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Inequality and the Changing Role of Differential Fertility

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Abstract

Recent public discussion has focused on inequality and its adverse effects on economic growth. One theory is that inequality causes greater differential fertility; the difference in fertility between the poor and rich. Differential fertility yields fewer educated children, as the poor invest less in their numerous children. We show 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. 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. Without marketization the model yields a quantitatively significant biased estimate of inequality's impact on education through differential fertility. Policies, such as the minimum wage, that affect the cost of marketization, have a large effect on the fertility and labor supply of *high* income women. We apply the insights of this theory to the literatures of the economics of childlessness and marital sorting.

Keywords: Income Inequality, Marketization, Differential Fertility, Human Capital, Economic Growth.

JEL Classification Numbers: E24, J13, J24, O40.

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1 Introduction

Public discussion in recent years has focused on income inequality and its adverse effects on economic growth.[1] The rise in inequality has been dramatic.[2] Theoretical papers have proposed mechanisms by which inequality may be either conducive or detrimental for growth, while the empirical literature has yet to come to a consensus on the sign and magnitude of the effects of inequality.[3] There are a variety of mechanisms through which inequality may influence growth. One prominent theory, appearing in de la Croix and Doepke (2003) and Moav (2005), works through the effects of inequality on differential fertility, i.e. the gap in fertility between the poor and rich households. The consensus in the literature has been that rising inequality would lead to more differential fertility, at least after the demographic transition (Vogl 2016), and thus a lower rate of human capital accumulation. Hereafter, we refer to this mechanism as the standard theory. However, between 1980 and 2010, the period that experienced the most dramatic rise in inequality, the empirical relationship between family income and fertility substantially flattened and slightly reversed for the upper half of the income distribution (see Figures 1, 2, and 3). We propose and quantify a channel, namely, marketization, through which an increase in inequality may deliver the observed change in the differential fertility pattern, thereby positively impacting economic growth.

One of the central determinants of fertility emphasized in the literature is the opportunity cost of women's time in raising the children, which is higher for higher income women.[4] The notion we are advancing in this paper is that greater inequality makes it easier for wealthier women to purchase substitutes for their home production (i.e. childcare and housekeeping) in the marketplace. That is, higher income women marketize the time costs of childcare, negating the op-

[1] See, for instance, Obama (2013), Krueger (2012), among others.

[2] See Katz and Murphy (1992), Autor, Katz and Kearney (2008), and Heathcote, Perri and Violante (2010).

[3] The literature on inequality and growth is too vast and diverse to survey here. For an excellent collection of articles on this topic, see Galor, ed (2009).

[4] See Becker (1960), Ben-Porath (1973), Galor and Weil (1996) and Voigtländer and Voth (2013), among others.

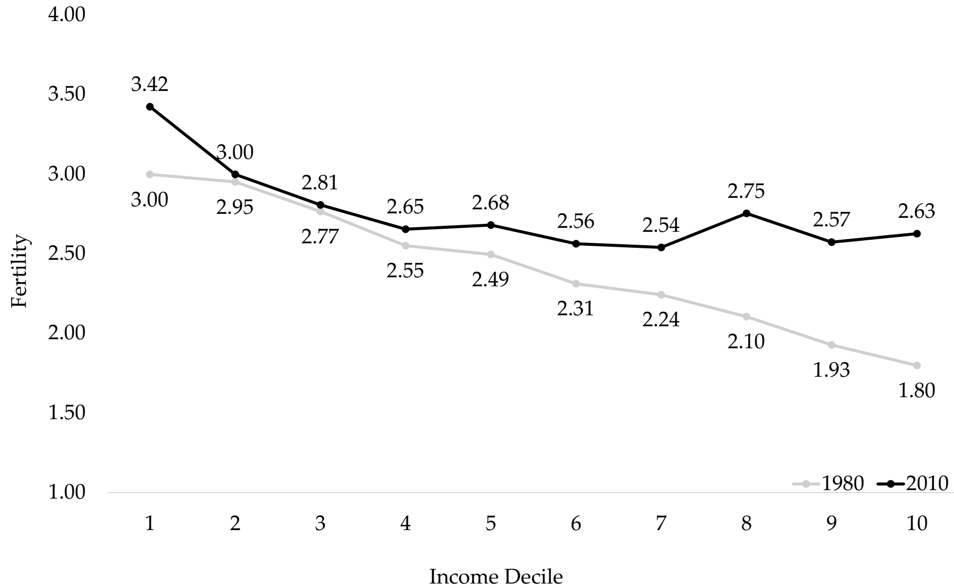


Figure 1: Fertility by Income Decile 1980 & 2010. Authors calculations using Census and American Community Survey Data. See Appendix A for more details.

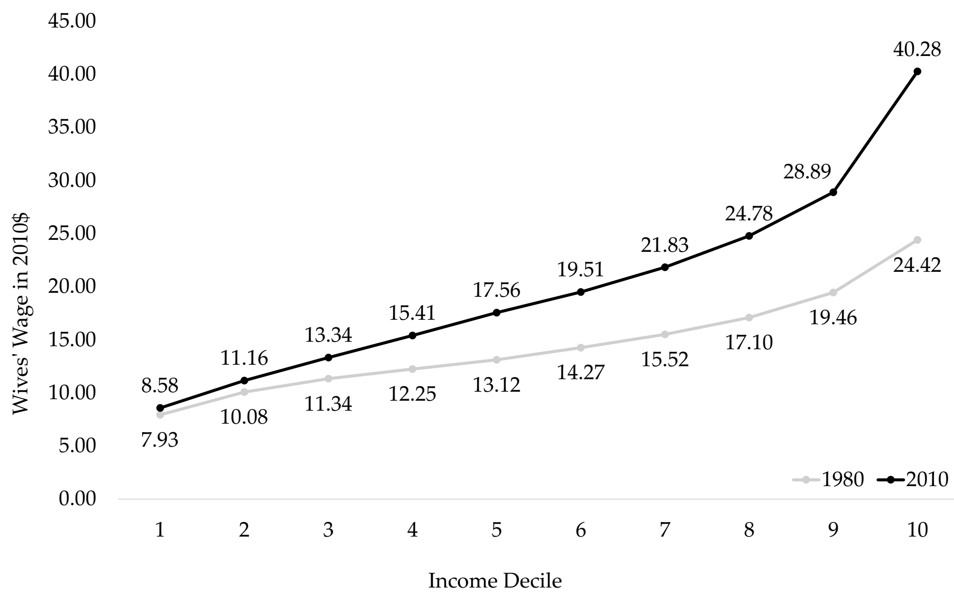


Figure 2: Wives' Wage by Income Decile 1980 & 2010. Authors calculations using Census and American Community Survey Data. See Appendix A for more details.

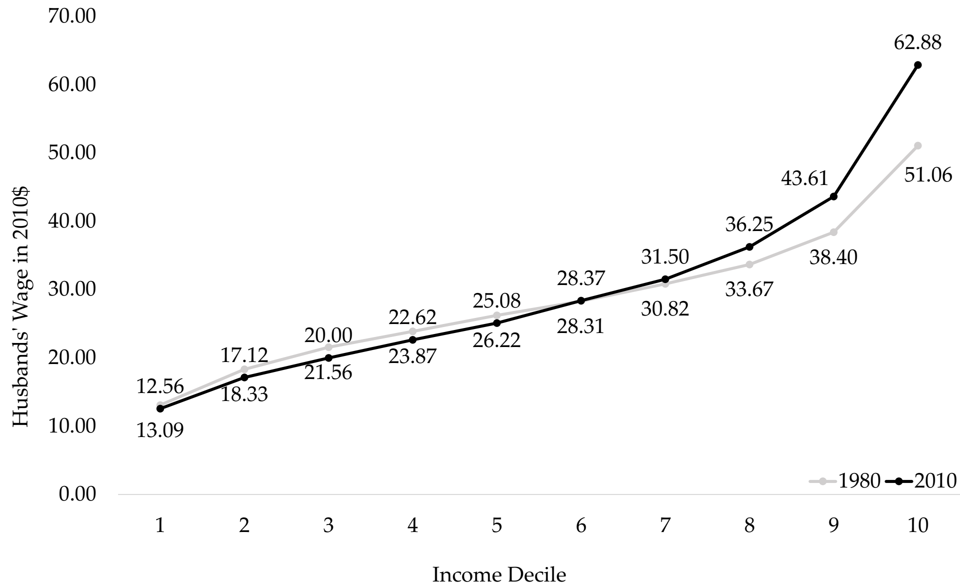


Figure 3: Husbands' Wage by Income Decile 1980 & 2010. Authors calculations using Census and American Community Survey Data. See Appendix A for more details.

