ISSN 2042-2695

CENTRE *for* ECONOMIC PERFORMANCE

CEP Discussion Paper No 1156

July 2012

Female Employment and Fertility - The Effects of Rising Female Wages

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E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

Abstract
Increases in female employment and falling fertility rates have often been linked to rising female wages. However, over the last 30 years the US total fertility rate has been fairly stable while female wages have continued to grow. Over the same period, we observe that women's hours spent on housework have declined, but men's have increased. I propose a model with a shrinking gender wage gap that can capture these trends. While rising relative wages tend to increase women's labor supply and, due to higher opportunity cost, lower fertility, they also lead to a partial reallocation of home production from women to men, and a higher use of labor-saving inputs into home production. I find that both these trends are important in understanding why fertility did not decline to even lower levels. As the gender wage gap declines, a father's time at home becomes more important for raising children. When the disutilities from working in the market and at home are imperfect substitutes, fertility can stabilize, after an initial decline, in times of increasing female market labor. That parents can acquire more market inputs into child care is what I find important in matching the timing of fertility. In a mode l extension, I show that the results are robust to intrahousehold bargaining.

Keywords: Fertility, female labor supply, household production, intrahousehold allocations
JEL Classifications: D13, E24, J13, J22

This paper was produced as part of the Centre's Macro Programme. The Centre for Economic Performance is financed by the Economic and Social Research Council.

Acknowledgements
I am grateful to Francesco Caselli, my advisor, and to Zsofia Barany, Wouter den Haan, Monique Ebell, Ethan Ilzetzki, Rigas Oikonomou, Albert Marcet, Michael McMahon, Rachel Ngai, Silvana Tenreyro, and seminar participants at the LSE for many comments and suggestions.

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Published by
Centre for Economic Performance
London School of Economics and Political Science
Houghton Street
London WC2A 2AE

1 Introduction

Between the 1960s and today, we have seen enormous changes to the economic and demographic structure in all Western countries. There has been a decline in total fertility rates[1] and an increase in women's market hours (see figures 1 and 2 for US data).

Many authors explain both with a rise in female wages. An apparent puzzle, however, is that while female wages and market hours have continued to grow, since the 1970s fertility[2] has stopped falling.[3] Understanding the underlying fertility decisions is important since they affect population growth, labor force composition and social security systems, and thereby economic outcomes. In this paper I argue that the common driving force behind the trends in fertility and in female employment is the narrowing of the gender wage gap (shown in figure 3), rather than the level of female wages per se, since it changes the division of labor within the family. Because of increasing disutilities from working at home and in the market this reallocation has a nonlinear effect.

My explanation is based on the observation that men's home hours have increased, allowing women's home hours to fall. In the 1960s, when the wage gap was big, the catching up of females wages increases women's labor supply. The associated increase in the opportunity cost of women's time, who shoulder most of child care, lowers fertility, as argued by Becker (1960) or Galor and Weil (1996). But as relative wages become more equal over time, specialization in the household decreases. Consequently, male home hours increase, a father's time at home becomes more important for raising children, and the allocation of time between home and market work becomes more evenly balanced for men and women. If there is imperfect substitutability in the disutilities from working at home and in the market, the marginal utility cost of having an additional child can become constant, despite women working more hours in the market.

Circumstantial evidence in favor of this mechanism is provided by data on non-market hours. Using data from Aguiar and Hurst (2007), based on the American Time Use Survey since 1965, I show the trends in hours spent on home production, including time spent on child care and on obtaining goods, in figure 4.[4] The data displays a shift in household

[1] The total fertility rate (TFR) is the average number of children that would be born if all women lived to the end of their childbearing years and bore children according to the current age-specific birth rates.

[2] The total fertility rate and children ever born (CEB), a measure of completed fertility, display similar trends. Based on US data for married women born 1826–1960, Jones and Tertilt (2008) report that CEB and TFR, shifted by 27 years, are moving strongly together. Consistently, CPS data display since 1999 virtually constant CEB to women of age 40–44. Jones and Tertilt (2008) also document a strong decline in fertility over the long-run; CEB to married women fell from about 5.5 children for the cohort born in 1928 to roughly 2 for the cohort of 1958.

[3] Most of the recent rise in the official total fertility rate is driven by the effects of immigration. For US-born women the incline is much less and fertility virtually flat since the late 1970s, as I show in appendix A.1.

[4] The measure is constructed as weekly hours spent on home production in a narrow sense, on obtaining goods, and on basic child care. Arguably, for many people child care is an activity that is more enjoyable than other forms of housework. Excluding child care from the measure of market work does not change the qualitative trends. This can be seen in the regression results of table 10 in appendix A.2.

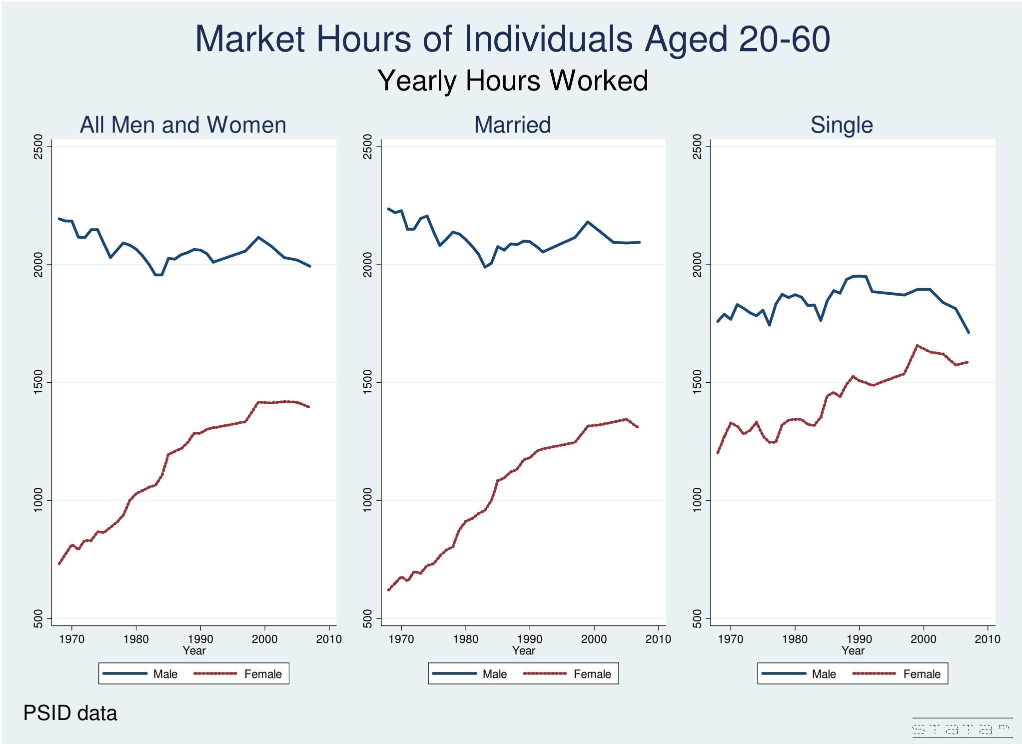


Figure 1: Male and Female Market Hours Worked

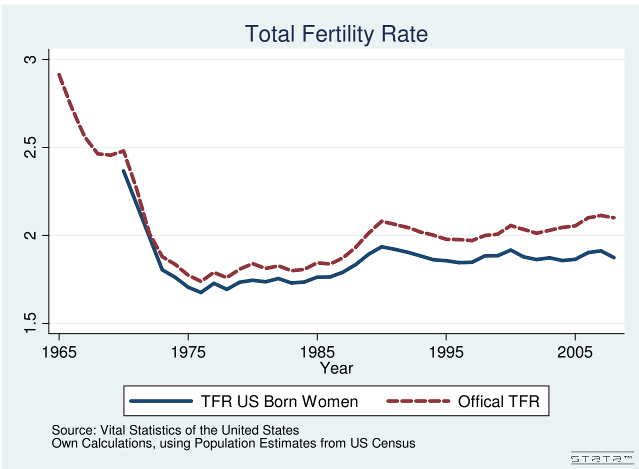


Figure 2: Total Fertility Rate

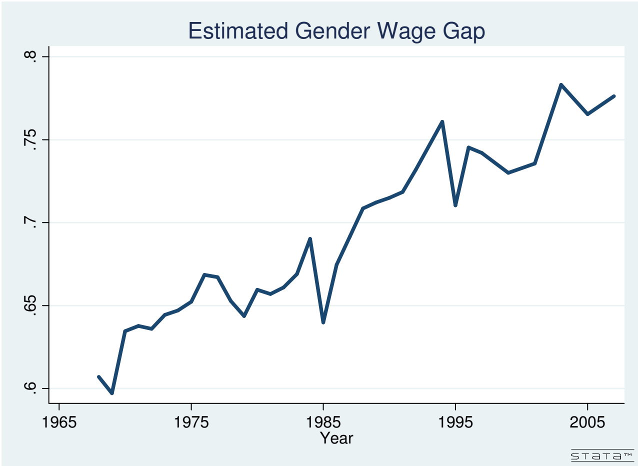


Figure 3: Gender Wage Gap (see section 3.1)

production from women to men, with an overall reduction of hours worked at home. My findings are consistent with the earlier work of Robinson and Godbey (2008), who find, based on time use data for 1965 to 1995, that there is convergence in activities across gender.[5]

The importance of considering intrahousehold allocations can be seen in the right panels of figure 4. While home hours of married men have increased over time, single men's hours of home production are constant, after an initial change between 1965 and 1975. This is consistent with the explanation I propose. Single men, without a female partner, are not affected by rising female wages, but married men spent more hours working at home –a trend in US data that has not received much attention by researchers yet, with the notable exception of Knowles (2007).[6] Single women, on the other hand, spend less time working at home, but the decline is not as pronounced as for married women, whose husbands devote more of their time to home production.[7]

To the best of my knowledge, the only previous paper that has noted the flattening out in total fertility rates and informally suggested an explanation in terms of increased male home production is Feyrer et al. (2008). My paper formally models and quantifies the endogenous response of male and female hours and their implications for fertility.[8] I

[5]They also report that average parental hours spent on child-care per child has been roughly constant. Ramey and Ramey (2010), on the other hand, include time spent teaching children and document a rise since the mid 1990s, especially for college educated parents.

[6]Burda et al. (2007) study time use data across various developed countries, and find that total work, the sum of home and market work, is virtually the same for men and women. For the US, Ramey and Francis (2009) report that total work of men and women has been constant throughout the 20th.

[7]In the Aguiar and Hurst (2007) data marital status is defined in a legal sense, and it is not possible to disentangle cohabiting from other singles. In figure 19 of the appendix I show that home hours have changed more for singles with children, who are more likely to be cohabiting, than for singles without children.

[8]Feyrer et al. (2008) explain the increase in male home hours with intrahousehold bargaining. I show that bargaining is not necessary; a change in relative wages *per se* implies not only a reallocation of work in the market, but also at home. However, I also explore a version with intrahousehold bargaining.

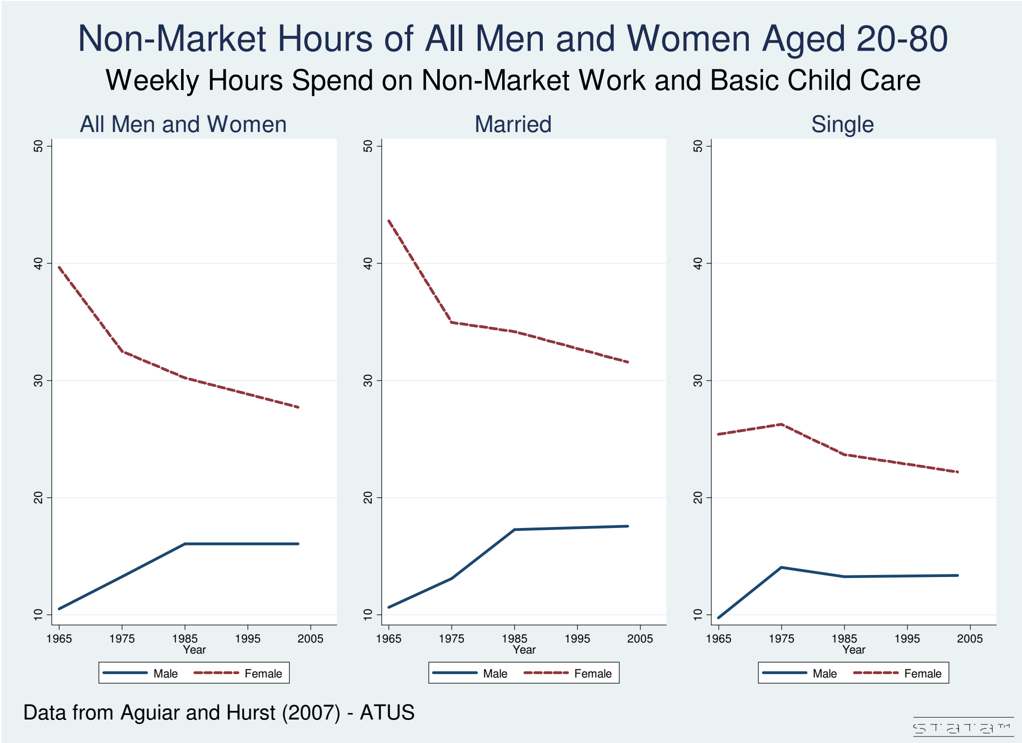


Figure 4: Male and Female Home Hours Worked

present a general equilibrium model matching the observed patterns of fertility and hours worked through an exogenous decrease in the gender wage gap. In the benchmark model I consider households maximizing the sum of male and female members utilities. A rise in female relative wages directly increases female labor supply and lowers female home production, whereas male time is getting devoted more to home activities and less to market work. Initially, when the gender wage gap is big, there is an overall drop in home labor and a couple devotes less time to having and raising children. However, when the gender wage gap is fairly small and shrinks further, the rise in male time spent working at home is almost big enough to keep total home labor constant. The reason for this differential reaction to improvement in female relative wages is in the increasing marginal disutility from working. Initially, specialization in the household meant a husband's labor supply was much higher than his wife's, and therefore he was less willing to spend more time on home production. But as relative wages become more equal, the spouses time allocation, and thus their disutilities from working, are getting closer to each other, and in the limit a drop in female home production is fully offset by men. To the extent that disutilities from market and home labor are imperfect substitutes, this reallocation of hours worked can be consistent with the couple's utility cost of child care remaining constant. On top of this, with the improvement in the wife's earnings, a couple can acquire more parental time saving inputs. Both the rise in male home labor and the higher use of parental time-saving inputs into home production is what I find key in explaining the flattening out of the total fertility rate.

In a model extension I show that these results are robust to intrahousehold bargaining. Calibrated against US data, my model suggests that for the trends in fertility changing relative wages *per se* are much more important than their bargaining-induced shifts in intrahousehold allocations.

Other papers that have studied the implications of the decline in the gender wage gap for both male and female hours are Jones et al. (2003) and Knowles (2007), but none of these papers has explored the implications for fertility. Galor and Weil (1996) present a unified framework to explain the rise in female employment and the fall in fertility that we observed until the mid 1970s. Since their mechanism links fertility decisions to the market value of women's disposable time[9], it cannot explain why fertility stopped falling when female wages continued improving. My model therefore highlights that the existing literature that assumes perfect specialization within families, such that women shoulder all of child care, has overlooked important implications of intrahousehold allocations.

2 The Model

2.1 Assumptions

I build a general equilibrium model of overlapping generations. Agents enter the economy as young adults at age 20 and can have children in the first period of their lives, before they turn 30. At age 60, agents retire, and they die deterministically at age 80. The advantage of this modeling approach is that it incorporates an explicit age structure and has implications for the demographic pyramid. Fertility leads to population growth and thereby affects future labor markets and factor prices, and also social security benefits. Moreover, I can feed in a life-cycle profile of wages which makes the model more realistic. The complication with this approach is, I need to keep track of when children are born, as this implies when they turn adults and leave their parent's household. Thus, I assume for tractability that each cohort can be represented by one representative household, formed by a representative male and female, which can have a continuous number of children. Also the length of the model period is motivated by tractability; a model period corresponds to 10 years.

2.1.1 Agents and Households

All agents, men and women, derive utility from consumption of a market good (c) and from having children (b), but derive disutility from working in the labor market (n) and at home (h). They discount the future with factor β.

[9]Other papers linking fertility decisions to the market value of women's disposable time include Greenwood et al. (2005) and Doepke et al. (2007).

Agents differ in terms of their gender ($g \in \{m, f\}$) and their age (j). I assume that all economic active men and women live in couple households, formed by one man ('husband') and one woman ('wife'). Children live with their parents. In other words, when children move out of their mother's and father's household, they find a spouse right away and form a new couple household. To keep things simple I assume that both spouses are of the same age and have the same deterministic life-span, which I denote by T_l. For computational tractability, I assume that women, and hence couples, can have children only in the first period of their (adult) life. I denote a couple's total number of children by b and the number of children living in their household by b_h. I assume that children leave the parental household after T_a periods. While parents derive utility from having a child as long as they are alive themselves, households do not leave bequests, abstracting from any further intergenerational altruism. Therefore agents start their economic-active life (at age $j = 1$) with zero assets and leave no assets when they die (at age $j = T_l$). Couples retire at age T_r, stop working in the market and receive social security benefits $\mathcal{T}_{ss}$ each period.

