Review of Economic Studies (2013) **80**, 1055–1085 doi:10.1093/restud/rds043

Advance access publication 4 December 2012

Why are Married Men Working So Much? An Aggregate Analysis of Intra-Household Bargaining and Labour Supply

JOHN A. KNOWLES

Economics Division, University of Southampton, CPC, and IZA

First version received March 2008*; final version accepted October* 2012 (*Eds.*)

Are macro-economists mistaken in ignoring bargaining between spouses? This article argues that models of intra-household allocation could be useful for understanding aggregate labour supply trends in the U.S. since the 1970s. A simple calculation suggests that the standard model without bargaining predicts a 19% decline in married-male labour supply in response to the narrowing of the gender gap in wages since the 1970s. However married-men's paid labour remained stationary over the period from the mid 1970s to the recession of 2001. This article develops and calibrates to U.S. time-use survey data a model of marital bargaining in which time allocations are determined jointly with equilibrium marriage and divorce rates. The results suggest that bargaining effects raised married-men's labour supply by about 2.1 weekly hours over the period, and reduced that of married women by 2.7 hours. Bargaining therefore has a relatively small impact on aggregate labour supply, but is critical for trends in female labour supply. Also, the narrowing of the gender wage gap is found to account for a weekly 1.5 hour increase in aggregate labour supply.

Key words: General aggregative models, Neoclassical, Time allocation and labour supply, Economics of gender, Marriage, Marital dissolution

JEL Codes: E130, J120, J160, J200, J220

1. INTRODUCTION

The economic position of women appears to have improved significantly relative to that of men over the last 40 years, as reflected in higher wages and stronger career prospects. Figure 1(a), for instance, shows that the mean wages for workers with more than 10 average weekly hours converged strongly over the period 1975–2001. To the extent that such changes improve the bargaining position of women relative to men, they provide an opportunity to contrast the aggregate implications of the "unitary" view of the household that dominates macro-economic analysis with the "collective" view increasingly favored by micro-economists.

The potential impacts of wage convergence have not been extensively studied at the aggregate level, largely because macro models of the household tend to ignore questions of intra-household

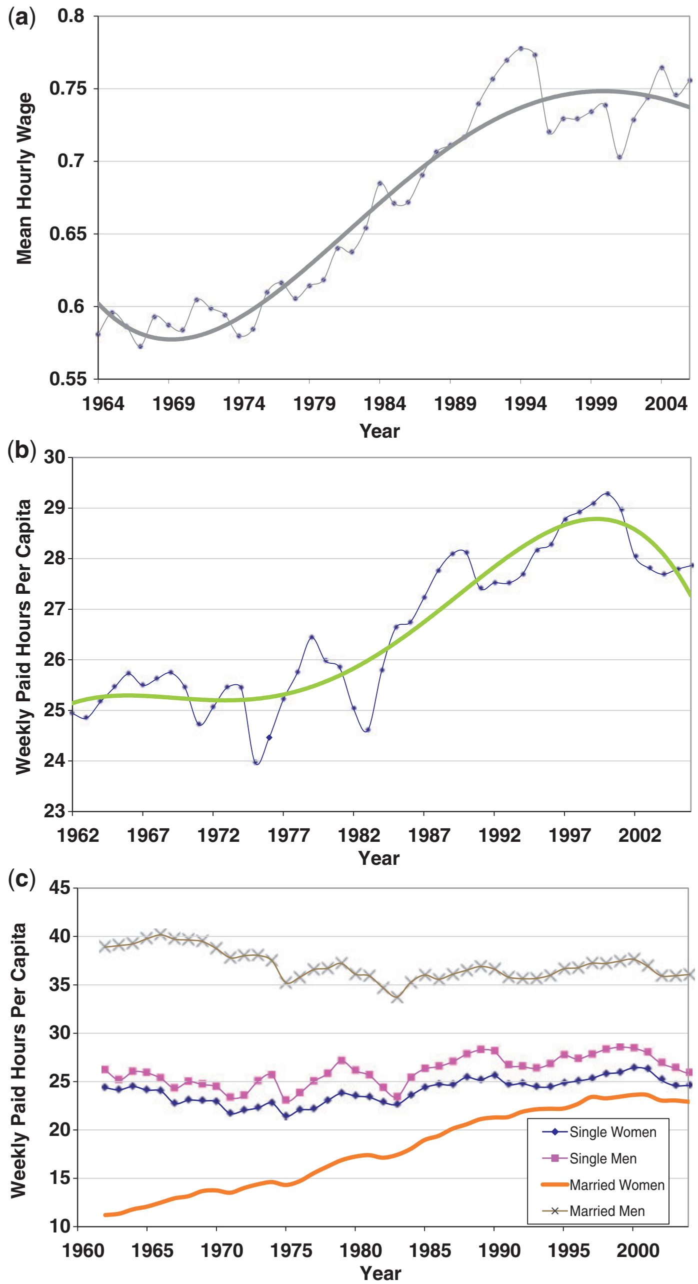

FIGURE 1

(a) Ratio of mean wages of women to those of men. Author's computations from the March CPS for population 18–65 years old working 10 h or more weekly at paid employment. (b) Per-capita hours in the March CPS. Based on author's computations from reported hours worked in previous week by persons aged 18–65. With fitted quartic polynomial trend line. (c) Per-capita hours by sex and marital status. Based on author's computations from March CPS, persons aged 18–65 allocation.[1] This article asks whether extending a standard macro model to include bargaining between spouses can enrich our understanding of the rise in married-women's labour supply observed in the U.S. over the period 1975–2003. The implications for aggregate labour supply and the decline of marriage are also examined. The analysis relies on a simple model of equilibrium bargaining between spouses that is both tractable and compatible with the highly aggregated models used in macro-economics.

While the evidence for reallocations in response to improved outside options is quite strong at the micro level, macro-economic models with households usually abstract from such effects by assuming that the household acts as an economic agent with a stable utility function. At the level of the micro data on labour supply, this "unitary" assumption has been shown repeatedly to be inferior to an approach that allows allocations within the marriage to depend on the economic position outside the marriage. For instance, Chiappori *et al.* (2002) find that the data reject the unitary model in favor of the "collective model with distribution factors", which is essentially an empirical implementation of bargaining between spouses, in the tradition of McElroy and Horney (1981). Empirical support for inter-temporal implications of this model was provided by Mazzocco (2007). The comparative neglect of inter-spouse bargaining by macro-economists is all the more surprising considering the central role of bargaining in the labour-search literature, and the obvious parallels between employment and marriage relationships, as discussed in Burdett and Coles (1999).

From the point of view of empirical analysis, an important advantage of employment relationships is that wages and output are in principle observable, whereas the utility allocation between spouses in a marriage is not. The standard practice in the collective-model literature has been to study paid labour time as a proxy for intra-household allocations; the implicit assumption has been that paid-labour is negatively related to leisure, and that an improvement in the outside option of the wife will result in an increase in her leisure, and hence a decline in her paid labour. A well-recognized problem with this approach is that it is only valid if the relative prices faced by the married household, as well as its wealth, are invariant to the forces underlying the changes in the outside options. Hence the collective-model literature is limited to the study of effects that leave these unchanged, such as local variations in divorce laws and in sex ratios of singles. Analysis of changes in relative wages therefore requires a more structural approach which can account for income and substitution effects of wages.[2]

The assumption that time outside of paid work equals leisure time is also unsuitable for historical comparisons of leisure allocations, because it ignores the time married people spend in household chores. Indeed Greenwood, Seshadri, and Yorukoglu (2005) [GSY hereafter] have argued that rising labour productivity at home accounts for roughly half of the increase in married-women's labour supply since 1945, as the time required to accomplish the chores has diminished, due to the decline in prices of labour-saving home equipment. Over the 1975–2003 period, NIPA deflators show that in 2003 the price of home equipment relative to consumption prices stood at about 25% of the 1975 level. Since the main predictions of bargaining models for labour supply are based on the allocation of leisure, this suggests that it may be misleading to make inferences from labour supply without accounting for home-production time.

A sensible rationalization of the macro-economist's neglect of intra-household bargaining might be that the aggregate effects of reallocation are likely to be small. Jones, Manuelli, and McGrattan (2003) [JMM hereafter] have shown that a standard unitary

1. For a recent exception, see Lise and Seitz (2011), who find that accounting for trends in intra-household inequality substantially reduces the apparent increase in consumption inequality over the last 30 years.

2. Browning and Gortz (2006) find that variation in wife's leisure across Danish households is positively correlated with her consumption expenditures, supporting the hypothesis of bargaining over that of preference heterogeneity. This also rationalizes the use of leisure as a proxy for relative welfare in the household.

household model with home production can explain the rise in married-women's labour supply since 1950 in response to either the trend in the female–male wage ratio or in response to rising productivity at home, as in GSY. In both cases, they find that calibration to U.S. data implies that married-men's labour supply should have fallen, by somewhere between 5 and 8 hours weekly. However Figure 1(c) shows that married-men's weekly paid work hours, after a significant decline in the 1960s, remained essentially stationary over the 1972–2001 period whereas women's relative wages were rising. This suggests that the shortcomings of the unitary model may be significant at the macro level. Panels(b) and (c) of Figure 1 suggest that this may have direct implications for aggregate labour supply, which increased by roughly 20% over the same period.

In this article I show, using American surveys of household time use, that the problem of relative leisure is robust to accounting for home production. Although total working time of married people, both men and women has increased since 1975, the ratio of husband's non-working time to that of the wife is roughly constant over the period. This is supported by similar findings by Bech-Moen (2006) for the U.S. and Norway. Composition effects do not appear to be the main explanation: slicing the data more finely to account for heterogeneity in education, age, or female labour force participation only exacerbates the problem: the relative leisure of wives actually increased in most of the sub-categories, declining only among couples over age 50. Indeed, Burda *et al.* (2007), noting that the leisure ratio is independent of relative wages across a wide range of countries, call this the "iso-leisure" pattern, which they explain on the basis of social norms.

The argument developed here proceeds in two stages; first a model of marriage and allocations is developed; the model is equipped with a standard CES home-production technology, CRRA preferences, and a stochastic process for marriage quality. The marriage-equilibrium concept is similar to that of Chade and Ventura (2005) but allows for intra-household bargaining, as in McElroy and Horney (1981). Without bargaining, the model predicts a 12% decline in the leisure ratio, in response to the shrinking of the gender gap in wages. Given a level of married leisure of roughly 61 weekly hours per capita in 1975, that translates into a 7.3 hour weekly decrease in married-men's working time.

From the point of view of matching the iso-leisure fact, the key feature of the model is that the bargaining position of the spouses depends on the marriage-matching equilibrium, which depends in turn on the relative wage. The model shows that the stationary leisure ratio can be easily explained by the impact of relative wages on bargaining position, and hence without reference to social norms. Although the model is very stylized, this basic insight is clearly characteristic of the broad class of models used in macro-economics; the most important assumption being that household utility is within the CES class and separable across goods.

In the second stage, the article proposes answers to the essentially quantitative questions raised above: how much does intra-household bargaining change the model's responses of labour supply and home-production time to relative wages, taxes, equipment prices, or other shocks to the economic environment? How much do each of these shocks contribute to the rise in aggregate labour supply?

The model is first calibrated to match time allocations for 1975 and 2003, so as to permit an accounting decomposition of the changes over time. Values for wages, non-labour income, and tax rates are fed in from survey data. We allow preferences and technology to be specific to each household type/year; the article shows how the parameters are identified explicitly from the moments of the data, so the model matches the time-allocation statistics and identifies shifts in technology and preferences. We then calibrate the marriage-matching process to observed marriage and divorce rates, allowing the value of single life to shift over time so as to match the marriage rates.

