



Why did rich families increase their fertility? Inequality and marketization of child care

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Abstract

A negative relationship between income and fertility has persisted for so long that its existence is often taken for granted. One economic theory builds on this relationship and argues that rising inequality leads to greater differential fertility between rich and poor. We show that the relationship between income and fertility has flattened between 1980 and 2010 in the US, a time of increasing inequality, as high income families increased their fertility. These facts challenge the standard theory. We propose that marketization of parental time costs can explain the changing relationship between income and fertility. We show this result both theoretically and quantitatively, after disciplining the model on US data. We explore implications of changing differential fertility for aggregate human capital. Additionally, policies, such as the minimum wage, that affect the cost of marketization, have a negative effect on the fertility and labor supply of *high* income women. We end by discussing the insights of this theory to the economics of marital sorting.

Keywords Income inequality · Marketization · Differential fertility · Human capital · Minimum wage

JEL Classification E24 · J13 · J24 · J31 · J38

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1 Introduction

A negative relationship between income and fertility has persisted for so long that its existence is often taken for granted in the literature (Jones and Tertilt 2008). This relationship has been typically explained by either the tradeoff between the quantity and quality of children, the opportunity cost of parental time, or both. Some of the many examples include Becker and Lewis (1973), Galor and Weil (1996), Galor and Weil (2000), and Doepke (2004). These mechanisms have led researchers to conclude that rising inequality would lead to a larger differential fertility between poor and rich households (de la Croix and Doepke 2003; Moav 2005).¹

However, despite the dramatic rise in income inequality seen in recent decades, the relationship between income and fertility has flattened as high income families increased their fertility, thereby challenging the conventional wisdom.² We argue that the ability to reduce the parental time burden by purchasing babysitters, housekeepers, and prepared food, lessens children's opportunity cost. As inequality grows, the cost of marketization (i.e. outsourcing) of the time cost of children for the rich shrinks relative to their income, allowing them to have more kids without sacrificing time and careers.

In this paper, we show that changes in inequality, and the associated decline in the price of market substitutes for parents' time with children, can quantitatively account for much of the changing relationship between income and fertility over time. We explore quantitatively and empirically the implications of our findings for aggregate human capital accumulation and policy (minimum wage).

Our point of departure is the standard model of fertility and educational investment in children, as in Galor and Weil (2000), applied to the case of inequality as in de la Croix and Doepke (2003) and Moav (2005). This model features both a quantity–quality tradeoff with respect to children as well as an opportunity cost of parental time in childcare. We analyze this model under the assumption that the cost of children can be marketized. We show that this one assumption is crucial for understanding the effects of inequality on differential fertility.

Turning towards our quantitative analysis, we calibrate the model to the US in 1980, when fertility and income had a negative relationship. We discipline the model by matching the salient features of cross-sectional US data. Namely, we match the income profiles of fertility rates, mother's labor supply, marketization expenditures, and college attainment rates.³ The model successfully fits the empirical targets with 8 parameters chosen to match 40 moments.

We then feed into the calibrated model the observed cross-sectional wages for 2010 and a price decline of home production substitutes. The model predicts the 2010 relationships between income and fertility and between income and mother's time at home. In the model (data), the fertility of couples with income in the top two deciles increases by 43.5% (39.9%) between 1980 and 2010. Our measure of differential fertility, which compares the average fertility of the top two deciles to that of the second decile, increases by 41.2% (38.5%). An alternative measure of differential fertility, comparing the fertility of the top half and bottom half of the income distribution, increases by 24.4% (18.6%). All of these results are untargeted.

¹ Galor and Moav (2002) argue that the opposite is true before the demographic transition. Relatedly, Vogl (2016) indeed finds that the income-fertility gradient was positive in less developed countries before they experienced the demographic transition.

² See Autor et al. (2008) and Heathcote et al. (2010) regarding rising inequality and Hazan and Zoabi (2015) regarding changing fertility patterns.

³ We measure marketization expenditures as the relative expenditures on childcare, as calculated from the Survey of Income and Program Participation (SIPP). See "Appendix A" for details.

Decomposing the mechanisms at work, we find that it is the change in the price of market substitutes relative to parental income, rather than the general income effect, that is the main driver behind our findings. Furthermore, this result depends critically on increasing inequality in parental wages. Our results imply that a naïve modeler, working in 1980 under the view of the standard literature, which ignores marketization, would have predicted a significant decline in fertility among high income households over time if she had been given perfect foresight over the evolution of income distributions.

One implication of our theory is that rising inequality increases aggregate human capital, and thus growth. This is due to the fact that the rich tend to provide more human capital to their children, as represented by college graduation rates. Thus, as inequality increases, the average human capital of the next generation grows as *relatively* more kids are born to richer families.

Turning towards policy implications, according to our theory, anything affecting the price of marketization should have an indirect effect on the labor supply and fertility, especially of high income women. One prevalent policy that may affect the price of marketization is the minimum wage. We show empirically that the minimum wage level indeed has a large pass-through effect on wages in the home production substitute (HPS) sector.⁴ Evaluating this effect in the context of the calibrated model allows us to quantify the impact of minimum wage laws on fertility and labor supply of high income women. This analysis is presented in Sect. 5.

Accordingly, we show that a disproportionately large number of workers in the HPS sector receive the minimum wage. Using cross-state time series variation in the minimum wage from 1980 to 2010, we show that the minimum wage has a statistically significant and economically meaningful effect of about 58 cents increase in HPS sector wages for every dollar increase of the state minimum wage. We take an instrumental variables approach, as in Baskaya and Rubinstein (2012), as OLS may be biased as states tend to raise the minimum wage during good economic times.

We employ this estimated effect to perform a policy experiment, using the model to measure the effects of raising the minimum wage to \$15/h, as per Bernie Sanders, on the labor supply and fertility of high income women.⁵ These women reduce their labor supply and fertility as marketizing becomes more expensive.⁶ We confirm the model prediction with respect to labor supply by estimating the empirical elasticity of the labor supply of high income women with respect to the minimum wage. We do so using cross-state time series variation in the minimum wage from 1980 to 2010 and the instrumental variable approach discussed above. The empirical elasticity is also negative, but quantitatively larger in absolute value than that of the model.

We conclude by discussing that explicit modeling of outsourcing of home production can also help us understand additional aspects of marital sorting (Greenwood et al. 2017).

Hazan and Zoabi (2015) was the first paper to document the flattening of the fertility profile by mother's education, due to rising fertility rates among highly educated women. They qualitatively study a similar model to the one presented here to show theoretically the role of marketization. Furthermore, they exploit cross-state variation in wages and find that the wages of childcare workers, relative to mothers' wages, are negatively correlated with

⁴ We define these sectors as in Mazzolari and Ragusa (2013).

⁵ See <http://berniesanders.com/issues/a-living-wage>.

⁶ Doepke and Kindermann (2016) argue that policies that lower the childcare burden on mothers are significantly more effective at increasing fertility as compared to general child subsidies. We argue that the minimum wage is a policy that *increases* the childcare burden on mothers, and hence decreases fertility.

the propensity to have an extra child. This reduced-form evidence supports the quantitative analysis done in this paper. However, we differ in several critical ways. First, we document the flattening of the fertility-*income* profile. Second, we quantitatively evaluate the role of rising wage inequality and decreasing prices of home production substitutes, through the mechanism of marketization, in explaining this pattern. Finally, we examine theoretically and quantitatively the implications of inequality and marketization for human capital accumulation and minimum wage policy.

This paper is related to a large literature on motherhood and labor supply. Attanasio et al. (2008) builds a life cycle model of fertility and labor force participation. They argue that reductions in child care costs can quantitatively account for the increase in labor supply of young mothers. Furtado (2016) finds that an increase in unskilled migration lowers wages in the child care services sector, and increases both fertility and labor supply.⁷ Interestingly, she finds that native women with a graduate degree increase their labor supply and fertility much more than native women with just a college degree. Similarly, Cortés and Tessada (2011) exploit cross-city variation in immigration concentration, and show that an increase in low-skilled immigration increases labor supply, of women in the top quartile of the wage distribution.⁸ These women reduce time spent on housework and purchase more services as substitutes. Interestingly, Cortés and Pan (Forthcoming) show that increased marketization of household work allows women both to enter occupations that demand high levels of effort, and lowers the earnings gap in those occupations. While the importance of marketization of home production has been widely recognized (e.g. Greenwood et al. 2005a, b), the consequences of rising inequality on differential fertility in the presence of the possibility to outsource home production have not been widely studied.⁹

We continue as follows. Section 2 presents our motivating evidence. Section 3 describes the theoretical framework of our analysis. Section 4 provides details on the parameterization of the model, along with quantitative results. Section 5 analyzes the effects of the minimum

⁷ Notice that this tackles inequality from another direction. Rather than focus on a rise in inequality due to rising wages among high income households, she is studying an increase in the supply of low wage workers. Our mechanism is agnostic as to the source of rising inequality.

⁸ Using data from Hong Kong, Cortés and Pan (2013) show that the ability to hire foreign workers as live-in help increases labor force participation of mothers. They argue that child care cost reduction through immigration is a market alternative to child care subsidies.

⁹ The literature on women's labor force participation is too vast to summarize here. However, a few papers showing how women's labor supply is related to structural transformation and taxes are worth noting, as they illuminate further potential effects of marketization on the economy. Akbulut (2011) argues that work at home, in which women have a comparative advantage, and work in services are quite similar. Thus, when demand for services rises, women's labor force participation rises as well. Buera et al. (2013) develop this argument further: they use a quantitative model of sectoral reallocation and specialization between men and women to evaluate various causes of structural transformation. Cerina et al. (2018) argue that the rise of high skill women entering the labor force, due to the increased skill premium, contributed to job polarization. When these women enter the labor force the high skill employment shares increase. As a side effect of their employment, these women also must now marketize their home production, leading to an increase in low skill employment in the HPS sector. Rendall (2018) argues that women's labor force participation and the service sector are strongly affected by taxes. Kaygusuz (2010) and Bar and Leukhina (2009) study the effects of changes in married couples' taxation on the rise of married female labor force participation in the US, while Guner et al. (2012) argue that participation would be even higher if the U.S. were to adopt a system of individual based taxation of married households. Duernecker and Herrendorf (2018) argue that labor productivity in home production in the US has stagnated in recent decades, while it has risen in other places such as Germany. Their result is based on the fact that wages of household workers, what we call HPS workers, have stagnated in the US but risen in Germany. They explain the US stagnation with the prevalence of cheap immigrant labor, which has become more widely used by richer Americans in home production.

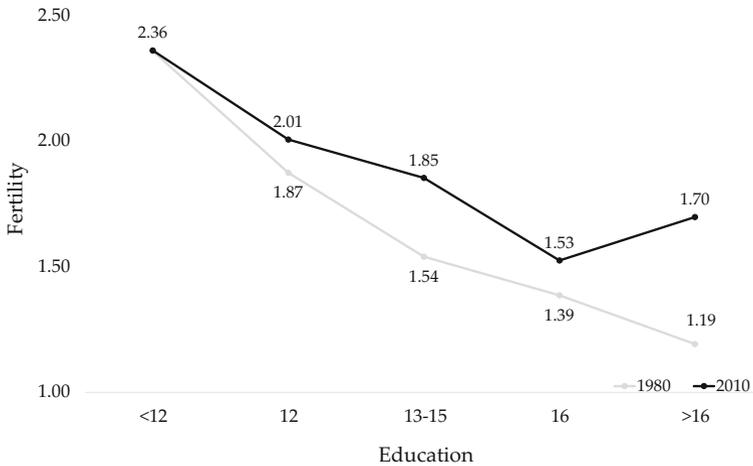


Fig. 1 Fertility by Women's Education 1980 and 2010. *Notes:* authors calculations using Census and American Community Survey Data, using all native-born American women. Fertility rates are hybrid fertility rates. “< 12” refers to women with less than a high school degree. “12” refers to women who graduated high school. “13–15” refers to women with some college. “16” refers to college graduates. “> 16” refers to women with advanced degrees

wage on labor supply and fertility through the lens of the calibrated model. Section 6 discusses implications of marketization on the literatures on marital sorting. We conclude in Sect. 7.

2 Motivating evidence

In this section, we describe our motivating evidence. We first show data on cross-sectional fertility changes and inequality. We then use cross-state variation in the relative wage of high income women to HPS sector workers, and show that states that had a larger increase in this ratio saw a larger increase in high income fertility.

Figure 1 shows fertility rates in the US in 1980 and 2010 for all native-born women, separated into five education groups: less than a high school degree (< 12 years), a high school degree (12 years), some college (13–15 years), a college degree (16 years), and an advanced degree (> 16 years).¹⁰ We measure fertility of a given education group using “hybrid fertility rates” (HFR) (Shang and Weinberg 2013), which augments the total fertility rate (TFR) for women over the age of 25 with children ever born (CEB) at age 24.¹¹ Fertility rates in 1980 are strongly negatively correlated with education, as has often been noted by the literature. However, in 2010, fertility rates are much flatter, and even rising between the “college degree” and “advanced degree” groups.

In this paper, we are concerned with the impact of inequality and marketization on the relationship between *income* and fertility. As such, we measure inequality by 10 income deciles, rather than 5 education groups. Furthermore, we restrict attention to white, non-Hispanic Americans in order to abstract from changes in demographics over time. Additionally, we

¹⁰ Hazan and Zoabi (2015) show a very similar pattern when restricting the data to white non-Hispanic women.

¹¹ Formally, $HFR_t = n_{24,t} + \sum_{a=25}^{55} AFR_{at}$, where $n_{24,t}$ is the average number of children ever born at age 24 in year t and AFR_{at} is the age-specific fertility rate for women of age a in year t . We estimate HFR separately for each education group.