Let the absolute size of the cohort of *couples* of age j in period t be

$$S_t(j) \tag{1}$$

In period t, the population share of the cohort aged j is then

$$\mu_t(j) = \frac{S_t(j)}{\sum_{k=1}^{T_l} S_t(k)} \tag{2}$$

I apply a model of collective household behavior, as introduced by Chiappori (1988). The male and the female partner have their own preferences, and derive felicity u_m and u_f respectively. Since they hold wealth jointly and might have children together, they solve a joint maximization problem. In particular, the couple household solves a Pareto program with relative weight θ attached to the husband's and $1 - \theta$ to the wife's utility. In the *benchmark model*, the household behaves as a *unitary* agent and $\theta = 0.5$ throughout.

For the model *with household bargaining*, I assume that the Pareto weight is determined through Nash bargaining over the surplus generated by marriage, where the threat point of a spouse is not entering the marriage (at age $j = 1$). To simplify the computations, I assume *full-commitment* such that the weights –once determined– remain constant over a household's lifetime and there is no divorce. In general, the outcome of the bargaining depends on each partner's relative outside option of staying single. Life-time utilities of single men and women differ to the extent that they face different wages. The outcome of the bargaining therefore depends on relative wages, and the Pareto weight (θ) is a function of the gender wage gap over the couple's life-time ($\{\chi_{t+j-1}\}_{j=1}^{T_l}$).

2.1.2 Fertility

Childbearing imposes a time-cost on the mother (τ_b), whereas child-care requires more home production (x), which could be done by the father, the mother, or both.[10]. A further input to home production are goods acquired in the market (e). Although I refer to this home-labor saving input for simplicity as home appliances, in a more broader sense this can also include paid domestic help, such as hiring nannies.

I assume that the amount of the home good needed is

$$\bar{x} = \bar{x}(b_h) \text{ with } \bar{x}'(b_h) > 0 \tag{3}$$

Couples can have children only in the first period of their lives. Bearing a child reduces the mother's disposable time by τ_b in that period.

2.1.3 Household Production

Following Olivetti (2006) and Knowles (2007), I assume that the home good is produced using a technology that is consistent with substitution among household member's time (h) and home appliances (e), which I model as a flow to simplify matters, according to

$$x_h = e^{\gamma} H^{1-\gamma}$$

where home labor input is

$$H = z_m h_m + z_f h_f$$

and z_m and z_f are the male and female home labor productivities, respectively.

A change in spouse's relative wages will have an effect on market hours, home hours, as well as on home appliances used. Rising market wages could lead to increases in market hours and decreases in home hours –such as we have observed in the data for married females–, without a drop in home production, as the household can acquire more home appliances. In other words, the technology allows, to some degree, for a marketization of inputs to home production[11].

The home good is non-storable and is a public good within the household.

2.1.4 Market Technology

Assume there is a final goods technology of the form

$$Y_t = A K_t^{\alpha} N_t^{1-\alpha} \tag{4}$$

[10] The former assumption is similar to Erosa et al. (2010), the latter is as in Knowles (2007) and similar to Greenwood and Seshadri (2005)

[11] In a structural transformation framework, Ngai and Pissarides (2008) study substitutions between home and market production, but do not distinguish between male and female labor.

aggregating total market labor (N) and capital (K) into a final good which can be used for consumption (c), investment in future capital stock, and for home appliances (e), which I model as a flow to simplify matters. Capital depreciates at a rate δ each period.

The final goods sector is competitive. Factor prices are therefore equated to marginal products, implying for the rental rate of capital (r) and wage rate per efficiency unit of labor (w)

$$\begin{aligned} r_t &= \alpha A K_t^{\alpha-1} N_t^{1-\alpha} - \delta \\ w_t &= (1-\alpha) A K_t^{\alpha} N_t^{-\alpha} \end{aligned} \tag{5}$$

2.1.5 Endowments and Markets

Each individual is endowed with one unit of time that they can split between working in the market (n) and at home (h); the remainder is leisure. Since childbearing lowers a woman's effective time endowment (by τ_b), the male and female time constraints are

$$n_m(j) + h_m(j) \leq 1 \text{ for } j = 1,\ldots,T_l$$
$$n_f(j) + h_f(j) \leq \begin{cases} 1 & \text{for} \quad j = 2,\ldots,T_l \\ 1 - \tau_b b & \text{for} \quad j = 1 \end{cases}$$

Since in the data there is a clear age-profile in wages, I assume an age-dependent endowment of efficiency units of labor for men $p_m(j)$ and for women $p_f(j)$.

The model will imply for the wage of a woman of age j relative to a man of the same age that $\frac{w_f(j)}{w_m(j)} = \frac{p_f(j)}{p_m(j)}$. A gender wage gap corresponds in the model therefore to different labor productivities across gender. In reality, of course, differences in pay for same occupation and similar qualifications may be the result of discrimination. One way of rationalizing the simplifying modeling assumption of differential productivities is, because of discrimination, women, with same abilities as men, have sorted into less productive occupations. I will take women's relative earnings, after controlling for observables such as education, in year t from the data and denote this time-varying gender wage gap by χ_t and impose $p_{f,t}(j) = \chi_t p_m(j)$.

Once agents have passed the retirement age T_r they can no longer generate labor income which corresponds to $p_m(j) = p_f(j) = 0$ for $j \geq T_r$. After retirement the couple receives social security benefits $\mathcal{T}_{ss}$.

There is no uncertainty and agents' income is not subject to shocks. Agents can trade an asset with return r_t. The economy is closed.

2.1.6 Preferences

Agents derive utility from consumption of the market good and enjoy having children, but have disutility from working in the market or at home. In particular, assume that preferences are additively separable and given by[12]

$$u_g(c,n,h,b) = \frac{c^{1-\sigma}-1}{1-\sigma} - \left(\phi_n\left(\frac{n^{1+\eta}}{1+\eta}\right)^{\frac{s-1}{s}} + \phi_h\left(\frac{h^{1+\varepsilon}}{1+\varepsilon}\right)^{\frac{s-1}{s}}\right)^{\frac{s}{s-1}} + \phi_b\frac{b^{1-\sigma_b}-1}{1-\sigma_b} \tag{6}$$

These preferences feature imperfect substitutability of disutilities of working in the market or at home. I view it as realistic to allow the utility cost of these two very different activities to differ, but nonetheless there is a relationship between the two: The marginal disutility of supplying an additional hour of market work is increasing in the time worked at home, and vice versa. These preferences allow for time allocations, consistent with the data, such that both men and women work in the labor market and in the household –even when male and female time are perfect substitutes.

I assume that there is a subsistence level in consumption of the home produced good. A household needs to produce a certain amount of the home good x, which is increasing in the number of children living in the household (b_h). As a simplifying assumption, following Knowles (2007), agents do not derive any further utility from home production, and this constraint will be binding, $x = \bar{x}(b_h)$.

2.1.7 Government

The government provides a pay-as-you go social security system. Similar to the US system, it levies a constant social security tax τ_{ss} on labor income and redistributes the proceeds as benefits $\mathcal{T}_{ss}$ to retired households. Hence

$$\mathcal{T}_{ss,t} = \frac{\tau_{ss}\cdot w_t N_t}{\sum\limits_{j=T_r}^{T_l}\mu(j)} \tag{7}$$

2.2 Couple Household's Optimization

In the benchmark model I consider households in which spouses get equal weights ($\theta = 0.5$), such that the household behaves like a unitary agent. Since I assume for the bargaining model full commitment to the sharing rule determined when both partners meet (see section 5.1), in both scenarios the Pareto weight θ is constant over the couple's lifetime. Consider the optimization problem of a couple household of age j with current wealth a, total number of children b, of which b_h are still living at home. Let $u_g(c_g, n_g, h_g, b)$ denote the own utility function of the member of gender $g \in \{m, f\}$. The household's resources from financial assets are $a(1+r)$. Households before retirement can earn a labor income net of taxes of $\tilde{w}_m(j)n_m + \tilde{w}_f(j)n_f$, where $\tilde{w}_m(j) = (1-\tau_{ss})p_m(j)w$ is the net

[12] Adding utility from children in this additive form is generalizing Galor and Weil (1996) and Greenwood and Seshadri (2005), who assume simply $ln(b)$.

male wage and $\tilde{w}_f(j) = \chi\tilde{w}_m(j)$ the net female wage. After reaching the retirement age (T_r) households receive social security benefits $\mathcal{T}_{ss}$.

After having decided at the beginning of their lives on the number of children (b), for age $j \geq 2$ the value functions of the representative couple household solves[13]

$$V_C(a; b, j) = \max_{\substack{a', e, c_m, c_f \\ n_m, n_f, h_m, h_f}} \theta u_m(c_m, n_m, h_m, b) + (1-\theta)u_f(c_f, n_f, h_f, b) + \beta V_C(a'; b, j+1) \quad (8)$$

subject to the constraint set:

$$a' = \begin{cases} (1+r)a + \tilde{w}_m(j)n_m + \tilde{w}_f(j)n_f - c_m - c_f - e & \text{for} \quad j < T_r \\ (1+r)a + \mathcal{T}_{ss} - c_m - c_f - e & \text{for} \quad j \geq T_r \end{cases} \quad (9)$$

$$\bar{x}(b_h) = e^{\gamma}\left(z_m h_m + z_f h_f\right)^{1-\gamma} \quad (10)$$

$$b_h(j) = \begin{cases} b & \text{for} \quad 1 \leq j < T_a \\ 0 & \text{for} \quad j > T_a \end{cases} \quad (11)$$

$$n_m + h_m \leq 1 \text{ and } n_f + h_f \leq 1 \quad (12)$$

$$V_C(\cdot; T_l + 1) = 0 \text{ and } a_{T_l+1} = 0 \quad (13)$$

$$\{w_m(k), w_f(k), r(k)\}_{k=j}^{T_l} \text{ known} \quad (14)$$

In the first period of a household's life, the value function is different. Then the couple decides on the number of children (b), from which the parents will derive utility throughout their lifetime. Since I am focusing on a representative couple, the household can choose any non-negative continuous quantity. At model age $j = 1$, when the household starts out and is without any assets ($a = 0$), the value function solves

$$V_C(0; b; 1) = \max_{\substack{b, a', e, c_m, c_f \\ n_m, n_f, h_m, h_f}} \theta u_m(c_m, n_m, h_m, b) + (1-\theta)u_f(c_f, n_f, h_f, b) + \beta V_C(a'; b; 2) \quad (15)$$

subject to the constraints (9) to (14), with the female time constraint (12) modified to be

$$n_m + h_m \leq 1 \text{ and } n_f + h_f \leq 1 - \tau_b b \quad (16)$$

since having children lowers the mother's disposable time.

There is no closed form solution to this optimization problem, but the usual Euler equations hold. Numerically, I solve a couple's deterministic finite life-time optimization problem (8) conditional on a fertility history backwards, making use of the intratemporal first-order conditions, which I show in the appendix. Then I choose the number of children that maximizes the couple's life-time value function in the first period of their lives (15).

[13] To economize on notation, I do not index variables by time, but it should be understood that age (j) takes on this intertemporal role.

The optimal choice of number of children b is –off corners– such that

$$\phi_b b^{-\sigma_b} \sum_{j=1}^{T_l} \beta^{j-1} = \frac{\theta}{\gamma} \sum_{j=1}^{T_a} \beta^{j-1} c_m(j;b)^{-\sigma} \left(\frac{\bar{x}(b)}{z_m h_m(j;b) + z_f h_f(j;b)} \right)^{\frac{1-\gamma}{\gamma}} \bar{x}'(b) \tag{17}$$

$$= \frac{\theta}{z_m} \sum_{j=1}^{T_a} \beta^{j-1} \left(\phi_n \left(\frac{n_m(j;b)^{1+\eta}}{1+\eta} \right)^{\frac{s-1}{s}} + \phi_h \left(\frac{h_m(j;b)^{1+\varepsilon}}{1+\varepsilon} \right)^{\frac{s-1}{s}} \right)^{\frac{1}{s-1}} \tilde{\phi}_h h_m(j;b)^{\zeta} \bar{x}'(b)$$

$$= \frac{1-\theta}{z_f} \sum_{j=1}^{T_a} \beta^{j-1} \left(\phi_n \left(\frac{n_f(j;b)^{1+\eta}}{1+\eta} \right)^{\frac{s-1}{s}} + \phi_h \left(\frac{h_f(j;b)^{1+\varepsilon}}{1+\varepsilon} \right)^{\frac{s-1}{s}} \right)^{\frac{1}{s-1}} \tilde{\phi}_h h_f(j;b)^{\zeta} \bar{x}'(b)$$

where $\tilde{\phi}_h = \phi_h(1+\varepsilon)^{1/s}$ and $\zeta = \frac{(s-1)\varepsilon-1}{s}$.

Intuitively, when choosing a fertility plan the couple is outweighing benefits and costs from having children. The marginal benefit of having this extra child arises from higher felicity for the rest of couple's lifetime, the left-hand side of (17). The marginal cost of having more children lies in the need for more home production, for as long as the child lives with the parents (T_a periods). To increase home production, the couple devotes more time to home labor and uses more home appliances. Both adjustments reduce consumption of the parents. As male and female home labor rises, the parents find it more costly to supply as much labor to the market, and therefore generate less income. Since home appliances are acquired in the market, disposable income for goods consumption drops further. This marginal cost to the parents is, when time constraints are slack, the right-hand side of (17). If a mother's time constraint was binding, the time cost of having the baby would have a further effect of lowering consumption, since she would have less time to divide between market work and home production and loses earnings potential ($\tau_b w_f$).

2.3 Equilibrium

An equilibrium is an allocation of prices and quantities such that all couple households are optimizing life-time utility, the representative firm maximizes profits, the government budget balances, all market clears, and population growth is determined by past fertility decisions. In particular, factor prices are determined competitively by (5), government budget balances requires for social security (7), and households of all ages solve their optimization problem (8) and (15), including the bargaining (31) when the household is formed. Moreover, factor markets clear according to[14]

$$N_t = \sum_{j=1}^{T_r} S_t(j)\left(p_m n_{m,t}(j) + p_f(j) n_{f,t}(j)\right) \tag{18}$$

$$K_t = \sum_{j=1}^{T_l} S_t(j) a_t(j) \tag{19}$$

and the size of cohorts of *adult couples* is given by

$$S_t(j) = \begin{cases} \frac{1}{2} S_{t-T_a}(1) b_{t-T_a} & \text{for} \quad j = 1 \\ S_{t-1}(j-1) & \text{for} \quad 2 \leq j \leq T_l \\ 0 & \text{for} \quad j > T_k \end{cases} \tag{20}$$

On the right hand side the shift of T_a periods appears since children turn adult after T_a periods and have been born when their parents where of age $j = 1$. The factor 1/2 in front reflects the fact that children born are half boys and half girls, and a couple household consist of a man and a woman (of the same age). Notice that in this model the population growth rate might change over time, which in turn affects the capital-labor ratio.

The model implies for period t a *working-age* average male and female labor supply of

$$N_{m,t} = \sum_{j=1}^{T_R-1} \tilde{\mu}_t(j) n_{m,t}(j) \tag{21}$$

$$N_{f,t} = \sum_{j=1}^{T_R-1} \tilde{\mu}_t(j) n_{f,t}(j) \tag{22}$$

where $\tilde{\mu}_t(j) = \mu_t(j) / \left(\sum_{k=1}^{T_R-1} \mu_t(k)\right)$ is the mass of the aged j cohort relative to the working-age population. Similarly, average (over all ages) home hours and appliances are

$$H_{m,t} = \sum_{j=1}^{T_l} \mu_t(j) h_{m,t}(j) \tag{23}$$

$$H_{f,t} = \sum_{j=1}^{T_l} \mu_t(j) h_{f,t}(j) \tag{24}$$

$$E_t = \sum_{j=1}^{T_l} \mu_t(j) e_t(j) \tag{25}$$

[14] I solve for the equilibrium using a Auerbach and Koltikoff (1987) type algorithm. This entails 1. guessing time-paths for aggregate state variables and thereby of factor prices, 2. solving the optimization problems of all households given the guesses, 3. aggregating over all generations alive and computing the deviations from the guessed paths, 4. If the deviations are sufficiently small, the equilibrium has been found; if not, update the guesses and iterate until consistent.

Since couples can have children only at the beginning of their adult lives, the total fertility rate in period t is simply given by the number of children the representative household of model age $j = 1$ has in that period

$$TFR_t = b_t \tag{26}$$

3 Calibration

I choose parameters such that the model replicates in a base year the total fertility rate and married male and married female hours worked, both at home and in the market. I calibrate all parameters as time-invariant, and the only exogenous change over time is in the gender wage gap. A model period is set to 10 years. I calibrate the model parameters against data for 1965, taking the demographic structure of that year, the size of cohorts and the population growth rate, as given. For the required amount of home production, I make use of the cross-sectional variation of married men's and women's hours against the number of children in the household. table 1 lists all model parameters, along with a value taken from the literature[15], or whether it is to be set in a calibration exercise.

In the literature the range of estimates of the labor share in home production is very wide. Studies that include housing as capital or equipment used for home production typically find a relatively low value, close to the one of market production, e.g. Greenwood et al. (1995), while Benhabib et al. (1991), who exclude housing, estimate a very high value of 0.92. In my model, the need for home production is *at the margin* entirely arising from having children living in the household, and does not correspond closely to either study. Since parents can acquire home production inputs in the market, such as hiring nannies or paid domestic help, the share of time-saving inputs acquired in the market, γ, should be higher than the Benhabib et al. (1991) value. As a benchmark I consider an intermediate value of $\gamma = 0.2$, but I conduct a series of robustness checks, see section 7.

3.1 The Gender Wage Gap as Ratio of Residual Wages

To construct a series of the gender wage gap to feed into the model, I use data from the Panel Study of Income Dynamics (PSID) for the United States from 1968 to 2007.[16]First I regress for individuals aged 20 to 59 the logarithm of real wages on a set of observables,

[15] As an approximation to the first order, the Frisch elasticity of market labor supply –when time-constraints are slack– is $\frac{1}{\eta}$.