portunity cost of the childcare time. Figure 1 shows that most of the changes in fertility between 1980 and 2010 happened among high income women. The theory we just described suggests that these women should increase their fertility when inequality, as measured by their wage relative to the price of home production substitutes, increases. Empirically, this pattern can be seen in the US cross state time series. Figure 4 shows that states that have seen greater changes in inequality between 1980 and 2010, as defined by the percent change in the relative wage of high income women to workers in the home production substitute sector, have seen a greater percent increase in fertility of these women. This supports the notion that, where market substitutes are relatively cheap (as measured by the wage of their workers), high income women have more children. The slope of the curve in Figure 4 suggests that a one standard deviation increase in this measure of changes in inequality accounts for 0.4 of a standard deviation in the change of high income women's fertility. Additionally, Furtado (2016) finds that an increase in unskilled migration lowers wages in the childcare services sector, and increases both fertility and labor supply. Interestingly, she finds the effect

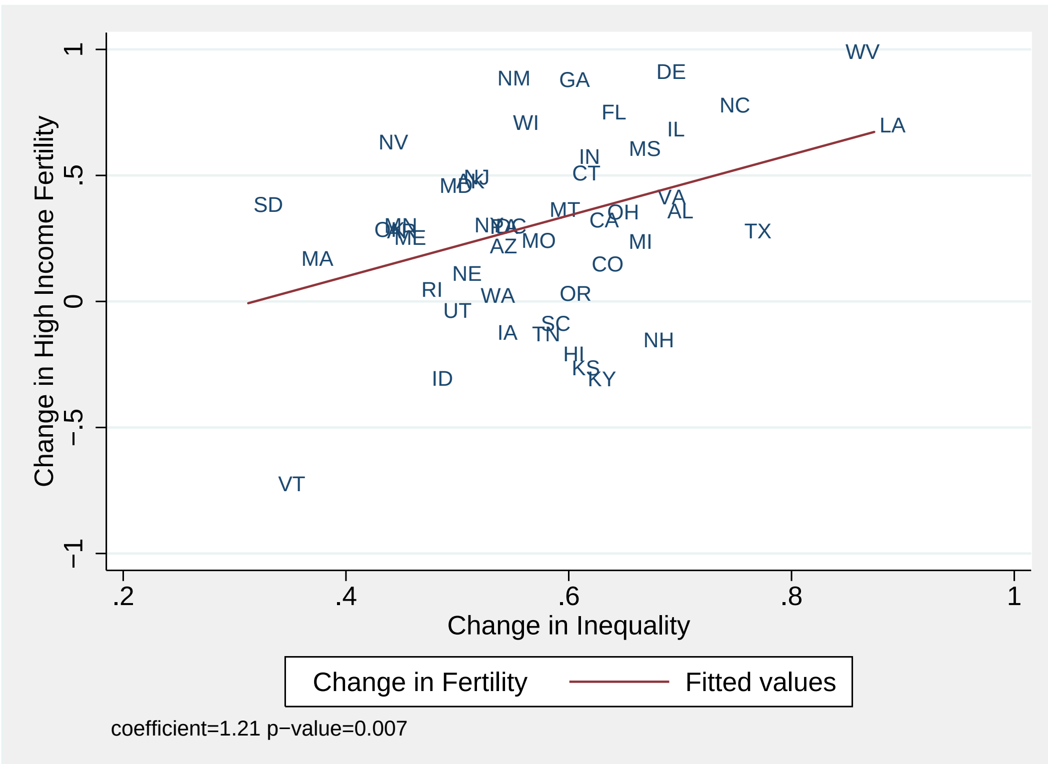


Figure 4: The change in inequality at the state level is defined as the percent change in the ratio of the average wage of women in the top two deciles to the average wage in the home production substitute sector. The change in fertility is defined as the percentage change in hybrid fertility rates for the top two decile women. See Appendix A for more details on the exact definition of these variables.

to be differential. Native women with a graduate degree increase their labor supply and fertility much more than native women with just a college degree. While the importance of marketization of home production has been widely recognized (e.g. Greenwood, Seshadri and Vandenbroucke 2005a, Greenwood, Seshadri and Yorukoglu 2005b), the consequences of rising inequality on differential fertility in the presence of the possibility to outsource home production have not been widely studied.[5]

To motivate our analysis, we perform a back-of-the-envelope calculation as to the effects of changing differential fertility on college attainment. To do so, we fix the 1980 cross-sectional relationship between the decile of family income and college attainment rates of children born in 1980.[6] We then use the cross-sectional relationship between the decile of family income and fertility, observed in 2010, to infer the counterfactual college attainment for the 1980 cohort. We find that the effects of changing differential fertility pattern imply a 1.7 percentage point increase in aggregate college attainment rates. It follows that, if an increase in inequality is responsible for the emergent differential fertility pattern, it may also lead to more college attainment. Throughout our analysis, we take the approach of analyzing the effects of changes in differential fertility on future generation's human capital by taking the empirical relationship between parent's income decile in 1980 and the fraction of their children who graduated college. The reason to do so is two-fold. First, we do not have data as to the fraction of children born in 2010 who will graduate college, as they are still quite young. Second, holding constant the relationship between income and college attainment rates allows us to abstract from changes in this profile when examining how changes in differential fertility affect college attainment rates.[7]

We take the 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

[5]One exception is Hazan and Zoabi (2015), who document a flattening of fertility by mother's education class, due to rising fertility rates among highly educated women. They qualitatively study a similar model to the one presented here, but do not do any quantitative analysis.

[6]The college attainment rates by parents' income decile are calculated based on the NLSY97 cohort study. See Appendix A for details.

[7]For instance, this approach allows us to abstract from how changes in college tuition costs and returns to college affect the relationship between parent's income and the education of their children. We discuss this more in Appendix C.

(2003) and Moav (2005), and analyze it under the assumption that the cost of children can be marketized. We show theoretically that the implication of this one assumption for the effects of inequality on differential fertility, and thus human capital, is crucial. Additionally, we differentiate between mothers and fathers, and discuss the implications of whether or not men face a time cost of children. In particular, if men do not face a time cost of children, then the standard theory would suggest that growing inequality among men would lead to a flattening, or even rising, relationship between income and fertility, as children are a normal good. We use the assumption that men do not face a time cost of children, which gives the standrard model the best possible chance to match the data. Thus, our approach in the quantitative analysis is conservative.

Turning towards our quantitative analysis, we calibrate the model to the US in both 1980, when fertility and income had a negative relationship, and 2010, when the relationship had become U-shaped. In the model, we allow for wages to change between 1980 and 2010, as observed in the data, for the price of home production substitutes to decline (Greenwood et al. 2005b), and for the technology of raising children to improve. We discipline the model by matching the salient features of cross-sectional US data in 1980 and 2010. Namely, we match fertility rates, mother's labor supply, the relationship between parents' income and child's college attainment rates, and an index of marketization.[8] We show that changes in male income can explain at most half of the increase in college attainment due to different fertility over time, conservatively attributing more than half of the rise in college attainment due to differential fertility on increased marketization.