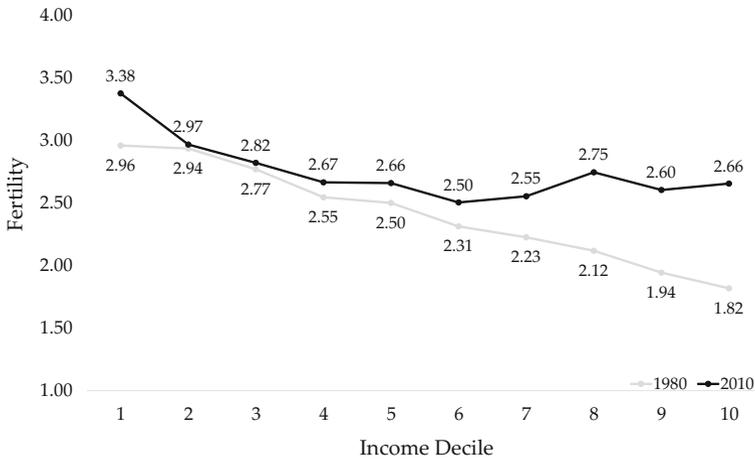


Fig. 2 Fertility by Income Decile 1980 and 2010. *Notes:* authors calculations using Census and American Community Survey Data. The sample is restricted to white, non-Hispanic married women. Fertility rates are hybrid fertility rates, constructed by age-specific deciles. Deciles are constructed using total household income

focus on married couples for two reasons. First, this allows us to abstract from differences between the fertility considerations of different types of households, and second it allows us to more easily calculate income deciles, without having to compare between single households and (potentially) dual income households. Couples are allocated into income deciles according to their income rank among couples of the same female-age. We measure decile-specific moments (e.g. male wages by decile) by deriving the age-specific averages for the given decile, and then averaging across ages. These moments capture the experience of a hypothetical couple that goes through life maintaining its decile ranking among other couples of their cohort. Figure 2 reports fertility rates by income decile for our sample of white non-Hispanic married couples. In 1980, there was a clear negative relationship between income and fertility. Fertility rates in 2010 were little changed for the bottom half of the income distribution. However, fertility patterns have changed starting at the 5th decile, representing a flat, or even a somewhat U-shaped relationship between income and fertility. The difference between 1980 and 2010 is most pronounced for the top deciles. The increase in fertility among the most educated women (Fig. 1) closely corresponds to the increase in fertility among couples from the higher deciles (Fig. 2). In particular, 9th (10th) decile women saw an increase in fertility of 0.64 (0.83) children, while the highest education group saw an increase of 0.51 children.

This change in fertility occurred at a time of rising inequality. This is seen in Figs. 3 and 4, which show wages for wives and husbands, respectively, for each decile in each year in real 2010 dollars.

The theory proposed in this paper suggests that women should increase their fertility when their wages relative to the price of home production substitutes increase. Empirically, this pattern can be seen in the US cross-state time series. Figure 5 shows that states that have seen a greater percent change in the relative wage of high income women (9th and 10th decile of family income as defined above) to workers in the home production substitute sector, between 1980 and 2010, have also seen a greater percent increase in fertility of high income women. This supports the notion that, where market substitutes have become relatively cheaper (as measured by the change in relative wages of workers in the sector), high income women

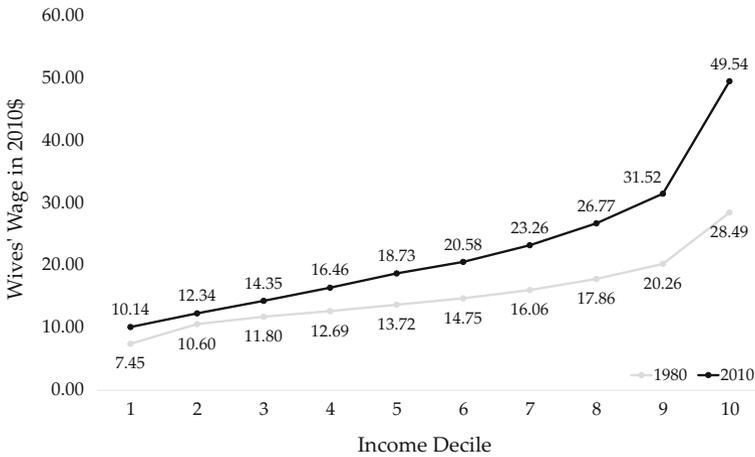


Fig. 3 Wives' Wage by Income Decile 1980 and 2010. *Notes:* authors calculations using Census and American Community Survey Data. The sample is restricted to white, non-Hispanic married women. Deciles are constructed age-by-age, using total household income. Representative wages for each decile is the average of these decile-specific wages from ages 25 to 50. See “Appendix A” for more details

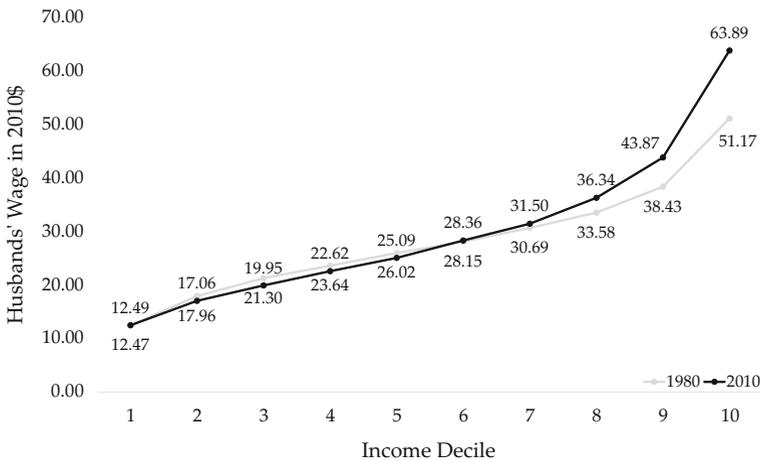


Fig. 4 Husbands' Wage by Income Decile 1980 and 2010. *Notes:* authors calculations using Census and American Community Survey Data. The sample is restricted to white, non-Hispanic married men. Deciles are constructed age-by-age, using total household income. Representative wages for each decile is the average of these decile-specific wages from ages 25 to 50. See “Appendix A” for more details

have increased their fertility by more. In Section A of the Online Appendix we show the robustness of this relationship to controlling for changes in male wages, differential regional trends, and dropping outlying observations.¹²

Additional data sources corroborate this story and paint a more thorough picture of changing time allocation patterns. Female labor supply and childcare expenditures rise with family

¹² Additionally, when using the sample of all native-born American women, as in Fig. 1, and replacing high income women with women with advanced degrees, the regression coefficient is practically the same as in Fig. 5.

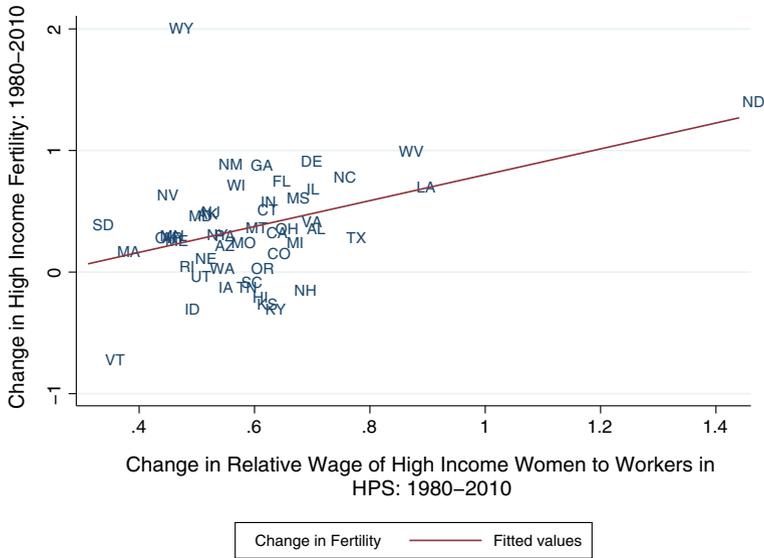


Fig. 5 Cross-State Inequality and Fertility. *Notes* The change in the relative wage of high income women to workers in HPS at the state level is defined as the percent change in the ratio of the average wage of women in the top two deciles to the average wage in the home production substitute sector. The change in fertility is defined as the percentage change in hybrid fertility rates for the top two decile women. Changes from 1980 to 2010. Deciles are constructed age-by-age by total household income, and wages of women are averaged over ages. Wages of HPS workers, as defined in “Appendix A;” are constructed by state-year. See “Appendix A” for more details on the exact definition of these variables. Data for high income women are restricted to white, non Hispanic, married women. Data on HPS sector workers are not restricted

income decile. All deciles saw an increase in female labor supply, especially the top ones. These patterns will be discussed in Sect. 4 in the context of comparing model and data. Finally, data from Time Use Surveys show that females in the top three income deciles reduced their home production activities by over 16 h per week. In contrast, couples in the bottom three deciles reduced home production time by only 7 h per week. Our model will not distinguish between various types of home production activities. We take the stance that all those activities are needed to run a household and raise children.¹³

3 Model

There is a unit measure of households composed of married females (f) and males (m) that are heterogenous on the wage offers that the members receive, denoted w_f and w_m , respectively. The household derives utility from consumption c , number of children n , and their quality w_k (income per child). This approach is as in Galor and Weil (2000) and Moav (2005). The income per child is uncertain, and given by

$$w_k = \begin{cases} \omega \cdot w_{nc} & \text{w.p. } \pi(e) \\ w_{nc} & \text{w.p. } 1 - \pi(e) \end{cases}, \tag{1}$$

¹³ Time directly devoted to children actually remained roughly unchanged for the top income families, partly because their fertility increased and partly due to the more inclusive definition of time spent in direct child care activities applied in later survey years.

where w_{nc} is the income for non-college graduates, $\omega > 1$ is the college premium, and $\pi(e)$ is the probability of receiving a college degree as a function of their education good. The utility function, given the realization of the children’s income, is assumed to be:

$$u = \ln(c) + \alpha \ln(n) + \tilde{\beta} \ln(w_k). \tag{2}$$

We assume that all siblings in a family have the same realization of education uncertainty. Thus, parents in this model maximize the following expected utility:¹⁴

$$\mathbb{E}[u] = \ln(c) + \alpha \ln(n) + \tilde{\beta} \ln(w_{nc}) + \tilde{\beta} \ln(\omega) \pi(e). \tag{3}$$

Notice that the non-college income appears in the utility as a constant, and does not affect the household’s decisions. Hence, we drop this constant in the analysis below.

We assume that π takes the form of:

$$\pi(e) = \ln(b(e + \eta)^\theta). \tag{4}$$

We choose this functional form for the probability of a child graduating college as it generates a negative relationship between fertility and income through a quantity–quality tradeoff.¹⁵ Notice that plugging (4) into (3) and dropping the constant term, $\tilde{\beta} \ln(w_{nc})$, yields:

$$\mathbb{E}[u] = \ln(c) + \alpha \ln(n) + \beta \ln(b(e + \eta)^\theta), \tag{5}$$

where $\beta = \tilde{\beta} \ln(\omega)$, which is similar to the objective function used in de la Croix and Doepke (2003) and Moav (2005). We continue our analysis on the basis of (5).

Parents are required to spend the same amount of resources on the quality of each child. Thus, the budget constraint is given by:

$$c + p_n n + p_e e n = w_f + w_m, \tag{6}$$

where p_n , defined below, captures both the time and market goods costs associated with raising a child, regardless of quality. p_e is the exogenously given price of a unit of education (quality). We are following the approach of Galor and Weil (2000), where the expenditures are on one side of the budget constraint, and full income on the other side of the budget constraint. To do so, we use p_n to denote the cost of the quantity of children, as a composite of the opportunity cost of mother’s time (t_f) and home production substitutes described below. Thus, $p_n n$ is the cost of quantity of a child, including the opportunity cost of time.

We assume a technology for child rearing that includes marketization. Accordingly, we assume that kids require family resources combining mother’s time, t_f , with an aggregation of two market substitutes for home production: time of HPS workers, t_{hps} , and durables d , such as washing machines and dishwashers. t_f and market inputs are used in the production of kids according to:

$$n = A \left(\phi t_f^\rho + (1 - \phi) \left(\phi_m t_{hps}^{\rho_m} + (1 - \phi_m) d^{\rho_m} \right)^{\frac{\rho}{\rho_m}} \right)^{\frac{1}{\rho}}, \tag{7}$$

¹⁴ An alternative formulation would allow for the uncertainty over college to be resolved child-by-child. The advantage to our approach is that it allows for a closed-form solution to the model.

¹⁵ Notice that this function is not bounded between 0 and 1. However, this is not an issue in our calibration, as for any range of e chosen, it is possible to pick parameters such that $\pi(e) \in [0, 1]$. Becker and Tomes (1976) discuss conditions necessary on the π function such that it would yield a negative relationship between income and fertility, specifically that the elasticity of the human capital production function with respect to e is increasing. See also Jones et al. (2010) Our functional form both meets this criteria and yields a closed form solution.

where $0 < \phi < 1$ controls the relative importance of mothers' time in the production of children, $\rho \leq 1$ controls the elasticity of substitution between the mother's time and home production substitutes, A determines the total factor productivity (TFP) of child production, while $0 < \phi_m < 1$ and $\rho_m \leq 1$ control the relative importance of, and the elasticity of substitution between, t_{hps} and d . This production function explicitly takes into account the ability to marketize parental time in child rearing with two types of market substitutes t_{hps} and d . For ease of exposition, we denote the aggregate of market substitutes to be:

$$m \equiv \left(\phi_m t_{hps}^{\rho_m} + (1 - \phi_m) d^{\rho_m} \right)^{\frac{1}{\rho_m}}. \tag{8}$$

For simplicity of exposition, we will freely interchange between referring to t_{hps} and d and referring to m .