[16] In section A.4 of the appendix, I discuss the advantages of using data from the PSID, rather than from the CPS, and compare the data and results from these two surveys.

	Description	Value/Moment to Match
	Preference Parameters	
σ	elasticity of consumption	1 (log-utility)
σ_b	elasticity of demand for children	calibration
η	related to elasticity of market hours	2 (Domeij and Floden (2006))
ε	related to elasticity of home hours	calibration
s	CES elasticity of disutilities to work	calibration
ϕ_n	weight on disutility market labor	calibration
ϕ_h	weight on disutility home labor	calibration
ϕ_b	weight on utility from children	calibration
β	discount factor	0.947^{10} (Cooley and Prescott (1995))
	Market Technology	
α	capital share in market output	0.36 (Hansen (1985))
A	total factor productivity	1 (normalization)
δ	depreciation of capital	$1-(1-0.047)^{10}$ (Cooley and Prescott (1995))
$p_m(j)$	male wage profile	estimated, see section 3.1
τ_{ss}	social security tax rate	11% (Heer and Maußner (2009))
	Home Technology	
γ	share of market inputs in home	0.2 (and robustness checks)
z_m	male home labor productivity	1 (normalization)
z_f	female home labor productivity	1 (assuming $z_m = z_f$)
τ_b	time cost on mother per child	$\frac{1}{2}\frac{1}{10}$ (6 month)
$\bar{x}(b_h)$	amount of home good needed	cross-sectional variation
	Time Variant	
χ_t	gender wage gap	estimated, see section 3.1

Table 1: Model Parameters

including most importantly education. In particular I estimate by OLS

$$\log w_{i,t} = \beta_{0,t} + \beta_{1,t} Dfemale_{i,t} + L(j) + X_{i,t}\gamma + \epsilon_{i,t} \tag{27}$$

$$\text{where } Dfemale_{i,t} = \begin{cases} 1 & \text{if } i \text{ is female} \\ 0 & \text{if } i \text{ is male} \end{cases}$$

$L(j)$ is a polynomial in age

$X_{i,t}$ is a vector of other observables, such as a polynomial in years of education and race dummies

The estimated gender wage gap for year t, defined as the ratio of women's to men's relative earnings not explained by $X_{i,t}$, is then given by $e^{\beta_{1,t}}$. I give the full regression results in appendix C.1, and plot the implied series in figure 3. To construct the series of χ_t to feed into the model, where a period has a length of 10 years, I take the simple averages.[17] For the final steady state I assume that the gender wage gap is closed. I impose for the transition periods between the last available data point and the steady state, that χ_t grows at the same rate as over 1968–2007 until it reaches 1.

The estimates of equation 27 imply an age profile in wages, for male wages $p_m(j) = \exp(L(j))$, which I illustrate in figure 5. Then I impose for females

$$p_{f,t}(j) = \chi_t p_m(j) \tag{28}$$

where I obtained χ_t as described above.

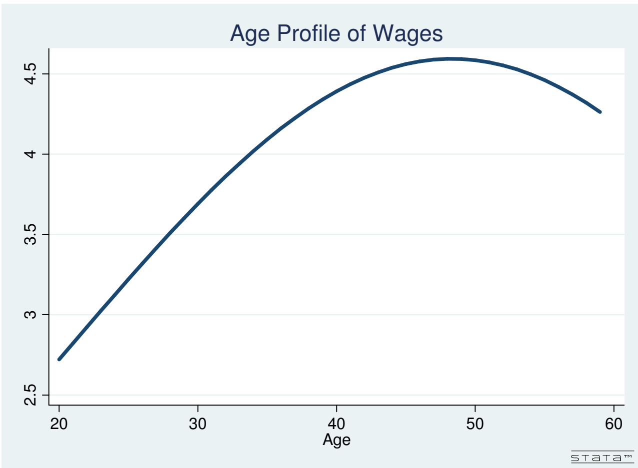


Figure 5: Age Profile of Wages

[17]As an alternative, I allow the gender wage gap to depend on time and age of the worker. The qualitative results do not change; see appendix E.

3.2 Home Production

To calibrate the required amount of home goods $\bar{x}(b_h)$, notice that the model implies that male and female home and market hours depend on the couple's Pareto weights, consumptions and the required amount of home good $\bar{x}(b_h)$. In particular, at an interior solution the household's first order condition imply

$$\bar{x}(b_h) = \left(\frac{\phi_h}{\phi_n} \left(\frac{1+\varepsilon}{1+\eta} \right)^{1/s} \frac{h_m^{\frac{(s-1)\varepsilon-1}{s}}}{n_m^{\frac{(s-1)\eta-1}{s}}} \frac{\tilde{w}_m}{z_m} \frac{\gamma}{1-\gamma} (z_m h_m + z_f h_f) \right)^{\gamma} \tag{29}$$

Conditional on all other parameters, this relationship can be used to back out of $\bar{x}(b_h)$ from the Aguiar and Hurst (2007) data, based on the American Time Use Survey. As a functional form I assume

$$\bar{x}(b_h) = \kappa_0 + \kappa_1 \cdot b_h^{\kappa_2} \tag{30}$$

and expect to find $\kappa_0 > 0$, $\kappa_1 > 0$ and $0 < \kappa_2 < 1$, which would mean home production is always positive and increasing in number of children, but at a decreasing rate. I choose the parameters $\kappa_0, \kappa_1, \kappa_2$ to replicate the observed cross-sectional variation of married men's and women's hours against the number of children in the household, according to (29). The details are given in appendix C.2.

3.3 Remaining Parameters

1965-Moments to be Matched	Data	Fictive S.S.	in Transition
Number of children (TFR)	2.913	2.9726	2.8493
Market hours of men	0.3886	0.3890	0.3907
Market hours of females	0.1120	0.1111	0.1139
Home hours men	0.0950	0.0950	0.0953
Home hours females	0.3896	0.3909	0.3893
Additional Target to be Matched			
Long-run TFR	2 (assumed)		2.0312

For the 1965 moments, the first column shows the value of the statistics in the data. The second column shows the model analogues, taking the demographics as given, when agents believe the gender wage gap to remain constant forever. The third column shows the model implied outcomes, when in 1965 agents learn the true future path of the gender wage gap. To discipline the calibration a restriction on the long-run number of children is added. For the long-run TFR, the last column shows the model's final steady state TFR.

Table 2: Calibration Targets

Six parameters are left to be chosen, but I have only the five targets of table 2 to match in 1965, the base year. Four parameters $(\phi_n, \phi_h, \varepsilon, s)$ correspond to the targets for male and female hours worked at home and in the market, and two parameters (ϕ_b, σ_b) are key for the fertility choice.

These parameters are, of course, calibrated jointly, but it is insightful to think of them as being chosen to match particular moments in the data. Notice that the optimality conditions for a household before retirement imply $\left(\frac{h_m(j)}{h_f(j)}\right)^{\frac{(s-1)\varepsilon-1}{s}} = \frac{z_m}{z_f}\chi(j)\left(\frac{n_m(j)}{n_f(j)}\right)^{\frac{(s-1)\eta-1}{s}}$. Intuitively, given the gender wage gap and relative home productivities, s is chosen to replicate the ratio of female to male labor supply. Then ε is set to match relative home hours. Then ϕ_n and ϕ_h are chosen so that absolute male and female market and home hours, respectively, equal the observed ones. Given these parameters, the cross-sectional variation in hours worked against the number of children gives, according to (29), the parameters $\kappa_0, \kappa_1, \kappa_2$, describing the required amount of home production $\bar{x}(b_h)$. Finally, the two parameters governing fertility have to be chosen. While ϕ_b captures the relative weight the household attaches to having children (compared to consumption), σ_b essentially captures the curvature. I restrict the calibration by choosing σ_b such that in the final steady state, the total fertility rate is approximately 2. A value of 2 seems natural, as the number of children born is just replacing previous generations. Moreover, it is close to most recent values for the US. Conditional on a value for σ_b, I calibrate the remaining five parameters to the data of 1965 under the fiction that households believed gender wage gap to remain constant forever. Then I solve the model for the final steady state, in which the gender wage is closed. If the implied long-run fertility rate differs from 2, I update the guess for σ_b until consistent. Table 3 shows the values found through this calibration exercise. They imply for the required amount of home production $\bar{x}(b_h) = 0.1813 + 0.0279(b_h)^{0.8845}$.

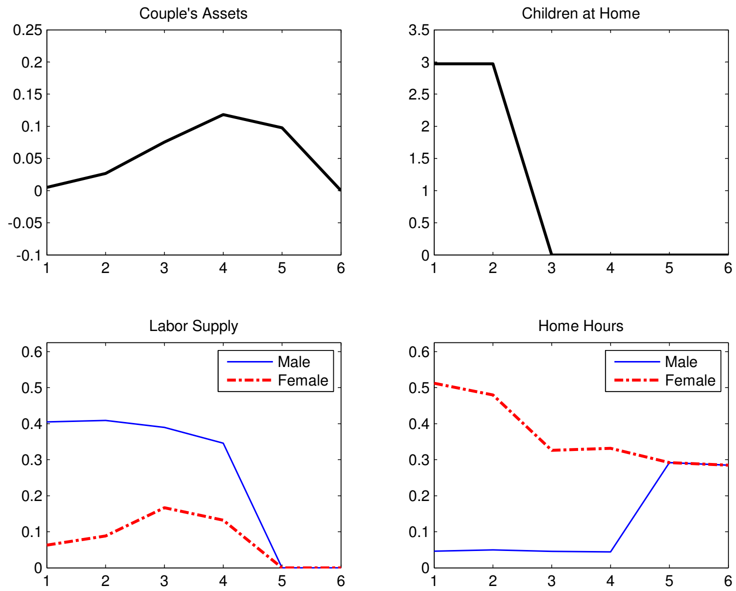
	Description	Value
σ_b	elasticity of demand for children	0.3950
ε	related to Frisch elasticity of home hours	3.5740
s	CES elasticity of disutilities to work	1.4041
ϕ_n	weight on disutility from market labor	2.6712
ϕ_h	weight on disutility from home labor	1.8398
ϕ_b	weight on utility from children	0.0515

Table 3: Calibrated Parameters

I perform a series of robustness checks, including alternative values for σ_b (and therefore of ϕ_b), and report the model results under alternative parameters in section 7.

4 Results of the Benchmark Model

To obtain the transition path of the calibrated model, I feed the series of the observed gender-wage gap into the model. For the first period I need initial conditions. I take the demographic structure from the data. Since I do not have age-specific data on household asset holdings for 1965, I initialize household asset holdings with the values of a fictive



This graphs plots the representative couple household's policy functions for assets, male and female market and home hours, as well as number of children living at home, over the life-cycle, from age $j = 1$ (20–29) to $j = T_l = 6$ (70–79).

Figure 6: Life-time Choices in the Initial Steady State

steady state in which agents believed the gender wage gap to remain constant forever.[18] It should be stressed that in the model young couples, who are the ones deciding on how many children to have, start out with zero assets. The initialization of asset holdings applies to older households only, and could affect fertility only through general equilibrium effects on wages or interest rates, which are likely to be small.

I assume that the economy will eventually reach a steady state in which male and female wages are equalized. Since fertility is a choice in the model, the age distribution evolves endogenously over time. Like Auerbach and Koltikoff (1987), I select the long-run equilibrium such that in the final steady state the growth rate of the population is constant. A constant number of children per couple is not enough to ensure this outcome, as an infinite echoing series of baby booms or busts might occur. Since a balanced growth path requires constant population growth to ensure a constant capital-labor ratio, I solve for the final steady state by solving a fixed-point problem for the population growth rate.[19]

4.1 Comparing the Steady States

Figures 6 and 7 show the policy functions of the representative couple in the initial and in the final steady state. In the initial steady state a couple has more than two children and there is population growth. Therefore, there are relatively more young households in the economy, who start out without any assets. As a consequence, the equilibrium interest rate is such that $\beta(1+r) > 1$, and consumption, both male and female, is increasing over the household's life-cycle. As consumption rises, an agent prefers to work less at a given wage. However, holding consumption and home production constant, labor supply increases in the wage rate. Since there is the age premium in wages (figure 5), these two effects work against each other, resulting in the labor supply plotted in the graph.

In the initial steady state, the positive gender wage gap implies gains from specialization in the couple household. Consequently, a wife shoulders most of the housework, and most of a couple's labor supply is coming from the husband. In the final steady state, on the other hand, the gender wage gap is closed, and there are no gains from specialization anymore.[20] Hours worked of men and women are therefore equalized, both in the market sector and at home.

Comparing the policy functions of the final and the initial steady state shows, most of the increase in female labor supply comes from young women, which is consistent with the empirical findings by Buttet and Schoonbroodt (2006) and Olivetti (2006).

4.2 The Transition in the Benchmark Model

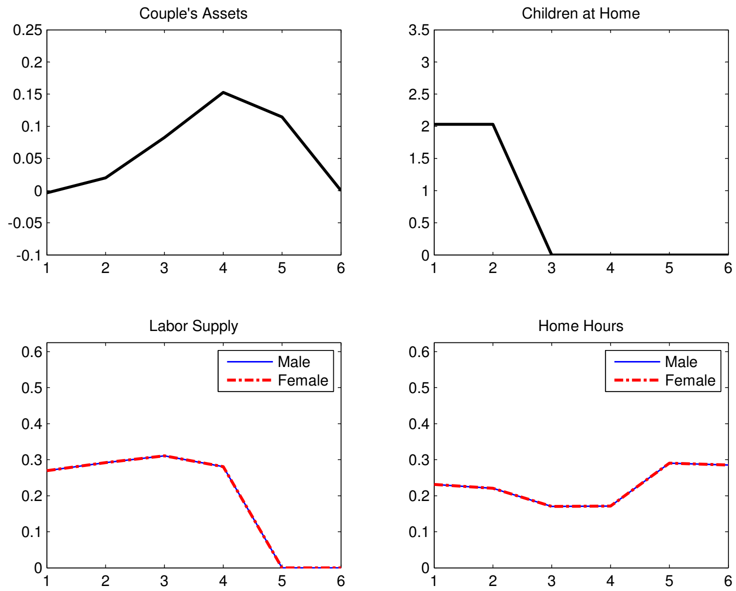
Figure 8 shows the transitional dynamics of the economy[21], starting from an initial situation ($t < 0$), in which wages were expected to remain constant at their 1965 values. Then at $t = 0$, corresponding to the year 1965, the true path of the gender wage gap gets known, but relative wages do not start changing before $t = 1$, year 1975. The economy starts to converge to a new steady state in which relative wages are equalized. During the transition the gender wage gap, shown in the upper-left panel, closes gradually. As a consequence, women work more hours in the market and less at home, whereas for men the opposite happens. Initially, fertility is declining as raising children becomes more

[18]This is the fictive steady state used for calibrating the model against the data. The age-distribution of 1965 is, however, not the stationary distribution, which would be implied by the population growth rate of this year.

[19]First I guess a population growth rate, which implies a stationary age distribution. Then I compute the steady state. In particular, the optimally chosen number of children, compared to the measure of oldest households gives an implied population growth rate, according to (20). I iterate to find the fixed point.

[20]By assumption male and female home productivities are equal throughout. Advances in technologies over the last century, such as infant formula, have brought male and female productivities closer together. Albanesi and Olivetti (2007) argue that this allowed female labor force participation to rise. In my framework, it also implies a rise in male participation at home.

[21]The transitional graphs in the main text show, in the interest of brevity, only the behavior of aggregate variables. Section D of the appendix shows the disaggregation by age.



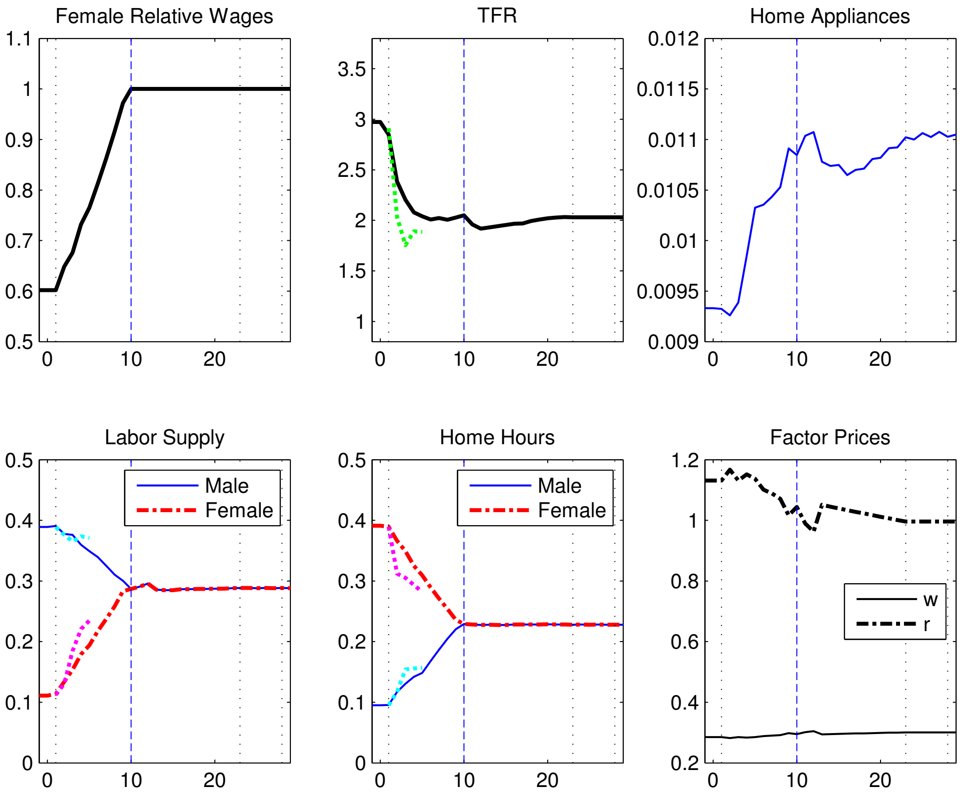
This graphs plots the representative couple household's life-cycle policy functions for assets, male and female market and home hours, as well as number of children living at home, under the prices of the final steady state. Since the gender wage gap is closed, hours worked of men and women coincide.