How important is it to include marketization in the model? To answer this question, we simulate the model under the counterfactual assumption that home production substitutes did not become relatively cheaper. We find college attainment rates would have *decreased* by 1.15 percentage points. That is, a naïve modeler, working in 1980 under the view of the standard literature, which does not allow for marketization, would have predicted a significant decline in college attainment rates over time if (s)he had been given perfect foresight over actual income

[8]The index of marketization is a measure of the relative use of market substitutes for parental time with children, as described in Appendix A.

distributions. Adding this counterfactual decrease implied by the standard theory to the increase seen in the data, the bias from not including marketization is a little under 3 percentage points of college attainment. To get a sense of how large this is quantitatively, we estimate that 27% of the white non-Hispanic non-immigrant Americans born in 1950 completed college by age 30. The corresponding estimate for the cohort born in 1980 is 37.9%. Thus, differential fertility impact on education is comparable to more than one-quarter of the general rise in education between these two cohorts. The bias induced by ignoring marketization is both quantitatively large and changes the sign of the estimated implications of inequality on education through differential fertility.

One implication of our theory is that anything affecting the price of marketization should have an effect on the labor supply of women, especially high income women, and their fertility. We show this formally in the model. One policy that may affect the price of marketization is the minimum wage. Indeed, we show that a disproportionately large number of workers in home production substitute sectors receive the minimum wage.[9] Using cross state time series variation in the minimum wage from 1980–2010, we show that the minimum wage has a significant effect on the wages of these workers, suggesting indeed that the minimum wage may have a strong impact on the price of home production substitutes. Standard OLS estimates of the effect of minimum wage laws on wages may be biased due to the endogeneity of the minimum wage; states tend to raise the minimum wage during good economic times. To address this issue, we take an instrumental variables approach, along the lines of Baskaya and Rubinstein (2012). Accordingly, we instrument for the state effective minimum wage with the federal minimum wage interacted with a measure of state liberalism. Indeed, our IV estimates of the impact of the minimum wage on the wages of home production substitute sector workers is somewhat lower than the OLS estimates, which suggests that the endogeneity of the minimum wage is not a first order concern for this particular empirical exercise. Our IV estimates are both statistically significant and economically meaningful, with an estimated effect of about 58 cents in higher wages for every dollar increase in a state's minimum wage.

[9] We define these sectors as in Mazzolari and Ragusa (2013).

We perform a counterfactual experiment in the model, asking what the effects of a rise of the minimum wage to $15/hour, as per Bernie Sanders, would have on labor supply, fertility, and the education of the next generation. Women reduce their labor supply and fertility, as marketizing becomes more difficult. We find this effect to be large and differential, with high income women responding much more than lower income women to the change in price. Specifically we find the the elasticity of labor supply of women in the 9th and 10th deciles with respect to the minimum wage is -0.27.[10] We confirm this by estimating this elasticity using cross state time series variation in the minimum wage from 1980–2010 and the instrumental variable approach as discussed above. Our estimated elasticities are less than one-standard error apart from the one implied by the model.

The negative relationship between income and fertility persisted for so long that its existence is taken for granted in the literature (Jones and Tertilt 2008).[11] We discuss how including marketization in the standard theory influences the analysis of two important phenomena. Specifically, we expand on the analysis of Baudin, de la Croix and Gobbi (2015), who find that highly educated women are more likely to be childless and attribute this fact towards the opportunity cost of raising children. We show that between 1990 and 2014, childlessness rates of highly educated women have decreased from more than 15% to less than 10%. In contrast, childlessness rates of less educated women has been fairly constant, fluctuating at around 10%. This is consistent with lower relative costs of marketization for women who gain the most of the rising in inequality. Finally, we discuss how marketization and differential fertility can affect the incentives to sort, complementing the mechanisms in the literature (Greenwood, Guner, Kocharkov and Santos 2016).[12]

[10] 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.

[11] The negative relationship between income and fertility that has prevailed at least since the 19th century until recently has been typically explained by either a quantity-quality trade off, an opportunity cost of parental time, or both. Some of the many examples include Becker and Lewis (1973), Galor and Weil (1996), and Galor and Weil (2000), Doepke (2004).

[12] For a survey of the family macroeconomics literature, see Greenwood, Guner and Vandenbroucke (2017).

We continue as follows. Section 2 describes the theoretical framework of our analysis. Section 3 provides details on the parameterization of the model, along with quantitative results. Section 4 analyzes the effects of the minimum wage on labor supply and fertility through the lens of the calibrated model. Section 5 discusses implications of marketization on the literatures on childlessness and sorting. We conclude in Section 6.

2 Model

2.1 Setup

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 (income per child). This approach is as in Galor and Weil (2000) and Moav (2005). The income per child is uncertain, and given by

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

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:

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

We assume that parents maximize their expected utility:

$$E[u] = \ln(c) + \alpha \ln(n) + \tilde{\beta} \ln(w_{nc}) + \tilde{\beta} \ln(\omega)\, \pi(e).^{13} \tag{3}$$

[13] Notice that this formulation assumes that all siblings in a family have the same realization of college attainment uncertainty.

Notice that the non-college income appears in the utility as a constant, and does not affect the household's decisions.

We assume that π takes the form of:

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

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. Notice that plugging (4) into (3) and dropping the constant term, $\tilde{\beta}\ln(w_{nc})$, yields:

$$u = \ln(c) + \alpha\ln(n) + \beta\ln\left(b(e+\eta)^{\theta}\right), \tag{5}$$

where $\beta = \tilde{\beta}\ln(\omega)$, which is exactly the objective function used in de la Croix and Doepke (2003) and Moav (2005).[14] 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:

$$c + TC(n) + p_e e n = w_f + w_m, \tag{6}$$

where $TC(n)$, defined below, represents the cost associated with producing n kids, and p_e is the exogenously given price of a unit of education. Our cost functions, $TC(n)$ will be linear in n, such that we can write $TC(n) = p_n n$, where p_n is the marginal cost of quantity.

Using (5) and (6) to solve for the utility maximization problem gives the following optimal solutions for e and n:[15]

$$e^* = \max\left\{\frac{\frac{p_n}{p_e}\frac{\beta\theta}{\alpha} - \eta}{1-\frac{\beta\theta}{\alpha}}, 0\right\}, \tag{7}$$

[14]To be precise, this is the exact objective function in de la Croix and Doepke (2003) when $\alpha = \beta$. Allowing β to differ from α does not change any of the qualitative results.

[15]We show the existence of a unique solution to the household problem in Appendix B.1.

$$n^* = \begin{cases} \left(1 - \frac{\beta\theta}{\alpha}\right)\left(\frac{\alpha}{1+\alpha}\right)\left(\frac{w_f + w_m}{p_n - \eta p_e}\right) & if \;\; e^* > 0 \\ \frac{\alpha}{1+\alpha}\left(\frac{w_f + w_m}{p_n}\right) & if \;\; e^* = 0 \end{cases} \tag{8}$$

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 market substitutes for home production, m, according to:

$$n = A\left(\phi t_f^{\rho} + (1-\phi)\, m^{\rho}\right)^{\frac{1}{\rho}}, \tag{9}$$

where $0 < \phi < 1$ controls the relative importance of mothers' time in the production of children, $\rho \leqslant 1$ controls the elasticity of substitution between the mother's and home production substitutes, and A determines the total factor productivity (TFP) of child production.

Given a level of fertility, n, $TC(n)$ is the solution to the cost minimization problem given by:

$$\begin{aligned} TC(n) &= \min_{t_f, m} t_f \cdot w_f + m \cdot p_m \qquad (10) \\ \text{s.t.} & \\ n &= A\left(\phi t_f^{\rho} + (1-\phi)\, m^{\rho}\right)^{\frac{1}{\rho}}, \end{aligned}$$

where p_m is the price of the market substitutes.

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

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

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

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

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, inequality may lead to higher levels of average human capital in the next generation through differential fertility.*

Importantly, n^* is U-shaped in w. We show this formally in Appendix B.2. The implication of the U shape is striking. When wage dispersion rises, differential fertility could change in either direction; there could be relative 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. Under the latter case, rising inequality leads to higher levels of human capital in the subsequent generations through differential fertility.