Given a level of fertility, n , let $TC(n)$ be the total cost of n children, independently of their education. $TC(n)$ is then the solution to the cost minimization problem given by:

$$TC(n) = \min_{m,d} \{ t_f \cdot w_f + m \cdot p_m \} \tag{9}$$

such that (7) holds, where p_m is the price of a unit of m , as comprised of w_{hps} and p_d , given by:

$$p_m \equiv \left(\phi_m^{\frac{1}{1-\rho_m}} w_{hps}^{\frac{\rho_m}{\rho_m-1}} + (1 - \phi_m)^{\frac{1}{1-\rho_m}} p_d^{\frac{\rho_m}{\rho_m-1}} \right)^{\frac{\rho_m-1}{\rho_m}}. \tag{10}$$

The results, in terms of conditional factor demand and total cost function, are given by:

$$t_{hps} = \frac{\left(\frac{\phi_m}{w_{hps}} \right)^{\frac{1}{1-\rho_m}}}{\left[\phi_m^{\frac{1}{1-\rho_m}} w_{hps}^{\frac{\rho_m}{\rho_m-1}} + (1 - \phi_m)^{\frac{1}{1-\rho_m}} p_d^{\frac{\rho_m}{\rho_m-1}} \right]^{\frac{1}{\rho_m}}} m,$$

$$d = \frac{\left(\frac{1-\phi_m}{p_d} \right)^{\frac{1}{1-\rho_m}}}{\left[\phi_m^{\frac{1}{1-\rho_m}} w_{hps}^{\frac{\rho_m}{\rho_m-1}} + (1 - \phi_m)^{\frac{1}{1-\rho_m}} p_d^{\frac{\rho_m}{\rho_m-1}} \right]^{\frac{1}{\rho_m}}} m,$$

$$t_f = \frac{\left(\frac{\phi}{w_f} \right)^{\frac{1}{1-\rho}}}{A \left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1 - \phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}} \right]^{\frac{1}{\rho}}} n, \tag{11}$$

$$m = \frac{\left(\frac{1-\phi}{p_m} \right)^{\frac{1}{1-\rho}}}{A \left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1 - \phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}} \right]^{\frac{1}{\rho}}} n, \tag{12}$$

$$TC(n) = \frac{1}{A} \left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1 - \phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}} \right]^{\frac{\rho-1}{\rho}} n \equiv p_n n. \tag{13}$$

Using (5) and (6) to solve for the utility maximization problem gives the following optimal solutions for e and n :¹⁶

$$e^* = \max \left\{ \frac{p_n \frac{\beta\theta}{\alpha} - \eta}{1 - \frac{\beta\theta}{\alpha}}, 0 \right\}, \tag{14}$$

$$n^* = \begin{cases} \left(1 - \frac{\beta\theta}{\alpha}\right) \left(\frac{\alpha}{1+\alpha}\right) \left(\frac{w_f + w_m}{p_n - \eta p_e}\right) & \text{if } e^* > 0 \\ \frac{\alpha}{1+\alpha} \left(\frac{w_f + w_m}{p_n}\right) & \text{if } e^* = 0 \end{cases}. \tag{15}$$

The solution for n , t_f , and m imply that an increase in $\frac{w_f}{p_m}$ yields a decrease in $\frac{t_f}{n}$ and an increase in $\frac{m}{n}$, as families marketize the time costs of children more.¹⁷ The ability of parents to substitute their own time with market goods and services leads to the following claim:

Claim 1 *When part of the time cost of children can be marketized, and $\rho \in (0, 1)$, rising inequality may lead to the fraction of children born to high income families to rise.*

This follows from the fact that n^* is either decreasing or U-shaped in w_f , in the interior solution region. This is shown in Section B.2 of the Online Appendix, where we formally discuss the shape of fertility across deciles, which differ on w_f and w_m , and over time. When the dispersion of w_f rises, differential fertility could change in either direction; there could be relatively more children born to poor households, if the downward sloping section of the U shape is dominant. However, there could also be relatively more children born to rich households. Changes in fertility patterns have implications for aggregate human capital levels.

Claim 2 *When part of the time cost of children can be marketized, and $\rho \in (0, 1)$, rising inequality may lead to higher levels of average human capital in the next generation through differential fertility.*

This claim holds in the case where rising dispersion of w_f increases the fraction of children born to high income households, and thus increases the average human capital of the subsequent generation.

Much of the literature has abstracted from the assumption that some of the time cost of children can be marketized, and assumed that p_n is proportional to w_f . If one makes such an assumption, Eqs. (14) and (15) reveal that fertility is strictly decreasing in w_f in the interior solution. We refer to this special case as the “Standard Theory.”¹⁸

Finally, a word must be said about two ways of modeling men and fertility. First, if men do not spend time raising children, as in our benchmark, then we say that there are “traditional gender roles”. Men’s wages under traditional gender roles act as any other form of wealth. A higher male wage yields more fertility, as can be seen directly in (15), through an income effect. Under this framework, it is possible that the changing fertility patterns in US data, where now high income households are likely to have relatively more children, can be explained by rising inequality among men, regardless of the ability to marketize. This is the assumption we make in our quantitative analysis below, as it allows for an alternative explanation for the emergence of the U-shape seen in the data.

¹⁶ We show the existence of a unique solution to the household problem in Section B.1 of the Online Appendix.

¹⁷ Additionally, if $\rho > 0$, there is an increase in relative spending on market substitutes, i.e. $\frac{p_m m}{w_f t_f}$ rises.

¹⁸ Notice that if p_n is proportional to w_f , and $w_m = 0$, then (15) collapses to the optimal fertility solution as in de la Croix and Doepke (2003) and Moav (2005).

Alternatively, we could assume “modern gender roles,” in which men do engage in child care. Thus, p_n does depend on w_m . Clearly, this could be modeled in a large number of ways.¹⁹ To understand the intuition of how modern gender roles interact with inequality and marketization, consider the extreme example of a Leontief function that aggregates time that husbands and wives spend in childcare into one “parental services” variable. For example, if men are required to spend 1 h of time in child care for every hour that their wife spends in child care, then couples can be seen as one person with $w = w_m + w_f$ with all the same implications for the interaction between inequality and marketization. This assertion applies more generally when men and women are not perfect complements in the production of children (Siegel 2017).

4 Quantitative exercise

In this section, we discuss the calibration of the model, the model fit, and breakdown of the mechanisms driving changing fertility patterns over time. We calibrate the model to 1980, and then study its implications under the 2010 wages and prices of home production substitutes t_{hps} and d . We begin by discussing the parameterization of the model and the model fit. We then test the model predictions for 2010 and break down quantitatively the various forces at work.

Throughout the quantitative exercise, we assume 10 representative couples that we map to income deciles, as described in “Appendix A.”

4.1 Parameterization

We defer discussion on ϕ_m and ρ_m , as well as w_{hps} and p_d until Sect. 4.3, and instead summarize the cost of all home production substitutes as p_m . The model has 10 parameters, $\Omega \equiv \{\alpha, \beta, \eta, \theta, b, \phi, \rho, p_e, A, p_m, 1980\}$. We now describe how we pick these parameter values, which are reported in Table 1.

Table 1 Calibrated parameter values

Parameter	Interpretation	Value	Indentification
α	Weight on # of children	0.45	Fertility
β	Weight on quality of children	0.67	Fertility
η	Basic education	2.06	Fertility
θ	Exponent π	0.43	College attainment
b	Scaling	0.87	College attainment
ρ	Elasticity mother’s time/ m	0.59	Labor supply
ϕ	Share of mother’s time	0.90	Labor supply
A	TFP child production	3.77	Index of marketization
$p_m, 1980$	Price of market substitutes 1980	1	Normalization
p_e	Cost of education	1	Normalization

¹⁹ For an analysis on how parents bargain over the allocation of time to childcare, see Gobbi (2018).

p_e and $p_{m,1980}$ are normalized to one without loss of generality.²⁰ The remaining 8 parameters are picked to match model moments to data moments from 1980. In particular, we match the profile of fertility, the profile of mother's time at home, the profile of college attainment rates of children born to different income deciles in 1980, and the index of relative expenditures on home good substitutes.²¹ Each profile contains 10 moments, representing the 10 deciles, yielding 40 moments. See "Appendix A" for a description of the empirical moments. The model has a closed form solution which can be inverted to infer parameter values from the data. Due to the high number of moments relative to parameters, we minimize the distance between the model moments and the data moments in order to obtain the best fit.

Formally, we pick parameters to minimize the mean squared error of the loss function:

$$\{\alpha, \beta, \eta, \theta, b, \phi, \rho, A\} = \arg \min \sum_i \left(\frac{M_i(\Omega) - D_i}{D_i} \right)^2, \quad (16)$$

where $M_i(\Omega)$ is the value of the model moment i when evaluated at parameter values Ω . D_i is the data value of moment i .

While all of these 8 parameters are picked together, certain moments inform on them more than others. With a slight abuse of language, we describe a parameter as being picked to match a target, while it is understood that all parameters are jointly determined against the empirical moments. Table 1 shows the results of our identification strategy described below.

We begin by discussing α , β , and η which are picked to match fertility rates by decile. As can be seen in Eq. (15), α plays a large role in determining the level of fertility, and can thus be thought of as being identified off the level of the fertility profile. The slope of fertility with respect to income depends on both an income effect, as kids are a normal good, and a substitution effect, as higher wages imply a higher opportunity cost of time with kids. In this model, fathers' wages, w_m , are purely an income effect, while mothers' wages contain both effects. β is important in determining the strength of the income effect. η controls the strength of the substitution effect. Thus, these three parameters are identified off the level and slope of the fertility profile with respect to both parents' wage offers.

Turning to θ and b , these parameters are closely related to education. First, however, notice that β and θ are inseparable in the utility function. However, θ affects the mapping between education expenditures, e , and college attainment, $\pi(e)$, while β does not. Thus, θ can be thought of as being identified off the slope of the profile of college attainment by decile, while β is identified off the slope of the fertility profile, as described above. As seen in Eqs. (14) and (15), b does not affect the amount invested in children or quantity of children. It does, however, impact the education obtained. Therefore, it can be identified by the level of the profile of college attainment.

ϕ , ρ , and A are the parameters of the production function for kids. ϕ and ρ control the tradeoff between mother's time and home production substitutes, m , in the production of children. ϕ controls the relative importance of the mother's time in child care, while ρ controls the substitutability between mother's time and market goods. A controls how much resources are needed for childcare, in particular the amount of market goods needed. These

²⁰ We show this formally in Section D of the Online Appendix. We delve into further detail on $p_{m,1980}$ as it relates to $w_{hps,1980}$ and $p_{d,1980}$ in Sect. 4.3, below.

²¹ Regarding the index of marketization, we use the childcare module of the Survey of Program Participation and Income (SIPP) to estimate relative uses of market substitutes. Our index measures are based off expenditures on childcare hours purchased in the marketplace. Since this is only one aspect of marketization, we use this to target the relative use of marketization across deciles, rather than taking the absolute expenditure levels literally. The implicit assumption is that there is a strong correlation between the use of childcare and other market substitutes for parents' time. See "Appendix A" for more details.

three parameters thus determine how many resources of each type are needed and available, per child, across the income distribution. As such, they can be thought of being identified off both the level and slope of the profile of mother's time at home and the index of marketization.

4.2 Parameters and model fit

Table 1 shows the calibrated parameter values. Notice that the parameter values found here are consistent with much of the literature. For instance, the calibrated value of α suggests that $\frac{\alpha}{1+\alpha} = 31\%$ of household resources are dedicated towards children. Lino et al. (2017) find that families with 2–3 children spend 37–57% of their expenditures on their children. Assuming that households have children at home for half of their adult life (de la Croix and Doepke 2004), our number of 31% is roughly consistent with the upper range of these estimates. While ϕ is somewhat high, this actually is conservative, as it reduces the importance of marketization in the calibration. Our value for ρ implies an elasticity of substitution between mother's time and market goods of 2.5, which is consistent with the higher estimates reported in Aguiar and Hurst (2007).

Figure 6 shows the model fit, matching 40 moments with 8 parameters. The model successfully fits empirical targets for 1980, by decile, despite its parsimonious nature. The top left panel shows the model and data for mother's time at home. The top right panel shows the model fit for fertility. The bottom left figure shows the model fit for college attainment rates of children born to families in different deciles in 1980. Finally, the bottom right shows the model fit for the index of marketization.

Overall, the model fit is excellent. Beginning with women's time at home, the match between the model and data is close to perfect. Turning towards fertility, both the model and data exhibit a strongly negative relationship between income decile and fertility rates, with the exception of the first decile.²² The model is also able to capture the level of college attainment, by decile, almost perfectly. Finally, the index of relative marketization is well matched, showing that relative marketization rates in the model are similar to those in the data.

The average fraction of household income spent on market substitutes is 4.7%. This seems quite reasonable; expenditures on market substitutes are a relatively small fraction of total household income.

4.3 Change in p_m

We next turn towards the calculation of the change in p_m between 1980 and 2010. m is composed of two types of market substitutes for home production: home production durables, d , such as dishwashers and washing machines, and time of HPS workers, t_{hps} . We first discuss the price change that we take of each type of input, and then discuss our choice of price reduction.

Greenwood et al. (2016) report a range of estimates from the literature of 2–13% annual price declines of home production durables, and in turn use 5%. We use 4% in order to be more conservative. Real wages of HPS workers in the Current Population Survey (CPS) have remained roughly constant, hence we do not change w_{hps} between 1980 and 2010. These observations on prices are not enough to calculate the change of p_m , as we also need ϕ_m and ρ_m , as in Eq. (10), and the relative price of inputs $\frac{p_d}{w_{hps}}$. However, they do indicate that a decline of p_m of roughly 2% a year is reasonable; a 4% decline in durables and a 0% decline in HPS

²² The imperfect fit results from a corner solution in education for the first two deciles.