This benchmark version of the model is then compared with the "unitary" version, in which the Pareto weights on the spouses are held constant, to make it comparable to the standard macro

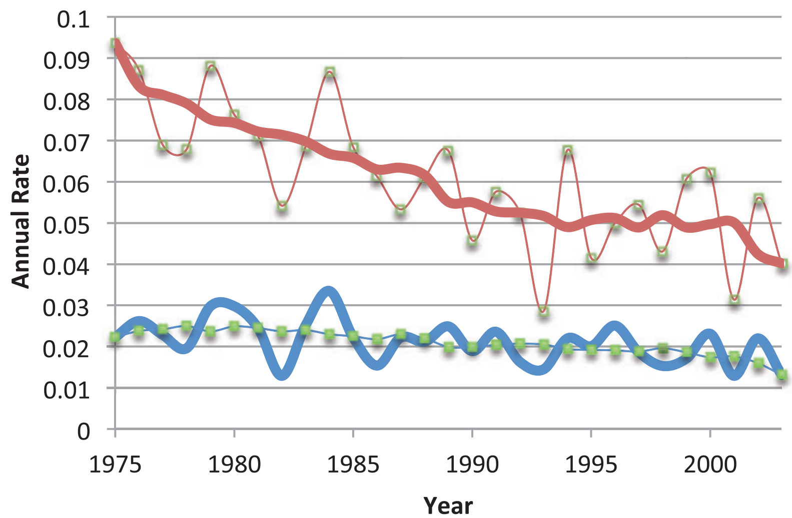

FIGURE 2

Marriage and divorce rates. Per single woman aged 18–65, as imputed from March CPS

approach. Finally, the model is subjected to a series of computational experiments in which all variables but one are kept at their 1975 levels; these experiments are carried out in both the unitary and bargaining versions of the model.

With regards to explaining the rise in wife's paid labour, the results suggest that the most important force is the closing of the gender gap in wages, as in JMM. This is more than simply a reallocation between husband and wife; the average labour supply of married couples increases by more than 6 weekly hours. However bargaining turns out to have little effect on per-capita hours, justifying the neglect of bargaining in models at the highest level of aggregation. With the Pareto weights constant, the error in the predicted per-capita hours is 0.8 h, about 12% of the increase observed since the 1970s.

In contrast to GSY, improvements in the home-production technology or the decline of home-equipment prices seem to have little impact on female labour supply. This is because accounting for the cost of husband's time in home-production reduces the measured equipment share in the home production technology to the point that diminishing marginal returns preclude any major impact of labour-saving equipment on time allocation. In the benchmark model, the declining equipment price frees up 1.2 h of the wife's time from home production, but most of this is absorbed into higher leisure. These two features, absent in GSY, plus the fact that the current article is focused on a later period in time, would appear to explain the divergence from their results.

Relative to the large literature on female labour supply and intra-household allocation, the main theoretical contributions of this article are (i) to put the model into an equilibrium context, where the outside options are determined endogenously; and (ii) to develop a simple version of the model that relates directly to the models used in macro-economics. These features mean that allocations between married couples can be related, through the model, to data on marriage and on the time-use decisions of single-person households; this disciplines the values of the outside options in the calibration.

The model in the current article can be seen as extending the two-period marriage-market models of Greenwood *et al.* (2000, 2003), where the analysis is limited by wage heterogeneity to one or two marriage opportunities per lifetime. A recent paper in which marriage and intra-household outcomes are modelled as jointly determined is Choo *et al.* (2008); they analyse female labour supply but, in the absence of a bargaining model are limited to the consideration of distribution factors, like the sex ratio. Similar concerns are also addressed in a recent paper on paid-labour supply and marriage by Jacquemet and Robin (2011).

It is important to stress that the extreme simplicity of my approach precludes direct comparison with life-cycle models of the trends in female labour supply. Attanasio, Low, and Sanchez-Marcos (2008) (ALS hereafter), for instance, use a lifecycle model to consider the role of returns to experience and the costs of child-raising; they abstract however from intra-household allocation and marriage decisions. My model on the other hand abstracts from important features in the ALS model, such as age and the intensive/extensive margin distinction; the results of this article suggest that it would be useful to extend the lifecycle approach to allow for marriage decisions and bargaining between spouses.

2. TRENDS IN TIME ALLOCATION

The data sets usually used in the analysis of labour supply lack systematic information on unpaid work; this turns out to be critical for distinguishing different versions of the household model, which hinges on the response of total work time, including unpaid work, to changes in relative prices. The goal of this section is to document patterns in non-working time by studying these changes. The strategy is to use the March CPS, the standard source of macro labour-time data, to document the trends in paid labour and relative wages and show that the trends are driven by the behaviour of married people. Since unpaid work time is not documented in the CPS, we then turn to time-use surveys and show that the relative leisure ratio has been stationary over the 1975–2003 period. In the Supplementary Appendix, we propose a reconciliation of the discrepancies between the two data sources.

2.1. *Paid-labour supply trends: CPS*

Figure 1, which shows the labour supply trend by sex and marital status, the trend in relative wages, and the per-capita hours trend, is based on the March Supplement of the CPS, from 1962 to 2006. To filter out the role of cyclical fluctuations, Table 1 averages the data over several years. The population is restricted to civilians age 18–65, a standard definition of working-age adulthood. Younger people are likely to be constrained by compulsory schooling, and older people by mandatory retirement, social security rules, and disabilities. The weekly hours variable is the reported hours worked last week.[3]

For married women it is clear that average weekly hours of paid labour increased steadily, from an average of 11.8 in the 1962–66 period to 22.97 in 1994–2001. For single women, there is no trend and, hours fluctuate between 22 and 26 over these periods. For single men, the pattern is similar, a stationary series that fluctuates between 24 and 28 weekly hours. For married men, hours are essentially constant at 36 from 1976–2003.

The wage trend shown in Figure 1(a) is computed by dividing annual earnings by annualized hours worked, as given by the hours worked last week response. To avoid noise from people with low hours, the sample for this calculation is restricted to people who worked at least 10 h.

Average hours worked per person in 1971 was 24.7, slightly lower than in 1962. Figure 1(b) shows that, over the next 28 years, average hours rose steadily to 29.3 in 2000, an increase of nearly 18% .

3. Similar results obtain if instead we multiply usual weekly hours by number of weeks worked.

TABLE 1
Trends in paid hours per capita, March CPS ages 18–65

Years	Sample		Weekly hours	Per-capita hours
1962–66	Women	Single	24.22	25.24
		Married	11.79	
	Men	Single	25.71	
		Married	39.44	
1967–75	Women	Single	22.54	25.37
		Married	13.76	
	Men	Single	24.52	
		Married	38.60	
1976–85	Women	Single	23.07	25.45
		Married	16.73	
	Men	Single	25.13	
		Married	35.74	
1986–96	Women	Single	24.89	27.69
		Married	21.36	
	Men	Single	27.20	
		Married	36.20	
1997–2001	Women	Single	25.95	29.01
		Married	23.47	
	Men	Single	28.22	
		Married	37.30	
2002–06	Women	Single	24.67	27.84
		Married	22.97	
	Men	Single	26.52	
		Married	36.01	

To compare the lifecycle and cohort effects, Figure A1 (Appendix) shows age–hours profiles for 10-year birth cohorts of married men and women. Those for women rise significantly with each successive cohort; by 3 h at age 30 when we move from the 1930s to the 1940s cohorts, by an additional 7 h to the 1950s cohort, and by another 3 h from the 1950s to the 1960s cohort. In contrast, the age–hours profiles of married men are essentially identical over all cohorts. This also means that there is no question here of substitution of labour time across the lifecycle in response to changes in married-women's roles: the shape of the men's profiles do not change systematically as we move across cohorts.

It may be interesting to explore the possibility that the lack of trend in husband's hours is driven by conflicting trends between households where the wife works and those where she does not, or by a rise in household where the wife works. Figure A1 shows that for wives aged <50 years, husband's hours are stationary after 1974 for both household types. In all cases, husbands work more in households where the wife is also working. For households where the wife is older than 50, there is decline in husband's hours until 1984 for households where the wife is not working, and stationarity thereafter. The stationarity of husband's paid working hours therefore holds even when age and labour force status are accounted for, except that, for the oldest group, the stationary period starts somewhat later.

Another possibility is that paid work hours are fixed by custom at a rigid number, such as 40 h per week. We measure average weekly hours in the March CPS in the 1990s by age, sex, and occupation type (managerial/professional versus other). As Figure A3(a) in the Appendix shows, the median, at all age groups in the 1990s is indeed 40. Furthermore, for men older than 25, the 25th percentile is also close to 40. However in all cases, a significant fraction of working people work 30 h or less, or 60 h or more, per week, even conditional on age and occupation type. This analysis suggests that there is no lack of options for adjusting paid-working time. In any case, the model implies that if this constraint is binding, the household can respond by adjusting home-work hours, which are presumably free from the institutional rigidities that operate in the work place.

2.2. *Non-working time: the time-use surveys*

To track trends in unpaid work and hence non-working time, we follow the existing literature in relying on a collection of cross-sectional time-use surveys beginning in 1965 and culminating in the first wave of the American Time Use Survey in 2003. These appear to be the only source of representative data on home-production time apart from cooking and cleaning, notably child care and shopping time, as well as unpaid work time and leisure activities. This is important because it is well-known (Gershuny and Robinson, 1988) that married-couple's allocation of home-production time has shifted since the 1960s, with husbands apparently bearing a larger share of house work than in the past.

Because of inconsistent design over the years, comparison of variables from the time-use surveys requires standardization of activities into broader categories. Results for this type of exercise are reported by Robinson and Godbey (1997) and Aguiar and Hurst (2007); from the regression methods of the latter, for instance, we learn that, over the period 1965–2003, leisure for men increased by roughly 6–9 h per week (driven by a decline in market work hours) and for women by roughly 4–8 h per week. Robinson and Godbey (1997) also find that women's total work declined over the 1965–1985 period.

For the purposes of the current article, however, a closer look at the data is warranted for three reasons. First, while the existing results concern the population as a whole, we need to examine the time allocation of married people. Second, the results reported in previous papers concern trends since 1965, with little information on the period that is critical for the analysis here, 1975 to the end of the 1990s. The 1965 survey is not in fact representative, as the representative component consists of a small ($n = 1200$) sample that restricts attention to people living in cities of population 30,000–280,000. Finally, while the labour literature analyses trends in leisure, defined as time in specified non-work activities such as attending social functions or watching TV, in the macro literature it is standard to divide discretionary time into paid work, home-production and non-working time.

Of the 168 h available each week, it is assumed that the minimum time required for sleep and personal care is 50 h, which turns out to be the first percentile in the pooled data for 1965, 1975, 1985, and 2003. The exact number assigned to this minimum time is without consequence for the analysis. The important point is that time spent in sleep and personal care includes a discretionary component, as documented by Biddle and Hamermesh (1990). This article assumes discretionary time is allocated between paid work and unpaid work; the residual is taken to be non-working time. The variables making up each of these categories are taken from the definitions of Aguiar and Hurst (2007).

Table 2(a) reports the time allocation of married people aged 18–65 according to these surveys. The table shows that working time did decline over the longer period since 1965, but all of this decline was before the period of interest begins in 1975. Since then the working time of both married men and women has increased, due to a rise in unpaid work for men and in paid work for women. The main point however is that while non-working time has declined slightly for both husbands and wives since 1975, the ratio of married-women's non-working time to that of married men has remained stable; 1.073 in 1975, 1.073 in 2003. Even after accounting for unpaid

TABLE 2(a)
Time allocation of married couples

Variables	1965		1975		1985		2003	
	Wives	Husbands	Wives	Husbands	Wives	Husbands	Wives	Husbands
Discretionary time	118	118	118	118	118	118	118	118
Paid work	11.54	42.07	14.8	38.17	17.6	35.51	21.82	38.2
Unpaid work	45.28	19.4	36.79	17.91	35.6	21.32	32.32	20.29
Total working time	56.82	61.47	51.59	56.08	53.2	56.83	54.14	58.49
Non-working time	61.18	56.53	66.41	61.92	64.8	61.17	63.86	59.51
Sample size	739	696	697	655	1122	966	4116	3774

Author's computations from married people aged 18–65 in time-use surveys. Observations with more than 4 weekly hours unaccounted for excluded.