We show in Figures 1, 2, and 3 that, empirically, rising inequality was associated with an increase in fertility among richer households between 1980 and 2010. This is due to the fact that the relationship between income and fertility was negative in 1980, and became U-shaped in 2010. Moreover, we show in Figure 4 that richer households increased their fertility more in states that experienced larger increases in income inequality. We then show in Section 3.3 that the model with marketization can account for relationship between income and fertility both in 1980 and 2010. Accordingly, rising inequality, through marketization, led to differential fertility favoring more children in richer households and thus more human capital. Counterfactuals show that abstracting from marketization would yield both the opposite result, and quantitatively meaningful differences in estimates of the effects of inequality on human capital through differential fertility.

2.2 What Are Men?

Our interest is in how rising inequality affects differential fertility through marketization of parents time. Implicitly, any model of endogenous fertility must take a stand on which (if either) parent is spending time with the children. Thus, we now turn to the issue of "What are Men?" and make two points. First, under traditional gender roles, where men did not spend time in child care, a rise of inequality could yield a positive relationship between income and fertility, regardless of a family's ability to marketize. We then show that this is less likely to be the case under modern gender roles, where men do spend time in childcare. We conclude that, for the purposes of our quantitative exercise undertaken in Section 3, the assumption of traditional gender roles is conservative, as explained below.

2.2.1 Traditional Gender Roles

Under traditional gender roles, men do not spend time in child care. When including men in the model, they therefore would turn up as strictly an income effect. That is, richer men have more children. This view is expressed in Galor and Weil (1996).

Formally, we say that there are "traditional gender roles" if the solution to fertility takes the form of (8) and p_n is independent of w_m. Men's wages under traditional gender roles act as any other form of wealth; they are simply an income effect. Higher male wages yields more fertility, as can be seen directly in (8).

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. To see this point, imagine that there is perfect sorting between men and women, such that high wage women are matched with high wage men. If there is an increase in the dispersion of male wages, then high income households become wealthier and have more children, while the opposite happens for poorer households. An increase in inequality could therefore lead to a flattening of the income-fertility profile, or a U-shape as seen in the data, or even an upward sloping profile.

2.2.2 Modern Gender Roles

Under modern gender roles, 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.[16] 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.

Under this assumption, men are required to spend one hour of time in child care for every hour that their wife spends in child care. In this model 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 imperfect substitutes in the production of children (Siegel 2017).

2.2.3 What Does This Mean For Us?

Implicitly, the standard theory must have been assuming something along the lines of modern gender roles, or they might not have gotten the result that rising inequality leads to a steeper income-fertility profile. We take the opposite approach and assume traditional gender roles.

This is a conservative assumption; there was a rise in marital sorting and inequality over our sample time period (Greenwood, Guner, Kocharkov and Santos 2014). Rising inequality could have led to richer families having more children simply because the man was earning more money, and not bearing a time cost of children. Allowing this mechanism in the model is therefore conservative; we give other mechanisms related to inequality, besides marketization, the best chance to explain the emergence of the u-shape. We expand on this discussion in Section 5.

[16] For an analysis on how parents allocate time to childcare, see Gobbi (2016).

3 Quantitative Exercise

In this section, we discuss the calibration of the model, the model fit, and breakdown the mechanisms driving changing fertility patterns over time. We fit the model to 1980 and 2010, allowing for three things to change. First, we feed in exogenously the wage changes observed in the data. Second, we allow the price of market substitutes to change (Greenwood et al. 2005b). Third, we allow for a neutral technological change in the production of children, A, over time. We begin by discussing the parameterization of the model, followed by the model fit, and then break down quantitatively the various forces at work.

3.1 Parameterization

This model has 12 parameters, $\Omega \equiv \{\alpha, \beta, \theta, b, \eta, \phi, \rho, p_e, A_{1980}, A_{2010}, p_{m,1980}, p_{m,2010}\}$. We now describe how we pick these parameter values, which are reported in Table 1.

p_e and $p_{m,1980}$ are normalized to one without loss of generality.[17] The remaining 10 parameters are picked to match model moments to data moments. In particular, we match the profile of fertility, by decile, in 1980 and 2010, the profile of mother's time at home in 1980 and 2010, the profile of college attainment in 1980, and the index of relative expenditures on home good substitutes in 1980 and 2010.[18] See Appendix A for a description of the empirical moments. Each profile contains 10 moments yielding 70 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 a best fit.

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

[17] We show this formally in Appendix D.

[18] Data is not available for the 2010 cohort on college attainment rates, as the children have yet to finish elementary school.

function:

$$\{\alpha, \beta, \theta, b, \eta, \phi, \rho, A_{1980}, A_{2010}, p_{m,2010}\} = \arg\min \sum_i \left(\frac{M_i(\Omega) - D_i}{D_i} \right)^2, \qquad (14)$$

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 10 parameters are picked together, certain moments inform on them more than others. At 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, η, and $p_{m,2010}$, which are picked to match fertility rates by decile in both 1980 and 2010. η is equivalent to a lump sum transfer to families with the value ηp_e. Changes in the value of this transfer relative to other household income sources should show up in shifts in the level of the fertility profile. Additionally, α can be identified by the slope of the profile of fertility in 1980. Lower prices of home production substitutes, $p_{m,2010}$, raise fertility rates in 2010, differentially by decile. Thus, together, these three parameters are identified off of the fertility profiles.

We next turn to β, θ and b, as these parameters are closely related to education, and indirectly related to the quantity-quality tradeoff in the model. Beginning with β and θ, these two parameters are almost inseparable. Indeed, when simply looking at their role in the utility function, they are completely inseparable as $\beta \ln(b(e+\eta)^\theta) = \theta\beta \ln(b(e+\eta))$. However, θ affects the mapping between education expenditures, e, and college attainment, $\pi(e)$, while β does not. β can therefore be thought of as being identified off of the changing quantity-quality tradeoff between 1980 and 2010, as represented by the change in the slope of the fertility profile, while θ is used to get the slope of the profile of college attainment by decile. As seen in Equations (7) and (8) 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.

Our final four internally calibrated parameters are ϕ, ρ, A_{1980} and A_{2010}. 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_{1980} controls how much resources are needed for childcare, in particular the amount of time mothers spend with their children in 1980. These three parameters are thus identified off both the level and slope of the profile of mother's time at home in 1980 and the index of marketization by decile in 1980 and 2010. A_{2010} is identified off the change in this profile over time, as in, the 2010 profile of mother's time with children.

Table 1 shows the calibrated parameter values.

Table 1: Calibrated Parameter Values

Parameter	Interpretation	Value
α	Weight on # children	0.34
β	Weight on quality of children	0.48
θ	Exponent π	0.42
b	Scaling	1.01
η	Basic edu.	1.45
ϕ	Share of mother's time	0.94
ρ	elasticity wife/m	0.60
A_{1980}	TFP child production, 1980	4.58
A_{2010}	TFP child production, 2010	1.01*A_{1980}
$p_{m,1980}$	Price of market substitutes 1980	1
$p_{m,2010}$	Price of market substitutes 2010	4% Annual decrease
p_e	Cost of education	1

Before turning to the model fit, notice that the parameter values found here are consistent with much of the literature. For instance, the calibrated value of α suggests that $\frac{\alpha}{1+\alpha} = 25\%$ of household resources are dedicated towards children. Lino, Kuczynski, Rodriguez and Schap (2017) find that families with 2-3 children, as is in the norm in the model, 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 25% is consistent with half of the cost estimated by Lino et al. (2017). The rise in TFP in child production is quite modest, at 1% total over a 30 year period. The decline in the price of marketization is also quite modest a 4% annual decline in price of market goods. This is at the middle range of the values reported in Greenwood et al. (2016), who in turn use 5%. 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, is along the lines of the upper range of estimates reported in Aguiar and Hurst (2007).