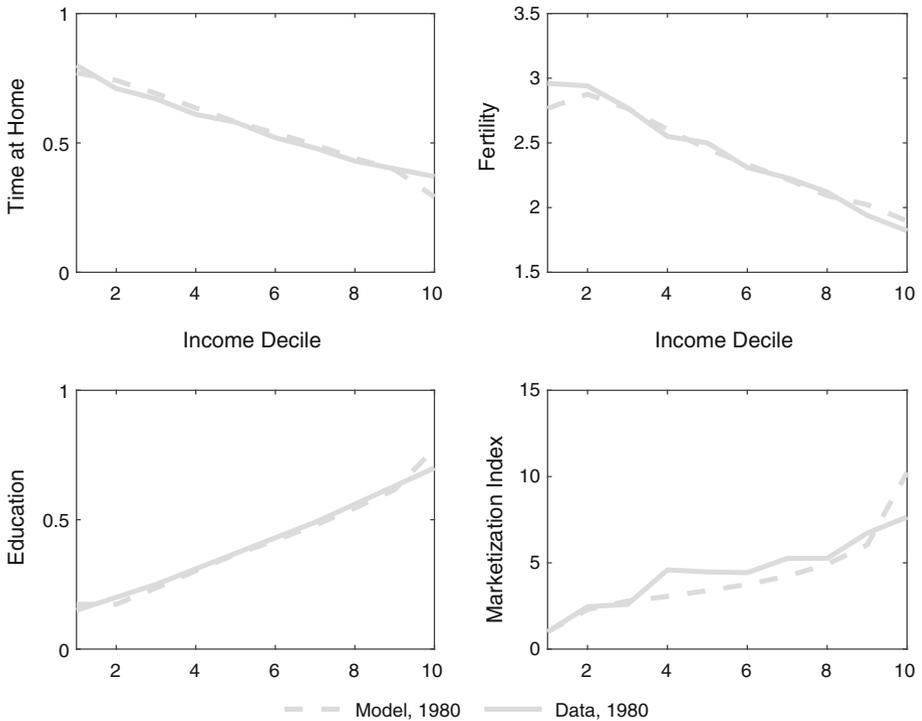


Fig. 6 Model Fit Notes: The top left panel, “Time at Home,” is mother’s time at home as measured by women’s time not working in the data, and t_f in the model. The top right panel, “Fertility,” is n in the model and hybrid fertility rates in data. “Education” is the fraction of children born to each decile who graduate from college in the data and $\pi(e)$ in the model. “Marketization index” is the expenditures on babysitters, by decile, relative to the 1st decile in the data, and $\frac{p_m m(d)}{p_m m(1)}$ in the model, where $m(d)$ is the amount of market goods m purchased by decile d . “Model, 1980” refers to the calibrated model in 1980. “Data, 1980” refers to the relevant data described in this note and the text

worker costs suggests 2% as a midpoint. We next do a more formal analysis of the interaction of durables and HPS workers in home production in order to explore changes in p_m .

Pulling out w_{hps} from Eq. (10) allows us to write p_m as a function of $\frac{p_d}{w_{hps}}$:

$$p_m = w_{hps} \left(\phi^{\frac{1}{1-\rho_m}} \left(\frac{p_d}{w_{hps}} \right)^{\frac{\rho_m}{\rho_m-1}} + (1 - \phi_m)^{\frac{1}{1-\rho_m}} \right)^{\frac{\rho_m-1}{\rho_m}}. \tag{17}$$

Minimizing costs yields expenditures on durables relative to expenditures on HPS workers, which are given by:

$$\frac{p_d d}{w_{hps} t_{hps}} = \left(\frac{p_d}{w_{hps}} \right)^{-\frac{\rho_m}{1-\rho_m}} \left(\frac{1 - \phi_m}{\phi_m} \right)^{\frac{1}{1-\rho_m}}. \tag{18}$$

In order to calculate the empirical counterpart to (18), we take the Survey of Consumer Expenditures (CEX) in 1980 and 2010. Our sample is married white households of ages

25 to 50.²³ We find that the ratio of expenditures on durables relative to HPS workers is 3.60 in 1980 and 1.45 in 2010.²⁴

Dividing (18) in 2010 by (18) in 1980, yields:

$$\frac{\left(\frac{p_d d}{w_{hps} t_{hps}}\right)_{2010}}{\left(\frac{p_d d}{w_{hps} t_{hps}}\right)_{1980}} = \left(\frac{\left(\frac{p_d}{w_{hps}}\right)_{2010}}{\left(\frac{p_d}{w_{hps}}\right)_{1980}}\right)^{-\frac{\rho_m}{1-\rho_m}} \quad (19)$$

Substituting into (19) the fact that the ratio of relative expenditures in the data is $\frac{1.45}{3.60}$ and the change in relative prices of durables to HPS workers (declined by 71%), we can infer that $\rho_m = -2.88$. This implies strong complementarity between the two inputs, with an elasticity of substitution of approximately 0.25. We are still missing two unknowns necessary to calculate the change in p_m over time: $\left(\frac{p_d}{w_{hps}}\right)_{1980}$ and ϕ_m . In principle, we have two more data moments we can target, the first being the fact that (18) is equal to 3.6 in 1980 and the second being elasticity of substitution between t_f and d reported in Aguiar and Hurst (2007). The latter target would yield ϕ_m from (20) and the former target would then allow to solve for $\left(\frac{p_d}{w_{hps}}\right)_{1980}$ from (18). In practice, Aguiar and Hurst report a range of elasticities, making it difficult to know which one to target. In the model, the elasticity of substitution between t_f and d is given by:

$$\epsilon = \frac{(1 - \phi)(1 - \phi_m)(d/m)^{\rho_m} + \phi(t_f/m)^{\rho}}{(1 - \rho)(1 - \phi)(1 - \phi_m)(d/m)^{\rho_m} + (1 - \rho_m)\phi(t_f/m)^{\rho} + (\rho_m - \rho)(1 - \phi_m)\phi(t_f/m)^{\rho}(d/m)^{\rho_m}} \quad (20)$$

We calculate this elasticity for each decile and average over the deciles.²⁵

A 2% annual decline of p_m , as suggested above, is consistent with $\phi_m = 0.163$ and an average ϵ of 1.61.²⁶ This value for the elasticity between mother’s time and purchased durable goods lies within the range of estimates of Aguiar and Hurst. We also perform robustness checks by directly targetting elasticities of 1.78 and 1.45, reported in Aguiar and Hurst. We refer to these robustness exercises as “high ϵ ” and “low ϵ ,” respectively.

4.4 Results

4.4.1 Main experiment

We assess the implications of changing wages and p_m by introducing their 2010 values into the benchmark model. This is our main experiment. We measure the contribution of these changes to explaining fertility and time allocation trends by comparing the main experiment predictions to the actual 2010 data.

²³ There is well known bias in CEX data, such that comparing the CEX and the National Income and Product Accounts (NIPA) over time shows substantial divergences. Attanasio et al. (2012) surveys some of the literature on this subject. As a result, we only use CEX to examine relative expenditures on different types of goods, rather than absolute expenditures.

²⁴ For durables, we calculate expenditures using house furnishing and equipment expenditures (“houseecq”). For demand for HPS workers, we use babysitters and housekeepers expenditures (“domsrvcq” in 2010, and “housopcq” in 1980).

²⁵ Sato (1967) derives an equivalent expression for this elasticity using expenditure shares of the inputs.

²⁶ The decile specific ϵ is monotonically increasing and is in the range of 1.54–1.73.

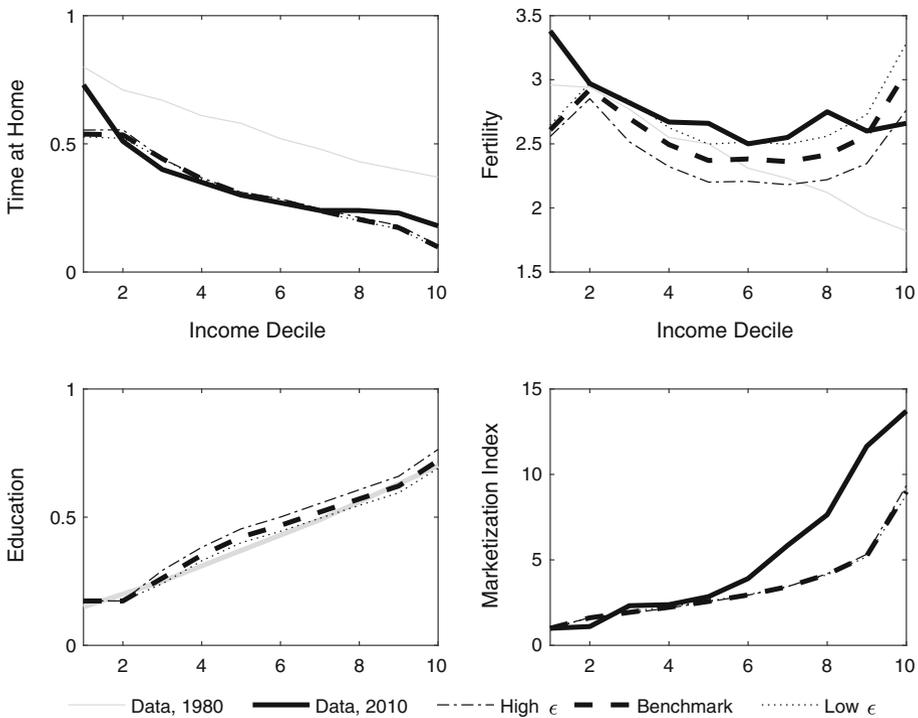


Fig. 7 Main experiment. *Notes:* the top left panel, “Time at Home,” is mother’s time at home as measured by women’s time not working in the data, and t_f in the model. The top right panel, “Fertility,” is n in the model and hybrid fertility rates in data. “Data 2010” refers to the data, as described in the text. “Benchmark,” “High ϵ ” and “Low ϵ ” refer to the main experiment’s prediction for 2010, for the benchmark case, the “high ϵ ” case, and the “low ϵ ” case, respectively. The “main experiment” refers to introducing the 2010 values of w_m , w_f , and p_m into the calibrated model

Figure 7 repeats Fig. 6, using the prediction of the main experiment and the 2010 data.²⁷ We report the results of the main experiment for the benchmark case as well as the low and high ϕ_m cases. The top left panel shows the model’s prediction for women’s time at home, and includes the 1980 data for comparison. The model’s prediction is quite close to the actual data, though the model somewhat understates time spent at home for the first decile. Overall, the model accounts for the change in female labor supply quite well, and is not very sensitive to changes in ϕ_m .

The top right panel shows the model’s prediction for fertility, and again shows the 1980 data for comparison. With the exception of the rise in fertility between the first and second deciles, which is due to corner solutions in the model, the model accurately captures the

²⁷ There is one point worth discussing about time allocations. Our model focuses on understanding time allocation between home production and work, implicitly assuming that the total time on non-leisure activities has not revealed a systematic trend. American Time Use Survey (ATUS) data, however, suggests that leisure may have slightly declined between 1975 and 2003 for the group of married females that we consider: by 6 h per week for the top deciles and 3.5 h for the bottom deciles. These are based on our own calculation, and we note that the 1975 ATUS gets reduced to a very small sample once we apply our sample restrictions. If this extra time is devoted towards *quantity* of children, rather than *quality* (time spent reading to children, other education), then our results may be slightly biased for 2010. However, the basic point that the model broadly captures trends in the data is unaffected by this potential mismeasurement.

declining fertility rates through the fifth decile, and the subsequent flattening/rising fertility rates. Consistent with the data, the main experiment generates little changes in fertility over time for low income couples and large increases in fertility for the high income couples. Here, the level of fertility, but not the general shape, is more sensitive to changes in ϕ_m , as can be seen in the high and low ϕ_m cases. The rise in fertility of the top decile is overstated, with fertility in the model being higher than that of the data by approximately 0.4 children. Overall, the main experiment goes a long way in generating the observed changes in fertility rates and labor supply of married women between 1980 and 2010.

The bottom left panel shows the model prediction for college graduation rates of children born to couples from different deciles in 2010. There is no data on the graduation rates of these children, as they are still too young, so we show the comparison to the 1980 data, which is almost identical to the 1980 model as seen in Fig. 6. This panel shows that college graduation rates barely change over time in the model, implying that high income couples raised fertility without sacrificing quality investments in children.

The bottom right panel shows the index of marketization in 2010. The model prediction for the lower half of the income distribution is quite good. For deciles 5–8, the model somewhat understates the rate at which households increase their marketization. Notice that this is also the interval in which fertility in the model is somewhat lower than in the data. There is a sharp kink in the index of marketization at decile 9, exactly where the model begins to overstate fertility rates. Given that this index is a measure relative to the first decile, it is unsurprising that it is insensitive to ϕ_m . The level of market expenditure on children grows by a factor of 3.2 for the top income couples and a factor of 2.5 for the second lowest income decile. Overall, the model does an impressive job accounting for the 2010 data patterns with changes in wages and the price of home production substitutes alone.²⁸

We can also quantitatively compare the model with empirical results in the literature. Mazzolari and Ragusa (2013) study the effects of inequality on demand for home production substitutes. They look at cross-city variation in US employment growth in the home production substitutes sector between 1980 and 2005. Thus, they are estimating changes in demand for home production substitutes during our time period. They find that a one standard deviation (4% points) increase in a city's top decile wage bill is associated with a 8–16% growth in the number of hours in the home services sector.²⁹ Our model's counterpart is 13%, when taking an average of the corresponding result in the benchmark model (1980) and the main experiment (2010).

We next break down the results of the main experiment and explore the implications of differential fertility for human capital.