TABLE 2(b)
Composition of unpaid work

Variables	1975		2003	
	Wives	Husbands	Wives	Husbands
Commute+job-related	2.71	6.54	2.02	4.06
Cooking and indoor chores	21.31	1.98	14.86	3.33
Shopping	6.18	3.8	6.55	4.24
Other home production	2.36	4.53	4.06	7.01
Child care	4.23	1.06	4.83	1.65
Total unpaid work	36.79	17.91	32.32	20.29

Author's computations from married people aged 18–65 in time-use surveys.

working time therefore, married-women's non-working time is not responding relative wages in the way predicted by the unitary model.

Table 2(b) shows that unpaid working time is composed largely of time spent cooking and cleaning in the case of the women; while this component has increased 50% for men, it was still only 3.33 h weekly on average in 2003, compared to 14.9 h for wives. Commuting and Job-related time declined for both men and women, even though time in paid work did not. The 2.5 h decline for men in time spent in Job-related was largely offset by small increases in other categories. One category that increased for both men and women was child care (excluding time spent playing with children); the effect is small however relative to the other changes, so it does not appear worth worrying how time spent in this category might be mis-measured. Overall, men in 2003 were spending two more hours in "Other home production" per week, and one more in "Cooking and Other Indoor Chores" than in 1975. The lack of trend in relative non-working time therefore is robust to how we treat child-care time.

Table 3(a) and (b) shows that conditioning on observables such as age, education, and labour force status does not explain the stationarity of relative non-working time. The relative wages of the sub-samples are shown in Table 3(a), which gives the female/male wage ratios for people working 10 h or more per week. For the 25–54 age group, the ratio of mean wages rises from 0.6 in the 1967–74 period to 0.76 in the 1995–2000 period. For the 55–65 age group, the wage ratio is the same in both periods. For those with less than a bachelor's degree (BA), the ratio evolves from 0.6 to 0.76; for those with a BA or more, the trend is weaker, from 0.66 to 0.72, falling back to 0.69 in the 2000–06 period. Table 3(b) shows that, over the 1975–2003 period, only one group of husbands gets an increase in relative non-working time; those with educational attainment equal

TABLE 2(c)
Composition of non-working time

Variables	1975		2003	
	Wives	Husbands	Wives	Husbands
"Leisure 1"	34.5	33.07	32.43	35.51
Net personal care	25.4	23.31	24.44	20.12
Other non-working time	6.51	5.54	6.99	3.88
Total non-working time	66.41	61.92	63.86	59.51

Author's computations from married people aged 18–65 in time-use surveys. "Leisure 1" refers to variable defined in Aguiar and Hurst (2007).

TABLE 3(a)
Female–male wage ratios by age and education

Age	Years					
	1962–66	1967–74	1975–84	1985–94	1995–2000	2000–06
18–24	0.83	0.81	0.84	0.92	0.91	0.90
25–54	0.59	0.60	0.63	0.74	0.76	0.75
55–56	0.65	0.65	0.60	0.64	0.63	0.66
Education						
< HS	0.59	0.58	0.61	0.71	0.74	0.75
HS	0.61	0.61	0.64	0.73	0.76	0.76
College	0.58	0.60	0.66	0.75	0.76	0.75
BA	0.64	0.66	0.66	0.73	0.72	0.69

Author's computations from the CPS population of people aged 18–65 who worked at least 10 h weekly on average.

TABLE 3(b)
Non-working time of married people

Sub-sample		Wife-husband ratios of non-working time			
		1965	1975	1985	2003
Years of education	< 12	1.08	1.02	1.08	1.01
	12 years	1.06	1.14	1.03	1.06
	13–15 years	1.20	0.98	1.03	1.08
	16 or more	1.01	1.07	1.11	1.10
Working		0.89	0.97	1.01	1.04
Age	25–55	0.83	0.94	1.03	1.04
	55–70	1.12	1.01	0.95	1.06

Author's computations from the time-use surveys.

to 12 years, the equivalent to a high-school diploma. The wife's relative non-working time falls in this case from 1.14 to 1.06. For all other groups, wife's relative non-working time increases or stays constant. Most significantly, when the sample is restricted to spouses who are working, the wife's relative non-working time increases from 0.97 to 1.04. The effect appears to be strongest among younger couples; the increase for married people aged 25–55 is from 0.94 to 1.04. Among the 55–70 age group the rise in wife's relative non-working time is much weaker, from 1.01 to 1.06, which may be due to the fact that the wage change is much smaller for this group as shown in Table 3(a) and (b), from 0.66 to 0.69. Far from accounting for the failure of husband's non-working time to rise, the observables seem to exacerbate the issue by revealing that in fact it is the wife's relative non-working time that is increasing within most groups.

Could it be that there is a rigidity, perhaps due to social norms, that restricts married couples from freely adjusting leisure time? It is generally difficult to examine this in the time-use surveys because they sample individuals, rather than households. However in 1985, the sample included 531 married couples. Figure A3(b) in the Supplementary Appendix shows, the husband–wife ratios of non-working time for this sample. Although it is clear that the distribution is centred around one, considerable dispersion exists. A similar result for Australia, Germany, and the U.S. is obtained by Burda *et al.* (2007). Although analysing the source of this dispersion is outside the scope of the current article, it seems to indicate that there is no lack of flexibility in the allocation of non-working time.

3. A MODEL OF MARRIAGE AND LABOUR SUPPLY

This section describes a simple equilibrium marriage model. We first work out the efficient allocations, taking as given the Pareto weight the household puts on each spouse. Holding these weights fixed corresponds to the standard unitary model used in macro-economics. We then extend the model by nesting a bargaining theory in which the Pareto weights depend on the value of leaving the marriage. Finally, we work out how the equilibrium weights depend on full income by marital status for all household types. A simple example of the model is then fully worked out to show how the main features determine labour supply.

3.1. *Household structure*

There is a large population comprised of two sexes $i \in \{H, W\}$ in equal numbers, who are otherwise *ex ante* identical and live through an infinite succession of discrete periods. Individual agents have zero mass. At the beginning of each period, people are either married or single. Married people learn their realization of a match-quality shock ε, then choose whether to stay together or to divorce. If they divorce, they must then wait until the next period to meet a new potential spouse. This shock has an unconditional distribution Φ; realizations are independent across pairings, but may be persistent within. Let the conditional distribution be $F\left(\varepsilon', \varepsilon\right)$. The cost of divorce is $d_{\mathrm{c}} \geq 0$.

All people who enter the period as singles are randomly paired with a single of the opposite sex. The new pairs then learn their match quality ε, choose allocations and decide whether to marry. After the marriage decisions, all married couples choose their time allocations over market and house work, and get utility from leisure, match quality, and consumption of market goods.

Each agent i has a one-unit time endowment, which is allocated across three competing uses: leisure l_i, work outside the household n_i, and home work h_i. There is a time cost t_n per unit of outside work. The time constraint for each agent i is

$$l_i + n_i (1 + t_n) + h_i = 1.$$

- Agents derive utility from leisure l_i, as well as the consumption of a market good c and a home good g. We assume a CES utility function:

$$u(c, l, g) = \frac{\sigma_c}{1-\sigma_1} c^{1-\sigma_1} + \frac{\sigma_l}{1-\sigma_1} l^{1-\sigma_1} + \frac{\sigma_g}{1-\sigma_1} g^{1-\sigma_1}.$$

- Preferences of individuals over infinite streams of utility are represented by the discounted sum:

$$E_0 \left(\sum_{t=0}^{\infty} \beta^{\mathrm{j}} \left[u(c_t, l_t, g_t) + J_{i,t}^{\mathrm{M}} \varepsilon_{i,t} \right] \right),$$

where M indicates marital status and $J_{i,t}^{\mathrm{M}}$ is an indicator equal to one if the agent is in a married household at the end of period t.

The home good is produced using inputs of housework time $(h_{\mathrm{H}}, h_{\mathrm{W}})$ from each spouse, as well as a flow of home equipment e_{q}, according to a production function $G\left(e_{\mathrm{q}}, h_{\mathrm{H}}, h_{\mathrm{W}}\right)$. In order to allow both singles and married to be modelled as operating the same technology, we assume the effective labour input of married couples is CES in the individual inputs:

$$h(h_{\mathrm{W}}, h_{\mathrm{H}}) = \left[\eta_0 h_{\mathrm{W}}^{1-\eta_1} + (1-\eta_0) h_{\mathrm{H}}^{1-\eta_1}\right]^{1/(1-\eta_1)}.$$

Let the effective time input be h and the goods input be e_{q}. The home-production function is

$$G\left(h, e_{\mathrm{q}}\right) = z\left[e_{\mathrm{q}}^{1-\theta}\right] h^{\theta}.$$

3.2. *Markets, prices, and taxation*

A unit of outside labour n_i by a worker of sex i produces w_i units of a consumption good, which is consumed within the period.[4] Both the wage $\widetilde{w}_i$ and the work cost t_n are parameters which evolve exogenously. Households also have some endowed non-labour income, equal to $y_{\mathrm{M}}^{\mathrm{nl}}$ for married couples and y_i^{nl}, $i \in \{H, W\}$ for singles. Income is taxed according to a progressive tax schedule that distinguishes between married and single households. The tax bill of a household of type i with gross (taxable) income Y_i is given by a continuously differentiable function $T_i(Y_i)$. The household buys home equipment e_{q} at price p_{q} per unit.

3.3. *Optimal allocations*

We show in the Supplementary Appendix how to write the decision rules as functions of the average and marginal tax rates, which we denote $T^{\mathrm{A}}, T^{\mathrm{M}}$, respectively. Of course these expressions only give the optimal decisions when evaluated at the correct tax rates, but this is easily resolved through iteration on the taxable income Y^{T}, using the tax function $T\left(Y^{\mathrm{T}}\right)$ to update the tax rates, given the decision rules.

3.3.1. Singles.

The indirect utility flow of a single-person household with wage w is

$$U_i^{\mathrm{S}} \equiv \max_{c,l,h,e_{\mathrm{q}}} \left\{u\left(c, l, G\left(h, e_{\mathrm{q}}\right)\right)\right\}$$

subject to

$$c + w_i l + T\left(Y^{\mathrm{T}}\right) = w_i(1-h) + y_i - p_{\mathrm{e}} e_{\mathrm{q}},$$

4. Note that we have ruled out savings, an important feature of standard macro-economic models. In the current model, the savings margin would affect aggregate labour supply, but, in the absence of divorce, have no impact on relative labour. As our model allows for divorce, the impact on relative labour would depend on how wealth is allocated at divorce, and on the degree of assortment on wealth implied by the marriage-market equilibrium. Including wealth therefore complicates considerably the equilibrium concept and the computation. See Cubeddu and Rios-Rull (1997) for analysis of a marriage-market equilibrium with wealth and divorce.

where w_i is the wage, p_{e} the price of equipment, and y_i the non-labour income of the household. Taxable income is

$$Y^{\mathrm{T}}=w_i(1-l-h)+y_i.$$

The reduced-form demand functions, which depend on the budget-constraint multiplier λ, are

$$[c,l,g]=\left[\left(\frac{\sigma_c}{\lambda}\right)^{1/\sigma_1},\left(\frac{\sigma_l}{\lambda w^{\mathrm{M}}}\right)^{1/\sigma_1},\left(\frac{\sigma_g}{\lambda D^{\mathrm{M}}}\right)^{1/\sigma_1}\right],$$

where D^{M} is the effective marginal price of home goods, as derived in the Supplementary Appendix, and $w^{\mathrm{M}}\equiv w\left(1-T^{\mathrm{M}}\right)$ is the effective marginal wage for the single type. The full income of the household is

$$Y^{\mathrm{F}}=D^{\mathrm{A}}\left(\frac{\sigma_g}{\lambda D^{\mathrm{M}}}\right)^{1/\sigma_1}+\left(\frac{\sigma_c}{\lambda}\right)^{1/\sigma_1}+w^{\mathrm{A}}\left(\frac{\sigma_l}{\lambda w^{\mathrm{M}}}\right)^{1/\sigma_1},$$

where D^{A} is the unit cost of home production. The solution for the budget multiplier λ is given in the Supplementary Appendix.