3.2 Model Fit

Figure 5 shows the model fit. The top left panel shows the model and data for mother's time at home, by decile, in 1980, while the top right panel shows the same for 2010. The second row panel on the left shows the model fit for fertility, by decile, in 1980, while the panel to its right shows the same for 2010. The third row left figure shows the model fit for college attainment rates by decile in 1980. Since we do not yet know the college attainment rates for those children born in 2010, we cannot compare the model predictions with the empirical results. However, the third row right panel compares the model in 1980 with the model prediction in 2010, showing that the model does not predict the relationship to change much over time. Finally, the bottom row shows the model fit for the index of marketization, with the left panel showing the fit in 1980 and the right in 2010.

Overall, the model fit is excellent. Beginning with labor supply, with the exception of the first decile, the match between women's time at home between the model and data is close to perfect.[19] Turning towards fertility, in both the model and data in 2010 the relationship between income decile and fertility becomes flat starting at the 5th income decile. This stands in stark contrast to 1980, where both the model and data exhibit a strongly negative relationship between income

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

decile and fertility rates. The model is therefore highly successful in capturing the changes in differential fertility over time. The ability of the model to account for changing fertility patterns is not obvious; the model without marketization cannot match the US time series data, as we show below. The model is able to capture the level of college attainment almost perfectly. Finally, the index of relative marketization is well matched in both time periods, giving credence to the idea that differences in marketization in the model between deciles are comparable to those in the data for both time periods.

While matching the relative index of marketization by decile gives confidence in relative marketization rates, what about levels of marketization? What about elasticities to changes in inequality?

The average fraction of household income spent on market substitutes is 6.8% in the model in 2010, and lower in 1980. This seems quite reasonable; expenditures on market substitutes are a relatively small fraction of total household income, and growing over time with increased use of market substitutes.

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 (four percentage 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.[20] Our model generates a rise of slightly over 12%. The model's sensitivity of marketization to wages is thus in the middle of the range of estimates in their paper. Notice that this moment is untargeted.

3.3 Results

In this section, we breakdown the results of the model, exploring the implications of differential fertility on human capital, and the mechanisms driving differential fertility in the data.

[20] This is the range of their IV estimates. See their Table 2.

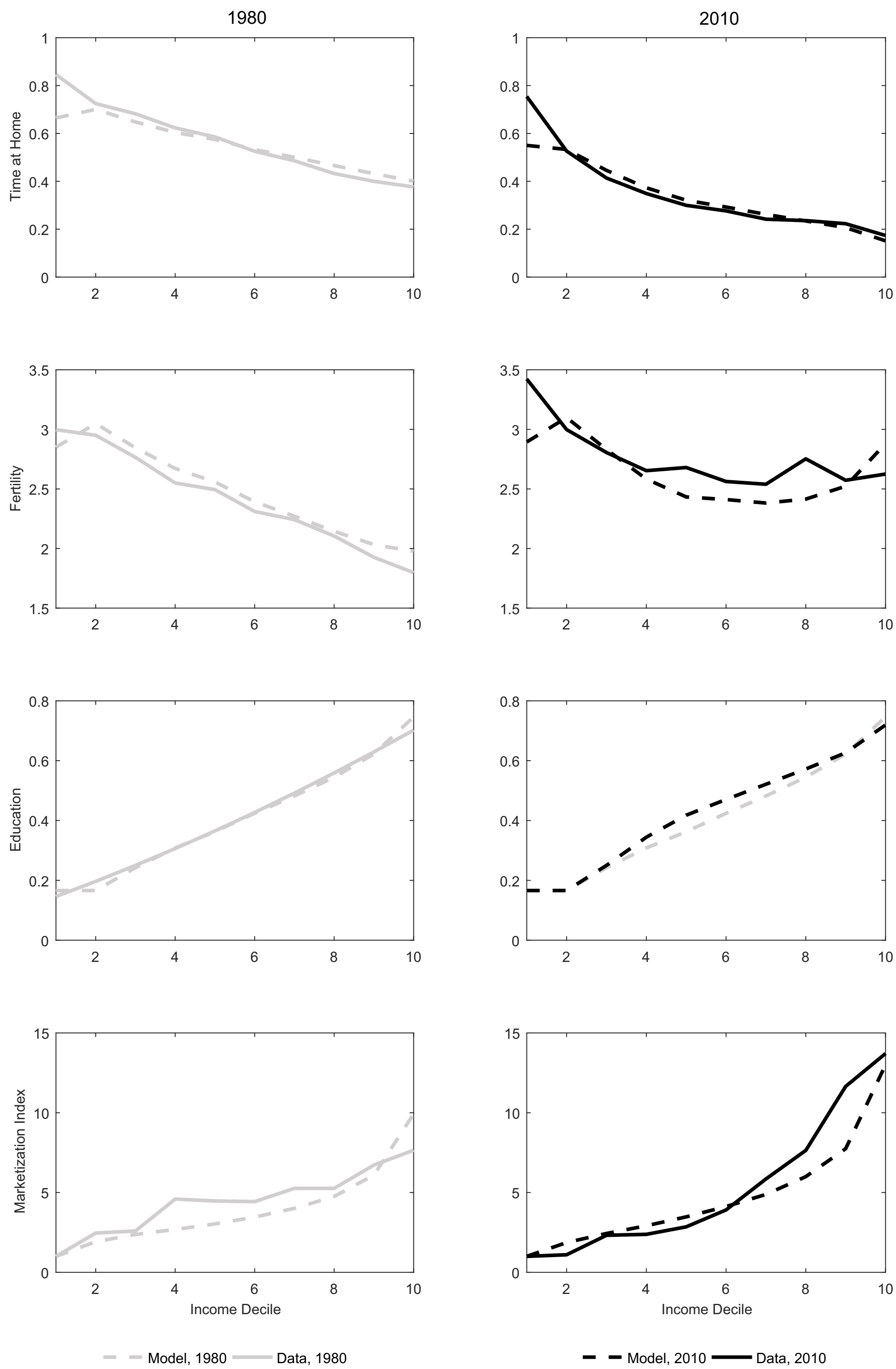


Figure 5: Model Fit

As discussed in the introduction, our measure of the effects of differential fertility on human capital is the average college attainment of the next generation. We measure this using the fertility rates in the model against the actual college attainment rates by decile in the 1980 data.[21] Empirically, differential fertility accounts for 1.7 percentage points (p.p.) increase in college attainment. The model results shown above generate 1.75 p.p. increase, rising from 38.25% to 40.0%, which is quite similar to the data.[22]

There are two general mechanisms leading to changes in differential fertility in the model, namely increased marketization and the income effect. We now address each in turn.

In Figure 6 we recalculate the model results in 2010 holding constant $\frac{w_f}{p_m}$, by decile, between 1980 and 2010.[23] This maintains the same relative cost of marketization in the 2010 model as was in the 1980 model, allowing us to explore the importance of marketization for our results. As can be clearly seen, fertility is downward slopping in 2010 as it had been in 1980, rather than U-shaped as in 2010.[24] This is directly along the lines of the standard theory. Calculating the change in college due to differential fertility in this case yields that only 37.1% of children born in 2010 would have ended up graduating college had marketization not become relatively cheaper, by decile. That is, the mechanism explored in the standard theory would predict a 1.15 p.p. *decrease* in education due to differential fertility between 1980 and 2010, as marketization is ignored, as opposed to the 1.75 p.p. *increase* the model measures. This is despite the fact that rising male inequality may have led to a flattening of the fertility profile due to the income effect, as discussed in Section 2.2.3. Thus, as we observe above, a naïve modeler,

[21]As explained above, we use the 1980 data both since the 2010 data won't be available for decades to come, and because this allows us to disentangle the effects of differential fertility from generally rising trends in college attainment.