We use the following measures in our discussion. We measure “High Income Fertility” as the average fertility of the top two deciles. We use two measures of the fertility gap (differential fertility) between high and low income couples. MDF1 is computed as the ratio of top two decile fertility to 2nd decile fertility. We choose to focus on the 2nd decile rather than the bottom decile because the latter is affected by various welfare programs that we do not model. MDF2 is computed as the ratio of fertility in the top half of the income distribution to fertility in the bottom half of the income distribution.³⁰

²⁸ In Section C of the Online Appendix we include changes in college tuition and the college premium as additional exogenous forces. The results remain largely unchanged, as these shocks exhibit offsetting effects and do not interact with wages or p_m .

²⁹ This is the range of their IV estimates. See their Table 2.

³⁰ Formally, high income fertility is expressed as $\frac{n(10)+n(9)}{2}$, MDF1 is expressed as $\frac{n(10)+n(9)}{2}/n(2)$, and MDF2 is expressed as $\sum_{i=6}^{10} n(i)/\sum_{i=1}^5 n(i)$, where $n(i)$ is the fertility rate of decile i .

Table 2 Results: model mechanisms

	Data (1)	Main experiment		
		Baseline (2)	No change in marketization (3)	No change in w_m (4)
% Δ High Inc Fert	39.9%	43.5%	– 27.6%	30.0%
% Δ MDF1	38.5%	41.2%	– 2.4%	24.1%
% Δ MDF2	18.6%	24.4%	– 4.4%	15.1%
Δ CG (pp)	1.70	2.39	– 0.53	1.60

“High Inc Fert” is the number of children born to the top 2 deciles. “MDF1” is the fertility of the top two deciles relative to the fertility of the 2nd decile. “MDF2” is the fertility of the top half of the income distribution relative to the fertility of the bottom half of the income distribution. “CG” is the fertility-driven measure of aggregate college attainment. See Footnotes 30 and 31 for the formal definitions of these variables. All changes refer to between 1980 and 2010. Column (1), “Data,” reports data changes. Column (2), “Baseline,” reports changes implied by the Main Experiment. Column (3) “No change in Marketization” and Column (4), “No change in w_m ” report changes for the two counterfactual experiments that supplement the Main Experiment, as described in Sect. 4.4.2

Finally, we introduce a fertility-driven measure of aggregate college attainment, which we compute by weighing the 1980 empirical college attainment profile by the appropriate fertility profile (in both the model and data by year).³¹ We keep the relationship between income decile and college graduation fixed at the 1980 level for two reasons. First the data on college attainment rates for children born in 2010 will not be available until around 2035. Second, this measure allows us to isolate the effects of changing differential fertility on aggregate college attainment.

Table 2 summarizes the data, the main experiment results, and the breakdown of model mechanisms. The first column shows the data percentage changes in high income fertility, MDF1, MDF2, and the percentage point (p.p.) change in fertility-driven aggregate college attainment (see Footnote 31). High income fertility rose by 40%. Low income (second decile) fertility remained almost constant. These two facts combine to imply that MDF1 increased by almost 40% (38.5% to be precise). MDF2 increased by 18.6%. Overall, changes in differential fertility imply a 1.70 p.p. increase in college attainment rates of the next generation. The second column reports implications of the main experiment. In the model, high income fertility rises by 43.5%, MDF1 increases by 41.2%, MDF2 increases by 24.4%, and college attainment rates of the next generation rise by 2.39 p.p.³² Recall that none of the data moments reported here are targeted. These results show that changes in wages together with falling prices of HPS goods (introduced by the main experiment) go a long way in explaining the observed trends in fertility, namely the rise in high income fertility and the decline in differential fertility.

4.4.2 Decomposing the main experiment

There are two mechanisms through which rising inequality leads to changing differential fertility in the main experiment. The first is increased marketization, as measured by changes

³¹ Formally, the fertility-driven measure of college attainment is computed as $CG = \sum_d \frac{n(d)}{\sum_d n(d)} \pi_{1980}^{data}(d)$, where $\pi_{1980}^{data}(i)$ is the empirical college graduation rate of children born in decile i in 1980.

³² When calculating the college attainment rates in the model using the π in the main experiment, the college attainment rate rises from 38.3% in 1980 to 42.8% in 2010, an even larger increase.

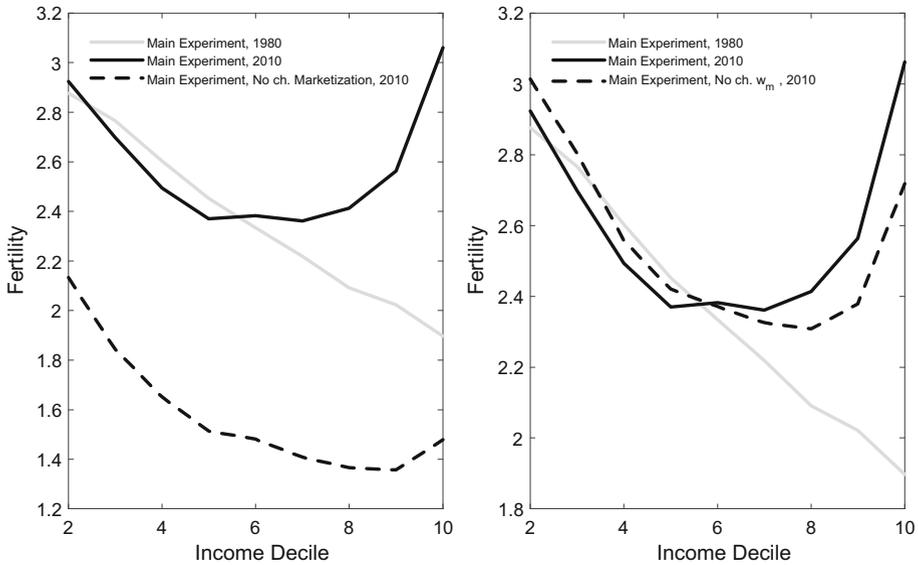


Fig. 8 Counterfactuals. *Notes:* fertility is n in the model. “Main Experiment 1980” is the model calibrated to 1980, while “Main Experiment 2010” is the Main Experiment in both panels. Left panel: The curve labeled “Main Experiment: No ch. Marketization” is fertility in the 2010 model using the same relative price of market substitutes ($\frac{w_f}{p_m}$), by decile, as in 1980. Right Panel: The curve labeled “Main Experiment: No ch. w_m ” is fertility in the 2010 model using the male wages from 1980

in $\frac{w_f}{p_m}$. The second is the income effect on demand for children, as measured by changes in w_m . We now evaluate each in turn.

Contribution of marketization

To assess the contribution of marketization, we recompute the main experiment except we adjust p_m , by decile, so that decile-specific $\frac{w_f}{p_m}$ are at their 1980 levels. We do so by varying p_m by decile.³³ We refer to this experiment as the “Main Experiment: No change in Marketization.” Relative to the main experiment, this counterfactual shuts down the movement in the relevant measure of marketization cost, thereby allowing us to explore its importance for our results. Figure 8 (left panel) depicts the results.³⁴ As can be clearly seen, without a decreasing relative price of marketization, high income fertility falls drastically. This is the exact opposite of what happened in the data.³⁵ This is directly along the lines of the standard theory; without marketization, increases in inequality decrease fertility among high income families.

³³ As can be seen from Eqs. (11) and (12), this implies that $\frac{t_f}{m}$ remains constant, by decile, over time.

³⁴ We leave out the first decile in Fig. 8, because the model generates a corner solution and because couples in this decile qualify for various welfare programs that our model does not capture. This is not crucial as the effects of marketization on the first decile are minimal.

³⁵ Notice that the level of fertility is lower for all deciles. This is due to the fact that female wages grew more than male wages. Specifically, as can be seen from Eq. (15), the positive income effect generated by male wage growth is counterbalanced by a larger increase in the price children driven by rising female wages.

Column 3 of Table 2 reports the results for this counterfactual experiment. We see that, without the fall in the price of marketization, high income fertility counterfactually falls by 27.6%. More importantly, and consistent with the standard model, MDF counterfactually falls, using both measures. This in turn decreases college attainment by 0.53 p.p. as opposed to the 1.70 p.p. *increase* the data measures. This is despite the fact that rising male inequality is at work here. Thus, as we observe above, a naïve modeler, working in 1980 and ignoring marketization, would have predicted a widening of differential fertility and thus a decline in college attainment rates over time if she had been given perfect foresight over actual income distributions.³⁶ Adding this counterfactual decrease implied by the standard theory to the increase seen in the data, we find that the bias from ignoring changes in marketization is 2.23 p.p. of college attainment. This estimate implies that differential fertility's impact on education is substantial. To put things in perspective, 2.23 p.p. is equivalent to roughly one-quarter of the rise in college attainment between the 1950 and 1980 cohorts of white, non-Hispanic non-immigrant Americans (27% and 37.9%, respectively). Thus, the bias induced by ignoring marketization is both quantitatively large and changes the sign of the estimated implications of inequality on differential fertility, and thus education.

Contribution of male income growth

To assess the contribution of changing male wages, we recompute the main experiment holding the decile-specific male incomes (w_m) at their 1980 levels. We refer to this experiment as the “Main Experiment: No change in w_m .” Figure 8 (right panel) illustrates our findings. As can be seen, the prediction for 2010 is quite similar to that of the main experiment, with somewhat lower fertility rates for high income households. The intuition is clear; those households saw a great rise in male income which, through the income effect, should increase fertility. Shutting down this mechanism leads to less fertility.³⁷

Column 4 of Table 2 summarizes the results for this counterfactual experiment. When abstracting from changes in male income, high income fertility still rises 30%, which is 69% of the 43.5% increase in the main experiment. This means that the income effect can explain at most 31% of the increase in high income fertility. MDF1 (MDF2) increases 24.1% (15.1%), which is 59% (62%) of the 41.2% (24.4%) increase in the main experiment, implying that the male income effect can explain at most 41% (38%) of increased MDF. Finally, the college attainment rates of the next generation rise by 1.60 p.p., which is 67% of the increase in the main experiment, implying that the male income effect can explain at most 33% of the increase in college attainment attributed to changing differential fertility.³⁸

We note two more interesting facts about this exercise. The first is that the findings are under the extreme assumption of traditional gender roles. If men bore a time cost of children as well, then marketization would presumably be an even stronger force for differential fertility in the model. Thus, our findings are conservative. Second, we note that this measure of the impact of the income effect on differential fertility captures all of the empirical mechanisms causing an increase in male wages by decile, including sorting. To see this point, imagine that

³⁶ Notice that the standard theory does not allow for any marketization, while in our counterfactual exercise we do not allow the relevant cost of marketization to fall over time. Thus, while the two exercises are not perfectly comparable, the underlying economics is similar.

³⁷ The opposite happens for the low end of the distribution where male real incomes actually fell over time.

³⁸ Notice that these two exercises show that marketization and the income effect do not add up to the total effect. This is because there is an interaction between the two mechanisms; when p_m decreases, the positive effect of w_f on the price of children (p_n) weakens, as seen in Equation (6) of the Online Appendix, thereby allowing the income effect of wages on fertility to grow in strength.

sorting increases, with no other change in inequality. Then the higher deciles would begin to measure higher male wages. Thus, this exercise can be thought of as capturing the upper bound of the effect of rising marital sorting on differential fertility.

A further look into the marketization mechanism

Delving deeper into our results, we perform two more exercises in order to disentangle the roles of falling p_m and rising female wage inequality on fertility. First, we expand on the exercise described above as “Main Experiment: No change in Marketization,” which illustrated the importance of changes in $\frac{w_f}{p_m}$, by separately analyzing the effects of changing w_f and p_m . Figure 9 (left panel) shows the main experiment’s fertility rates, by decile, in 1980 and 2010. It then adds two curves. The curve “1980 with 2010 w_f ” shows the 1980 model with women’s wages from 2010. The curve “1980 with 2010 p_m ” shows the 1980 model with marketization prices from 2010. As can be seen, simply changing w_f lowers fertility rates. However, the relationship between income and fertility flattens greatly after the 5th decile, as in the data, and even turns positive for between the 9th and 10th deciles. As opposed to this, if only p_m changes, fertility increases. Here, the first deciles have a positive relationship between income and fertility due to the corner solution in e . However, by the 4th decile, the relationship becomes negative, flattening out only after the 8th decile.

We conclude two things from this exercise. First, inequality in women’s wages was a significant force for the flattening relationship between income and fertility. Second, the interaction of changes in w_f and p_m is what allows the model to match both the level and shape of the fertility profile in 2010. The importance of interaction effects is seen mathematically in Equation (6) of the Online Appendix which derives the (positive) effect of w_f on the cost of children (p_n). When inputs in home production are substitutes, the fall in p_m decreases the magnitude of this effect, thereby weakening the negative effect of w_f on fertility and allowing the positive income effects of w_f and w_m to get relatively stronger.

The second exercise is to show, mechanically, what is causing the change in fertility patterns between the two inputs into child production, viz. mother’s time (t_f) and market substitutes (m), as in (7). Figure 9 (right panel) shows the 1980 and 2010 fertility profiles in the main experiment. The curve “1980 m with 2010 t_f ” shows what fertility would have looked like had the 1980 levels of m been combined with the 2010 levels of t_f . Since mother’s time at home is decreasing for all deciles between 1980 and 2010, the level of fertility is lower. However, for our purposes, it is important to note that fertility would still have been negatively correlated with income. The curve “1980 t_f with 2010 m ” shows what fertility would have looked like had the 1980 levels of t_f been combined with the 2010 levels of m . Since all deciles purchase more market substitutes in 2010, fertility is higher. However, it is clear that it is the differential rise in the use of home production substitutes that led to a flat, or even increasing, relationship between income and fertility.