We also find that the equipment share of home-production costs is

$$\frac{p_{\mathrm{e}}e_{\mathrm{q}}}{w^{\mathrm{A}}h+p_{\mathrm{e}}e_{\mathrm{q}}}=\frac{\tau(1-\theta)}{\theta+\tau(1-\theta)},$$

where $\tau\equiv\frac{1-T^{\mathrm{M}}}{1-T^{\mathrm{A}}}$ represents the progressivity of taxes, and $w^{\mathrm{A}}=w\left(1-T^{\mathrm{A}}\right)$ is the effective unit cost of leisure.

3.3.2. Married Households. The married household is assumed to maximize a welfare function consisting of a weighted sum of the welfare of each spouse $i\in\{H,W\}$. The state of a marriage is given by the quality shock ε. There is no commitment, so the decisions made by a new marriage are the same as those of an existing marriage with the same quality ϵ. Allocations are given by the solution to the household planner's problem where μ_i is the Pareto weight on spouse i in the planner's objective function.

Since we assume utility is separable in the home good, and that spouses each get the same utility from the home good, we can let the total utility flow from the home good be $v\left(G\left(H(h_{\mathrm{M}},h_{\mathrm{W}}),e_{\mathrm{q}}\right)\right)$.

The couple chooses the husband's allocation $(c_{\mathrm{M}},l_{\mathrm{M}},h_{\mathrm{M}})$ and the wife's allocation $(c_{\mathrm{F}},l_{\mathrm{F}},h_{\mathrm{F}})$ and home equipment e_{q} to maximize

$$v\left(G\left(H(h_{\mathrm{M}},h_{\mathrm{W}}),e_{\mathrm{q}}\right)\right)+\mu_{\mathrm{M}}u^{\mathrm{M}}(c_{\mathrm{M}},l_{\mathrm{M}})+\mu_{\mathrm{W}}u_{\mathrm{W}}^{\mathrm{W}}(c_{\mathrm{W}},l_{\mathrm{W}})$$

subject to

$$c_{\mathrm{M}}+w_{\mathrm{M}}l_{\mathrm{M}}+c_{\mathrm{F}}+w_{\mathrm{W}}l_{\mathrm{W}}+T\left(Y^{\mathrm{T}}\right)=w_{\mathrm{M}}(1-h_{\mathrm{M}})+w_{\mathrm{W}}(1-h_{\mathrm{W}})-p_{\mathrm{e}}e_{\mathrm{q}}$$

and the time constraints for each spouse:

$$h_{\mathrm{M}}+l_{\mathrm{M}}\leq 1$$

where Y^{T} represents taxable income:

$$Y^{\mathrm{T}}=w_{\mathrm{M}}(1-l_{\mathrm{M}}-h_{\mathrm{M}})+w_{\mathrm{W}}(1-l_{\mathrm{W}}-h_{\mathrm{W}})+y.$$

If we take as given the marginal wages $w_{\mathrm{M}}^{\mathrm{M}}, w_{\mathrm{W}}^{\mathrm{M}}$ of the husband and wife, respectively, and let λ represent the budget-constraint multiplier, we can write the reduced-form demand functions as

$$[c_i, l_i, g]=\left[\left(\frac{\mu_i \sigma_c}{\lambda}\right)^{1/\sigma_1}, \left(\frac{\mu_i \sigma_l}{\lambda w_i^{\mathrm{M}}}\right)^{1/\sigma_1}, \left(\frac{\sigma_g}{\lambda D^{\mathrm{M}}}\right)^{1/\sigma_1}\right],$$

where D^{M} is the effective marginal price of home goods for married couples. The home-production inputs end up being all proportional to the demand for home goods:

$$\left[h_{\mathrm{M}}, h_{\mathrm{W}}, e_{\mathrm{q}}\right]=\left[\frac{g}{x_g}, \frac{x_w g}{x_g}, \frac{x_e g}{x_g}\right],$$

so the unit price of the home good is independent of the output level. The expressions for the optimal values of the ratios $x_g \equiv g/h_{\mathrm{M}}$, $x_e = e/h_{\mathrm{M}}$, and $x_w = h_{\mathrm{W}}/h_{\mathrm{M}}$ are given in the Supplementray Appendix. Note the tight relationship of the wage ratio to the ratio of wife's time to that of the husband:

$$x_w=\frac{h_{\mathrm{W}}}{h_{\mathrm{M}}}=\left(\frac{w_{\mathrm{M}}}{w_{\mathrm{W}}}\frac{\eta_0}{1-\eta_0}\right)^{1/\eta_1}. \tag{1}$$

The equipment share of expenditure is given by

$$\frac{p_e x_e}{w_{\mathrm{M}}^{\mathrm{A}}+w_{\mathrm{W}}^{\mathrm{A}} x_w + p_e x_e}=\frac{\hat{\tau}(1-\theta)}{\theta+\hat{\tau}(1-\theta)}, \tag{2}$$

where $\hat{\tau}$, by analogy with the expression for singles, represents the effective progressivity of taxation of married couples (derived in the Supplementary Appendix). These explicit solutions for all the decisions rules will be very useful for providing a transparent identification scheme in the calibration section.

3.3.3. Implications for relative leisure. The first-order conditions for the spouses' leisure imply that if the Pareto weights are constant, then the ratio of marginal utilities for leisure will be proportional to the relative wage:

$$\frac{u_l^{\mathrm{M}}(c_{\mathrm{M}}, l_{\mathrm{M}}, g)}{u_l^{\mathrm{W}}(c_{\mathrm{W}}, l_{\mathrm{W}}, g)}=\frac{w_{\mathrm{M}}}{w_{\mathrm{W}}}\frac{1-\mu}{\mu}.$$

Since the wage ratio $w_{\mathrm{M}}/w_{\mathrm{W}}$ has fallen over time, the ratio of marginal utilities must have fallen too; concavity of the utility function leisure implies that husband's leisure should have risen relative to that of the wives. Using the CES specification above, the prediction can be made quantitative. The wife–husband leisure ratio is given by

$$\frac{l_{\mathrm{W}}}{l_{\mathrm{H}}}=\left[\frac{w_{\mathrm{M}}}{w_{\mathrm{W}}}\frac{\mu_{\mathrm{W}}}{\mu_{\mathrm{M}}}\right]^{1/\sigma}.$$

Blau and Kahn (1997) report that the average wages of women working full time rose, as a fraction of men's, from 0.60 to 0.76 over the period 1975–1995. If we follow Attanasio *et al.*

(2008) in setting $\sigma=1.5$, the prediction is that married-women's leisure should have declined 12.4% relative of that of their husbands, an effect on the order of 7 h.

Note that these implications are independent of the tax function and the home-production technology. With joint taxation, the relative wage of husband and wife is unaffected, so any increase in wife's labour supply induced by changes in the tax schedule should leave the leisure ratio unchanged. Similarly, the allocation of working time between home and paid work affects neither the marginal utility of leisure nor the relative wages, so the leisure ratio is independent of the home technology or relative productivity of the spouses at home. Both of these are special cases of the general point that wealth effects in the model cannot directly affect leisure ratios.

3.4. *Determination of the Pareto weights*

Our theory of the Pareto weights is that they are functions of the gains from marriage, relative to divorce, as in a wide range of papers from McElroy and Horney (1981) to Chiappori *et al.* (2002) to Greenwood *et al.* (2003). We assume that this mapping can be represented by a bargaining solution. We will consider two types of solution: the standard Nash bargaining solution, and the Egalitarian bargaining solution. The latter is very useful because for special cases it renders the model tractable, so that we can solve for equilibrium allocations and marriage decisions.[5] In the case of a linear Pareto frontier, *i.e.* fully transferable utility, a standard assumption in the labour-matching literature, the Egalitarian solution is equivalent to the Nash bargaining solution with equal bargaining power.

In what follows we consider a stationary environment; relative wages are constant, so the only source of divorce is random variation in match quality; as spouses will agree on the states of the world in which divorce is preferable, commitment is not an issue in this environment.[6]

Let $U_i^{\mathrm{M}}\left(\mu_i, Y^{\mathrm{M}}\right)+\varepsilon$ represent the indirect utility flow to agent i from a marriage where μ_i is the Pareto weight on agent i, and ε is the current realization of a random variable representing the quality of the marriage. Let V_i^{M} indicate the value to a person of sex i of being married and V_i^{S} that of being single. Let Φ represent the unconditional CDF of ε; this is the distribution from which the match-quality realization is drawn for new matches. Let $F\left(\varepsilon'|\varepsilon\right)$ represent the conditional distribution for on-going matches.

Standard arguments show that there exist thresholds $\varepsilon^{\mathrm{M}}, \varepsilon^{\mathrm{D}}$ such that marriage occurs only if $\varepsilon > \varepsilon^{\mathrm{M}}$ and divorce only if $\varepsilon < \varepsilon^{\mathrm{D}}$, and that with positive divorce costs, $\varepsilon^{\mathrm{D}} < \varepsilon^{\mathrm{M}}$. If we take μ_i' as fixed, the value to spouse i of being in the marriage is

$$V_i^{\mathrm{M}}(\mu_i,\varepsilon)=U_i^{\mathrm{M}}\left(\mu_i,Y^{\mathrm{M}}\right)+\varepsilon\ldots$$
$$\ldots+\beta\left[F\left(\varepsilon^{\mathrm{D}}|\varepsilon\right)\left(V_i^{\mathrm{S}}-d_{\mathrm{c}}\right)+\left(1-F\left(\varepsilon^{\mathrm{D}}|\varepsilon\right)\right)EV_i^{\mathrm{M}}\left(\mu_i',\varepsilon'\right)\right]. \tag{3}$$

Similarly, for singles, let the indirect utility flow be U_i^{S}, so that we can write the value of being single as

$$V_i^{\mathrm{S}}=U_i^{\mathrm{S}}+\beta\left[\Phi\left(\varepsilon^{\mathrm{M}}\right)V_i^{\mathrm{S}}+\int_{\varepsilon^{\mathrm{M}}}V_i^{\mathrm{M}}\left(\mu_i',\varepsilon'\right)d\Phi(\varepsilon)\right]. \tag{4}$$

5. The Egalitarian solution, while it lacks the scale invariance of the standard Nash solution, is more intuitive; indeed Kalai (1977) argues that this solution implements a Rawlsian approach to justice.

6. The computational methods we use can be extended to the case of wage trends with perfect foresight, provided we assume full commitment at the time of marriage, but the solutions are difficult to characterize analytically.

Define the gains from marriage, relative to divorce, as

$$W_i^{\mathrm{D}}(\mu_i,\varepsilon)=V_i^{\mathrm{M}}(\mu_i,\varepsilon)-V_i^{\mathrm{S}}-d_{\mathrm{c}},$$

where the divorce cost $2d_{\mathrm{c}}$ is assumed to be paid equally by each spouse.

Definition 1. *A bargaining solution $B(W_{\mathrm{H}},W_{\mathrm{W}})$ is a mapping from a pair of functions $W_{\mathrm{H}}^{\mathrm{D}}(),W_{\mathrm{W}}^{\mathrm{D}}()$ to a Pareto weight μ on spouse H. The weight on spouse W is given by $1-\mu$.*

Notice that this definition allows B to map on to any Pareto-optimal allocation. The main restriction relative to the set of all possible bargaining solutions, is that solutions depend only on the gains from marriage. This is quite standard in the literature on household labour supply, and is consistent with the result of Chiappori *et al.* (2002) and others who find that labour supply of married couples responds to variables ("distribution factors") that affect the value of single life, such as divorce rules, or the sex ratio of singles.

