1/dv \approx -0.003$. So expression (12) is satisfied if dL_1/dt_1 is negative, equal to -4.398.
- In the first line, $dL_1/dt_2 \approx -0.125$ and $dt_1/dt_2 \approx 0.046$. Given that the term in braces in expression (13) consists of positive terms, the whole expression is satisfied if dL_1/dt_1 is negative.
- In the second line, $dL_1/dt_3 \approx 0.382$ and $dt_1/dt_2 \approx -0.260$. So expression (13) is again satisfied if dL_1/dt_1 is negative.

We also consider a few SCELI results:

- In the first line, $dL_1/dt_2 \approx -0.196$ and $dt_1/dt_2 \approx 0.143$. So expression (13) is satisfied if dL_1/dt_1 is negative.
- In the second line, $dL_1/dt_3 \approx 0.049$ and $dt_1/dt_2 \approx -0.050$. So expression (13) is satisfied if dL_1/dt_1 is negative.

TABLE 4
A selection of coefficients from Table 3, in a three-decimal point format

Coefficient		SCELI'87		ISER'99		Tab.3	Variable
unpaid work regression	non-work regression	Tab.3, Col. 1	Tab.3, Col 3	Tab.3, Col. 2	Tab.3, Col. 4	Line	
dt_1/dt_2		0.143		0.046		8	Unpaid work contribution by spouse
	dL_1/dt_2		-0.196		-0.125		
dt_1/dt_3		-0.050		-0.260		9	Unpaid work contribution by other adult
	dL_1/dt_3		0.049		0.382		
dt_1/dw		-1.307		-0.995		10	Hourly wage
	dL_1/dw		-5.993		0.667		
dt_1/dv				-0.003		11	Weekly non-labor income
	dL_1/dv				0.014		

From expression (11a) we obtain:

$$\frac{dL_1}{dw_1} = \left(\frac{dL_1}{dt_1}\frac{dt_1}{dw_1}\right) + \left[\frac{b}{a}C_2\left(Rt_1^{\ Y}\ \frac{-q}{q+1}(w_1/P)^{\frac{-2q-1}{q+1}}\ \frac{1}{P}\right)\right] \qquad (14)$$

The terms in braces consist of a product of positive terms and "-q". However, according to the ISER results (Table 4, third line), $dL_1/dw_1 \approx 0.667$, $dt_1/dw_1 \approx -0.995$, and, as concluded above, dL_1/dt_1 is negative, conceivably, -4.398. So the product of $(dL_1/dt_1 \times dt_1/dw_1) \approx (-4.398) \times (-0.995) > 0.667$. The latter is the estimated value of dL_1/dw_1. Hence, for expression (14) to hold, the product of the terms in braces has to be negative. Therefore "q" must be positive.

According to the SCELI results, $dL_1/dw_1 \approx -5.993$, $dt_1/dw_1 \approx -1.307$. If, as we concluded above (in the last two bullets), dL_1/dt_1 is negative, then the product of $(dL_1/dt_1 \times dt_1/dw_1)$ is positive. Consistency now requires that the product of the terms in braces in expression (14) be negative and sufficiently large to offset the positive effect of the first product of terms. Once again, we conclude that "q" must be positive.

As already discussed at the description of expression (5) this indicates that in women's eyes, market-made and domestically (home)-made commodities are rather complementary to each other.

5. The diagrammatical representation of the model and the econometric results

According to our theory, time is allocated among three different uses. This requires the modification of the simple paid-work/leisure mod-

el and conventional textbook diagram that goes with it (and yields the individual labor supply curve), in order to incorporate unpaid work and domestic production.

In the case of a lone adult, this is done by affixing a hump-like domestic production function onto her monetary budget constraint (capturing her wage-earnings and other income) as in Figure 1. Here, we place it between points "B" and "D" on the budget constraint and ensure it exhibits diminishing returns to scale. Alternatively, the hump could be affixed on top of "corner E", especially in the case of a homemaker.

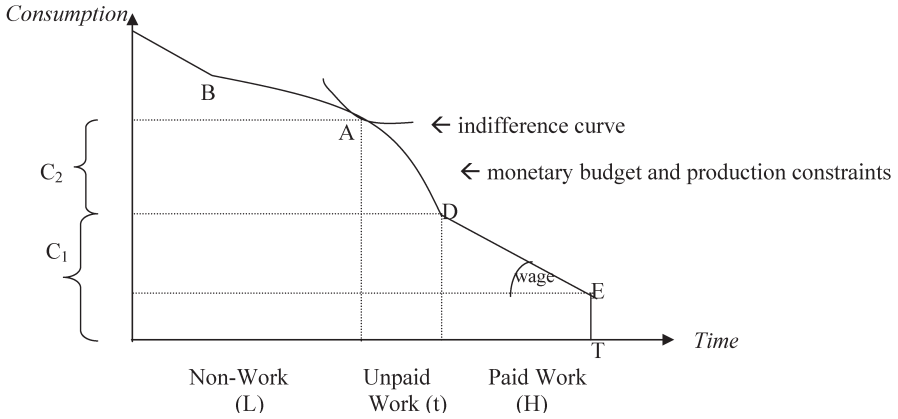
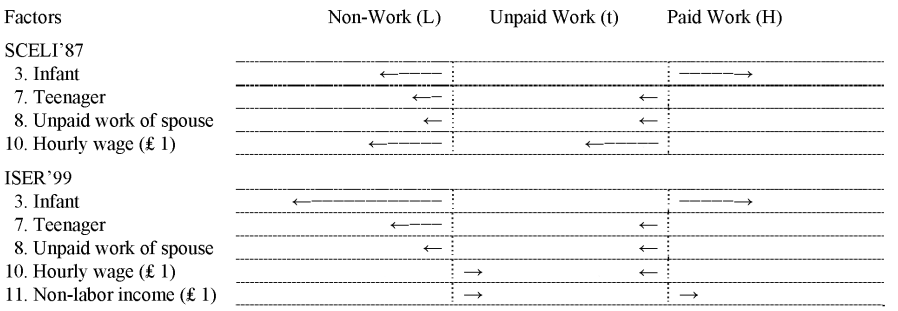


FIGURE 1: Utility maximization subject to income and time constraints. The determination of time allocation.