5 The minimum wage, revisited

In this section, we first discuss the theory as to why the price of marketization (p_m) has a greater effect on higher income couples. We then show empirically, using cross-state variation, that the minimum wage has a large effect on wages in the home production substitutes sector. Our theory then implies that changes in the minimum wage will have an impact on fertility and labor supply of high income couples. We use the benchmark model to quantify these

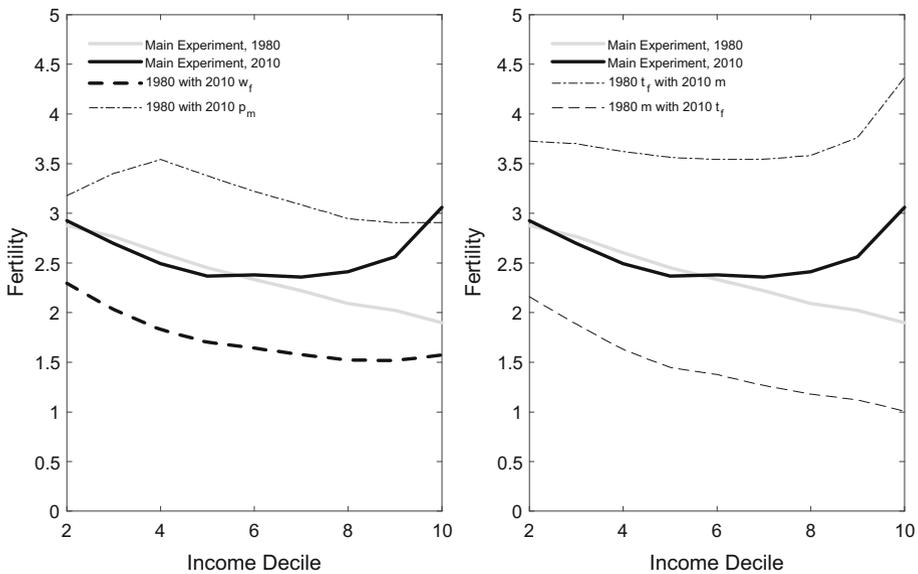


Fig. 9 Disentangling results. *Notes:* Fertility is n in the model. “Main Experiment 1980” is the model calibrated to 1980, while “Main Experiment 2010” is the Main Experiment in 2010 in both panels. Left panel: The curve labeled “1980 with 2010 w_f ” shows fertility in the 1980 model with women’s wages from 2010. The curve labeled “1980 with 2010 p_m ” shows fertility in the 1980 model with marketization prices from 2010. Right Panel: The curve “1980 m with 2010 t_f ” shows fertility with the 1980 levels of m combined with the 2010 levels of t_f . The curve “1980 t_f with 2010 m ” fertility with the 1980 levels of t_f combined with the 2010 levels of m

effects. We end by turning to a reduced form empirical analysis to estimate the effect of the minimum wage on the labor supply of high income women and find even larger effects than those implied by the model.

5.1 Minimum wage: theory

The effects of minimum wage laws have been widely studied, but these studies focus on the labor supply of low wage workers (Manning 2016). The theory presented thus far makes a stark prediction; anything that changes the price of home production substitutes, such as caretakers for children, should affect the labor supply and fertility of *all* households. Thus, the minimum wage should also affect the labor supply of women whose own wages are not directly impacted by the minimum wage. We focus our attention only on women from the 5th decile onwards in order to completely abstract from the direct effect of minimum wage laws on wage offers. We show that the labor supply of these women is affected through the indirect impact of minimum wage laws on the price of market substitutes for home production, as represented by p_m in the model.

Claim 3 *If $\rho \in (0, 1)$, an increase in the minimum wage decreases labor supply, when fertility cannot adjust, that is, $\frac{\partial t_f}{\partial p_m} |_{n=n_0} > 0$. Moreover, the effect is differential across the income distribution. A sufficient condition for the effect to be increasing with wages is $\rho > \frac{1}{2}$. That is, $\frac{\partial^2 t_f}{\partial p_m \partial w_f} |_{n=n_0} > 0$ if $\rho > \frac{1}{2}$.*

Proof Follows directly from differentiating (11) with respect to p_m , and then again with respect to w_f , holding n constant. \square

One can think of the effect of the minimum wage on labor supply holding fertility constant as a short run effect. That is, if fertility decisions have already been completed, then labor supply changes as described by Claim 3. However, the minimum wage will also affect fertility for families that can still adjust their fertility choices.

Claim 4 *Increases in the minimum wage decrease fertility. That is, $\frac{\partial n}{\partial p_m} < 0$.*

Proof Follows directly from differentiating (15) with respect to p_m .

The magnitude of the effects of the minimum wage on fertility are differential across the income distribution, but it is theoretically ambiguous whether the magnitude increases or decreases with income. We show below that, in our calibration, the richer households see the greatest decline in fertility. Notice that an increase in the minimum wage increases the mother's time allocated per child, but decreases overall fertility. Therefore, the net effect on labor supply is theoretically ambiguous. Again, we show that in our calibration, an increase in the minimum wage lowers female labor supply, and more so for high wage women.

5.2 Minimum wage: quantitative analysis

What are the effects of minimum wage changes on marketization? To answer this question, we first estimate the passthrough rate of the minimum wage to HPS sector wages by exploiting cross-state variation in the minimum wage over time. We show that the minimum wage has a strong impact on average wages of workers producing home production substitutes. We then use our estimates to conduct a policy experiment in the model by calculating a change in the price of these goods following an increase of the federal minimum wage to \$15/h, as suggested by Bernie Sanders during the 2016 presidential election. We ask the model how a change in p_m in line with this minimum wage increase would affect labor supply and fertility across the income distribution. We end with a further comparison of the model-implied labor elasticity with our own IV estimates based on US cross-state data.

Using CPS data from 1980–2010, we compute the real wage of workers in the industries of the economy associated with home production substitutes.³⁹ Figure 10 shows the distribution of the real wage, relative to the minimum wage, both for the industries of the economy associated with home production substitutes and other sectors of the economy. The figure clearly shows that workers in industries of the economy associated with home production substitutes are much more likely to earn wages that are close to the minimum wage.

In order to infer the effect of the minimum wage on the wages of home production substitute sector workers, we estimate regressions of the following structure:

$$w_{ist}^{\text{HPS}} = \alpha + \beta w_{st}^{\text{min}} + \gamma \bar{w}_{st} + \delta_{\text{below}} + \delta_t + \delta_s + \delta_{\text{age}} + \delta_{\text{educ}} + \delta_{\text{Hispan}} + \delta_{\text{race}} + \delta_{\text{occ}} + \epsilon_{ist}, \quad (21)$$

where w_{ist}^{HPS} is the real wage of individual i working in the HPS sector, in state s in year t , w_{st}^{min} is the real minimum wage in state s in year t . This is computed as the maximum between the state and the federal minimum wage.⁴⁰ \bar{w}_{st} is the average wage of workers outside of the HPS sector in year t and state s . This allows us to control for state level economic

³⁹ The selection of these industries follows Mazzolari and Ragusa (2013).

⁴⁰ The data source for the minimum wage by state and year is Vaghul and Zipperer (2016).

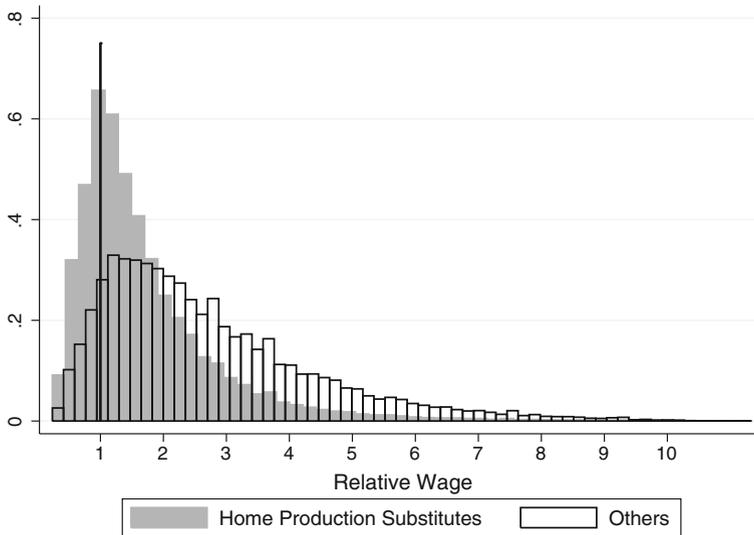


Fig. 10 Wage distribution notes: the distribution of real wages, relative to the effective real minimum wage in each state and year, by sector of the economy. Data from Current Population Survey, 1980–2010, using all workers. Home Production Substitute sector workers as defined in “Appendix A”

fluctuations that may affect wages in the HPS sector.⁴¹ δ_t , δ_s , δ_{age} , δ_{educ} , δ_{Hispan} , δ_{race} , and δ_{occ} are year dummies, state dummies, and demographic controls including age dummies, educational dummies, a dummy for being Hispanic, race dummies, and occupational dummies, respectively. δ_{below} is an indicator that is equal to one if that person is making at least the minimum wage and zero otherwise. We include this variable to control for the fact that there are many workers, roughly 30%, for whom the minimum wage does not seem to be binding. While we are not proposing a theory as to why these workers are paid less, we want to include them separately in our regression.⁴² ϵ_{ist} is an error term.

Estimating (21) using OLS may yield an upward biased estimate of β if states tend to raise the minimum wage during good economic conditions, when wages in general are rising. We take two approaches to address this issue. First, we estimate (21) including on the right hand side the average wage in state s and year t .⁴³ The idea is that if HPS sector workers’ wages have similar cyclicity as the rest of the workers in the economy, then the estimate of the relative wage implicitly controls for economic conditions. Second, we take an instrumental variables approach along the lines of Baskaya and Rubinstein (2012). The approach relies on two assumptions. The first is that the federal minimum wage is exogenous to local economic conditions, and therefore exempt from the critique above. However, whether or not the federal minimum wage binds is endogenous to the state. Accordingly, the second assumption is that the level of liberalism in the state determines how likely the federal minimum wage is to bind. Thus, our instrument for the minimum wage in state s and year t is the interaction between

⁴¹ Our results below show that this variable is not important quantitatively or statistically for our findings.

⁴² For example, about 9% of workers in this sector are in managerial occupations, of whom 90% earn wages above the minimum wage with an average of 2.5 times the minimum wage.

⁴³ We calculate this average wage without workers in the home production substitute sector in order to avoid the reflection problem (Manski 1993).

the federal minimum wage in year t and an index of state s liberalism from before the sample time period (Berry et al. 1998, 2010).⁴⁴

The coefficient of interest is β , which shows the dollar change in HPS sector wages when the minimum wage increases by a dollar. Table 3 reports the results of the estimation. Column 1 controls for year and state fixed effects and for having a wage that is below or above the minimum wage. Column 2 adds the state average of real wages. Column 3 repeats Column 1 but replaces year fixed effects with region-year fixed effects. Column 4 adds to Column 3 demographic controls. Column 5 adds to Column 4 the state average real wage. As can be seen by comparing these columns, the estimate of the impact of the minimum wage on the wages in the HPS sector is relatively stable, declining slightly only when adding the demographic controls. The OLS estimates thus imply that a \$1 increase in the minimum wage yields approximately a 65–77 cent increase in wages in the HPS sector. Columns 6–10 repeat Columns 1–5, but instruments for the effective minimum wage in the state using the interaction of state liberalism and the federal minimum wage as described above. The IV estimates indicate that a \$1 increase in the minimum wage yields approximately a 55–75 cent increase in HPS wages.⁴⁵

To calculate how a change in the minimum wage to \$15/h affects the average wage in the HPS sector in 2010, we proceed as follows. First, we calculate the average wage in the HPS sector. Then, we create a counterfactual wage for everyone. This wage is equal to the actual wage if the person earned less than the minimum wage. That is, we assume that people who earn less than the minimum wage are unaffected by changes in the minimum wage.⁴⁶ For everyone else, their counterfactual wage is equal to their old wage + (15–minimum wage)*0.58. That is, we increase their wages by the estimated β from Column 10, our most demanding specification in Table 3, multiplied by \$15 less the minimum wage in that individual's state in 2010. We then compare the average of this counterfactual wage to the average observed wage, and find it to be 21.1% higher. Using the price of m , as given by (17), along with the inferred parameter values described in Sect. 4, we find that a 21.1% increase in HPS wages would imply a 12.8% increase in p_m . Thus, for our exercise, we increase p_m by 12.8%. We focus on couples in the top half of the income distribution whose own wages are presumably unaffected by changes in the minimum wage.

The results are shown in Fig. 11. The top panel shows fertility under the higher minimum wage relative to the benchmark model fertility in 2010. The bottom panel shows the relative mother's time at home. A higher minimum wage decreases fertility, and more so for higher income households. It also increases mother's time at home, and more so for higher income households. The magnitudes are large. A 10th (5th) decile household decreases fertility by 12.1% (8.8%), while the mother spends 9.0% (2.4%) more time at home. Notice that these numbers are for women under the assumption that they can adjust fertility. What about those who are "locked in" their fertility choice? We recalculate changes in mother's time at home

⁴⁴ We use the average of their nominate measure of state government ideology from 1960–1980. The index of state liberalism has a range of 1–100, with more liberal states receiving a higher score, with an average (standard deviation) of 62.3 (11.3).

⁴⁵ We also estimated (21) in log–log specifications which follow Table 3. In all specifications we obtain estimates that are highly significant and approximately equal to 0.5, with no clear difference between the OLS and the 2SLS estimates. An elasticity of 0.5 would imply a somewhat larger effect of changing the minimum wage on p_m than the one implied by the level regressions reported in Table 3.

⁴⁶ We are unsure why a person in our sample is earning less than minimum wage. It could be that this is a result of misreported data, lack of enforcement of the minimum wage, or an uncovered sector (waiters). To be conservative, we assume these people are unaffected by the minimum wage. Had we assumed them to be affected, then the counterfactual wage estimated here would be even higher, yielding a greater estimated impact of the minimum wage on home production substitute sector wages.