Figure 7: Life-time Choices in the Final Steady State

costly to the parents.

What is striking in the transition process is that fertility flattens out *before* the gender wage gap is closed (at the blue dashed line). While the gender wage gap is closing, the model implies a reallocation of labor across gender. When female wages rise, a household finds it optimal to increase the wife's labor supply and to decrease her time working at home. However, since relative wages have changed, but not relative productivities at home, this reallocation entails an increase in men's home production. In all periods, the couple also acquires more home appliances to substitute for the overall drop of their time working at home. However, the link between higher female relative wages and lower fertility breaks at some point.

The change in relative wages alters the environment in which the couple makes its economic decisions. Initially, when the gender wage gap is big, there is a great degree of specialization in the household, resulting in a husband working substantially more in the labor market than his wife, but much less at home. In this situation, due to increasing marginal disutility from working, a husband is not prepared to put in much more time at home when his wife works more hours in the market. A rise in female relative wages directly increases female labor supply, and lowers female, as well as total, time spent on home production. As the couple devotes less time to having children, fertility falls sharply, despite the rise in home appliances. However, in later periods when the gender wage gap is fairly small, the spouses time allocation and, thus, their disutilities from working are very similar. When then the wage gap shrinks further, the rise in male home hours is, at



This graphs shows the benchmark model's transition over time, that is implied by the narrowing of the gender wage gap (upper-left panel). The dotted lines show the data, which is available until 2005 ($t = 5$) only.

Figure 8: Transition Path of the Unitary Model ($\theta = 0.5$)

a given level of home production, i.e. number of children, almost big enough to keep total home labor constant; in the limit of equalized wages, a drop in female home production is fully offset by men. On top of this, with the improvement in the wife's earnings, the couple can acquire more parental time saving inputs.

For the optimal choice on how many children to have, however, the couple outweighs the benefits from having an additional child with the utility cost of child care. The reallocation of a man's time from market to home, which comes with the change in relative wages, might actually reduce his marginal cost of having an additional child, although his share of child care rises, since the disutilities are imperfect substitutes and his initial time allocation was very unbalanced. Similarly, a mother's marginal cost might increase, fall, or not be affected at all. The model results clearly suggest that for the first part of the transition, as female relative wages improve, the parents' marginal utility cost is increasing, and therefore they prefer to have fewer children. But when the gender wage gap is sufficiently small and shrinks further, their marginal cost is not affect, resulting in a constant fertility rate.

I will show in the next two sections that key in understanding why fertility did not fall further is the rise in male home labor, that we have observed in the data. While qualitatively the rise in male participation in home production can yield a flattening out of the fertility rate, I find that the higher use of parental time-saving inputs into home production is important in matching the timing. However, a marketization of home production alone is not sufficient to explain the data.

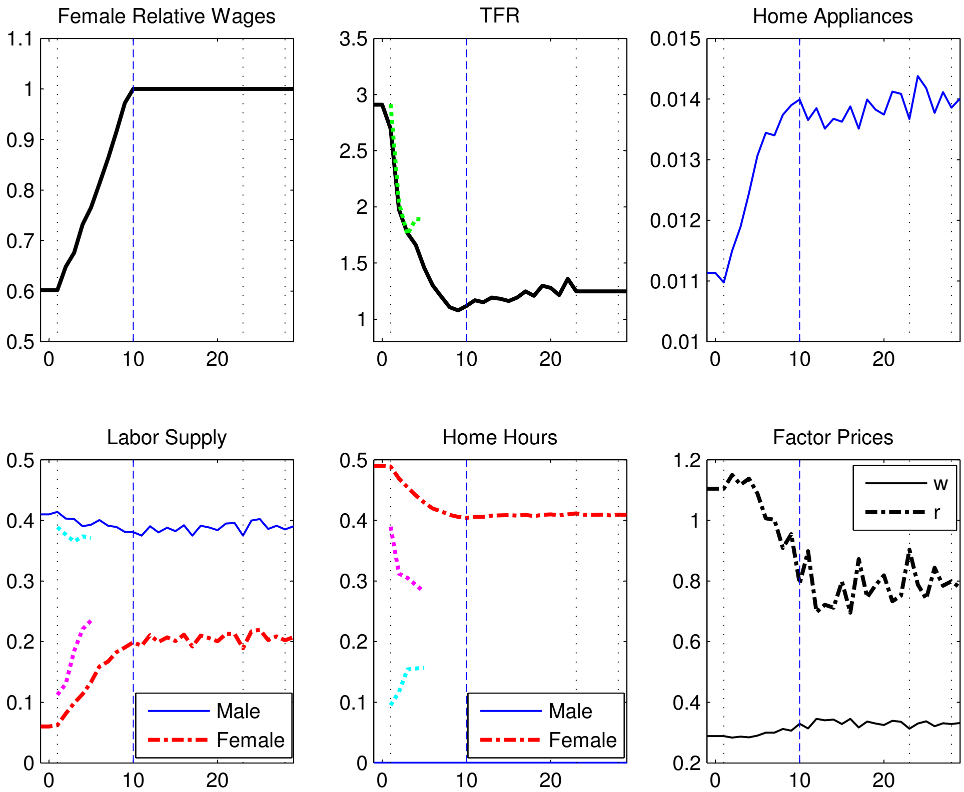
4.3 Counterfactual: The Absence of Male Home Labor

In this part I am shutting down the rise of male home labor. In the existing literature on fertility it is commonly assumed that child-care is a function of female time only. By setting male home productivity to zero, my model nests this as a special case. Notice that in this counterfactual exercise, men and women do not become 'identical' in the final steady state. Although their wages will eventually be equalized, specialization in the household persists because of the different home productivities.

Not to confound changes in technology with changes in preferences, I keep all preference parameters at their baseline values, but set $z_m = 0$ and adjust z_f such that the household still chooses in 1965 the same number of children as in the data.[22] Figure 9 shows the transition of the model, when men cannot counteract the fall in women's home hours.

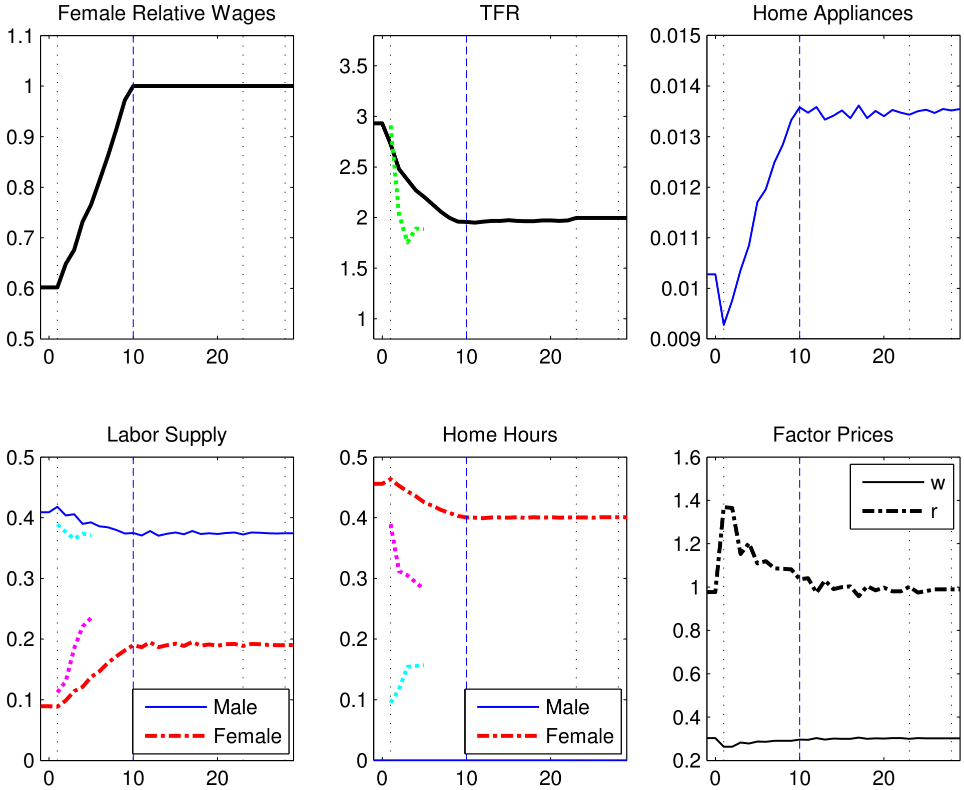
It implies a monotone drop in fertility as long as female wages catch up– which is inconsistent with the data. Throughout the transition, parents are having fewer and

[22]Since by assumption of $z_m = 0$ this model variant is doomed to fail along the dimension of male home hours, notice that I could not apply the calibration strategy of the benchmark model, which has H_m as one of the targets.



For the model without male home production, this graphs plots the transition implied by the narrowing of the gender wage gap (upper-left panel) over time. The dotted lines show the data, which is available until 2005 ($t = 5$) only.

Figure 9: Transition Path of the Unitary Model ($\theta = 0.5$) with $z_m = 0$



For model without male home production under the alternative calibration, this graphs plots the transition implied by the narrowing of the gender wage gap (upper-left panel) over time. The dotted lines show the data, which is available until 2005 ($t = 5$) only.

Figure 10: Transition of the Unitary Model ($\theta = 0.5$) with $z_m = 0$, Alternative Calibration

fewer children, since child-care hours continue to fall, when women's market labor supply rises. As women's income increase, couples also acquire more home appliances, but this marketization of home production is not strong enough to prevent fertility from falling. Only once the gender wage gap has closed, the optimal number of children stabilizes.

4.3.1 Alternative Calibration of the Model without Male Home Production

As an alternative calibration for the $z_m = 0$-model, I adjust the parameters capturing the choice of number of children, such that also this model variant has a total fertility rate of 2 in the final steady state. More specifically, I take the benchmark calibration, with $z_m = 0$ and $z_f = 1$, and adjust (ϕ_b, σ_b) to target a long-run TFR of 2, but keeping 1965's TFR at the observed value. Given all other parameters from the benchmark, this adjustment yields $\phi_b = 0.0872$ and $\sigma_b = 0.9625$. Then I solve for the transition of the model under this alternative calibration and show the results in figure 10. Also under these alternative parameters, the model without male home production predicts that the total fertility rate falls as long as the gender wage gap shrinks. That parents use more market inputs into home production is not sufficient for generating a flattening out of the fertility rate before the gender wage gap has closed.

To conclude, in the benchmark model of above, it is the rise in male home labor, which counteracts the fall of female time inputs into child raising, that is key in understanding why the fertility decline ended.

4.4 No Marketization of Home Production

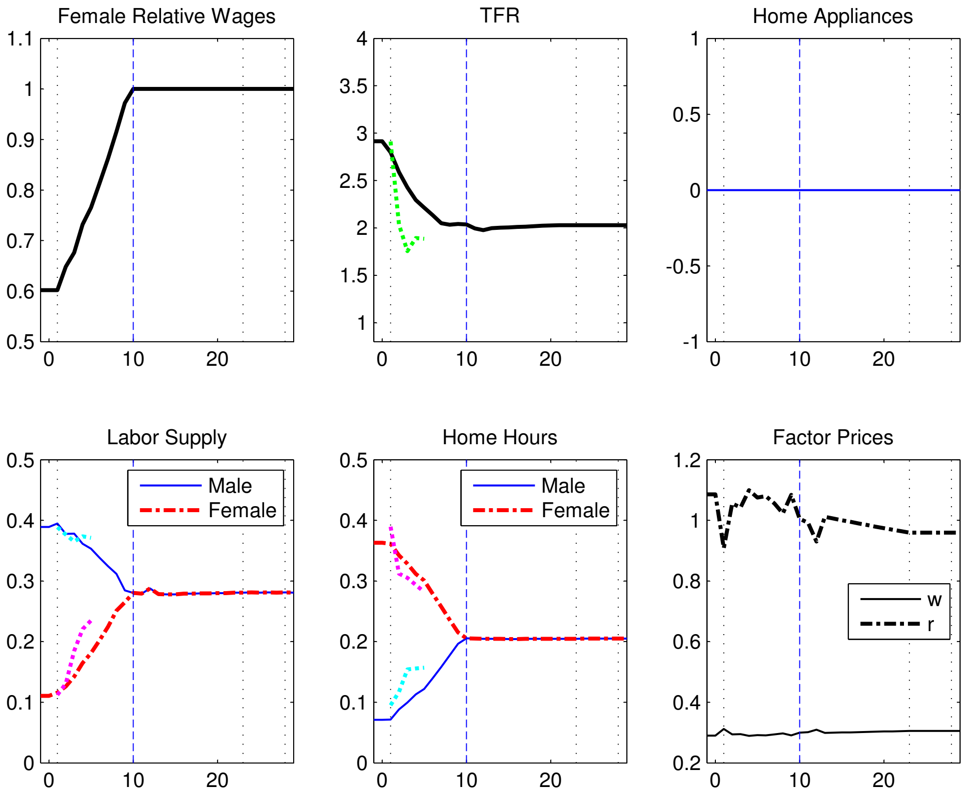
Since the previous section concludes that the rise in male home production is important in understanding why fertility did not fall further, one might wonder whether the marketization of home production matters for the trends in fertility after all. As I show in this section, that parents can use more time-saving inputs at home when female wages rise, is not crucial for replicating the flattening out of the total fertility rate qualitatively. However, it is important in matching the timing.

To rule out marketization of home production, consider a simpler version of the model in which home production is a function of male and female home hours only. This is the special case of $\gamma = 0$. I use the same calibration strategy as for the benchmark model, in order to give both models equal chances in matching the data.[23]

Figure 11 shows the transition of this model variant. Also the model without marketization predicts that fertility stops falling before the gender wage gap is closed (in $t = 10$, at the dashed line). This shows that the reallocation of men's time from market to home, and of women's time from home to the labor market is, in principle, sufficient in breaking the direct link between higher female wages and fewer children. However, this version of the model predicts that fertility does not flatten out before the year 2025 ($t = 7$), but in the data the fertility rate has been constant already since the late 1970s. The benchmark model featuring marketization of home production, on the other hand, gets closer and predicts, as shown in figure 8, a flat fertility rate since 1995 ($t = 4$). In section 6, below, I compare the different versions of the model and the data in greater detail.

[23]The same calibration strategy as for the benchmark model gives the following parameters: $\sigma_b = 0.750$, $\varepsilon = 3.4935$, $s = 1.4073$, $\phi_n = 2.6281$, $\phi_h = 1.8434$, $\phi_b = 0.0524$ implying $\bar{x}(b_h) = 0.3762 + 0.0515(b_h)^{0.9254}$. They imply for the targets:

1965-Moments to be Matched	Data	Fictive S.S.	in Transition
Number of children (TFR)	2.913	2.9134	2.7982
Market hours of men	0.3886	0.3890	0.3949
Market hours of females	0.1120	0.1104	0.1159
Home hours men	0.0950	0.0711	0.0715
Home hours females	0.3896	0.3630	0.3616
Additional Target to be Matched			
Long-run TFR	2 (assumed)		2.0279



For the model without marketization, this graphs plots the transition implied by the narrowing of the gender wage gap (upper-left panel) over time. The dotted lines show the data, which is available until 2005 ($t = 5$) only.

Figure 11: Transition Path of the Unitary Model ($\theta = 0.5$) with $\gamma = 0$

5 The Bargaining Model

Since Feyrer et al. (2008) have argued that changes in women's household status is important in explaining the time series in total fertility, I introduce next household bargaining. The only modification to the benchmark model is that now the Pareto weights in the household's optimization program are determined endogenously.

Here, rising relative wages also improve women's say in household decision making, which corresponds in my model to a higher weight on women's utility in a couple's optimization program. I assume that this weight is the result of a Nash bargaining over the surplus generated by marriage. The wife's bigger say reduces her share of housework, relative to her husband, by more than what a change in relative wages per se would imply.

5.1 Determination of Intrahousehold Weights

The solution to the couple's optimization program at a given Pareto weight θ defines a sequence of life-time utilities $\{V_{C,m}(j|\chi,\theta),\ V_{C,f}(j|\chi,\theta)\}_{j=1}^{T_l}$ for the man and the woman who form the household. I follow McElroy and Horney (1981) and assume that the sharing rule θ is the result of Nash Bargaining. When both partners meet at the beginning of their adult lives, i.e. at model age $j=1$, they bargain *under full commitment* over the surplus generated from marriage. The threat point of each partner is staying single, rather than entering the match. In equilibrium, the weights are then the solution to

$$\theta = \arg\max_{\tilde{\theta}} [V_{C,m}(1|\chi,\tilde{\theta}) - V_{S,m}(1|\chi)][V_{C,f}(1|\chi,\tilde{\theta}) - V_{S,f}(1|\chi)] \tag{31}$$

where $V_{C,m}(1|\chi,\tilde{\theta})$ and $V_{C,f}(1|\chi,\tilde{\theta})$ are the husband's and wife's lifetime utilities at age $j=1$ that are implied by the joint optimization program, and $V_{m,S}(1|\chi)$ and $V_{f,S}(1|\chi)$ are the life-time utilities if the man or the women stayed single (at age $j=1$), given the series of the gender pay gap that they face over their lives ($\chi = \{\chi_j\}_{j=1}^{T_l} = \{\frac{w_f(j)}{w_m(j)}\}_{j=1}^{T_l}$).