It is useful to contrast two common examples. The "Egalitarian" solution μ^{E} is defined as the value of μ that equalizes the gains from marriage. Hence μ^{E} solves:

$$\frac{W_{\mathrm{M}}^{\mathrm{D}}(\mu^{\mathrm{E}},\varepsilon)}{W_{\mathrm{W}}^{\mathrm{D}}(1-\mu^{\mathrm{E}},\varepsilon)}=1.$$

A nice feature of this concept is that it is easy to solve because the symmetry implies terms that are common to both sides drop out. The Nash solution by contrast takes into account both the gains and the curvature of the Pareto frontier, *i.e.* the marginal cost of transferring utility. The first-order condition (FOC) for the Nash solution μ^{N}, with equal bargaining power, is

$$\frac{W_{\mathrm{M}}^{\mathrm{D}}(\mu^{\mathrm{N}},\varepsilon)}{W_{\mathrm{W}}^{\mathrm{D}}(1-\mu^{\mathrm{N}},\varepsilon)}=-\frac{\partial W_{\mathrm{M}}^{\mathrm{D}}(\mu^{\mathrm{N}},\varepsilon)/\partial\mu}{\partial W_{\mathrm{W}}^{\mathrm{D}}(1-\mu^{\mathrm{N}},\varepsilon)/\partial\mu}.$$

With concave utility, the right-hand side is declining in μ^{N}; this reduces the elasticity of the Nash solution with respect to gains from marriage. It turns out that while the Nash solution is insufficiently elastic to fully account for the stability of relative leisure, the Egalitarian solution is too elastic. In the quantitative analysis we will therefore rely on a convex combination of the two solutions to generate Pareto-optimal allocations.

3.5. *Matching equilibrium*

The marriage threshold ε^{M} sets the marriage surplus to zero, relative to single life. Similarly the divorce threshold ε^{D} sets the marriage surplus to zero, relative to divorce. The wedge between the two is a function of the divorce cost d_{c}. These two thresholds define the market-clearing conditions in a stationary marriage-market equilibrium.

Definition 2. *A* stationary recursive equilibrium *of the matching market with progressive tax functions $T_i(\cdot)$ and bargaining solution $B(W_{\mathrm{H}},W_{\mathrm{W}})$, consists of a pair of thresholds $\{\varepsilon^{\mathrm{M}},\varepsilon^{\mathrm{D}}\}$, a Pareto weight μ, and for each household type $i\in\{M,S_{\mathrm{W}},S_{\mathrm{H}}\}$, allocations, tax rates $\{T_i^{\mathrm{M}},T_i^{\mathrm{A}}\}$ and value functions $\{V_i^{\mathrm{M}}(\mu_i,\varepsilon),V_i^{\mathrm{S}}\}$ such that:*

(1) The value functions solve the Bellman equations (3) and (4) for men and women, given the prices $\{w,y,p_{\mathrm{q}}\}$ and thresholds.

(2) *The threshold ε^{M} sets to zero the gains from marriage, relative to remaining single, while ε^{D} sets to zero the gains from marriage, relative to divorce.*
(3) *The allocations implied by the Pareto weight μ equal those generated by the bargaining solution: $\mu = B\left(W_{\mathrm{H}}^{\mathrm{D}}, W_{\mathrm{W}}^{\mathrm{D}}\right)$, where W_i represents the gain of spouse i from marriage, relative to divorce.*
(4) *The allocations generate, for each household type i, a level of taxable household income Y_i^T such that $T_i'\left(Y_i^{\mathrm{T}}\right) = T_i^{\mathrm{M}}$, and $T_i\left(Y_i^{\mathrm{T}}\right)/Y_i^{\mathrm{T}} = T_i^{\mathrm{A}}$.*

3.6. *Computation*

The model's solution is computed using a three-step iterative strategy. First we solve the time-allocation problem of married couples, and derive the indirect utility as a function of the Pareto weight, given the continuation values. Second, we solve for the marriage and divorce thresholds, exploiting the fact that with efficient separation rates, these will be the same for any Pareto-optimal sharing rule. Finally we compute the updated Pareto weights and value functions, and repeat the procedure until convergence.

With progressive taxation, the tax rate depends on the labour income of the household, and hence on the leisure allocations. The time-allocation problem is therefore solved by guessing the labour income (and hence the tax rate), solving for the leisure allocation, and updating the guess until we have guessed the correct labour income, given μ. Thus the static components of the model are easily solved.

The solution strategy for the equilibrium $\left(\varepsilon^{\mathrm{M}}, \varepsilon^{\mathrm{D}}, \mu\right)$ in the marriage market takes as given a set of approximations for the values V_i^{M} of being married, as functions of ε. We search over the unit simplex in R^2 to find a pair $\left(\varepsilon^{\mathrm{M}}, \varepsilon^{\mathrm{D}}\right)$ of stationary marriage and divorce rates. To compute the marriage/divorce thresholds, we define the minimum weight $\underline{\mu}_i^{\mathrm{M}}(\varepsilon)$ as the Pareto weight that leaves a single agent of sex i indifferent between marriage and single life: $W_i\left(\underline{\mu}_i^{\mathrm{M}}, \varepsilon\right) = 0$. Similarly we can define $\underline{\mu}_i^{\mathrm{D}}(\varepsilon)$ as the value that leaves a married agent of sex i indifferent between marriage and divorce. The surplus equals the sum of the gains $W_j\left(\mu_j, \varepsilon\right)$, so we can find ε^{M} by solving $\underline{\mu}_{\mathrm{W}}^{\mathrm{M}}\left(\varepsilon^{\mathrm{M}}\right) + \underline{\mu}_H^M\left(\varepsilon^{\mathrm{M}}\right) = 1$. The divorce threshold ε^{D} is computed in a similar way. Of course if ε is iid then $\varepsilon^{\mathrm{D}} = \varepsilon^{\mathrm{M}} - 2d_{\mathrm{c}}$.

Once we know the thresholds, we can use the Bellman equation (3) to compute the bargaining solution for any ϵ in $\left[\epsilon^{\mathrm{D}}, \epsilon^{\mathrm{M}}\right]$. The approximations to the value functions are then updated by splining the value of marriage for each spouse on a grid over $\left[\epsilon^{\mathrm{D}}, \epsilon^{\mathrm{M}}\right]$. We then repeat the procedure with these solutions replacing the initial guesses.

This procedure converges monotonically in the Euclidean norm to a fixed point for $\varepsilon^{\mathrm{M}}, \varepsilon^{\mathrm{D}}$. At the fixed point, all of the equilibrium conditions hold, by construction.

With the solutions in hand, there is at least one potential reason why it may be important to base statistics from the model on simulations. As discussed earlier, the Nash equilibrium yields a Pareto weight that depends on the marriage quality. If this is persistent then the average marriage quality, and hence the allocations, will be functions of the marriage (and divorce) rates. Even with iid quality, the non-linearity of the decision rules may cause the average of the decisions to differ from the decisions of the average householders of each type. Therefore the statistics reported below are based on simulations of the model at the solution.

4. CALIBRATION

The goal of the calibration is provide an analytic tool to help understand the change in time-allocation patterns since 1970. The strategy is to supply an accounting decomposition of the changes: we find a set of parameter values such that the model matches exactly the time-allocation patterns and marriage rates for each of 2 years: 1975 and 1995, given measurements on the exogenous parameters such as wages, non-labour income, and home technology. This procedure therefore identifies changes in preferences and technology explicitly, using the optimality conditions derived in the Supplementary Appendix.

The time-allocation targets are drawn from Table A2 in the Supplementary Appendix, where we reconcile the relevant discrepancies between the March CPS and the time-use survey data summarized in Table 2(a)–(c).

The calibration is in two stages; first we choose parameters for the time-allocation problem to match time-use statistics and the NIPA equipment share of consumption, then in the second stage for the marriage-matching problem, we choose parameters to match marriage and the wife–husband leisure ratio for the 2 years. Given that the model yields explicit solutions for time allocation, we can use the equations in which the equilibrium variables $\left[\epsilon^{\mathrm{M}},\epsilon^{\mathrm{D}},\mu\right]$ do not enter to infer most of the time-allocation parameter values. Given these, we calibrate the remaining free parameters to match the equilibrium marriage and divorce rates, and the wife/husband leisure ratios.

4.1. *Income and taxes*

From the March CPS, we have labour income and total personal income for the whole sample in every year. The wage is computed as the ratio of labour income to hours worked and averaged each year over the population aged 18–65 of each sex. This results in the estimates reported in Table A3 in the Supplementary Appendix and imply a growth of real wages of 19% over the period. Non-wage compensation, which is excluded from the CPS measure, also grew rapidly over the period. According to Meisenheimer (2005), analysis of the National Compensation Survey reveals that total compensation per hour in the non-farm business sector actually grew 32% between 1979 and 2003, the excess over reported wage growth being due to a 55% growth in benefits.

We take non-labour income to be the excess of total personal income over reported labour income. The mean estimates, reported in Table A4 in the Supplementary Appendix, in terms of ratios to mean full labour income, *i.e.* the sum of the observed wages, are on the order of 4% for married and 6% for singles. In terms of realized or observed income, this corresponds to about 12% for married and 18% for singles.[7]

The tax function is taken from Guner *et al.* (2012). This is a three-parameter, continuously-differentiable function:

$$T(y)=\alpha+\alpha_1\ln(y/\bar{y}),$$

where the average tax rate for the household with average income $\bar{y}$ equals α_0 and the marginal tax rate $\alpha_0+\alpha_1$. The function is fitted for the years 1970 and 2000 to IRS data on average tax rates, by income of the household and filing type (married or single).[8] For married couples in 1970 the coefficients are $(0.096, 0.0814)$ and in 2000 $(0.1023, 0.0733)$, while for singles they

7. In aggregate, macro-economists usually find non-labour income to be about a third of GDP. Supposing our population to be representative of the economy as a whole this would lead us to expect non-labour income to average about 10% of full income, so the CPS measurements appear to be quite low. The relatively low capital income in our sample may be explained by measurement error in the CPS, as capital income is quite concentrated in the wealthiest minority of the population, or by exclusion from the sample of the retired population, which is likely to have a particularly high share of non-labour income. This is not a major concern for the current exercise, as we are taking wages as exogenous, and so the capital/income ratio has little role to play.

8. I am grateful to Remzi Kayusz for supplying the 1970 coefficients. The historical data are available for 1916–1999 at the IRS web Statistics on Income web.

are $(0.1597, 0.0857)$ in 1970 and $(0.1547, 0.0497)$ in 2000. The tax functions are normalized by average household income in each year. Note that the marginal tax rate for the married household with average income is roughly 0.18 in both 1970 and 2000, suggesting that the decline of marginal tax rates of the 1980s was a short-run phenomenon, at least in regards to married couples. Marginal tax rates for singles did decline, from 0.25 to 0.2 at the average income. The calibrated tax functions are shown in Figure A6.

4.2. *Technology parameters*

We use equation (1) to set the substitutability parameter η_1 for married-couples' home labour to match the change in the home-production time ratio:

$$\eta_1 = \frac{\log\left(\frac{w_{\mathrm{M}}}{w_{\mathrm{W}}}\right)_{2003} - \log\left(\frac{w_{\mathrm{M}}}{w_{\mathrm{W}}}\right)_{1975}}{\log\left(\frac{h_{\mathrm{W}}}{h_{\mathrm{M}}}\right)_{2003} - \log\left(\frac{h_{\mathrm{W}}}{h_{\mathrm{M}}}\right)_{1975}}.$$

This yields a value of $\eta_1 = 0.33$, which implies a high elasticity of substitution between the labour of husband and wife.[9]

An important advantage of the Cobb–Douglas production function relative to a more general specification is that it provides a clean way to calibrate the role of equipment, as represented by the parameter θ. From the NIPA we have observations on a related quantity, the share of home equipment in total NIPA consumption expenditure, shown in Figure A4(a), and the decline of the relative price of home equipment, shown in A4(b). The NIPA series for equipment and furniture spending, appears to fluctuate between 4% and 6% of total consumption.

We can replicate the observed equipment share X^{EG} of production spending by setting

$$\theta = \frac{\left(1 - X^{\mathrm{EG}}\right)\hat{\tau}}{\left(1 - X^{\mathrm{EG}}\right)\hat{\tau} + X^{\mathrm{EG}}},$$

where $\hat{\tau}$ is the effective progressivity of the tax schedule for married couples, as defined in the Supplementary Appendix. A similar procedure is applied to singles.

We assume work costs are proportional to time spent working, and for each year set τ to match the ratio of unpaid work-related time to paid work time, averaged over all household types.