Table 3 The effect of the minimum wage on the wage in industries associated with home production substitutes

	OLS					2SLS				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Minimum real wage	0.764*** (0.059)	0.771*** (0.053)	0.770*** (0.063)	0.665*** (0.058)	0.648*** (0.056)	0.747*** (0.169)	0.645*** (0.133)	0.550*** (0.267)	0.632*** (0.248)	0.582*** (0.247)
State FE	Yes									
Year FE	Yes	Yes	No	No	No	Yes	Yes	No	No	No
Region × year FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Average state wages	No	Yes	No	No	Yes	No	Yes	No	No	Yes
Demographic controls	No	No	No	Yes	Yes	No	No	No	Yes	Yes
1st stage <i>F</i> -statistic	–	–	–	–	–	16.47	15.90	26.72	26.93	26.08
Obs.	228,197	228,197	228,197	228,197	228,197	228,197	228,197	228,197	228,197	228,197
<i>R</i> ²	0.258	0.259	0.259	0.372	0.372	0.258	0.258	0.259	0.372	0.372

Standard errors in parentheses are clustered at the state level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Sample comprises workers in industries of the economy associated with home production substitutes for the years 1980 to 2010 using CPS data. Demographic controls include age fixed effects, education fixed effects, occupation fixed effects, Hispanic and race fixed effects. The instrument for Columns 6–10 is the interaction between average state liberalism between 1960 and 1980 and the real federal minimum wage

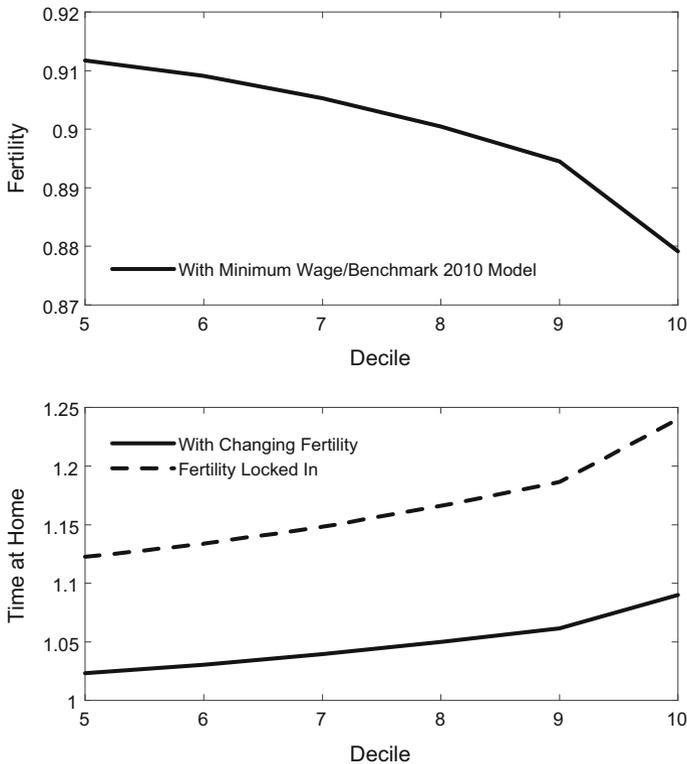


Fig. 11 Minimum wage: quantitative results. *Notes:* the top panel shows fertility (n) in the 2010 version of the model, with a \$15 minimum wage, divided by fertility in the benchmark 2010 model. The bottom panel shows mother's time at home (t_f) in the 2010 version of the model, with a \$15 minimum wage, divided by mother's time at home in the benchmark 2010 model. The curve "With Changing Fertility" reports this ratio when fertility is allowed to change with the increased minimum wage, while the curve "Fertility Locked In" reports this ratio when households are forced to maintain the same fertility rate as in the benchmark 2010 model

keeping the model's fertility fixed. A 10th decile mother increases time at home by 24.0%, while a 5th decile mother increases it by 12.3%. These numbers are larger as the family has not had a chance to scale back fertility. The short run effect on labor supply is also significant. The average reduction in labor supply by women in the 9th and 10th deciles is 3.25%. We find the elasticity of high income female labor supply with respect to the minimum wage to be roughly -0.1 in the model.

In order to verify this model prediction, we estimate directly from the data the effect of the minimum wage on the labor supply of high income women. Specifically, we estimate regressions of the following structure:

$$\log Hours_{ist} = \alpha + \beta \log w_{st}^{\min} + \delta_t + \delta_s + \delta_{age} + \delta_{educ} + \delta_{Ind} + \delta_{occ} + \epsilon_{ist}, \quad (22)$$

where $\log Hours_{ist}$ is the log of yearly hours supplied by woman i , living in state s , in year t . All other variables have already been described. Notice that β is the elasticity of labor supply with respect to the minimum wage. We use CPS data for the years 1980–2010. Our sample is comprised of white non-Hispanic married women aged 25–54, whose real hourly

wage is in the 9th or 10th decile in each five year age group, state, and year.⁴⁷ Again, as in the estimation of β in Eq. (21), estimating (22) with OLS might induce an upward bias if hours of high income women and the state minimum wage are procyclical. To overcome this issue we estimate (22) using 2SLS when, again, state s minimum wage in year t is instrumented with the interaction between the federal minimum wage in year t and an index of state s liberalism from before the sample period.

Table 4 reports estimates of β . Column 1 only controls for year and state fixed effects. Column 2 repeats column 1 but replaces year fixed effects with region-year fixed effects. Column 3 adds to Column 2 age and education fixed effects. Column 4 adds to Column 3 industry fixed effects, Column 5 replaces the industry fixed effects in Column 4 with occupation fixed effects. Finally, Column 6 includes both industry and occupation fixed effects. As can be seen from the table, all of the OLS estimates are very close to 0 and none are even remotely significant. Columns 7–12 repeat Columns 1–6, but instrument for the state minimum wage. All of the estimates are statistically significant and economically meaningful. They imply that the elasticity of labor supply of high income women with respect to the minimum wage is in the range of -0.66 to -0.41 . This empirical elasticity is thus larger than that of the model.

Finally, Table 5 repeats Table 4 for men. As can be seen from the table, all the OLS and the 2SLS estimates are close to 0 and none are even remotely significant. This is exactly what is expected under the assumption of traditional gender roles.

6 Sorting

In this section we discuss how marketization affects the endogenous incentives for marital sorting by education. Greenwood et al. (2016) show how a narrowing gender wage gap, rising skill premium, and technological improvement in home goods (cheaper marketization) lead to, among other things, a rise in sorting. The intuition is as follows. When the gender gap is narrow, women's wages are relatively more important for the household, increasing the desire for men to marry higher wage women. The same is true as the skill premium rises. More relevant for our story, they find that cheaper marketization leads to a rise in married women's labor force participation, which they argue is important for the desire to sort. "A skilled man is indifferent on economic grounds between a skilled and unskilled woman if neither of them works, assuming that skill doesn't affect a woman's production value at home. When both work, however, the skilled woman becomes the more attractive partner, at least from an economic point of view" (Greenwood et al. 2016, p. 35). Fertility is not discussed in Greenwood et al. (2016). However, if children comprise an additional benefit to marriage, the mechanism proposed in this paper would reinforce the mechanisms they study.

To see this point, consider a man who is choosing between two women, one with a high wage and the other with a low wage. In 1980, the man would face a tradeoff. The high wage woman would provide more income, and thus consumption, but at a cost of fewer children. In 2010, the high wage woman could marketize her time with children, such that there is no more tradeoff. That is, the man would not have to choose between high wages and a large family, yielding more of an incentive to marry a high wage woman. This argument is consistent with the fact that marriage outcomes for college educated women have improved

⁴⁷ We drop 1% of outlying observations, specifically those groups with top wages of less than 10.9 dollars per hour or more than 60 dollars per hour, measured in 1999 dollars.

Table 4 The effect of the minimum wage on the labor supply of high income women

	Dependent variable: log yearly hours											
	OLS						2SLS					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log min. wage	-0.032 (0.087)	-0.008 (0.069)	-0.022 (0.065)	0.038 (0.049)	0.021 (0.053)	0.039 (0.052)	-0.544*** (0.177)	-0.664*** (0.250)	-0.632*** (0.225)	-0.503*** (0.208)	-0.405* (0.217)	-0.429* (0.233)
Year FE	Yes	No	No	No	No	No	Yes	No	No	No	No	No
Region × year FE	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Education FE	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Industry FE	No	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
Occupation FE	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
1st stage <i>F</i> statistic	-	-	-	-	-	-	15.72	24.13	24.25	24.39	24.46	24.62
Obs.	85,506	85,506	85,506	85,506	85,506	85,506	85,506	85,506	85,506	85,506	85,506	85,506
<i>R</i> ²	0.013	0.015	0.047	0.256	0.291	0.310	0.012	0.014	0.046	0.255	0.291	0.309

Standard errors clustered at the state level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the log of yearly hours worked. Sample of White non-Hispanic married women aged 25–54, whose real hourly wage is in the 9th and 10th deciles. Women are assigned to hourly wage decile by state, year and 5-year age group

Table 5 The effect of the minimum wage on the labor supply of high income men

	Dependent variable: log yearly hours											
	OLS						2SLS					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Log min. wage	0.043 (0.034)	0.011 (0.031)	0.004 (0.028)	0.002 (0.026)	-0.009 (0.027)	-0.011 (0.027)	-0.118 (0.115)	-0.117 (0.149)	-0.036 (0.123)	0.031 (0.122)	-0.061 (0.122)	-0.032 (0.119)
Year FE	Yes	No	No	No	No	No	Yes	No	No	No	No	No
Region × year FE	No	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Age FE	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Education FE	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes
Industry FE	No	No	No	Yes	No	Yes	No	No	No	Yes	No	Yes
Occupation FE	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes
1st stage <i>F</i> statistic	-	-	-	-	-	-	15.27	25.10	25.18	25.42	25.32	25.63
Obs.	100,243	100,243	100,243	100,243	100,243	100,243	100,243	100,243	100,243	100,243	100,243	100,243
<i>R</i> ²	0.013	0.015	0.067	0.160	0.202	0.211	0.013	0.015	0.067	0.160	0.202	0.211

Standard errors clustered at the state level are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is the log of yearly hours worked. Sample of White non-Hispanic married men aged 25–54, whose real hourly wage is in the 9th and 10th deciles. Men are assigned to hourly wage decile by state, year and 5-year age group

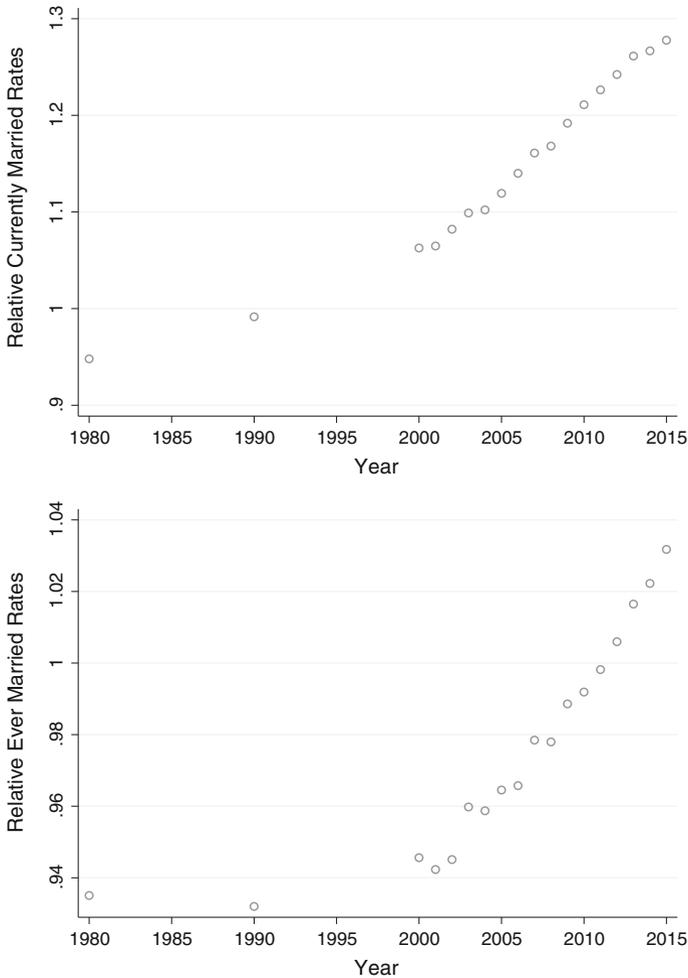


Fig. 12 Marriage markets. *Notes:* the top panel shows the fraction of women with at least a college degree who are currently married divided by the fraction of other women who are currently married. The bottom panel shows the fraction of women with at least a college degree who have ever been married divided by fraction of other women who have ever been married. The data is from the US census and ACS. The sample is comprised of white, non-Hispanic women ages 35–44

relative to non college educated women, measured by the fraction of those ever married or currently married (Fig. 12, for data on white non-Hispanic women, ages 35–44).

While these data are not conclusive, they are suggestive of a path for promising future research.

7 Conclusions

In this paper we have shown that the relationship between income and fertility has flattened between 1980 and 2010 in the US, a time of increasing inequality, as the rich increased

their fertility. These facts challenge the standard theory according to which rising inequality should steepen this relationship. We propose that marketization of parental time costs can explain the changing relationship between income and fertility. We show this result both theoretically and quantitatively, after disciplining the model on US data. When abstracting from changes in marketization, the model behaves according to standard theory, generating a drop in differential fertility contrary to what happened in the data. We discuss implications for college attainment.

We have used the calibrated model to shed new light on the effects of changes in the minimum wage. Specifically, we have shown that an increase in the minimum wage to \$15/h, as per Bernie Sanders, would imply an increase in the cost of market good substitutes for home production of about 13%. This increase would have a significant detrimental effect on the labor supply and fertility of women, whose own wages are not directly affected by the minimum wage increase. The response is higher for high wage women.