To find the value of the threat points, consider the optimization problem of male and female singles. Since they cannot have children, the value function of a single agent of gender $g \in \{m, f\}$ solves

$$V_{S,g}(a;j) = \max_{c,,n,h,e,a'} u(c,n,h,0) + \beta V_{S,g}(a';j+1) \text{ for } j \geq 1 \tag{32}$$

$$\text{subject to}$$

$$a' = \begin{cases} (1+r)a + \tilde{w}_g(j)n - c - e & \text{for} \quad j < T_r \\ (1+r)a + \frac{\mathcal{T}_{ss}}{2} - c - e & \text{for} \quad j \geq T_r \end{cases}$$

$$\bar{x}(0) = e^{\gamma} H^{1-\gamma} \text{ with } H = z_g h$$

$$n + h \leq 1$$

$$V_{S,g}(\cdot; T_l + 1) = 0 \text{ and } a_1 = T_{l+1} = 0$$

$$\{w_g(k), r(k)\}_{k=j}^{T_l} \text{ known}$$

I find the singles' value function at age $j = 1$ numerically. Then I solve the Nash bargaining problem (31) to find a household's Pareto weight. The resulting sharing rule depends on the life-time series of the gender wage gap ($\theta = \theta(\chi)$), since it changes the outside option of females relative to males. In other words, the spouse's bargaining position depends on their relative wages. Typically the husband's weight is increasing in his relative life-time wages.

5.2 Dependence on the Weights

A rise in wives' Pareto weights, relative to their husbands, –a drop in θ– makes them better off through a intrahousehold reallocation of consumption and hours worked. One optimality condition that is particular useful in illustrating the mechanism of the model is the ratio of male to female home hours. When both time constraints (12) are slack, the optimal division of home labor for retired couples is given by[24]

$$\frac{h_m}{h_f} = \left(\frac{1-\theta}{\theta}\frac{z_m}{z_f}\right)^{1/\varepsilon} \text{ for } j \geq T_r \tag{33}$$

Increase in women's relative Pareto weight imply an increase in the share of men's home hours. Numerically I find that this also the case for working-age couples. An improvement in a woman's bargaining position therefore decreases her share of home hours and lowers *her* opportunity cost of having children. However, as her partner then has to contribute more to home production, *his* preferred number of children is falling.

[24]One can show that as $s_l \to \infty$, making the choice of home and market hours separable, the optimality condition (33) also holds for working-age couples.

5.3 Calibration

As for the benchmark model in section 3, I calibrate the model with intrahousehold bargaining against data for 1965. I report the obtained parameter values in table 4, and the targets and their counterparts in the model table 5. The calibrated parameters imply for the required amount of home production $\bar{x}(b_h) = 0.1923 + 0.0299(b_h)^{0.8793}$.

	Description	Value
σ_b	elasticity of demand for children	0.4800
ε	related to Frisch elasticity of home hours	4.1041
s	CES elasticity of disutilities to work	1.3673
ϕ_n	weight on disutility from market labor	2.3727
ϕ_h	weight on disutility from home labor	2.4044
ϕ_b	weight on utility from children	0.0764

Table 4: Calibrated Parameters for the Bargaining Model

1965-Moments to be Matched	Data	Fictive S.S.	in Transition
Number of children (TFR)	2.913	2.8371	3.0463
Market hours of men	0.3886	0.3889	0.3941
Market hours of females	0.1120	0.1111	0.1008
Home hours men	0.0950	0.0948	0.0902
Home hours females	0.3896	0.3885	0.4001
Additional Target to be Matched			
Long-run TFR	2 (assumed)		2.0205

For the 1965 moments, the first column shows the value of the statistics in the data. The second column shows the model analogues, taking the demographics as given, when agents believe the gender wage gap to remain constant forever. The third column shows the model implied outcomes, when in 1965 agents learn the true future path of the gender wage gap. To discipline the calibration a restriction on the long-run number of children is added. For the long-run TFR, the last column shows the model's final steady state TFR.

Table 5: Calibration Targets for the Bargaining Model

5.4 Steady State Comparison

Table 6 shows the model implied variables for the 1965-steady state, taking the age distribution as given, and the final steady state with endogenous distribution across age. The steady state results of the bargaining model, rows 1 and 2, confirm, improvement in women's relative wages lead to a reduction in men's Pareto weight in household decision making. In the final steady state, in which the gender wage gap is assumed to have disappeared, both spouses have an equal weight in the household optimization ($\theta = 0.5$), whereas initially, when men earned relatively more, husbands accrued a bigger weight.

Not surprisingly, in response to higher wages, female labor supply increases and women's share of home production decreases. Fertility is lower in the long run, when

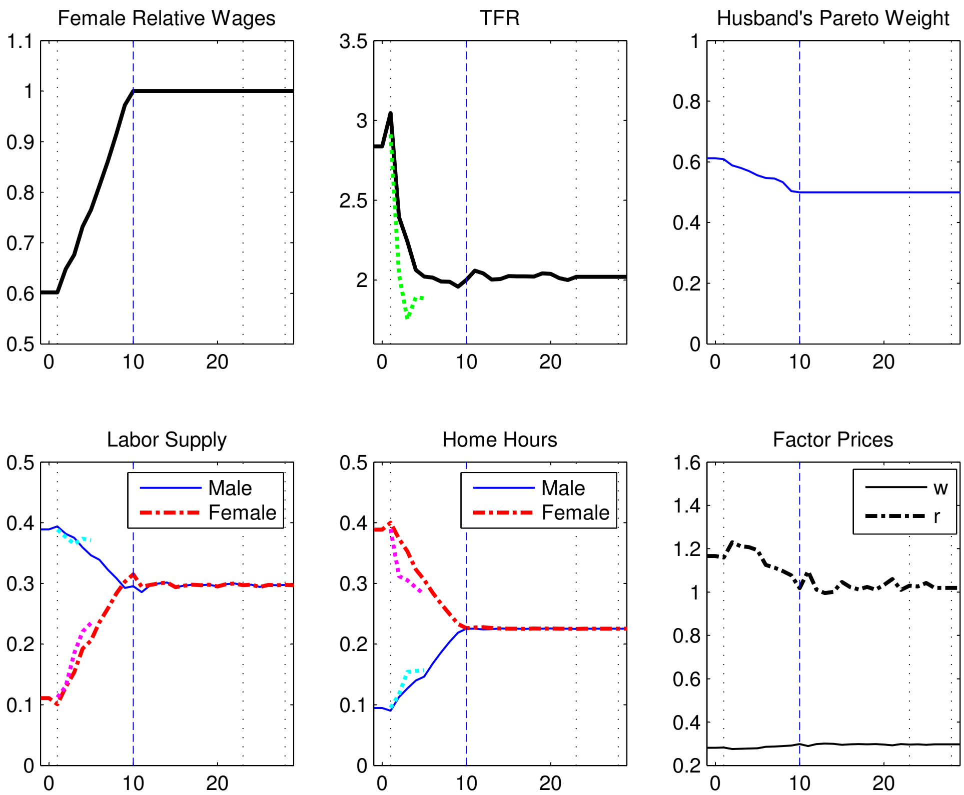
χ	$\mu(j)$	θ	TFR	N_m	N_f	H_m	H_f
0.602	1965 data	endogenous 0.612	2.8371	0.3889	0.1111	0.0948	0.3885
1.000	endogenous	endogenous 0.500	2.0205	0.2972	0.2972	0.2254	0.2254
1.000	endogenous	fixed at 0.612	2.0884	0.2407	0.3600	0.2351	0.2158

Table 6: Steady States Comparisons

the gender wag gap has closed. In the bargaining model there are three forces driving fertility decisions. Firstly, higher wages exert a positive income effect increasing a couple's desire to have children. Secondly, higher relative earnings to women affect the division of market and home labor between men and women. In particular, men have to contribute more to home production, leaving women with more disposable time, which tends to boost fertility. Thirdly, however, the bargaining effect has differential effects on men and women. While a higher Pareto weight on females increases the number of children a mother wants to have, it reduces the optimal number for men, who will need to provide more input to child care.

To disentangle the effects, I conduct a counterfactual exercise. I vary women's relative wages, but keep the Pareto weights constant. The last row of table 6 shows the steady state results under a fixed weight of $\theta = 0.612$, which was found to be optimal under $\chi = 0.602$. Comparing them with the row above highlights the role of household bargaining: Under my calibration, household bargaining reduces fertility in the final steady state. While the improvement in women's say in the household, which comes along with the shrinking of the gender wage gap, increases their preferred number of children, it reduces the optimal number of children for fathers, who need to work more and more at home due the mothers' bigger say. The number of children the couple chooses is in between the optimal numbers for both spouses. Overall I find that when female relative wages are high and women's Pareto weights increase, fertility drops. The intuition is that higher relative female wages *per se* imply that, optimally, a husband provides more home hours. When in addition the husband's relative weight falls, he needs to supply yet more home hours, which reduces his utility substantially. Consequently, the higher female relative wages are, the faster the male preferred number of children drops; they prefer reducing home production over having more children. Wives do prefer to have more children in this case, but the increase in their weight in the household optimization is not strong enough to overcome the drop in husbands' optimal number of children.

Thus, bargaining adds a third force on fertility: When higher female relative wages decrease a father's bargaining position, he does not want to have as many additional children, as he would have desired if his Pareto weight had remained constant. For women, bargaining has the opposite effect. As their weight increases, their optimal number of children does not fall by as much in response to higher female wages. These two opposing



This graphs plots the transition of the model with intrahousehold bargaining. The gender wage gap (upper-left panel) closes exogenously over time. As a consequence the husband's relative Pareto weight, shown for newly matched households (age $j = 1$), falls (upper-right panel). The dotted lines show the data, which is available until 2005 ($t = 5$) only.

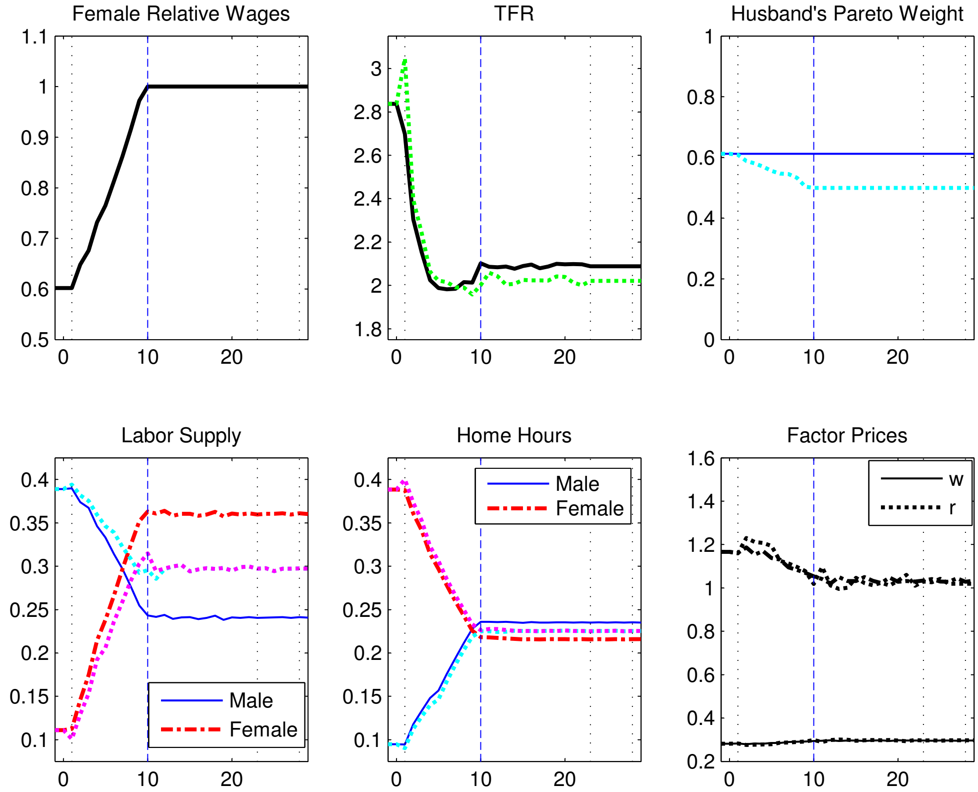
Figure 12: Transition Path of the Bargaining Model

forces lead to a hump-shape in the household's fertility choice against the female's relative Pareto weight.

5.5 The Transition Path

Figure 12 shows the transitional dynamics of the economy in the presence of intrahousehold bargaining. As the gender wage gap closes, the husband's relative weight in household decision declines, until in the final steady state with equalized wages both spouses have equal say and $\theta = 0.5$. Notice that at $t = 0$ households learn the true future path of the gender wage gap, but relative wages do not start changing before $t = 1$. Since Pareto weights depend on life-time relative wages, the improvement in the wife's relative wages reduces the newly-matched husband's Pareto weight, already in $t = 0$. This bargaining effect increases female relative consumption, and ceteris paribus reduces her hours worked. The reallocation of home hours from women to men is therefore stronger than what is explained by changes in relative wages per se.

To further investigate how bargaining affects the transition, I conduct again a counterfactual experiment. I take the bargaining model under *the same calibration*, but keep the Pareto weights artificially at their initial 1965 level. The implied transition path is shown in figure 13. The same income and substitution effects are at work, but only in



This graphs plots the hypothetical transition if men's Pareto weight remained at their initial level. The gender wage gap (upper-left panel) closes exogenously over time. The dotted lines reproduce the transition path of the model with bargaining-determined Pareto weights.

Figure 13: Counterfactual Transition: Holding Pareto Weight Constant

figure 12, here reproduced by the dotted lines, the bargaining effect is present. With household bargaining, in response to higher relative wages, women get a bigger say in decision making, and their husbands' relative weights decline. As a consequence, men's share of housework rises by more than what is explained by relative wages alone. Since initially home hours differ a lot by gender, men's disutility from putting in more time at home is relatively small, but the marginal gains to women is big. The couple finds it, therefore, optimal to have more children when bargaining shifts the burden of housework towards men. Thus, when the gender wage gap is big and consequently home hours very unequal, intrahousehold bargaining tends to boost fertility. However, when home hours are already rather equal because the gender wage gap is fairly small, bargaining effect has the opposite effect on fertility. Rising relative female wages *per se* imply that, optimally, a husband provides more home hours. When in addition the husband's relative weight falls, he needs to supply yet more home hours, which reduces his utility substantially. Consequently, the higher female relative wages are, the faster drops the male preferred number of children; they prefer reducing home production over having more children. Wives do prefer to have more children in this case, but the increase in their weight in the household optimization is not strong enough to overcome the drop in husband's optimal number of children.

While initially, when the gender wage gap is big, the bargaining effect leads to higher fertility, in the longer run it lowers fertility. Overall, I find, however, that the effect of intrahousehold bargaining on fertility is rather small, and the behavior of fertility over time is, qualitatively, as in the benchmark model.

6 Confronting the Models and the Data

In this section, I compare the predictions of the different versions of the model to each other and to the observed variation in the data. Table 7, lists the relative changes from 1965 to 2005, and figure 14 shows the transition paths of the various models and the data for married men and women.

	Data		**Model**			
	Married only	All Individuals	Benchmark	$z_m = 0$	$\gamma = 0$	Bargaining
TFR	−35.3 (US-born mothers)		−28.4	−45.9	−20.9	−33.6
N_m	−5.6	−7.3	−10.7	−5.1	−10.6	−12.1
N_f	+109	+87.5	+70.3	+114.3	+56.4	+104.3
H_m	+70.8	+61.2	+55.7	0	+70.8	+62.3
H_f	−24.5	−27.6	−20.6	−12.2	−16.8	−23.6
'RSS', $\frac{1}{5}\sum_{i=1}^{5}(m_i^{model} - m_i^{data})^2$, against						
		data for married only	0.0355	0.0923	0.0647	0.0023
		data for all individuals	0.0087	0.0962	0.0280	0.0065
'Normalized RSS', $\frac{1}{5}\sum_{i=1}^{5}(\frac{m_i^{model} - m_i^{data}}{m_i^{data}})^2$, against						
		data for married only	0.4240	0.2843	0.4788	0.5805
		data for all individuals	0.0735	0.3166	0.1361	0.1022

H_m and H_f correspond to the Aguiar and Hurst (2007) data for 2003. TFR in 2005 is based on my calculations for TFR of US-born women only, but for 1965 it is for the entire US population. The error due to data limitations is likely to be small, as in the 1970s US-born TFR was closely following the aggregate. I also do not have enough information to decompose fertility into wedlock and out-of-wedlock births. The m_i in the success measures are the relative changes from 1965 to 2005 in TFR, N_m, N_f, H_m , H_f.