[22]When calculating the college attainment rates in the model using the model's prediction for graduation by decile, the number rises from 38.1% to 41.7%, an even larger increase.

[23]While we leave out the first decile, as the model indicates a corner solution, this is not crucial. The effects of marketization on the first decile are minimal.

[24]Notice that the *level* of fertility is lower for all deciles. This is due to the higher wage growth for women than for men across all deciles. Specifically, as can be seen from Equation (8), the small income effect generated by the growth in men's wage is counterbalanced by a larger increase in the price of the market substitute goods. What matters for our quantitative results, however, is the fraction of children representing each decile in the next generation.

working in 1980 and ignoring marketization, would have predicted a significant decline in college attainment rates over time if (s)he had been given perfect foresight over actual income distributions.[25] Adding this counterfactual decrease implied by the standard theory to the increase seen in the data, the bias from not including marketization is a little under 3 percentage points of college attainment. As noted above, this estimate implies that differential fertility's impact on education is comparable to more than one-quarter of the general rise in education between these two cohorts of white, non-Hispanic non-immigrant Americans born in 1950 and 1980. Thus, the bias induced by ignoring marketization is both quantitatively large and changes the sign of the estimated implications of inequality on education through differential fertility.

In Figure 7 we recalculate the model results in 2010 holding constant w_m at its 1980 value. This allows us to measure the income effect on fertility in the model due to men's rising wages and increased marital sorting, as described in Section 2.2.3. As can be seen, counterfactual model for 2010 is quite similar to the actual model results for 2010, 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. However, quantitatively this effect is relatively small, which can both be seen by comparing the counterfactual model with the actual model in the Figure, and by recalculating college attainment rates. In the counterfactual model, 39.1% of children born graduate college when male wages are constant at the 1980 level. This means that the income effect can explain at most one half of the rising college attainment rates due to changing differential fertility, leaving at least 0.9 percentage points of the rise due to marketization.

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 con-

[25]Notice that the standard theory does not allow for any marketization, while in our counterfactual exercise we do not allow for cheaper marketization over time. Thus, while the two exercises are not perfectly comparable, the basic idea of no changing marketization is explored.

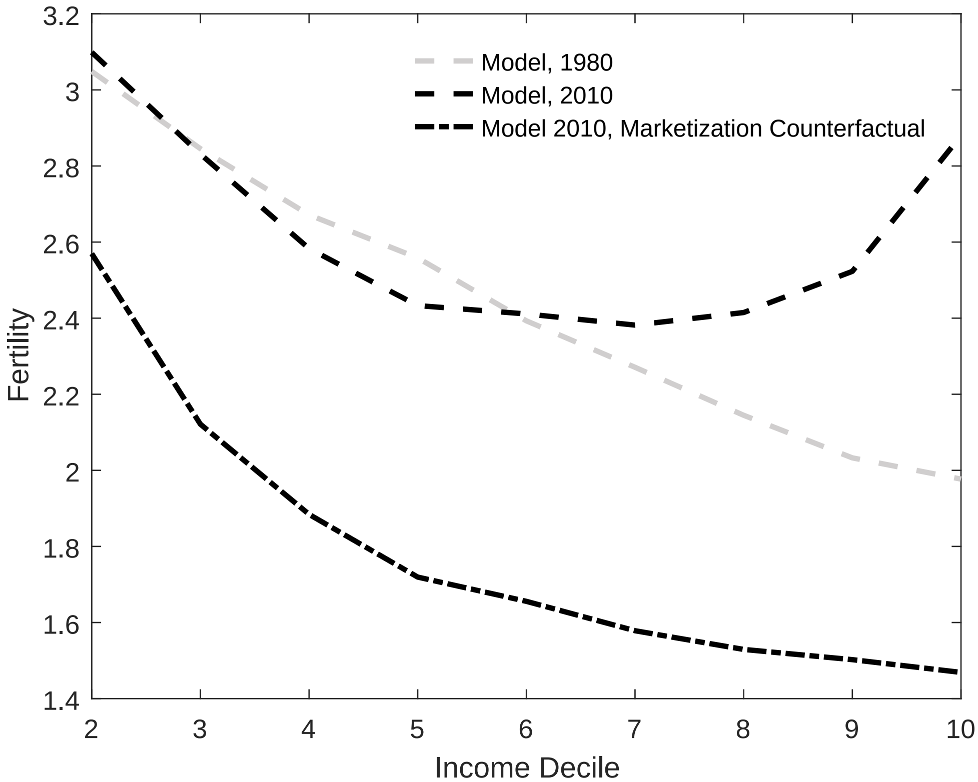


Figure 6: No Marketization Results. The curve labeled "Marketization Counterfactual" is the 2010 model using the same relative price of market substitutes, by decile, as in 1980.

servative. 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 sorting increases, with no other change in inequality. Then the higher deciles would begin to measure higher male wages. Thus, this exercise captures the maximum effect of rising differential fertility in the data due to increased marital sorting and an income effect through men.

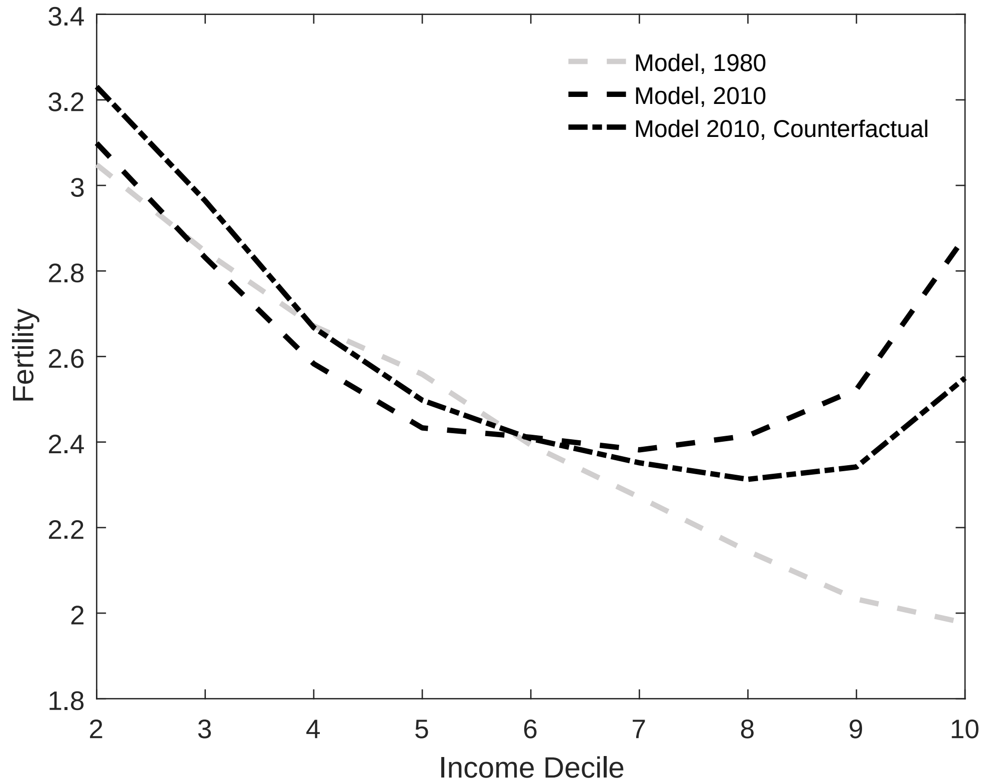


Figure 7: Men's Wages Constant Results. The curve labeled "Model 2010 Counterfactual" is the 2010 model using the male wages from 1980.

4 The Minimum Wage, Revisited

In this section, we first discuss the theory as to why the price of marketization has a differential effect on the higher income part of the income distribution. We then show empirically, using cross state variation, that the minimum wage does indeed have a large effect on the wages in the home production substitutes sector. We then ask the model how large the effects of a minimum wage increase are on labor supply and fertility. 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 elasticities that are close to the implied elasticity in the model.