4.3. *Preference parameters*

We set the utility curvature parameter σ_1 to 1.5, the same value taken by Attanasio *et al.* (2008) to represent standard practice. With the technology parameters in place we can infer the amount of consumption of the home good from the data on home hours, as well as the effective prices of the home good. For each household type we set the utility parameters σ_c, σ_l, σ_g so that the model exactly matches the average hours spent on home production, leisure, and paid work. For

9. An interesting implication of this value is that the fact that wives spend much more time than husbands in home production is entirely explained by the wage differential; the productivity parameter value $\eta_0 = 0.475$, which implies roughly equal productivity of spouses at home, is required in order to generate the observed home-labour ratios. Of course if the model were to be expanded to allow for other factors that might have caused the home-hours ratio to fall over time, then the elasticity estimate would be considerably reduced.

singles, we can express expenditure on each good as a share of consumption expenditure:

$$X^{\mathrm{HC}} \equiv \frac{w^{\mathrm{A}}h + p_e e_q}{c} = \left(\frac{\sigma_g}{D^{\mathrm{M}}\sigma_c}\right)^{1/\sigma_1} \frac{w^{\mathrm{A}} + p_e x_e}{x_g},$$

where the proportions $x_e = e_q/h_{\mathrm{M}}$ and $x_g = h_{\mathrm{M}}/g$, as well as the effective home-production price D^M, are derived in the Supplementary Appendix.

Assuming we can observe X^{HC}, then we can infer the ratio of preference weights as

$$\frac{\sigma_g}{\sigma_c} = \left(X^{\mathrm{HC}} \frac{x_g}{w^{\mathrm{A}} + p_e x_e}\right)^{\sigma_1} D^{\mathrm{M}}.$$

Of course we can do the same for the leisure-expenditure ratio X^{LC},

$$X^{\mathrm{LC}} \equiv \frac{w^{\mathrm{A}} l}{c} = \frac{w^{\mathrm{A}} \left(\frac{\sigma_l}{w^{\mathrm{M}}}\right)^{1/\sigma_1}}{(\sigma_c)^{1/\sigma_1}}$$

from which we infer the ratio:

$$\frac{\sigma_l}{\sigma_c} = \left(\frac{X^{\mathrm{LC}}}{w^{\mathrm{A}}}\right)^{\sigma_1} w^{\mathrm{M}}.$$

Imposing that the weights sum to 1 then results in values for each utility parameter.

4.4. *Free parameters*

We impose that μ is given by the weighted sum of two bargaining solutions. Let ω be the weight on the Egalitarian bargaining solution and $(1-\omega)$ the weight on the Nash solution.[10]

The stochastic process for ϵ is arbitrarily fixed to an iid standard normal with mean zero and variance $\sigma = 2$.

There are therefore five free parameters. Three parameter values are held constant over the two calibration dates: the relative joy of being single $q_{\mathrm{W}}/q_{\mathrm{M}}$, the divorce cost d_{c}, and the weight ω on the Egalitarian bargaining solution. The joy of being single q_W is allowed to vary across the two dates in order to match the change in marriage rates over time.

The statistical targets we use set these parameters consist of the marriage rate π^{M}, the divorce rate π^{D}, and the relative leisure $l_{\mathrm{W}}/l_{\mathrm{H}}$. There are therefore six potential targets. Since there are only five parameters in the loop, we drop one of the targets, the divorce rate for 2003. Matching this would require higher persistence in ϵ to allow divorce rates to fall when marriage rates rise. Since persistence makes the model more difficult to compute, it is natural to begin by abstracting from this feature. The initial conditions for the simulation consists of the fraction of women married by age 18 and a vector of marriage quality, assumed to be above the threshold, for these women. In practice, the mass of these women is so small that they make little difference for the quantitative results.

Because official estimates of the empirical marriage and divorce hazard rates are not available after 1995, these are computed instead from the annual transitions in the distribution marital status in the March CPS according to a simple procedure described in the Supplementary Appendix, starting from the fraction of women already married by age 18. This ensures that the hazard rates are consistent with the population fractions, as shown in Table A6 in the Appendix.

10. Recall that this is to get the required elasticity of relative leisure, holding constant the relative joy of single life $q_{\mathrm{W}}/q_{\mathrm{M}}$. An alternative strategy would be to go with one bargaining solution and back out the variation in $q_{\mathrm{W}}/q_{\mathrm{M}}$.

TABLE 4(a)
Time-allocation results

Statistic	1975		2003	
	Data	Model	Data	Model
Wives HP home time	35.23	35.15	30.03	29.99
Husbands home time	11.7	11.68	17.55	17.53
Single-womens home time	21.72	21.77	21.14	21.14
Single-mens home time	10.5	10.5	13.21	13.25
Equipment share	0.056	0.056	0.046	0.046
Wives leisure	65.05	64.91	62.78	62.7
Husbands leisure	61.93	61.79	59.97	59.89
Single-womens leisure	70.91	71.08	70.21	70.2
Single-mens leisure	77.42	77.4	74.63	74.87
Wives paid work	15.08	15.23	23.06	22.88
Husbands paid work	38.01	37.8	36.62	36.68
Single-womens paid work	21.26	21.34	24.09	24.09
Single-mens paid work	25.55	25.55	26.9	27.01

TABLE 4(b)
Marriage-market calibration results

Statistic	1975		2003	
	Data	Model	Data	Model
Marriage rate	0.0929	0.0854	0.0458	0.0442
Divorce rate	0.0249	0.0241	0.0178	0.0352
Wife/husband leisure ratio	1.0505	1.0553	1.0469	1.0423

TABLE 5(a)
Values of time-allocation parameters

Type	Year	Theta	Utility weights		
			Consumption	Home good	Leisure
Married	1975	0.898	0.260	0.051	0.689
	2003	0.919	0.323	0.070	0.607
Single men	1975	0.817	0.224	0.026	0.750
	2003	0.879	0.254	0.038	0.709
Single women	1975	0.906	0.193	0.072	0.735
	2003	0.928	0.213	0.072	0.715
Work Costs					
	1975	0.178	Substitutability of home labour		0.475
	2003	0.106			

4.5. *Results*

The statistical targets that were used to choose the parameter values are shown in Table 4(a) and (b), and the resulting parameters in Table 5(a) and (b). In addition to the 26 targets shown there, the work-related time from Table A2 was used to set the values of the work costs, for a total of 28 targets. However the procedure described above uses the leisure-expenditure shares, not the actual leisure times; leisure times of married couples are therefore not pinned down, leaving 26 targets.

TABLE 5(b)
Values of free parameters

Parameter	Value
Joy of single life: women/men	1.25
Men's joy of single life 1975	0.83
Men's joy of single life 2003	0.71
Divorce cost	5.29
Weight on Egalitarian solution	0.38

The resulting time-allocation parameter values are shown in Table 5(a). It is clear that the calibration implies a limited role for home equipment: the home-output elasticity with respect to labour input is around 90% for all household types, leaving only 10% for equipment. This means that doubling the amount of home equipment purchased would increase home output by only 7%. Even for single men in the 1970s, who appear to be more reliant on equipment, with an 80% labour share, doubling equipment would result in home output increasing by $<15\%$. The reason θ turns out so low is that the cost of the labour inputs is so high; for married couples, accounting for the cost of the husband's time significantly reduces the apparent role of equipment.

In regards to preferences, we see another reason limiting the impact of home technology: the utility weight on home goods is very small, in the 3–7% range. This implies relatively low expenditure shares; wealth effects will be largely absorbed by the other goods, such as leisure, with expenditure shares on the order of 2/3. In Greenwood *et al.* (2005) for example, technical change increases married-women's paid labour by "liberating" women from home production; however that paper abstracts from both husband's time input and the leisure margin, implying larger effects on paid labour than would obtain in the current article.

Another interesting implication of the time-allocation data is that the utility weight on leisure has decreased over time; this is implied by the observation that expenditure shares on leisure have decreased since 1975. While all three household types seem to care less now about leisure, the decline is by far the greatest for married couples. Per-capita leisure however is relatively stable, declining only by 1/2 h, because the composition of the population has shifted from low-leisure types (married households) to high-leisure types (singles). This of course consistent with leisure having increased over the much longer run, documented in Aguiar and Hurst (2007), who analyse per-capita trends since 1965, and Vandenbroucke (2009), who documents the rise in leisure time since the 19th century.

The results for the free-parameter values, shown in Table 5(b), imply that women get more direct utility from single life than men do; $q_W/q_M = 1.25$; this is needed to explain why wives get roughly the same leisure as husbands despite having lower wages (and hence higher pecuniary gains from marriage).

The calibrated divorce cost is fairly high; 5.29 is equivalent to 4 years of full income for married couples in 1975, 2.6 years in 2003. This is related to the dispersion in the marriage shock; less dispersion would imply a lower divorce cost to match the data, since very bad shocks would be less frequent. Higher persistence would also reduce calibrated divorce costs, as married quality would be higher on average than under the unconditional process.

The model puts 40% weight on the Egalitarian and 60% on the Nash solution. This comes from matching the elasticity of the wife/husband leisure ratio, given that we have imposed that there is no shift in the relative utility from single life. The role of the Nash solution is to reduce the elasticity of μ with respect to relative wages. It also turns out that, under the Nash solution, the Pareto weight is a declining function of ϵ, because men's gains increase with ϵ relative to women's gains from marriage; for low ϵ the main component of gains is the pecuniary gain, which is larger for women, while for large values the main component is marriage quality, which is assumed to be equal. Therefore there is a potential for changes in the marriage rates to affect allocations through μ.

Finally, the model implies that the decline of marriage is unrelated to wages or income; the sum of the utilities (net of q_W, q_M) of a single man and a single woman increases by 0.27, about 4%, from 1975 to 2003, so that singles are indeed better off, but that of married couples increases by 0.36 (about 5%), so marriage rates would have increased slightly if left to these influences alone. Marriage decline is explained in the model entirely by a preference shift, the rise of q_W, q_M. The results is a marriage rate of 8.5% in 1975 for the benchmark model, compared to a target of 9.3%, and 4.4% in 1975, compared to a target of 4.6%. The magnitude of the decline is therefore very similar in the model (48%) and the data (51%).

5. EXPERIMENTS

How much of a difference does bargaining make in our assessment of labour-supply trends? In other words, does it matter whether we allow for bargaining when assessing the impact on labour supply of the historically changing variables that we take as exogenous, such as wages, the home-equipment price and the effective tax rate of working wives? In this section we describe a set of computational experiments aimed at answering these questions.

The idea is that, for each, experiment, all parameters are fixed at the benchmark calibration values for 1975, except for the parameter that the particular experiment is concerned with, which is set to its 2003 value. The main results are reported in Table 6, which explicitly explores the role of bargaining in generating responses to changes in relative wages and to changes in preferences, which turn out to be the two main forces at work in the model. Columns (1) and (7) show the benchmark outcomes for 2003 and 1975, respectively; the other columns correspond to experiments. Columns (2) and (5) for instance show the results for the case where the utility-function parameters $(\sigma_c, \sigma_l, \sigma_g)$ alone are allowed to adjust to their 2003 values; in Column (2) with bargaining, and in Column (5) without. The same applies to Columns (3) and (6), except that now it is the relative wage that is allowed to adjust. Those experiments where bargaining turns out not to play an important role are shown in Table A6 in the Supplementary Appendix.

5.1. *Paid hours*

It is clear from Table 6 that relative wages can, on their own, account for the entire increase in paid work of wives. Indeed in Column (6) we see an excessive increase, to 25.9 paid hours, compared to the observed 2003 level of 22.9 h in Column (1). This implies a significant decline in the wife–husband leisure ratio, from 1.04 to 0.93, a typical result for the unitary model. In Column (3) however, we see that the response of the Pareto weight, through bargaining, brings the ratio back up to 1.02, and married-women's paid work returns to a realistic 23.2 weekly hours. Bargaining, therefore, is playing the critical role in maintaining the leisure ratio; the improved economic position of single women causes the married allocation to shift in favour of wives, offsetting the direct impact of relative wages on the leisure ratio.

Column (2) shows that the shifting utility parameters $(\sigma_c, \sigma_l, \sigma_g)$ play virtually no role in accounting for the rise in married-women's paid hours. This is surprising, as we saw earlier that the weight married couples put on leisure appears to have declined considerably. In fact, we see in Column (5) that under the unitary model the effect of the preference shift on the wife's paid hours appears much larger, about 1.7 h weekly. However the preference shift also makes single women better off relative to single men, and so increases the relative leisure of married women, offsetting the direct impact on paid hours.