Table 7: Relative Changes (%) over 1965–2005

The benchmark model performs better than the model version ruling out male participation at home ($z_m = 0$), and than the version not allowing for marketization of home production ($\gamma = 0$). But qualitatively all models with male home production are quite successful. They imply (i) that the fertility rate should stabilize before the gender wage gap is closed, and (ii) a secular rise in men's time devoted to home production. The $z_m = 0-$model, on the other hand, fails in generating a flattening-out of fertility before

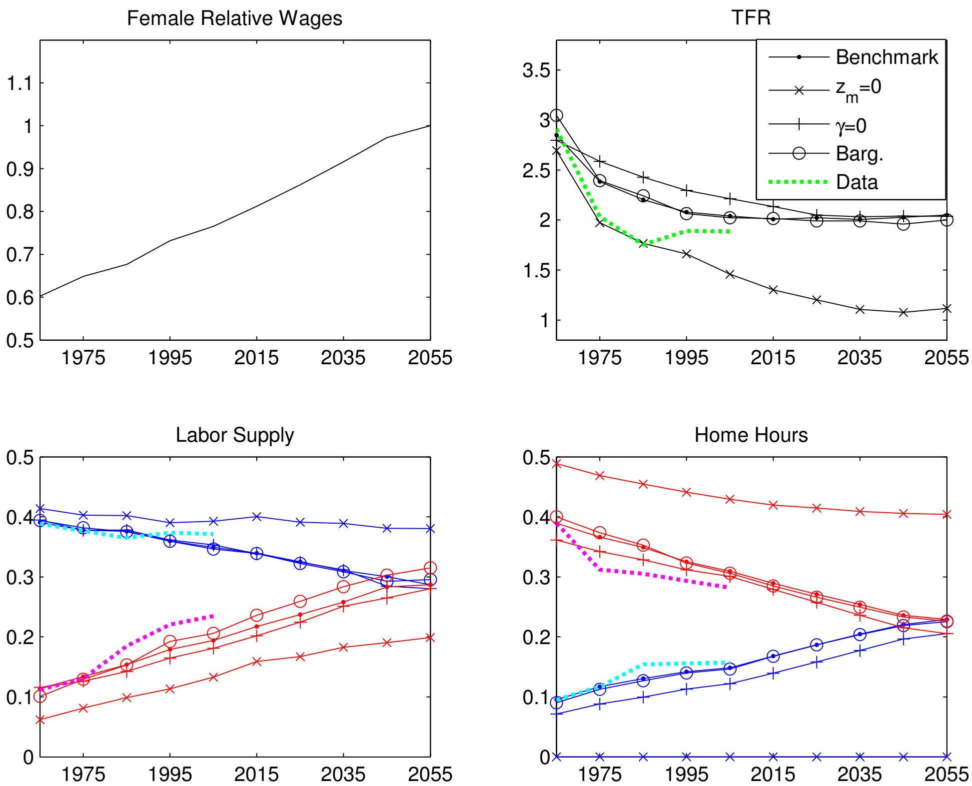


Figure 14: Comparing the Models and the Data

the gender wage gap has closed. This suggests that key in understanding why fertility did not fall further, despite female wages kept improving, is the rise of male home labor.

However, all models predict that fertility would flatten out much later than observed in the data. In the benchmark model, the optimal number of children per couple stabilizes in 1995, but in the data the total fertility rate is virtually flat since the late 1970s.[25] In the model with $\gamma = 0$, which does not allow for marketization of home production or child care, fertility stabilizes even later. It also understates the rise in female labor supply, but overstates the number of children per couple.

Thus, quantitatively, both the rise of male time and the acquisition of time-saving inputs into home production are important in understanding why the fertility decline came to halt. Comparing the $\gamma = 0-$model to the benchmark, which uses $\gamma = 0.2$, also suggests, that the higher the share of market inputs into child care, the earlier fertility flattens out. In the next section I conduct a series of robustness checks, including this parameter.

[25]The reason for this timing failure of the model could be that the gender wage gap closes faster for young women, who just enter the labor market, than for older women. But since it is young couples who have children, the benchmark calibration which uses the average gender wage gap might understate the speed of the transition.

7 Robustness Checks

	$\sigma_b = 0.25$	$\sigma_b = 0.3$	$\sigma_b = 0.395$	$\sigma_b = 0.6$
Final Steady State				
TFR	1.80	1.902	2.031	2.227
N_m	0.292	0.290	0.288	0.285
N_f	0.292	0.290	0.288	0.285
H_m	0.229	0.229	0.228	0.228
H_f	0.229	0.229	0.228	0.228

This table shows the final steady states of the different versions of the model, that are calibrated individually. The calibration follows section 3, but uses ad-hoc values for σ_b, rather than targeting a long-run TFR. The benchmark model is the one with $\sigma_b = 0.395$.

Table 8: Sensitivity Analysis: Varying σ_b

First, I perform a series of robustness checks on σ_b, which relates to the elasticity of utility with respect to children. For the benchmark model I chose σ_b to target a long-run total fertility rate of 2. Now I am lifting this restriction, and use various ad-hoc values for σ_b. All other parameters are chosen under the calibration strategy of section 3, using $\gamma = 0.2$ as in the benchmark. Table 8 shows the resulting final steady states. The higher σ_b, the higher is fertility in the final steady state, and the less fertility declines during the transition. To replicate the steep decline in TFR of the 1960s, however, the model needs a value for σ_b that is not too high. A very low value of σ_b, on the other hand, would imply a lower TFR than observed most recently. All values, however, do imply a flattening out of fertility before the gender wage gap is closed.

	$\gamma = 0$	$\gamma = 0.08$	$\gamma = 0.2$
Final Steady State			
TFR	2.027	1.99	2.031
N_m	0.281	0.285	0.288
N_f	0.281	0.285	0.288
H_m	0.205	0.235	0.228
H_f	0.205	0.235	0.228
Relative Changes (%) over 1965–2005			
TFR	−20.9	−23.4	−28.4
N_m	−10.6	−9.2	−10.7
N_f	+56.4	+65.2	+70.3
H_m	+70.8	57.7	+55.7
H_f	−16.8	−18.37	−20.6

This table shows the calibrated models' final steady states and the implied changes over 1965–2005. The models are calibrated individually, using the strategy outlined in section 3. The baseline model has $\gamma = 0.2$.

Table 9: Sensitivity Analysis: Varying γ

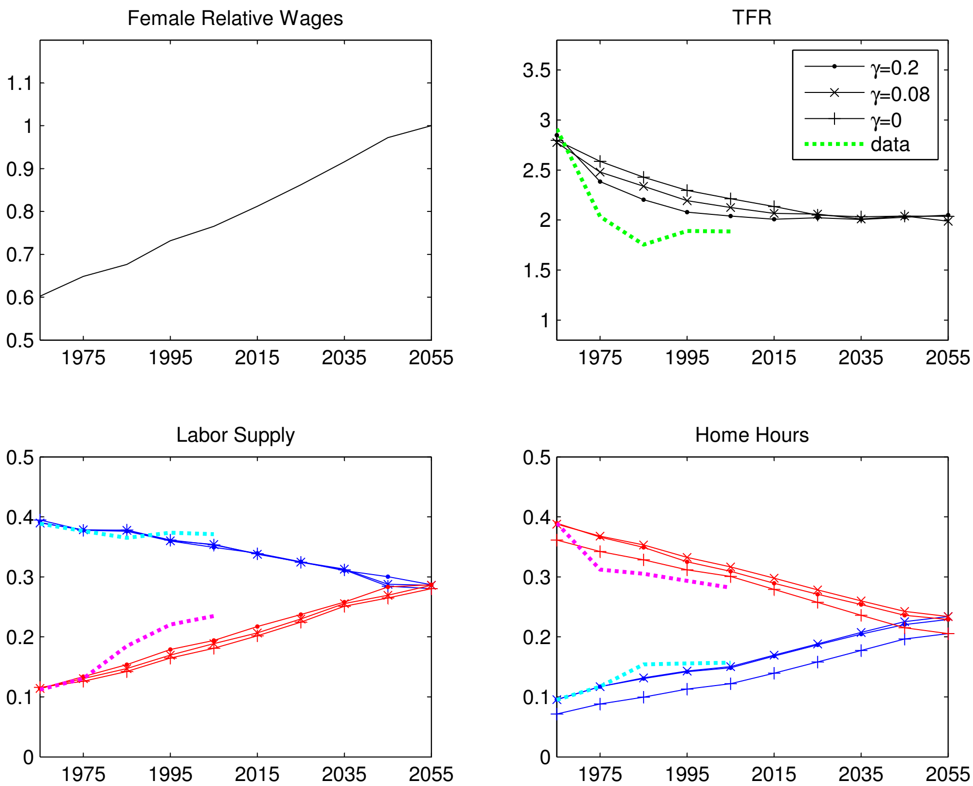


Figure 15: Sensitity Analysis: Varying γ

Next, I conduct a sensitivity analysis for the share of market inputs into home production, γ, since in the literature the range of estimates is wide, and in my model the interpretation of γ should include all market inputs into home production, not only appliances. In the benchmark model I set $\gamma = 0.2$, which is much bigger than the estimate of 0.08 by Benhabib et al. (1991) to allow for a greater marketization of child care, but below the upper-end value of Greenwood et al. (1995), who include housing capital and conclude that market inputs' share into home production does not differ from the capital share in market output ($\gamma = \alpha$). Since in my model home production is *at the margin* varying only with child care, which requires mainly human time, I work with a ($\gamma < \alpha$). In section 4.4, I have already shown the transition of the model with $\gamma = 0$. As a further sensitivity analysis, I also calibrate models based different values for γ, and solve their transition to steady state. Figure 15 and table 9 summarize the findings. The higher γ, the earlier the fertility rate stabilizes, bringing the model closer to the data.

8 Conclusion

In this paper I argue that the common force behind the observed trends in fertility and hours worked is the narrowing of the gender wage gap. I present a general equilibrium model in which having children increases the need for home production, and in which rising female relative wages have not only direct effects on employment, but also reallocate hours worked at home from women to men. Initially, because of the gender wage gap, women shoulder most of home production. When the wage gap shrinks, women's labor supply increases and total home production falls. Men, whose labor supply is much higher than their wives, are because of increasing disutility from working not willing to fully offset the drop in women's time working at home. As a consequence fertility falls. However, the smaller the gender wage gap is, the less of an effect there is on total home production, as the scope for specialization in the household decreases. Because of imperfect substitutability between the disutilities from working at home and in the market, the marginal utility cost of having an additional child can become constant when female relative wages are still improving, despite the change in hours worked, and fertility can remain flat.

Qualitatively the model predictions are consistent with the data: after an initial steep decline, fertility stabilizes before the gender wage gap has fully closed. The model also implies the secular rise of male home production and a fall in female time spent working at home. However, the model generates the flattening out of the total fertility rate later than observed in the data. While qualitatively the rise in male participation in home production can yield a flattening out of the fertility rate, I find that a higher use of parental time-saving inputs into home production helps in matching the timing. However, a marketization of home production alone is not sufficient. Both the rise in male home production and marketization are key in explaining why fertility did not decline to even lower levels.

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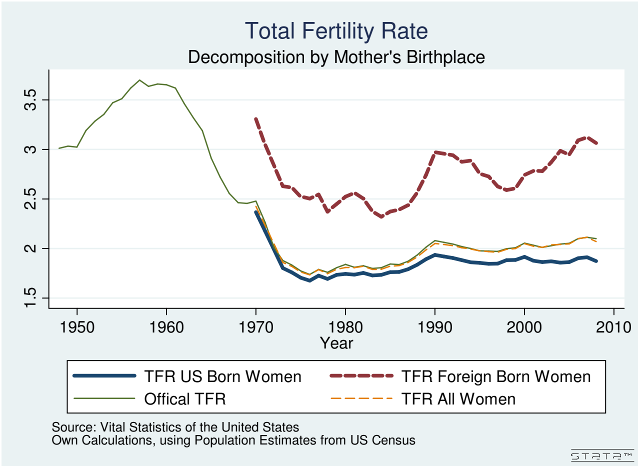

Figure 16: Total Fertility Rates by Mothers' Birthplace

A More on the Data

A.1 Fertility

The aggregate data for the US exhibits a U-shape with an incline in total fertility rate since the late 1970s. But over the last decades there has been a dramatic rise in the fraction of births to immigrant mothers. While in 1970 foreign-born mothers accounted for 7.2% of all births, in 2008 they account for 24.4%, as the Vital Statistics of the United States indicate. Since immigrant women have more children than the native population (in recent years), one might wonder whether the recovery of aggregate US fertility is not purely driven by the effects of immigration - which is outside of my model. Thus, I construct a series of total fertility rate for US-born women only. I take data from the US Vital Statistics, which, since 1970 (but not in 1972) lists live births by the mother's birthplace and five-year age brackets. To obtain age-specific birthrates by immigration status, I then divide the number of live births by the corresponding number of women in the population, for which I use IPUMS data (Census and American Community Survey) with linear interpolation between collection years. Finally I calculate the total fertility rates for the two groups by adding up the age-specific birthrates and multiplying by 5, as the age brackets are of five years width. As a consistency check, I do the same calculations for all women in the population, i.e. independent of their immigration status, and compare the constructed series to the official total fertility data. The two series align almost perfectly. Figure 16 shows the resulting breakdown. While in the aggregate US data total fertility has been rising since the late 1970s, this is mostly accounted for by a rise of births to immigrant mothers. Over that period, fertility of the native population has shown only a very modest incline, and has practically been flat. Fertility trends in most European countries have been very similar to the US. In figure 17 I show the total fertility rate for 20 European countries. These are the official numbers as published by Eurostat; for these countries I cannot construct a measure for fertility of native women only due to a lack of data.

A.2 Time Spent on Home Production

To highlight trends in home production, I use data from Aguiar and Hurst (2007), based on the American Time Use Survey (ATUS). Unfortunately the survey questionnaire in

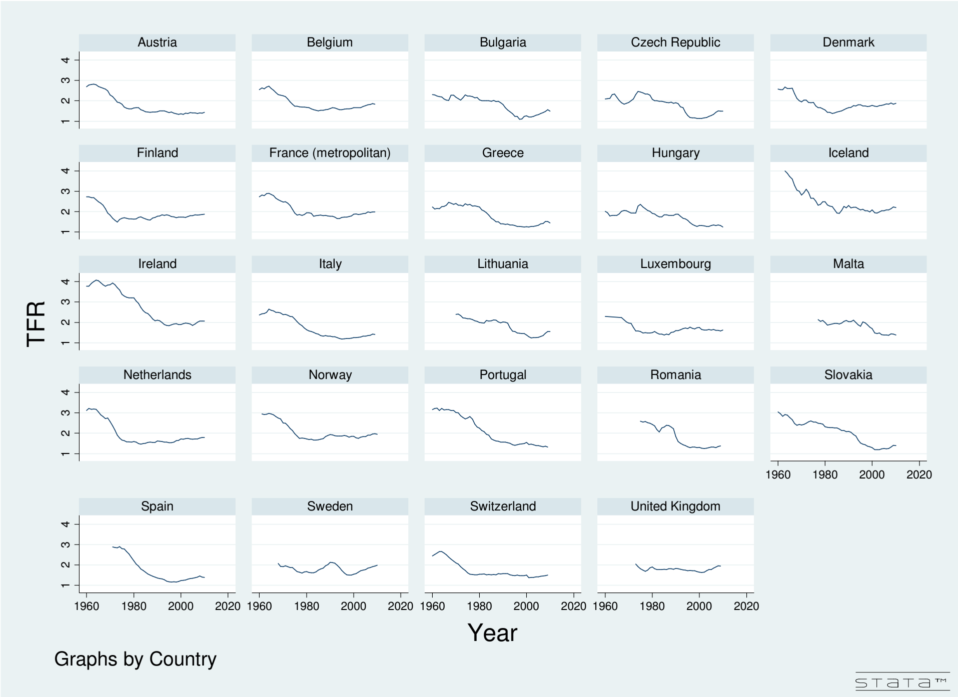

Figure 17: Total Fertility Rates in Europe

1993 did not ask for the family structure of respondents, such as marital status or number of children. Hence I drop 1993 from my analysis. Next, I need to define what activities asked from ATUS to include as home hours.

I start with the definitions of activities Aguiar and Hurst (2007) made:

1. 'Basic Child Care' (what Aguiar and Hurst call child care basic). This excludes time spent on teaching (in a broad sense) and playing with a child.

2. 'Full Child Care' (what Aguiar and Hurst call child care full) includes also teaching and playing with children.

3. 'Home Production', which is sum of time spent on preparing meals, housework, home and car maintenance, gardening and pet care and other domestic duties.

4. 'Non-Market Work' defined as 'Home Production' plus time spent on obtaining goods.

5. My *own and preferred* indicator 'Non-Market Work including Basic Child Care', which I construct as 'Non-Market Work' plus 'Basic Child Care'.

In all statistics and regressions with the dataset I make use of the adjusted weights that Aguiar and Hurst (2007) provide. While the ATUS was designed to be nationally representative when started in 1965, in subsequent years the survey provides weights for respondents. Aguiar and Hurst (2007) adjust these weights for the number of working days within the interview periods, as the survey asks for activities undertaken within a given week.