4.1 Minimum Wage: Theory

The effects of the minimum wage have been widely studied, but focus on the effects of policy changes on people at the lower end of the income distribution (Manning 2016). The theory presented thus far makes a stark prediction; anything that changes the price of home production substitutes (i.e., the price of marketization), such as caretakers for children, should affect the labor supply and fertility of *all* households. Thus, the minimum wage has an effect on the labor supply of women across the income distribution. Moreover, we now show this effect to be differential; it is increasing in the wage offer of a mother. In order to explore this idea, we abstract from the impact of the minimum wage on the wage offers of households, which is studied by most of the literature, to instead focus on how it affects the price of marketization.

Claim 2 *When mother's time, t, and other inputs, m, are gross substitutes, $\rho \in (0,1)$, an increase in the minimum wage decreases labor supply, when fertility cannot adjust, that is, $\frac{\partial t}{\partial p_m}|_{n=n_0} > 0$. 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, $\frac{\partial^2 t}{\partial p_m \partial w_f}|_{n=n_0} > 0$ 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. ■

One can think of the effect of the minimum wage on labor supply holding fertility constant as a short run effect. That is, fertility decisions have already been completed, then labor supply changes as described by Claim 2. However, the minimum wage affects fertility as well, differentially, for families that can still adjust their fertility choices.

Claim 3 *Increases in the minimum wage decrease fertility. That is,* $\frac{\partial n}{\partial p_m} < 0$*.*

Proof. Follows directly from differentiating (8) with respect to p_m. ■

The effects of the minimum wage on fertility are differential, but theoretically ambiguous. We show that, quantitatively, the net effect is fewer children in richer households in Section 3.3. 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 ambiguous. Again, we show the net effect to be lower labor supply, especially among higher wage households, following a minimum wage increase.

4.2 Minimum Wage: Quantitative Analysis

What are the effects of minimum wage changes on marketization? To answer this question, we first exploit 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 calculate a change in the price of these goods following an increase of the Federal minimum wage to $15/hour, as suggested by Bernie Sanders during the 2016 presidential election. We then ask the model how a change in p_m in line with this minimum wage increase would affect labor supply, fertility, and investment in children differentially across the income distribution.

Using CPS data from 1980-2010, we compute the real wage of workers in the industries of the economy associated with home production substitutes.[26] Figure

[26] The selection of these industries follows Mazzolari and Ragusa (2013).

8 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.

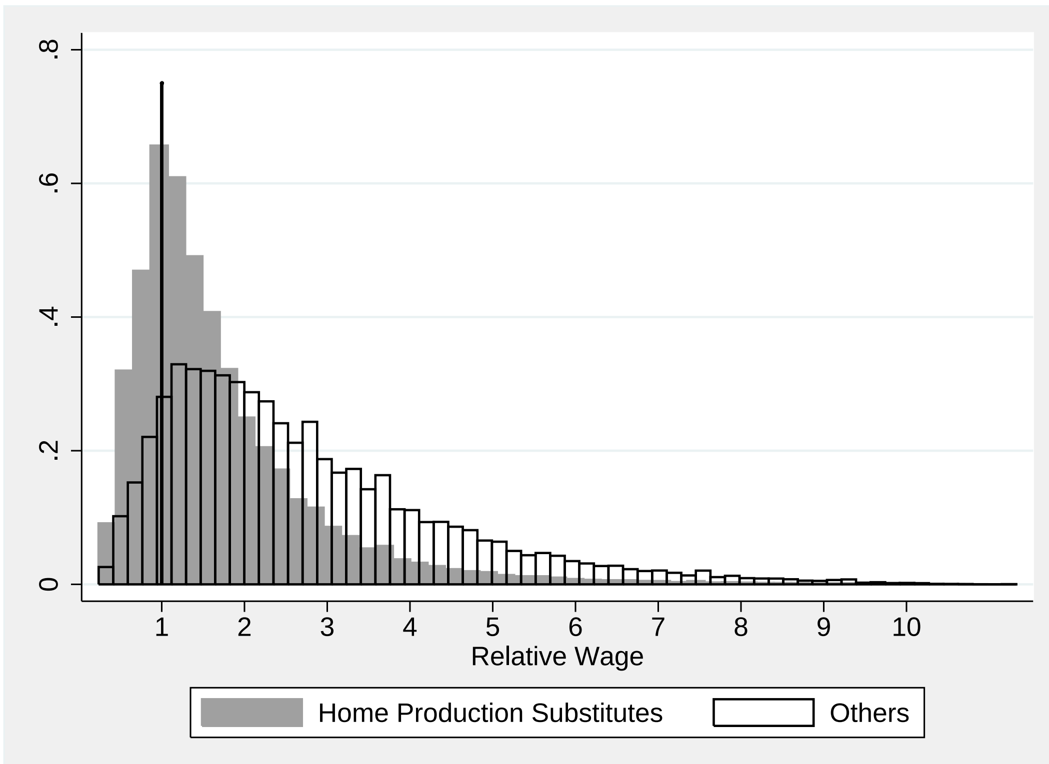


Figure 8: The distribution of the real wage, relative to the minimum wage, by sector of the economy.

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

$$w_{ist} = \alpha + \beta w_{st}^{\min} + \gamma \bar{w}_{st} + \delta_{below} + \delta_t + \delta_s + \delta_{age} + \delta_{educ} + \delta_{Hispan} + \delta_{race} + \delta_{occ} + \epsilon_{ist}, \tag{15}$$

where w_{ist} is the real wage of individual i working in the home production substitute (HPS) sector , living 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.[27] $\bar{w}_{st}$ is the average wage of workers not in the home production substitute sector in year t and state s. 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.[28] ϵ_{ist} is an error term.

Estimating (15) 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 (15) including on the right hand side the average wage in state s and year t.[29] The idea is that if HPS sector workers' wages have similar cyclicality 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 the federal minimum wage in year t and an index of state s liberalism from before the sample time period (Berry, Ringquist, Fording and Hanson 1998, Berry, Fording, Ringquist, Hanson and Klarner 2010).[30]

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

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

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

[30] We use the average of their nominate measure of state government ideology from 1960–1980.

The coefficient of interest is β, which shows the dollar change in HPS sector wages when the minimum wage increases by a dollar. Table 2 reports the results of the estimation. Column 1 only controls for year and state fixed effects and for having a wage that is below or above the minimum wage. Column 2 adds the average real wage in the state. Column 3 repeats Column 1 but replaces year fixed effects with region-year fixed effects. Column 4 adds to Column 1 demographic controls, again switching year fixed effects with region-year fixed effects. Column 5 adds to Column 4 the average wage in the state. 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 wages in the HPS sector.

To calculate how a change in the minimum wage to $15/hour affects average wages in these sectors, we proceed as follows, using observations from 2010. First, we calculate the average wage in the HPS sectors. 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. 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 in Table 2 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 percentage higher. Thus, for our exercise, we increase p_m by 21.1 percent. Note that we do not assume that this minimum wage change affects the wages of mothers or fathers in the model. That is, we are only asking how it affects people's ability to marketize. Accord-

The index of state liberalism has a range of 1 to 100, with more liberal states receiving a higher score, with an average (standard deviation) of 62.3 (11.3).

ingly, we only analyze the effects on deciles 5–10, and ignore the left tail of the distribution.

The results are shown in Figure 9. The top panel shows the fertility by decile with the higher minimum wage in 2010 relative to the benchmark model in 2010. The bottom panel shows the relative mother's time at home. The minimum wage decreases fertility, differentially more for higher income households, and increases mother's time at home, differentially for higher income households. The magnitudes are large. A 10^{th} (5^{th}) decile household decreases fertility by 13.5% (9.1%), while the mother spends 13% (3.9%) 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" to their fertility choice? We recalculate changes in mother's time at home for these mothers using the model's fertility in 2010 with the increased cost of marketization. A 10^{th} decile mother increases time at home by 30.7%, while a 5^{th} decile women increases it by 13.8%. 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 very large. The average reduction in labor supply by women in the 9^{th} and 10^{th} deciles is 5.76%. Since this is the response to a 21.1% increase in the minimum wage, it implies an elasticity of $-5.76/21.1 \approx -0.27$.