Key: The arrow sizes and directions correspond to the respective coefficient results of Table 3. The SCELI results derive from columns 3, 1 and i; and the ISER results derive from columns 4, 2 and ii.

FIGURE 2: Selected time allocation effects based on the regression results.

It is not necessary that the individual's indifference curve be tangent on the domestic production section of the consumption constraint; however, let us assume that it is tangent at point "A", so that the individual distributes her time in the three-ways indicated in the said figure. As a result, a wage increase generates the standard substitution effect

by pivoting the budget constraint and reducing non-work, *L*. However, the final time allocation outcome will depend not only on the income effect but also on the productivity effect, as both components of the constraint will be affected. In this case, the empirical evidence obtained from the female time-use regressions derived from our late 20th century British data suggest that a wage increment will result in a rise in paid work, *H*, a reduction in unpaid work, *t*, and dissimilar allocations with respect to *L*: A reduction of *L* among the typical SCELI'87 respondent, and a miniscule increase among the typical ISER'99 respondent.

In the case of a household consisting of a women and one (or more) adults, each contributes (a) the goods and services acquired through her/his paid work income and other monetary sources, and (b) her/his unpaid work production. So, each person's commodity production frontier resembles the one in Figure 1, and their interaction (giving, taking, sharing with dependents) recalls the exchange(s) among states engaging in international trade: each producing upon a certain Production Possibility Frontier bundle and consuming a different bundle. The mechanics of this time allocation, production and consumption model (with the various direct and indirect effects) yield a number of mathematical relationships that are sufficiently complex to thwart the determination of a straight-forward solution and values associated with it. So, Figure 2 provides a display of marginal results by using arrows to represent the direction and magnitude of these results, while maintaining the *L*, *t*, *H* arrangement of the three time-uses on the horizontal axis of Figure 1. We observe that a marginal increment in non-labor income (which is measured only in the 1999 sample) reduces paid and unpaid work and generates a positive non-paid work effect. The latter is in the same direction as the one produced by a marginal increment in the wage in the 1999 sample. On the other hand, the wage effect on non-work is in the opposite direction in the 1987 sample. At the same time, paid work increases and unpaid work decreases in both cases. Infants tend to increase unpaid work at the expense of non-work and paid work, whereas teenagers and the domestic contributions of spouses tend to stimulate very small amounts of additional work (both paid and unpaid) at the expense of female leisure, personal care etc.

6. Conclusions

The article studies the time allocation patterns of working-age women in Britain using diary data from 1987 and 1999. The samples display similar time allocations in terms of primary activities. On average, 69% of recorded diary time is directed towards non-work, 18-21% towards unpaid work, and the remainder 10-13% towards paid work. The distribution of paid work fluctuates considerably across the population with employment often taking the value of zero among homemakers, whereas unpaid work and non-work allocations are generally more inflexible and

take non-zero values (i.e., are uncensored). Overall, the statistics reflect women's needs for sleep, personal care and relaxation, attachment towards traditional female time-use allocations (of unpaid work), and occasional involvement in paid-work. The regressions of the uncensored time-use components also produce sets of roughly similar statistically significant coefficients. Additionally, the shapes of these functions appear more consistent with the SBC rather than the Tobit version of the (censored) labor supply. Whether this feature is specific to the two datasets or reflects limitations of the Tobit method or depends on the hazard used will have to be deduced from additional empirical analyses with other time-budget sets.

Table 3 decomposes the time allocation into a number of effects. It displays large constants for non-work (113-123 weekly hours) and smaller constants for unpaid work (10-13 weekly hours); a positive age-effect on female unpaid work activities, a negative age-effect on female paid work activities, and dissimilar age-effects on leisure and personal care; whereas the wage produces the reverse effects on leisure and personal care, has a negative impact on unpaid work and a positive impact on paid work. The recovered coefficients also suggest that an infant stimulates 17-19 weekly hours of unpaid female work at the expense of other time-uses, a child aged 3-5 generates a similar result in the 1999 sample, while other dependent children generally stimulate fewer hours of additional unpaid work. The children-effects of the non-work regressions are generally negative, but larger in the 1999 regression, thus reflecting changes in women's appreciation for paid work as well. Spousal and other adult unpaid work contributions have little impact on female time-use. Moreover, the 1999 data indicate that increments in non-labor income stimulate negligible yet additional non-work activity at the expense of work (both paid and unpaid).

The recovered coefficients from the unpaid-work and non-work functions are substituted in the outcomes of a simple model structured around the maximization of a household member's personal Cobb-Douglas utility function involving family consumption, *C,* and non-work, *L*. The adoption of a CES expression for *C*, consisting of purchased and domestically-produced goods and services (acquired via paid and unpaid work, respectively) introduces a substitution parameter. The econometric findings require it to be positive, suggesting that women view purchased and domestically-produced items rather as complements to each other. This ought to be of interest to policy-makers set to encourage or influence women to substitute household production with market production, and, perhaps, grounds for additional study into the issue.

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