TABLE 6

Main results with flexible (bargaining model) and rigid (unitary model) Pareto weights

Statistic		Bargaining model			Unitary model			
		2003	Preferences	Relative wage	2003	Preferences	Relative wage	BenchMark 1975
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Marriage rate		0.040	0.064	0.102	0.04	0.07	0.10	0.09
Divorce rate		0.037	0.029	0.021	0.04	0.03	0.02	0.02
Wife/husband leisure ratio		1.04	1.12	1.02	0.93	1.06	0.93	1.06
Paid work	Wives	22.94	15.04	23.22	26.42	16.67	25.90	14.97
	Husbands	36.52	43.40	32.70	33.82	42.32	30.61	37.63
	Single women	24.09	23.13	21.29	24.09	23.13	21.29	21.34
	Single men	27.01	27.67	25.26	27.01	27.67	25.26	25.55
Home work	Wives	30.02	41.05	24.72	30.02	41.05	24.72	35.15
	Husbands	17.55	13.64	14.45	17.55	13.64	14.45	11.68
	Single women	21.14	21.60	21.70	21.14	21.60	21.70	21.77
	Single men	13.25	13.07	10.54	13.25	13.07	10.54	10.50
Leisure	Wives	62.49	58.69	65.26	58.64	56.77	62.10	64.63
	Husbands	59.93	52.49	64.30	62.92	53.76	66.75	61.24
	Single women	70.20	69.14	71.22	70.20	69.14	71.22	71.08
	Single men	74.87	72.33	77.69	74.87	72.33	77.69	77.40

The unitary model imposes the mapping from marriage quality to Pareto weight that is derived from the 1975 Benchmark calibration.

The stability of men's hours on the other hand appears to be due to the conflicting effects of preferences and relative wages. Column (6) shows that, with rigid Pareto weights, the rise in the wife's relative wages would have driven husband's working hours down from 37.6 to 30.6, very much as we predicted from the back-of-the envelope computation in the theoretical section. Allowing for bargaining, Column (3) shows that the effect of the relative wage is much less severe, and results in the husband's working 32.7 h weekly. The static part of the calibration told us that in the preferences of married-couples consumption had gained in importance at the expense of leisure. Column (2) shows that on its own this would have increased husband's working hours by more than 4 h, to 42.3. However Table A7 in the Appendix, shows that this effect is largely offset in turn by wage and income growth, which on its own results in a 3-h decline. Finally, recall that preferences shifting on its own would also have increased with wife–husband leisure ratio; this effect, due to single women being made better off relative to single men, would have added 1.1 h to men's work hours. Bargaining is therefore an important component of the story, raising husband's labour supply by about 3.2 h relative to the unitary model, but there are also large effects that do not operate through bargaining.

In Column (2) of Table A6 in the Supplementary Appendix, we see that income and wage growth on their own cause labour supply to fall, as the preferences deviate from the balanced-growth (log) preference specification. Married-men's labour supply falls from 37.63 h to 34.3 h and that of married women from 15 h to 11.6 h. The effect is similar for singles: men's paid hours fall 1.8 h, from 25.5 h to 23.7 h, and that of women by 0.35 h. This makes the observed rise in per-capita hours all the more remarkable. Its clear from Table 4(a) and (b) that the main forces driving the rise in per-capita labour supply are the shifting utility parameters $(\sigma_c, \sigma_l, \sigma_g)$, which account for a 3.5 h increase of married-couple's labour supply, and the relative wage, which account for a 1.5 h increase. Declining work costs (Column (6) in Table A6) and equipment prices (Column (1) in Table A6) are seen to account for an additional 1.6 h increase in married-couple's labour supply. The effect of shifting taxes (Column (3) in Table A6) is negligible for married couples, but does generate a 0.7 h increase in paid work per single person. The effects are small, not because labour supply is unresponsive to taxes, but rather because the net variation in marginal tax rates over the period turns out to be quite small, particularly for married couples.

5.2. *Home production*

The main home-hours fact is that wife's time has declined relative to that of husbands; comparing the empirical targets in Columns (1) and (7) of Table 6 we see an increase of roughly 6 h for husbands, compared to a 5 h decline for wives. Column (3) in Table 6 indicates that 3 h of the husband's increase can be attributed to the shift in the relative wage; Column (2) shows that 2 h were due to the preference shift away from leisure. Columns(5) and (6) show that these effects are independent of bargaining, which is to be expected, as the theoretical model showed that the home-production decisions are independent of the Pareto weights. For wives' home hours, Column (3) shows that the relative-wage shift would, on its own, have caused a much larger decline, on the order of 10 hours, but this is offset in part by the effects of the preference shift (+6 h), shown in Column (2). The results therefore show that the direct effect of the relative-wage shift is reinforced, for men, by the preference shift, while for women the two effects partly offset each other.

In Table A6, we see income and wage growth also have a significant effect but smaller effect (-1.8 h) on married-women's home-production time, and the much smaller effects of equipment price on home-work hours of married women (-1.3 h) and men ($+0.5$ h). Even this minor impact however barely shows up in paid hours, being mostly soaked up by leisure time, as one might have guessed from the dominance of σ_l in the preference estimates. The net effect consists of a gain in wive's paid work of about a half hour. It is worth stressing however that the model abstracts from the accumulation of home equipment over time; allowing for accumulation would increase the estimated share of home goods in the production function, making price shifts more important.

A related concern might be the elasticity of substitution of the spouses time in the home-production function. Recall that this was calibrated by matching the decline in the wive's home-work relative to that of the husbands. A more sophisticated approach might consider the possibility of technical change that made husband's time more productive at home. An example of this early in the 20th century would be the invention of substitutes for mother's milk in nursing infants, as in Albanesi and Olivetti (2006). The impact of other examples, such as the advent of home-laundry machines, as in Greenwood *et al.* (2005) are probably still too early to explain the transition since the 1970s. Such forces, if found to be quantitatively significant in the 1970s, would reduce the calibrated wage-elasticity of labour supply, and thus weaken the impact of the relative wage on the home allocations.

5.3. *Marriage*

Marriage rates in the U.S. declined at a time of unprecedented prosperity and while women's wages were increasing relative to men's. It is tempting therefore to link the increased attractiveness of single life implied by these developments to the decline of marriage. However the main message regarding the decline of marriage is that it appears not be directly driven by changes in wages or technology.

In Table 6 we see that in the Benchmark model, the marriage rate declines from 9% in 1975 to 4%. Column (3) shows that if the only change had been in relative wages, this decline would not have occurred; indeed the marriage rate increases, to 10%; Column (6) shows that this is independent of the bargaining model. The best explanation that Table 6 has to offer, as shown in Columns (2) and (5), is that the shift in utility parameters $(\sigma_c, \sigma_l, \sigma_g)$ reduced the gains from marriage. Bargaining amplifies this effect by about 1/3: we see marriage rates decline to about 0.07 in the Unitary model, and to 0.64 in the Bargaining model.

Turning to Table A6, Column (5) shows that on its own the increasing preferences for single life (the rise in (q_W, q_H) can on its own reduce the marriage rate to 0.03, by far the largest force behind the marriage-rate decline.

Of course these two preference shifts were identified as residuals; the former from the time-allocation part of the calibration, the latter from the decline on marriage rates. The only significant measurable influence on marriage rates turns out to be the decline of the home-equipment price; Column (1) in Table A6 shows that on its own this drives the marriage rate down to 7.8% annually; hence this accounts for 17% of the marriage decline.[11]

These changes in preferences should be interpreted as proxies for influences outside the model; the result therefore implies that more structure is required in the model to isolate potential sources of the decline in marriage rates.

6. IMPLICATIONS FOR ANNUAL TRENDS

Although the main analysis in the atricle focusses on the long-run variation in labour supply, it is also possible to do a year-by-year comparison with the paid hours data, using annual variation in observed parameters, such as wages, and linear interpolation of the other model parameters. We use this method, to answer two questions: (i) over what years does bargaining contribute most to accounting for the divergence between the unitary model and the observed trend?; and (ii) how much would the assumption of commitment in marriage allocations change our analysis?

In the spirit of the previous analysis, we take as exogenous the actual observed trends in wages and equipment price; these are represented by a 10-year moving average, to minimize the role of short-term fluctuations. We assume agents are myopic, taking current wages and parameters as permanent. A more sophisticated analysis would allow agents to base their behaviour on predicted trends, or even assume perfect foresight at the time of marriage, and compute the transition path between the two stationary equilibria we calibrated. What we do here is a much simpler exercise, imposing that agents behave as though the economy were always in a stationary equilibrium. We think of this as an interesting and reasonable point of departure that precludes us having to deal with the complications associated with non-stationary equilibria in the marriage market.

To see how the behaviour of labour supply evolves, we compute for each year the equilibrium decision rules for each household type in the economy. We compute three different versions of the model economy. In the first, the Pareto weights μ for all households are fixed at the value from the 1970s calibration, as in the unitary case. In the second, the weights are fully flexible, as in our benchmark model; all households have the same weight in a given year, but the weight changes annually according to the same bargaining solution as in the main model. In the third version, we only allow the Pareto weight for new marriages to respond to current-year's information; previously married couples retain the value established at the time of marriage. Labour supply in the third experiment will therefore depend on the history of the economy, via the stock of married couples.[12]

11. The size of this effect could be increased by imposing a fixed cost of household formation, as in Greenwood and Guner (2009).

12. Marriage and divorce rates are imposed to match the annual rates we derived from the stocks of never-married and ever-married singles in the March CPS. This mainly matters for the third experiment, in which the marriages from

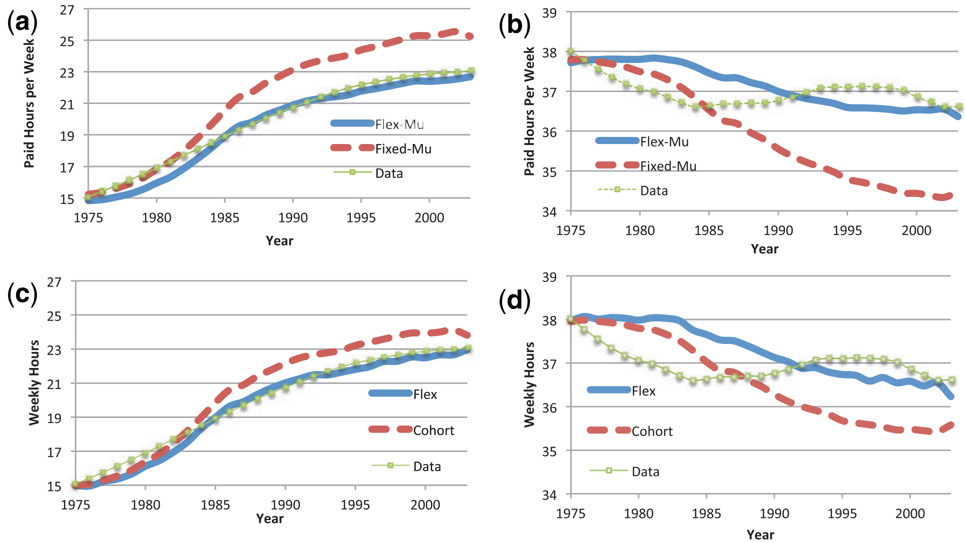

FIGURE 3

(a) Married women's paid-labour supply with fixed and flexible Pareto weights. (b) Married men's paid-labour supply with fixed and flexible Pareto weights. (c) Married women's paid-labour hours, with cohort-specific Pareto weights ("Cohort") versus flexible weights ("Flex"), compared to data. (d) Married men's paid-labour hours, with cohort-specific Pareto weights ("Cohort") versus flexible weights ("Flex"), compared to data

The results of these three experiments are shown in Figure 3. The top two panels compare labour supply under the flexible and the fixed specifications; the data series are also shown. In panel (a) we see that for married-women's labour supply, the model line virtually coincides with the data line except for the period 1976–1984, where it lies slightly below, by about 1 h. The line corresponding to the fixed Pareto weight on the other hand diverges from the data line starting in about 1983; the prediction error is already 2 h by 1985, and continues to grow to 2003. For married men's labour supply, on the other hand, shown in panel (b), the model with the fixed Pareto weight does better than the benchmark for the first 10 years. Over the 1985–2003 period however, the data remain stationary at just under 37 h weekly, while the fixed-weight line continues its steady decline down to 34 weekly hours. Over the same period, the flexible-weight series fluctuates around the data series. Overall we can say, in answer to our first question, that the unitary model fails to track labour supply data after the mid 1980s, so the contribution of the household bargaining model in matching labour supply is greatest after 1985.