We ended with a discussion on the insights our theory offers for the literature of the economics of marital sorting.

A Data

We employ the 1980 Census and the American Community Survey (ACS) 2010 Ruggles et al. (2010) for measuring incomes, fertility and work hours of each spouse. Additionally, we use the National Longitudinal Study of Youth 1997 (NLSY 97) for measuring educational attainment of children born around 1980, by family income. Finally, we employ the Survey of Program Participation and Income for measuring childcare expenditure by family income. In this study, we focus on the growth of inequality between 1980 and 2010. These years are chosen to allow us to follow the cohort from the NLSY 97 (born around 1980) for measuring their educational attainment by their parental income, while still studying the period of rising income inequality as defined by Autor et al. (2008).

A.1 Mapping of model objects to the data

The mapping between the model and the data is not trivial. In the model, there is one period of adult life which aims to capture the entire working-age lifecycle. In the data, we observe choices of various couples of different age (fertility, work hours, etc) for a period of one year. To map the model to the data, we take the view that a model couple goes through its lifecycle by behaving according to the average age-specific behavior of those couples in the data that it represents.

There are ten types of couples in the model, each of measure 0.1. Each type of couple stands in for exactly 10% of the entire population of married couples of working age. Married couples in the data are allocated into these deciles according to their observed income. We do so based on the ranking of the couples' observed annual income in their group, defined by the wife's age.

From the 1980 Census and 2010 ACS data, we need to derive decile-specific empirical moments for household lifetime income, male lifetime income, male and female wages, male and female lifetime work hours, and couple's lifetime fertility, $I_{f,i}^{year}$, $I_{m,i}^{year}$, $w_{f,i}^{year}$, $w_{m,i}^{year}$, $hours_{f,i}^{year}$, n_i^{year} , $hours_m^{1980}$ for each decile $i \in [1, 2, \dots, 10]$ and $year = 1980, 2010$. We state income and hours moments in annualized terms and report wages in hourly terms. This is done for clarity.

We restrict attention to white non-Hispanic married couples, aged 25–55, with the husband working at least 35 h per week and at least 40 weeks per year, following Autor et al. (2008). We also drop the couples in the bottom and top 2% of the male income distribution.

All data couples assigned to a particular income decile are used to derive the average statistics for the model couple representing that decile. To compute the decile-specific lifetime income and hours moments for men, we first average the appropriate quantity within the decile-age cells. For each decile, we then sum across ages.

In the model, all men work full time throughout their life cycle, which is normalized to be 1. This corresponds to the average lifetime hours of full-time male workers in 1980, $hours_m^{1980}$ (~ 2300 h in annualized terms). We infer the data counterpart of $w_{m,i}^{year}$ as $I_{m,i}^{year} / hours_m^{1980}$. Note that the 1980 average hours are used to derive $w_{m,i}^{year}$ in each year. This method ensures that the observed variation of total male incomes across deciles and time will be fully reflected in the purchasing power of couples in the model.

Note that when we consider say a 37 year old woman in 1980 in a given decile, we observe her work hours, which partly reflect her number of children and their age distribution. Our goal here, however, is to derive average working hours for a *hypothetical* woman that experiences her lifecycle according to the cross-sectional profile. We need to proxy the hours each woman would work if she were to follow the 1980s cross-sectional fertility profile, not that of her own cohort. To this end, we regress female work hours in a given year on the actual age distribution of her children (i.e. number of children under 2, 2–3, 4–6, 7–10, 11–17), income decile and age dummies. We then predict the average adjusted female hours in each decile and for each age using the children's age distribution implied by the cross-sectional fertility profile. For each decile, we sum these average adjusted hours across age groups to obtain $hours_{f,i}^{year}$ and infer the data counterpart of time spent in home production $t_{f,i}^{year}$ as

$$1 - hours_{f,i}^{year} / hours_m^{1980}.$$

We infer the data counterpart of $w_{f,i}$ as $I_{f,i}^{year} / hours_{f,i}^{year}$ (about 2050h in annualized terms).⁴⁸ We infer the empirical counterpart of n_i as a decile-specific hybrid Total Fertility Rate (TFR), as in Shang and Weinberg (2013). We first compute the average age-specific-birth-rate, based on all women in decile i . We then sum across all ages to compute decile-specific TFR. To obtain decile-specific hybrid TFR, we add on the average lifetime fertility among the 25 year-old women in the appropriate decile.⁴⁹

We estimate college attainment for 1980 from NLSY97. Specifically, using the 2011 wave, we observe non-black non-Hispanic individuals, born between 1980 and 1982, and assign them into income deciles according to their parental household income in 1996. We assume that individuals with at least four years of college are college graduates. We measure college attainment π_i^{1980} as the fraction of children with a college degree among all children in the appropriate decile.

⁴⁸ Note that if instead we were to impute wages for non-working females via a Heckman procedure and then take average wages for each decile, our model would not be able to accurately match both female income and female hours. Both of these quantities are critical to our analysis.

⁴⁹ Why not include younger women in our analysis and use the standard measure of TFR? We model time allocation between work and home production, and therefore prefer to focus on couples that completed educational investments. Using the hybrid fertility measure then enables us to correctly account for the number of children.

Finally, we use the childcare module of the Survey of Program Participation and Income (SIPP) to estimate relative uses of market substitutes.⁵⁰ Our index measures are based off of expenditures on childcare hours purchased in the marketplace. Since this is only one aspect of marketization, we use this to target the relative use of marketization across deciles, rather than taking the absolute expenditure levels literally. The implicit assumption is that there is a strong correlation between the use of childcare and other market substitutes for parents' time. To calculate childcare expenditures across deciles, we break households into 5-year age groups from 25–30 until 50–55. Within each group, we divide households into deciles according to their income. We then sum the childcare expenditures for each decile over the lifecycle. The index is this measure relative to the expenditures on childcare used by decile 1. As before, our sample is married, white, non-Hispanic households.

References

- Aguiar, M., & Hurst, E. (2007). Life-cycle prices and production. *The American Economic Review*, 97(5), 1533–1559.
- Akbulut, R. (2011). Sectoral changes and the increase in women's labor force participation. *Macroeconomic Dynamics*, 15(2), 240–264.
- Attanasio, O., Hurst, E., & Pistaferri, L. (2012). The evolution of income, consumption, and leisure inequality in the us, 1980–2010. NBER WP 17982.
- Attanasio, O., Low, H., & Sanchez-Marcos, V. (2008). Explaining changes in female labour supply in a life-cycle model. *The American Economic Review*, 98(4), 1517–1552.
- Autor, D. H., Katz, L. F., & Kearney, M. S. (2008). Trends in u.s. wage inequality: Revising the revisionists. *Review of Economics and Statistics*, 90, 300–323.
- Bar, M., & Leukhina, O. (2009). To work or not to work: Did tax reforms affect labor force participation of married couples? *The B.E. Journal of Macroeconomics (Contributions)*, 9(1), 1–28.
- Baskaya, Y. S. & Rubinstein, Y. (2012). Using federal minimum wages to identify the impact of minimum wages on employment and earnings across the u.s. states. (Unpublished Manuscript).
- Becker, G. S., & Lewis, G. H. (1973). On the interaction between the quantity and quality of children. *Journal of Political Economy*, 81, S279–S288.
- Becker, G. S., & Tomes, N. (1976). Child endowments and the quantity and quality of children. *Journal of Political Economy*, 84, S143–S162.
- Berry, W. D., Fording, R. C., Ringquist, E. J., Hanson, R. L., & Klarner, C. (2010). Measuring citizen and government ideology in the american states: A re-appraisal. *State Politics and Policy Quarterly*, 10, 117–135.
- Berry, W. D., Ringquist, E. J., Fording, R. C., & Hanson, R. L. (1998). Measuring citizen and government ideology in the american states, 1960–93. *American Journal of Political Science*, 42, 327–348.
- Buera, F. J., Kaboski, J. P., & Zhao, M. Q. (2013). The rise of services: The role of skills, scale, and female labor supply (No. w19372). *National Bureau of Economic Research*. <https://doi.org/10.3386/w19372>.
- Cerina, F., Moro, A. & Rendall, M. (2018). The role of gender in employment polarization (Unpublished Manuscript).
- Cortés, P., & Pan, J. (2013). Household production: Foreign domestic workers and native labor supply in hong kong. *Journal of Labor Economics*, 31(2), 327–371.
- Cortés, P., & Pan, J. (Forthcoming). When time binds: Substitutes to household production, returns to working long hours and the gender wage gap among the highly skilled, *Journal of Labor Economics*. <https://doi.org/10.1086/700185>.
- Cortés, P., & Tessada, J. (2011). Low-skilled immigration and the labor supply of highly skilled women. *American Economic Journal: Applied Economics*, 3(1), 88–123.
- de la Croix, D., & Doepke, M. (2003). Inequality and growth: Why differential fertility matters. *The American Economic Review*, 93(4), 1091–1113.
- de la Croix, D., & Doepke, M. (2004). Public versus private education when differential fertility matters. *Journal of Development Economics*, 73, 607–629.

⁵⁰ We use the 1990 childcare module as a proxy for the 1980 index of marketization, as this is the earliest available data. We use the 2008 module to derive the 2010 index.

- Doepke, M. (2004). Accounting for fertility decline during the transition to growth. *Journal of Economic Growth*, 9(3), 347–383.
- Doepke, M., & Kindermann, F. (2016). *Bargaining over babies: Theory, evidence, and policy implications*. NBER Working Paper w22072.
- Duernecker, G., & Herrendorf, B. (2018). On the allocation of time—A quantitative analysis of the roles of taxes and productivities. *European Economic Review*, 102, 169–187.
- Furtado, D. (2016). Fertility responses of high-skilled native women to immigrant inflows. *Demography*, 53, 27–53.
- Galor, O., & Moav, O. (2002). Natural selection and the origin of economic growth. *Quarterly Journal of Economics*, 117(4), 1133–1191.
- Galor, O., & Weil, D. N. (1996). The gender gap, fertility, and growth. *The American Economic Review*, 86(3), 374–387.
- Galor, O., & Weil, D. N. (2000). Population, technology, and growth: From malthusian stagnation to the demographic transition and beyond. *The American Economic Review*, 90(4), 806–828.
- Gobbi, P. (2018). Childcare and commitment within households. *Journal of Economic Theory*, 176, 503–551.
- Greenwood, J., Guner, N., Kocharkov, G., & Santos, C. (2016). Technology and the changing family. *American Economic Journal: Macroeconomics*, 8(1), 1–41.
- Greenwood, J., Guner, N., & Vandenbroucke, G. (2017). Family economics writ large. *Journal of Economic Literature*, 55(4), 1346–1434.
- Greenwood, J., Seshadri, A., & Vandenbroucke, G. (2005). The baby boom and baby bust. *The American Economic Review*, 95(1), 183–207.
- Greenwood, J., Seshadri, A., & Yorukoglu, M. (2005). Engines of liberation. *Review of Economic Studies*, 72(1), 109–133.
- Guner, N., Kaygusuz, R., & Ventura, G. (2012). Taxation and household labour supply. *The Review of Economic Studies*, 79, 1113–1149.
- Hazan, M., & Zoabi, H. (2015). Do highly educated women choose smaller families? *The Economic Journal*, 125(587), 1191–1226.
- Heathcote, J., Perri, F., & Violante, G. (2010). Unequal we stand: An empirical analysis of economic inequality in the united states 1967–2006. *Review of Economic Dynamics*, 13(1), 15–50.
- Jones, L. E., Schoonbroodt, A., & Tertilt, M. (2010). Fertility theories: Can they explain the negative fertility–income relationship? In J. Shoven (Ed.), *Demography and the economy* (pp. 43–100). Chicago: University of Chicago Press.
- Jones, L. E., & Tertilt, M. (2008). An economic history of fertility in the u.s.: 1826–1960. In P. Rupert (Ed.), *Frontiers of family economics* (pp. 165–230). Bradford: Emerald.
- Kaygusuz, R. (2010). Taxes and female labor supply. *Review of Economic Dynamics*, 13, 725–741.
- Lino, M., Kuczynski, K., Rodriguez, N., & Schap, T. (2017). *Expenditures on children by families, 2015*. United States Department of Agriculture, Technical report.
- Manning, A. (2016). *The elusive employment of the minimum wage*. CEP discussion paper no 1428.
- Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The Review of Economic Studies*, 60(3), 531–542.
- Mazzolari, F., & Ragusa, G. (2013). Spillovers from high-skill consumption to low-skill labor markets. *The Review of Economics and Statistics*, 95(1), 74–86.
- Moav, O. (2005). Cheap children and the persistence of poverty. *The Economic Journal*, 115(500), 88–110.
- Rendall, M. (2018). Female market work, tax regimes, and the rise of the service sector. *Review of Economic Dynamics*, 28, 269–289.
- Ruggles, S. J., Alexander, T., Genadek, K., Goeken, R., Schroeder, M. B., & Sobek, M. (2010). *Integrated public use microdata series: Version 5.0 [Machine-readable database]*. Minneapolis, MN.
- Sato, K. (1967). A two-level constant elasticity of substitution production function. *The Review of Economic Studies*, 34(2), 201–218.
- Shang, Q., & Weinberg, B. A. (2013). Opting for families: Recent trends in the fertility of highly educated women. *Journal of Population Economics*, 26(1), 5–32.
- Siegel, C. (2017). Female relative wages, household specialization and fertility. *Review of Economic Dynamics*, 24, 152–174.
- Vaghul, K., & Zipperer, B. (2016). *Historical state and sub-state minimum wage data*. Washington: Washington Center for Equitable Growth.
- Vogl, T. (2016). Differential fertility, human capital, and development. *Review of Economic Studies*, 83(1), 365–401.

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