All five measures of home hours show the same trend as in figure 4 over time: a secular decline for women and a rise for men. This robustness across the different measures is confirmed in OLS regressions for data on married respondents in 1965, 1975, 1985 and

Regressions of Non-Market Hours of Married Males and Females

VARIABLES	(1) Basic Child Care	(2) Full Child Care	(3) Home Production	(4) Non-Market Work	(5) Non-Market +Basic Child Care
Dummy Year 1975	-1.691***	-1.629***	-5.533***	-6.386***	-8.077***
	(0.353)	(0.405)	(0.888)	(0.985)	(1.065)
Dummy Year 1985	-0.252	0.290	-7.293***	-7.215***	-7.467***
	(0.334)	(0.394)	(0.727)	(0.828)	(0.914)
Dummy Year 2003	0.797***	2.302***	-10.68***	-11.40***	-10.60***
	(0.304)	(0.355)	(0.644)	(0.729)	(0.801)
Dummy 1975$\times$ Male	2.887***	2.580***	8.158***	8.700***	11.59***
	(0.429)	(0.492)	(1.062)	(1.227)	(1.324)
Dummy 1985$\times$ Male	1.934***	1.671***	14.06***	14.22***	16.15***
	(0.378)	(0.455)	(0.897)	(1.050)	(1.140)
Dummy 2003$\times$ Male	1.916***	1.456***	16.53***	17.11***	19.02***
	(0.350)	(0.417)	(0.758)	(0.889)	(0.973)
Dummy Male	-5.111***	-5.436***	-25.52***	-28.11***	-33.22***
	(0.296)	(0.348)	(0.658)	(0.782)	(0.857)
Number of Kids in Hh	2.323***	3.111***	2.306***	2.422***	4.745***
	(0.140)	(0.168)	(0.302)	(0.346)	(0.378)
(Number of Kids in Hh)^2	-0.182***	-0.274***	-0.168***	-0.192***	-0.374***
	(0.0319)	(0.0378)	(0.0571)	(0.0649)	(0.0742)
Age	-0.919***	-0.864***	-0.396	-0.463	-1.382***
	(0.134)	(0.157)	(0.341)	(0.383)	(0.417)
Age^2	0.0160***	0.0141***	0.0108	0.0129	0.0289***
	(0.00270)	(0.00317)	(0.00732)	(0.00819)	(0.00885)
Age^3	-8.86e-05***	-7.41e-05***	-6.27e-05	-8.06e-05	-0.000169***
	(1.69e-05)	(2.00e-05)	(4.90e-05)	(5.47e-05)	(5.88e-05)
Constant	19.36***	19.62***	29.32***	37.03***	56.39***
	(2.095)	(2.418)	(4.837)	(5.420)	(5.975)
Observations	17199	17199	17199	17199	17199
R^2	0.198	0.209	0.270	0.259	0.295

Robust standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 10: Different Measures of Home Hours of Married Agents

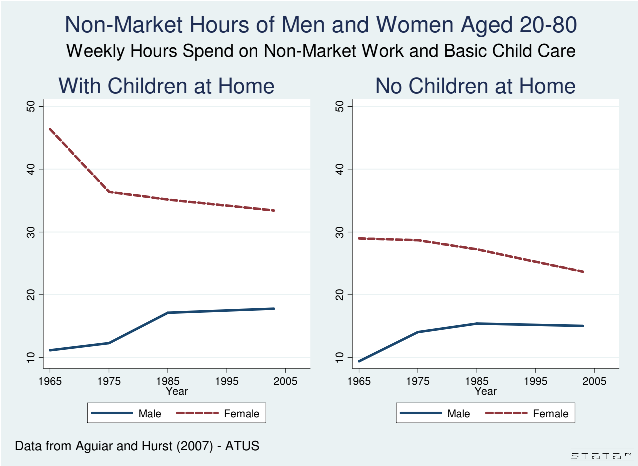

Figure 18: Home Hours for Households With and Without Children

2003. The results are shown in table 10. The coefficients of the year dummies indicate the time-trend for female home hours. The trend in male hours is given by the sum of coefficients of the year dummies and their corresponding interaction with the male dummy. Across the five measures, the only coefficients differing in signs are on the year 1985 and the year 2003 dummy for child care. For all other measures of home hours they are significantly negative, indicating a downward trend in female hours. The coefficient on the dummy for male respondents is significantly negative and substantially big (in absolute values). Moreover, the coefficients on the interaction of year dummies and the dummy for males is significantly positive and exceed the overall year effect. This indicates that in 1965 married men worked fewer hours at home than married women, and that over time male hours have been rising and female hours falling.

My preferred measure is 'Non-Market Work including Basic Child Care'. Although most parents might enjoy child care more than other domestic chores, I do include basic care, as it is a necessary task to be done. The change in home hours over time is similar across households with and without children (living at home), as shown in figure 18. While these two household types have different levels of home hours, both display the decline in women's and the rise in men's hours.

One final comment is in order. Since marital status in the Aguiar and Hurst (2007) data is defined in a legal sense, it is not possible to disentangle cohabiting from other singles. But since it is more likely that men and women who are not married, but have children together, are cohabiting, the current number of children can be employed as a proxy. Since changes in cohabitation affect mainly younger people, I plot in figure 19 non-market hours worked for men and women aged 20-40. Over time, as relative female wages rise, women spend less time working at home, whereas men devote more time to non-market work. These effects are strongest for married men and women, followed by singles with children. This evidence supports that single men with no children, who are more likely to be without a female partner, are not affected by female relative wages. For single women, however, the trends in home hours of those with and without children are very similar, and virtually flat.

Notice that in the dataset time spent on activities is measured in hours per week. In the model, agents have each period a time endowment of 1 that they can split between market work, home work, and leisure time. Assuming that people need 8 hours of rest every day, the principal total of 168 hours a week leaves 112 discretionary hours over

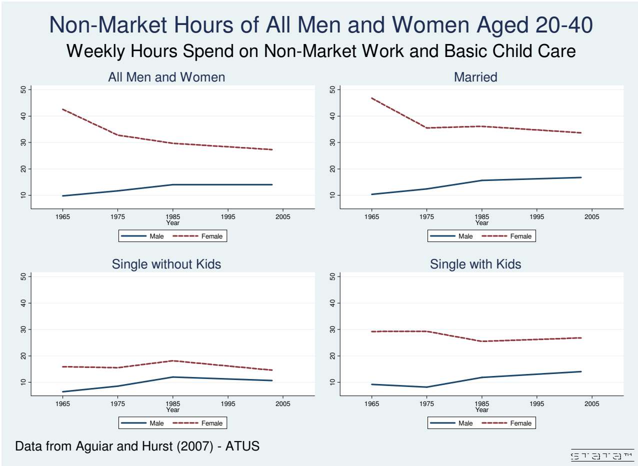

Figure 19: Home Hours for Young Households

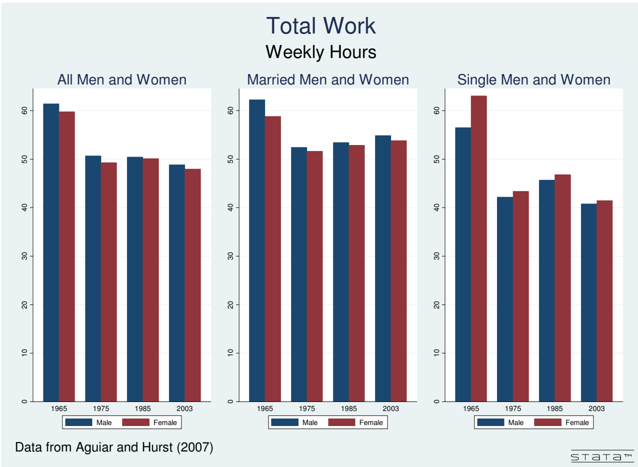

Figure 20: Sum of Home and Market Work

which people can decide. Hence to map data from Aguiar and Hurst (2007) into my model, I divide all hours by 112.

A.3 Market Work in the Time Use Data

I conduct the same analysis for market hours as I did for home hours. For n_m and n_f, I scale Aguiar and Hurst (2007)'s measure 'Work' down by factor 112, the endowment of discretionary hours per week. The measure 'Work' includes besides actual work, necessary travel and other work-related time spent, as well as time spent looking for work. I regress n_m and n_f separately for married males and married females on a polynomial in age, number of children, and year dummies[26]. The results are shown in table 11. Whereas for females the number of children at home does have a significantly and substantial negative effect on the hours they work in the market, there is no significant effect of children in the household on male hours worked.

The sum of weekly hours spent on market and home work is shown in figure 20. As a consistency check of my assumption that 2/3 of the weekly time is discretionary time, I

[26]Restricting the sample to married males and females below the age of 65 does not change the results substantially.

Regressions of Market Hours of Married Males and Females

VARIABLES	(1) Married Males	(2) Married Females
Dummy Year 1975	0.0394***	-0.0396***
	(0.0144)	(0.0109)
Dummy Year 1985	-0.00268	-0.0287***
	(0.0109)	(0.00866)
Number of Kids in Hh	-0.000359	-0.0344***
	(0.0128)	(0.00871)
(Number of Kids in Hh)^2	-0.000469	0.00286
	(0.00306)	(0.00188)
Age	-0.0101	0.00316
	(0.0236)	(0.0129)
Age^2	0.000580	0.000153
	(0.000559)	(0.000318)
Age^3	-7.31e-06*	-3.11e-06
	(4.25e-06)	(2.49e-06)
Constant	0.363	0.0951
	(0.314)	(0.163)
Observations	6211	7136
R^2	0.036	0.027

Robust standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$
Note: Omitted is the 2003 year dummy

Table 11: Regressions of Market Hours of Married Males and Females

compute in the data how many respondents' answers are consistent with $n + h \leq 1$. The assumption holds for 99.09% of the respondents.

A.4 PSID versus CPS Data

The sample size of the PSID is small compared to the Current Population Survey (CPS), which I retrieve from IPUMS, provided by King et al.. However, there are advantages of using the PSID data. Prior to 1975, the CPS did not ask respondents for the exact number of weeks worked last year (but only for a bracketing), and did not ask at all for the usual hours worked per week. Therefore one cannot construct a reliable measure of yearly hours worked before 1975. In all years since its launch in 1962, however, the CPS asked for hours worked in the previous week. I can map this too into my model. In particular, under my assumption that 2/3 of time is disposable, I divide 'hours worked last week' by $(2/3 \times 24 \times 7)$ to obtain a yearly analogue of male and female labor supply out of a time endowment of 1. Then I take averages over non-overlapping windows of 10 years, which is the length of one period in my calibrated model. In figure 21 I compare male and female market labor as indicated by the CPS and the PSID data. The data is very similar. Albeit the CPS suggests a slightly higher level for married men's labor supply, the two surveys show the same trends over time. Also hourly wages, calculated as last year's wage and salary income divided by last year's hours worked, in the CPS are not available before 1975. Therefore I can only obtain the gender wage gap from the regression specified in 27 from 1975 onward. In figure 22 I show the estimated gender wage gap based on PSID and on CPS data. For the available years, they are very similar. Calibrating the model against the smaller PSID sample, seems therefore unproblematic

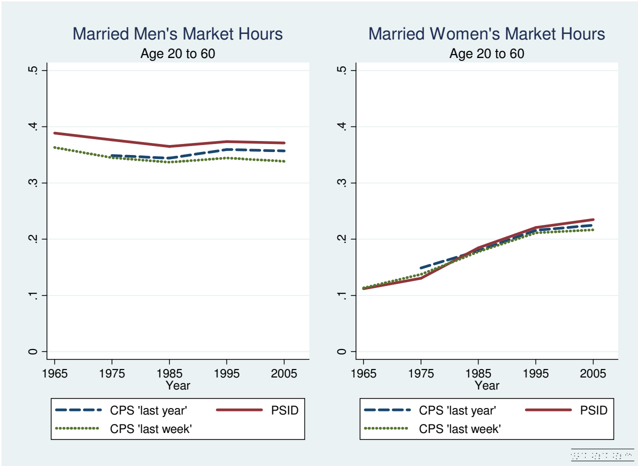

Figure 21: Hours Worked: PSID versus CPS

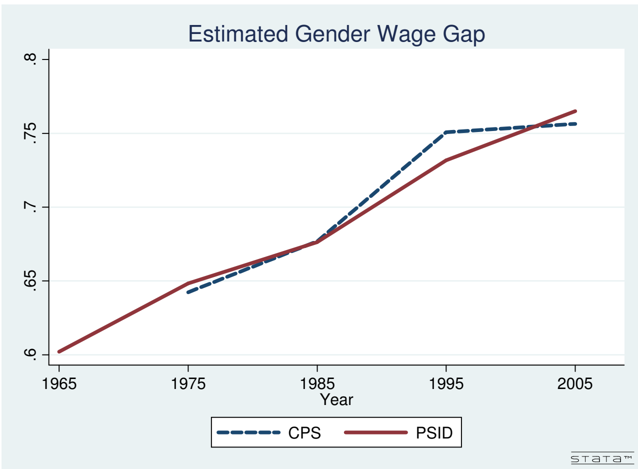

Figure 22: Gender Wage Gap: PSID versus CPS

for this paper.

B Derivations

B.1 Couple's Optimization Problem

To derive the intratemporal optimality conditions for the couple's optimization program, substitute out c_m and e in 8 from the constraints as

$$c_m = \begin{cases} (1+r)a + \tilde{w}_m n_m + \tilde{w}_f n_f - c_f - e - a' & \text{for } \quad j < T_r \\ (1+r)a + \mathcal{T}_{ss} - c_f - e - a' & \text{for } \quad j \geq T_r \end{cases}$$

$$e = \left(\frac{\bar{x}(b_h)}{(z_m h_m + z_f h_f)^{1-\gamma}} \right)^{\frac{1}{\gamma}}$$

Let the multiplier on the male and female time constraints (12) be λ_m and λ_f. To ease notation, let $I_b = b$ for $j = 1$ and $I_b = 0$ otherwise. Then, conditional on fertility choices and aggregate variables, the Karush-Kuhn-Tucker (KKT) conditions are:

$$\begin{aligned}
\frac{\partial V(a;b,j)}{\partial a'} &= \theta \frac{\partial u_m}{\partial c_m} \frac{\partial c_m}{\partial a'} + \beta \frac{\partial V(a', b', j+1)}{\partial a'} = 0 \Rightarrow \theta \frac{\partial u_m}{\partial c_m} = \beta \frac{\partial V(a'; b, j+1)}{\partial a'} \\
\frac{\partial V(a;b,j)}{\partial c_f} &= \theta \frac{\partial u_m}{\partial c_m} \frac{\partial c_m}{\partial c_f} + (1-\theta) \frac{\partial u_f}{\partial c_f} = 0 \Rightarrow \frac{\partial u_m}{\partial c_m} = \frac{1-\theta}{\theta} \frac{\partial u_f}{\partial c_f} \\
\frac{\partial V(a;b,j)}{\partial n_m} &= \theta \frac{\partial u_m}{\partial c_m} \frac{\partial c_m}{\partial n_m} + \theta \frac{\partial u_m}{\partial n_m} - \lambda_m = 0 \Rightarrow -\frac{\partial u_m}{\partial n_m} = \frac{\partial u_m}{\partial c_m} \tilde{w}_m - \frac{\lambda_m}{\theta} \\
\frac{\partial V(a;b,j)}{\partial n_f} &= \theta \frac{\partial u_m}{\partial c_m} \frac{\partial c_m}{\partial n_f} + (1-\theta) \frac{\partial u_f}{\partial n_f} - \lambda_f = 0 \Rightarrow -\frac{\partial u_f}{\partial n_f} = \frac{\theta}{1-\theta} \frac{\partial u_m}{\partial c_m} \tilde{w}_f - \frac{\lambda_f}{1-\theta} \\
\frac{\partial V(a;b,j)}{\partial h_m} &= \theta \frac{\partial u_m}{\partial c_m} \frac{\partial c_m}{\partial e} \frac{\partial e}{\partial h_m} + \theta \frac{\partial u_m}{\partial h_m} - \lambda_m = 0 \Rightarrow -\frac{\partial u_m}{\partial h_m} = -\frac{\partial u_m}{\partial c_m} \frac{\partial e}{\partial h_m} - \frac{\lambda_m}{\theta} \\
&\Rightarrow -\frac{\partial u_m}{\partial h_m} = \frac{\partial u_m}{\partial c_m} \frac{1-\gamma}{\gamma} \left(\frac{\bar{x}(b_h)}{z_m h_m + z_f h_f} \right)^{\frac{1}{\gamma}} z_m - \frac{\lambda_m}{\theta} \\
\frac{\partial V(a;b,j)}{\partial h_f} &= \theta \frac{\partial u_m}{\partial c_m} \frac{\partial c_m}{\partial e} \frac{\partial e}{\partial h_f} + (1-\theta) \frac{\partial u_f}{\partial h_f} - \lambda_f = 0 \Rightarrow -\frac{\partial u_f}{\partial h_f} = -\frac{\theta}{1-\theta} \frac{\partial u_m}{\partial c_m} \frac{\partial e}{\partial h_f} - \frac{\lambda_f}{1-\theta} \\
&\Rightarrow -\frac{\partial u_f}{\partial h_f} = \frac{\theta}{1-\theta} \frac{\partial u_m}{\partial c_m} \frac{1-\gamma}{\gamma} \left(\frac{\bar{x}(b_h)}{z_m h_m + z_f h_f} \right)^{\frac{1}{\gamma}} z_f - \frac{\lambda_f}{1-\theta} \\
&\lambda_m(n_m + h_m - 1) = 0 \text{ and } \lambda_f(n_f + h_f + \tau_b I_b - 1) = 0
\end{aligned} \tag{34}$$

The Envelope Condition is $\frac{\partial V(a;b,j)}{\partial a} = \theta \frac{\partial u_m}{\partial c_m}(1+r)$, implying $\frac{\partial V(a';b,j+1)}{\partial a'} = \theta \frac{\partial u_m}{\partial c'_m}(1+r')$, such that the usual Euler equation $\frac{\partial u_m}{\partial c_m} = \beta(1+r') \frac{\partial u_m}{\partial c'_m}$ follows.