Given that flexible Pareto weights play such an important role in matching labour supply over time, a useful next step for future research would be to compare the predictions of different types of bargaining models against the data. One basic question would be the role of commitment: can we assume that Pareto weights are fixed for the duration of the marriage, or do we need to allow the weights to vary within the marriage as well? In our third experiment, the trend is computed for a population in which the weights are fixed for each marriage cohort but allowed to vary between cohorts. In each new marriage, the allocation corresponds to the bargaining outcome

each year are carried over the following year, subject to the observed divorce rates, and new marriages formed at the observed marriage rates, as summarized in Figure 3.

from the trend computation described earlier. We refer to this commitment model as the “Cohort-weight” model; it is effectively a weighted average of the unitary and no-commitment bargaining (benchmark) models.

As the stock of married people is always large relative to the flow into marriage each year, the commitment model more closely resembles the unitary model than the benchmark model. Nevertheless, as shown in the lower panels of Figure 3, the Cohort-weight model generates a significant reduction of the prediction error, relative to the unitary model. In panel (c) we see that by the year 2000, the 2-h error for wive’s paid labour in the unitary case in the upper panel has been reduced to 1 h, and that the Cohort series follows the data much more closely throughout the period of analysis. A similar pattern holds for married-men’s paid labour, shown in panel (d); husband’s labour supply falls by one more hour than in the case of the flexible model, but this still constitutes a large reduction of prediction error relative to the fixed-weight model. The exercise suggests therefore even with full commitment, the benchmark bargaining process can still account for about half of the deviation between the data and the unitary model.[13]

7. CONCLUSION

The central point that motivated this article is that the absence of a strong relation between wages and relative leisure of spouses is far from being an indicator that bargaining may be safely ignored; to the contrary, in the context of Neoclassical models, this is a compelling indicator of the importance of household bargaining.

Standard explanations of rising female labour supply have strong implications for married men’s time allocations that have not been explored in the previous literature; the exception is Jones *et al.* (2003), who predict that men’s labour time should decline significantly. Time-use data in the U.S. suggest that this did not happen over the 1975–2003 period when the gender gap in wages was closing. This article showed that allowing for bargaining between spouses is a simple way to reconcile the trends in time allocation with the usual driving forces proposed in the literature. The size of the effects measured in the current article suggests that it would be useful for macro-economics to examine more closely the mechanism by which such inter-spousal allocations actually occur.

Are macro-economists mistaken in ignoring bargaining between spouses? The results indicate that the modelling of bargaining should not be a priority for all macroeconomic questions. Bargaining in the model has little to add to the analysis of events whose impacts on the value of single life are similar for both sexes. Even for events like shifts in relative wages, which do have strong implications for bargaining, the effects on husbands are nearly offset by those on wives, so that bargaining could be ignored in the analysis of per-capita labour supply, at least as a first pass.

Where bargaining appears essential is in the analysis of the response of sex-specific behaviour, such as married-men’s labour supply, to changes that affect the relative value of single life. We saw that the errors from the “unitary” version of the model were large relative to those of the bargaining model. The implications for future research are not limited to the shocks analysed here. The impact of improved birth control, the decline of stigmatization of divorce, or the advent of affirmative action in employment are also likely to have raised the value of single life more for

13. This suggests that if we were to extend the benchmark bargaining model to allow for commitment, the greater rigidity of the full commitment model implies that we would have to reduce the weight on the Nash bargaining in the calibration, in favour of the more elastic Egalitarian solution.

women than for men. In the light of the current results, it would be rash to interpret the impact of such changes on married-women's labour supply or on marriage rates without considering the implications for bargaining; small or insignificant labour-supply effects for instance may mask large welfare effects for married women.

The emphasis on bargaining in this article should not be taken too literally; it is intended as a shorthand for any mapping from outside options to the division of surplus, as in the micro-empirical literature on "collective" models of the household. The household model proposed here relies on a bargaining solution with divorce threat-points, but the same argument could apply to other models of intra-household allocation, provided that the division of surplus is allowed to depend monotonically on some measure of the relative value of disagreement that is increasing in own wages. Whether the actual determination occurs through bargaining, auctions, judicial decisions, or shifting social norms would seem to be without consequence for the basic argument.[14]

One might ask why married-men's working time declined in the period 1950–1975; the results of the wage-growth experiment in Table A6 suggest that we can expect labour-supply decline to accompany economic growth, and that bargaining has little to say about this effect. There are two further reasons that distinguish the 1950s and 1960s from the period studied here: (i) the gender wage gap was not declining; and (ii) divorce was costly and rare, so the outside options were likely to have been less relevant to married couples.

Finally, the model may also be useful for the analysis of tax reform. This did not have a major impact in the experiments because there was not much change in the tax schedules, at least for married couples, over the 1975–2003 period; the flattening of the tax schedule discussed by Prescott (2004) occurred in the 1980s, and appears to have vanished by the end of the 1990s. It remains to be seen therefore how a change in the progressivity of taxes might affect aggregate labour supply, and hence tax revenues. Because single women are poorer than single men, a more progressive tax system would shift bargaining power to wives, reducing their labour supply relative to that of husbands.

Because the current model is so abstract, the estimated effects presented above should be seen as provisional. Even a simple change like adding fixed costs of household formation could increase the importance of wage changes for explaining the decline of marriage. It would be interesting to see whether the addition of dynamics in the form of fertility, savings, or human-capital investments affect the interpretations presented here, but while it is clear that some of the results will change, the size of the bargaining effects suggests that bargaining will remain an important part of explaining time-allocation shifts over the last 40 years.

Acknowledgments. I am grateful to Jeremy Greenwood, Nezih Guner, Iourii Manovskii, Guido Menzio, Andrew Postlewaite, Victor Rios-Rull, Larry Samuelson, Raul Santaeulalia-Llopis, and Gustavo Ventura for helpful discussions.

Supplementary Data

Supplementary data are available at *Review of Economic Studies* online.

14. It should also be noted that there are two strong justifications for divorce threat-points. First, data about the lives of singles, such as labour supply, wages and marriage rates, can be used, in combination with a suitable model of single life, to estimate the threat-points. In this article, these threat-points are determined in the marriage-market equilibrium, as remarriage plays an important role in the value of being single. Second, the estimation results of Chiappori *et al.* (2002) at the micro level imply that household labour supply is better described by a bargaining model with divorce threat-points than one with non-cooperative marriage as a threat-point.

REFERENCES

AGUIAR, M. and HURST, E. (2007), "Measuring Trends in Leisure: The Allocation of Time over Five Decades", *The Quarterly Journal of Economics*, **122**, 969–1006.

ALBANESI, S. and OLIVETTI, C. (2006), "Gender Roles and Technological Progress" (2006 Meeting Papers 411, Society for Economic Dynamics).

ATTANASIO, O., LOW, H., and SANCHEZ-MARCOS, V. (2008), "Explaining Changes in Female Labour Supply in a Life-cycle Model", *American Economic Review*, **98**, 1517–1552.

BECH-MOEN, O. C. (2006), *Gender Differences in Market and Home Hours* (Mimeo, University of Oslo).

BIDDLE, J. E. and HAMERMESH, D. S. (1990), "Sleep and the Allocation of Time", *Journal of Political Economy*, **98**, 922–943.

BLAU, F. D. and KAHN, L. M. (1997), "Swimming Upstream: Trends in the Gender Wage Differential in 1980s", *Journal of Labor Economics*, **15**, 1–42.

BROWNING, M. and GORTZ, M. (2006), "Spending Time and Money within the Household" (Discussion paper, Oxford Department of Economics Discussion Paper Series).

BURDA, M., HAMERMESH, D. S. and WEIL, P. (2007), "Total Work, Gender and Social Norms" (IZA Discussion Papers 2705, Institute for the Study of Labor (IZA)).

BURDETT, K. and COLES, M. G. (1999), "Long-Term Partnership Formation: Marriage and Employment", *Economic Journal*, **109**, F307–F334.

CHADE, H. and VENTURA, G. (2005), "Income Taxation and Marital Decisions", *Review of Economic Dynamics*, **8**, 565–599.

CHIAPPORI, P.-A., FORTIN, B. and LACROIX, G. (2002), "Marriage Market, Divorce Legislation and Household Labor Supply", *Journal of Political Economy*, **110**, 37–72.

CHOO, E., SEITZ, S. and SIOW, A. (2008), "Marriage Matching, Risk Sharing and Spousal Labor Supplies" (Working Papers tecipa-332, University of Toronto, Department of Economics).

CUBEDDU, L. and RIOS-RULL, J.-V. (1997), "Marital Risk and Capital Accumulation" (Staff Report 235, Federal Reserve Bank of Minneapolis).

GERSHUNY, J. and ROBINSON, J. P. (1988), "Historical Changes in the Household Division of Labor", *Demography*, **25**, 537–552.

GREENWOOD, J. and GUNER, N. (2009), "Marriage and Divorce since World War II: Analyzing the Role of Technological Progress on the Formation of Households", In *NBER Macroeconomics Annual 2008*, Vol. 23, NBER Chapters (National Bureau of Economic Research, Inc.) 231–276.

GREENWOOD, J., GUNER, N. and KNOWLES, J. A. (2000), "Women on Welfare: A Macroeconomic Analysis", *American Economic Review*, **90**, 383–388.

GREENWOOD, J., GUNER, N. and KNOWLES, J. A. (2003), "More on Marriage, Fertility, and the Distribution of Income", *International Economic Review*, **44**, 827–862.

GREENWOOD, J., SESHADRI, A. and YORUKOGLU, M. (2005), "Engines of Liberation", *Review of Economic Studies*, **72**, 109–133.

GUNER, N., KAYGUSUZ, R. and VENTURA, G. (2012), "Taxation, and Household Labor Supply", *Review of Economic Studies*, **1**, 1–45.

JACQUEMET, N. and ROBIN, J.-M. (2011), "Marriage with Labor Supply", (Université Paris1 Panthéon-Sorbonne (Post-Print and Working Papers) halshs-00639313, HAL).

JONES, L. E., MANUELLI, R. E. and MCGRATTAN, E. R. (2003), "Why are Married Women Working So Much?" (Staff Report 317, Federal Reserve Bank of Minneapolis).

KALAI, E. (1977), "Proportional Solutions to Bargaining Situations: Interpersonal Utility Comparisons", *Econometrica*, **45**, 1623–1630.

LISE, J. and SEITZ, S. (2011), "Consumption Inequality and Intra-Household Allocations", *Review of Economic Studies*, **78**, 328–355.

MAZZOCCO, M. (2007), "Household Intertemporal Behaviour: A Collective Characterization and a Test of Commitment", *Review of Economic Studies*, **74**, 857–895.

MCELROY, M. B. and HORNEY, M. J. (1981), "Nash-Bargained Household Decisions: Toward a Generalization of the Theory of Demand", *International Economic Review*, **22**, 333–349.

MEISENHEIMER, J. R. (2005), "Real Compensation, 1979 to 2003: Analysis from Several Data Sources", *Monthly Labor Review*, **128**, 3–22.

PRESCOTT, E. C. (2004), "Why Do Americans Work So Much More Than Europeans?" *Federal Reserve Bank of Minneapolis Quarterly Review*, **28**, 2–13.

ROBINSON, J. P. and GODBEY, G. (1997), *Time for Life* (The Pennsylvania State University Press, University Park, PA).

VANDENBROUCKE, G. (2009), "Trends in Hours: The U.S. from 1900 to 1950", *Journal of Economic Dynamics and Control*, **33**, 237–249.