With the assumed preferences (6), (34) implies for the allocation of consumption between the spouses

$$c_f = \left(\frac{1-\theta}{\theta} \right)^{1/\sigma_c} c_m \tag{35}$$

and the remaining intratemporal first-order conditions become

$$\left(\phi_n\left(\frac{n_m^{1+\eta}}{1+\eta}\right)^{\frac{s-1}{s}}+\phi_h\left(\frac{h_m^{1+\varepsilon}}{1+\varepsilon}\right)^{\frac{s-1}{s}}\right)^{\frac{1}{s-1}}\tilde{\phi}_n n_m^{\frac{(s-1)\eta-1}{s}}=\frac{\tilde{w}_m}{c_m^\sigma}-\frac{\lambda_m}{\theta} \tag{36}$$

$$\left(\phi_n\left(\frac{n_f^{1+\eta}}{1+\eta}\right)^{\frac{s-1}{s}}+\phi_h\left(\frac{h_f^{1+\varepsilon}}{1+\varepsilon}\right)^{\frac{s-1}{s}}\right)^{\frac{1}{s-1}}\tilde{\phi}_n n_f^{\frac{(s-1)\eta-1}{s}}=\frac{\theta}{1-\theta}\frac{\tilde{w}_f}{c_m^\sigma}-\frac{\lambda_f}{1-\theta}$$

$$\left(\phi_n\left(\frac{n_m^{1+\eta}}{1+\eta}\right)^{\frac{s-1}{s}}+\phi_h\left(\frac{h_m^{1+\varepsilon}}{1+\varepsilon}\right)^{\frac{s-1}{s}}\right)^{\frac{1}{s-1}}\tilde{\phi}_h h_m^{\frac{(s-1)\varepsilon-1}{s}}=\frac{1}{c_m^\sigma}\frac{1-\gamma}{\gamma}\left(\frac{\bar{x}(b_h)}{H}\right)^{\frac{1}{\gamma}}z_m-\frac{\lambda_m}{\theta}$$

$$\left(\phi_n\left(\frac{n_f^{1+\eta}}{1+\eta}\right)^{\frac{s-1}{s}}+\phi_h\left(\frac{h_f^{1+\varepsilon}}{1+\varepsilon}\right)^{\frac{s-1}{s}}\right)^{\frac{1}{s-1}}\tilde{\phi}_h h_f^{\frac{(s-1)\varepsilon-1}{s}}=\frac{\theta}{1-\theta}\frac{1}{c_m^\sigma}\frac{1-\gamma}{\gamma}\left(\frac{\bar{x}(b_h)}{H}\right)^{\frac{1}{\gamma}}z_f-\frac{\lambda_f}{1-\theta}$$

$$\lambda_m(n_m+h_m-1)=0 \text{ and } \lambda_f(n_f+h_f+\tau_b I_b-1)=0$$

$$\text{where } \tilde{\phi}_n=\phi_n(1+\eta)^{1/s} \text{ and } \tilde{\phi}_h=\phi_h(1+\varepsilon)^{1/s}$$

$$\text{and } H=z_m h_m+z_f h_f$$

Off-Corners: When the time-constraints are not binding, i.e. with $\lambda_m=\lambda_f=0$, and the elasticity of substitution of disutilities to work goes to infinity, the optimality conditions for home production imply

$$\frac{h_m}{h_f}=\left(\frac{1-\theta}{\theta}\frac{z_m}{z_f}\right)^{1/\varepsilon} \quad \text{as } s\to\infty$$

which is equation (33) in the main text.

For general s or for corner solutions, either with $n_m+h_m=1$ and $\lambda_m>0$, or with $n_f+h_f+\tau_b I_b=1$ and $\lambda_f>0$, or both, there is no closed-form solution for the set of intratemporal first-order conditions. Hence I solve the set of non-linear KKT equations (36) numerically, conditional on the individual state variables (assets and number of children), and the aggregate state variables (interest rate, male and female wages).

For retired households (of age $j\geq T_r$) off corners, one can characterize the optimal choices as a function of consumption further. Since $\tilde{w}_m(j)=\tilde{w}_f(j)=0$ and thus $n_m(j)=n_f(j)=0$, the optimality conditions (36) imply

$$\frac{h_m(j)}{h_f(j)}=\left(\frac{1-\theta}{\theta}\frac{z_m}{z_f}\right)^{1/\varepsilon} \quad \text{for } j\geq T_r$$

C More on the Calibration

C.1 Gender Wage Gap as Ratio of Residual Wages

I use data from the Panel Study of Income Dynamics from 1968 to 2007. First I estimate for men and women between of age 20 to 59 equation (27) by OLS. The obtained estimates are shown in table 12.

Since $E[\log w_{i,t}|Dfemale_{i,t}=1]-E[\log w_{i,t}|Dfemale_{i,t}=0]=\beta_{1,t}$, the gender wage gap for year t is given by $e^{\beta_{1,t}}$, which I plot in figure 3 of the main text. To feed χ_t

VARIABLES	$\log w_{i,t}$	continued		continued		continued	
Dummy 1968	0.805***	Dummy 1987	0.773***	Dummy Fem.× 1972	-0.453***	Dummy Fem.× 1991	-0.331***
	(0.0266)		(0.0255)		(0.0184)		(0.0126)
Dummy 1969	0.848***	Dummy 1988	0.761***	Dummy Fem.× 1973	-0.440***	Dummy Fem.× 1992	-0.312***
	(0.0265)		(0.0256)		(0.0178)		(0.0124)
Dummy 1970	0.849***	Dummy 1989	0.754***	Dummy Fem.× 1974	-0.435***	Dummy Fem.× 1994	-0.273***
	(0.0263)		(0.0256)		(0.0170)		(0.0138)
Dummy 1971	0.878***	Dummy 1990	0.718***	Dummy Fem.× 1975	-0.427***	Dummy Fem.× 1995	-0.342***
	(0.0261)		(0.0251)		(0.0163)		(0.0139)
Dummy 1972	0.908***	Dummy 1991	0.713***	Dummy Fem.× 1976	-0.403***	Dummy Fem.× 1996	-0.294***
	(0.0258)		(0.0251)		(0.0161)		(0.0139)
Dummy 1973	0.914***	Dummy 1992	0.695***	Dummy Fem.× 1977	-0.405***	Dummy Fem.× 1997	-0.298***
	(0.0256)		(0.0250)		(0.0159)		(0.0153)
Dummy 1974	0.881***	Dummy 1994	0.760***	Dummy Fem.× 1978	-0.427***	Dummy Fem.× 1999	-0.315***
	(0.0254)		(0.0257)		(0.0156)		(0.0150)
Dummy 1975	0.893***	Dummy 1995	0.765***	Dummy Fem.× 1979	-0.441***	Dummy Fem.× 2001	-0.307***
	(0.0252)		(0.0258)		(0.0151)		(0.0143)
Dummy 1976	0.883***	Dummy 1996	0.738***	Dummy Fem.× 1980	-0.416***	Dummy Fem.× 2003	-0.245***
	(0.0253)		(0.0258)		(0.0148)		(0.0137)
Dummy 1977	0.891***	Dummy 1997	0.738***	Dummy Fem.× 1981	-0.420***	Dummy Fem.× 2005	-0.267***
	(0.0252)		(0.0260)		(0.0148)		(0.0136)
Dummy 1978	0.895***	Dummy 1999	0.800***	Dummy Fem.× 1982	-0.414***	Dummy Fem.× 2007	-0.253***
	(0.0252)		(0.0259)		(0.0147)		(0.0134)
Dummy 1979	0.866***	Dummy 2001	0.828***	Dummy Fem.× 1983	-0.402***	Dummy Black	-0.157***
	(0.0252)		(0.0258)		(0.0146)		(0.00290)
Dummy 1980	0.825***	Dummy 2003	0.781***	Dummy Fem.× 1984	-0.371***	Dummy Other Race	-0.0727***
	(0.0252)		(0.0256)		(0.0145)		(0.00680)
Dummy 1981	0.801***	Dummy 2005	0.772***	Dummy Fem.× 1985	-0.447***	Years of Educ.	0.0150***
	(0.0253)		(0.0255)		(0.0144)		(0.00240)
Dummy 1982	0.798***	Dummy 2007	0.780***	Dummy Fem.× 1986	-0.394***	(Years of Educ.)^2	0.00313***
	(0.0253)		(0.0254)		(0.0145)		(9.98e-05)
Dummy 1983	0.791***	Dummy Fem.× 1968	-0.499***	Dummy Fem.× 1987	-0.369***	Age	0.0631***
	(0.0253)		(0.0213)		(0.0145)		(0.000972)
Dummy 1984	0.779***	Dummy Fem.× 1969	-0.516***	Dummy Fem.× 1988	-0.345***	(Age)^2	-0.000653***
	(0.0254)		(0.0206)		(0.0144)		(1.25e-05)
Dummy 1985	0.797***	Dummy Fem.× 1970	-0.455***	Dummy Fem.× 1989	-0.340***		
	(0.0254)		(0.0195)		(0.0143)		
Dummy 1986	0.797***	Dummy Fem.× 1971	-0.450***	Dummy Fem.× 1990	-0.335***	Observations	235629
	(0.0255)		(0.0191)		(0.0128)	R^2	0.949
ctd. in next column		ctd. in next column		ctd. in next column			

Standard errors in parentheses
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 12: Regression of Log Wages

into the model, where a period is 10 years, I take the averages over the appropriate (non-overlapping) windows.

C.2 Required Amount of Home Production

I aim at finding the parameters of $\bar{x}(b_h) = \kappa_0 + \kappa_1 b_h^{\kappa_2}$ by exploiting the observed cross-sectional variation in a base year of male and female hours against the number of children in the household. Off-corners the intratemporal first-order conditions (36) for n_m and h_m imply

$$\bar{x}(b_h) = \left(\frac{\phi_h}{\phi_n} \left(\frac{1+\varepsilon}{1+\eta} \right)^{1/s} \frac{h_m^{\frac{(s-1)\varepsilon-1}{s}}}{n_m^{\frac{(s-1)\eta-1}{s}}} \frac{\tilde{w}_m}{z_m} \frac{\gamma}{1-\gamma} (z_m h_m + z_f h_f) \right)^{\gamma} \tag{37}$$

In the model, hours worked at home and in the market[27] depend on the amount of home goods needed. The dataset provided by Aguiar and Hurst (2007) includes respondents' wages and number of children in the household for some years. Thus, equation (29) can be used to back out the parameters of $\bar{x}(b_h)$, *conditional* on all other parameters. I map Aguiar and Hurst's data for 1985 into my model, by scaling hours worked such that the total time endowment is one, as explained above. Then I take averages by the number of children in the household. Finally I scale male wages from the collapsed data such that their mean equals the model's (cohort-size weighted mean) equilibrium wage. Since $\bar{x}(b_h) = \kappa_0 + \kappa_1 b_h^{\kappa_2}$, it follows

$$\kappa_0 + \kappa_1 b_h^{\kappa_2} = \left(\frac{\phi_h}{\phi_n} \left(\frac{1+\varepsilon}{1+\eta} \right)^{1/s} \frac{(h_m(b_h))^{\frac{(s-1)\varepsilon-1}{s}}}{(n_m(b_h))^{\frac{(s-1)\eta-1}{s}}} \frac{\tilde{w}_m}{z_m} \frac{\gamma}{1-\gamma} (z_m h_m(b_h) + z_f h_f(b_h)) \right)^{\gamma}$$

I solve this set of equations for $b_h = 0, 1, 2$ in the three unknowns $\kappa_0, \kappa_1, \kappa_2$, conditional on all other parameters.

C.3 Remaining Parameters

Where parameters could not be backed out from model's equilibrium conditions in combination with the data and could not be taken from the literature, I choose them to match features of the 1965 data. I take the demographic structure of 1965 as a given, and compute the cohort densities $\{\mu(j)\}_{j=1}^{T_l}$ from the United Nations World Population Prospects: The 2008 Revision.

Conditional on a guess for σ_b, I choose the remaining parameters to match the moments shown in table 2, under the fiction that agents assumed prices to remain constant. $\{\phi_n, \phi_h, \varepsilon, s\}$ are set to match N_m, H_m, N_f, H_f, while ϕ_b is set to match the total fertility rate in 1965. Next, I solve for the final steady state of the model under these parameters. If the final TFR is close to 2, I keep the values as calibrated parameters. If not I guess a new σ_b and return to choosing $\{\phi_n, \phi_h, \varepsilon, s\}$. To note is that changing one of the parameters in $\{\phi_n, \phi_h, \varepsilon, s\}$ triggers changes in $\kappa_0, \kappa_1, \kappa_2$ (see the previous section).

[27] The use of home appliances changes with the required amount, and this has –through the budget constraint– an effect on consumption, which affects labor supply, by (36).

D More Results

Figure 8 of the main text shows the model-implied behavior of aggregate variables, averaging over all households alive. Figure 23 also shows the disaggregated transition paths for the different age groups in the benchmark model ($\theta = 0.5; \gamma = 0.2$).

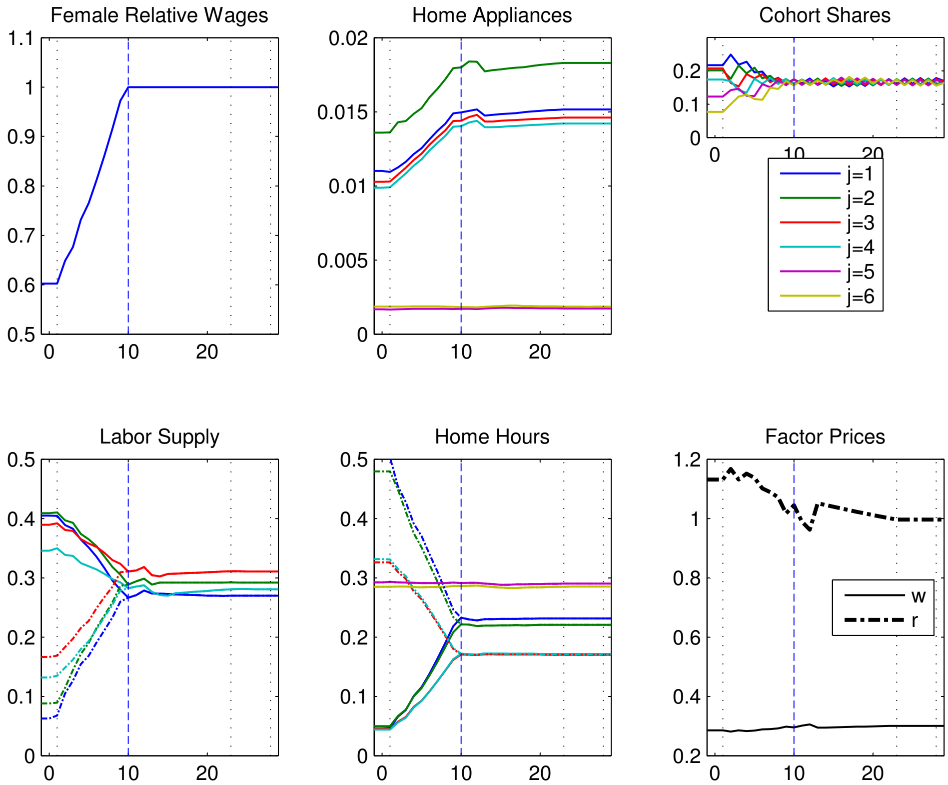

Figure 23: Transition of the Benchmark Model – Disaggregation by Age

E Alternative Model: Time and Age-Specific Gender Wage Gap

In an alternative model specification, I allow the gender wage gap to depend on time and age. For this model variant, I impose for female labor productivities

$$p_{f,t}(j) = \chi_t(j)p_m(j)$$

The transition of the unitary model, feeding in time- and age specific relative wages, under calibrated parameters, with $\gamma = 0.08$, is shown in figure 24. The results are similar to the benchmark calibration.

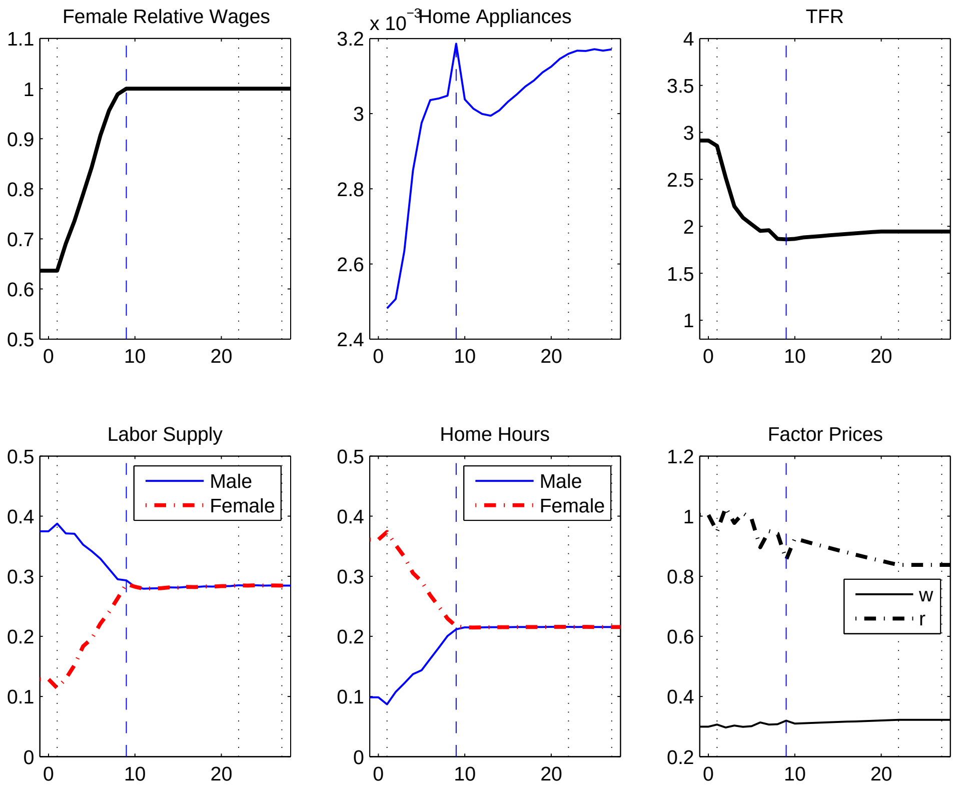

Figure 24: Transition Path of the Alternative Model

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