In order to verify this 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:

$$\log Hours_{ist} = \alpha + \beta \log w_{st}^{\min} + \delta_t + \delta_s + \delta_{age} + \delta_{educ} + \delta_{Ind} + \delta_{occ} + \epsilon_{ist}, \qquad (16)$$

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 been described in (15). 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 comprises white non-Hispanic married women aged 25-54, whose real hourly wage is in the 9^{th} and 10^{th}. Again, like in the estimation of β in Equation (15), estimating (16) with OLS might induce an upward bias if hours of high income women and the state minimum wage are procyclical.

To overcone this issue we estimate (16) using OLS and 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 3 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 non is 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 -0.65 to -0.38. Notice also that the difference between the implied elasticity in the model, -0.273, and the elasticities reported in Column 10-12 is less than one standard error. Both methodologies have their own advantages, the structural model being immune to the Lucas critique and the empirical approach allowing the data to speak directly. Thus, the consistency between the model elasticity and the empirical elasticity is reassuring.

Finally, Table 4 repeats Table 3 for men. As can be seen from the table, all the OLS and the 2SLS estimates are close to 0 and non is even remotely significant. This is exactly what was expected under the assumption of traditional gender roles (see Section 2.2.1).

5 Additional Implications of the Rise in Marketization

In this section, we discuss additional implications of the rise in marketization. We ask how marketization affects the endogenous incentives to sort and end with a

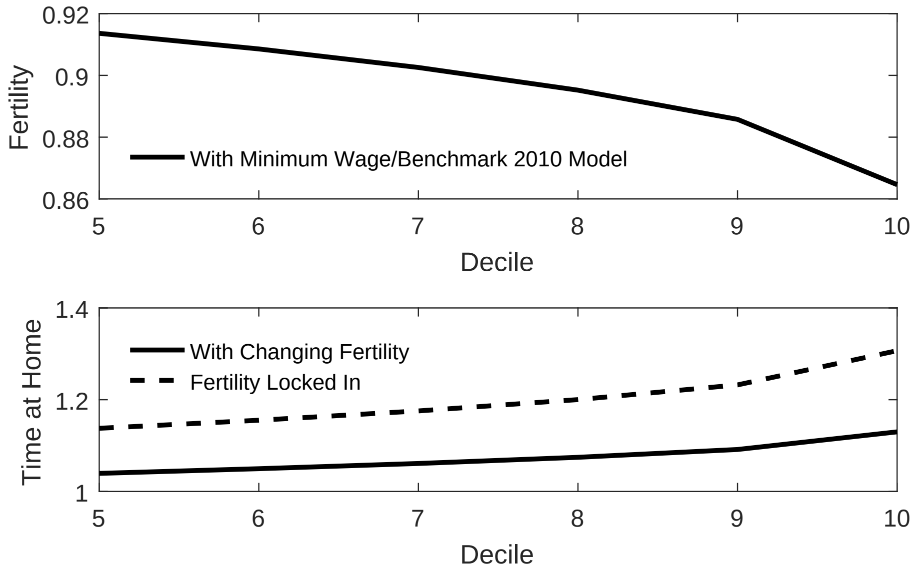


Figure 9: All curves show model variables in 2010 with a minimum wage of $15 divided by the same variables in the benchmark 2010 model.

discussion on how marketization affects childlessness rates of women.

5.1 Childlessness

How does the ability to marketize the cost of children affect fertility on the extensive margin among educated women?

Baudin et al. (2015) estimate childlessness by woman's education, for those over 45, in the 1990 US census. They find that highly educated women have relatively high rates of childlessness. In particular, they show that childlessness rates among married women with up to a college degree range between 6 to 10 percent, while childlessness rates among married women with Master degrees and Doctoral degrees are 13.7 and 19.1 percent, respectively. Baudin et al. (2015) attribute these high rates of childlessness to the high opportunity cost of these women raising children. According to our theory, this opportunity cost should be decreasing over time, as women marketize the cost of children more and more. Indeed, in Figure 10, we show that the rates of childlessness for women with more than a

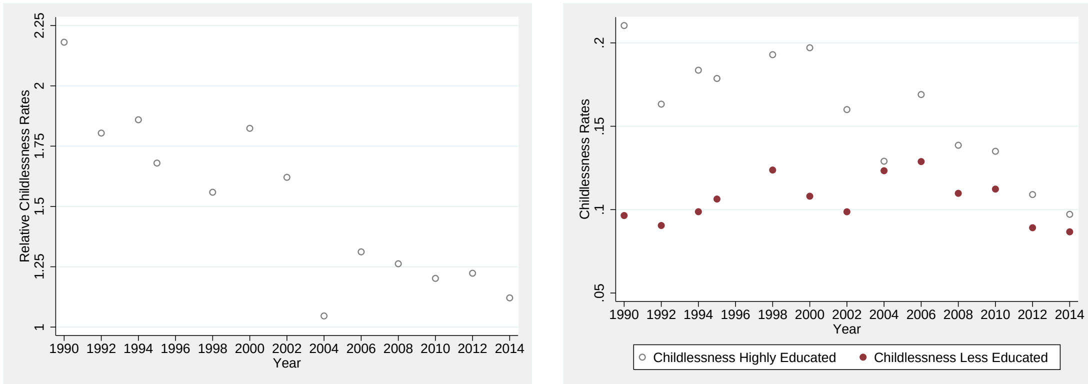


Figure 10: The left panel shows the childlessness rates of women with more than a college education to other women. The right panel shows the childlessness rates of women with more than a college education labelled "Highly Educated" and of women with up to a college education labelled "Less Educated". Data is from the Fertility and Marriage supplement of the Current Population Survey (CPS) from 1990–2014, and estimate childlessness among women ages 40–44. Women over 45 are not asked about their fertility history in this survey.

college degree relative to other women is decreasing over time.[31] Indeed, this rate falls from over two to almost 1, yielding no difference in childlessness rates by 2014. The change is driven by decreasing childlessness among educated women, as in our sample, the childlessness rates of other women, if anything, climb.

Indeed, in Figure 10, we show that the rates of childlessness for women with more than a college degree relative to other women is decreasing over time.[32] Indeed, this rate falls from over two to almost 1, yielding no difference in childlessness rates by 2014. The change is driven by decreasing childlessness among educated women, as in our sample, the childlessness rates of other women, if anything, climb.

[31]We are using more than college educated women relative to other women in a sample that is not restricted to white non-Hispanics in order to be consistent with Baudin et al. (2015). The results are not qualitatively sensitive to this sample selection.

[32]We are using more than college educated women relative to other women in a sample that is not restricted to white non-Hispanics in order to be consistent with Baudin et al. (2015). The results are not qualitatively sensitive to this sample selection.

5.2 Endogenous Sorting

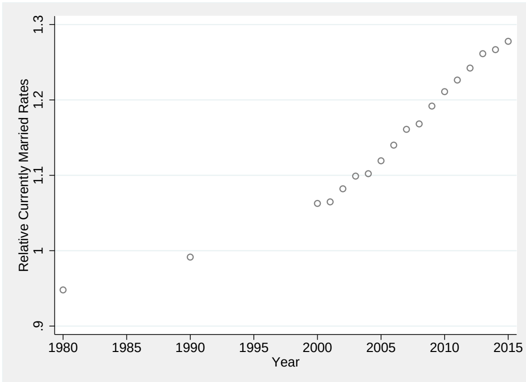
What affects the incentives to sort?

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. 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 effect 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). They do not discuss changes in fertility rates.

The mechanism proposed in this paper could be an additional force for the rise in sorting over time. 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 women 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 relative to non college educated women, measured by the fraction of those ever married or currently married (Figure 11).

6 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,



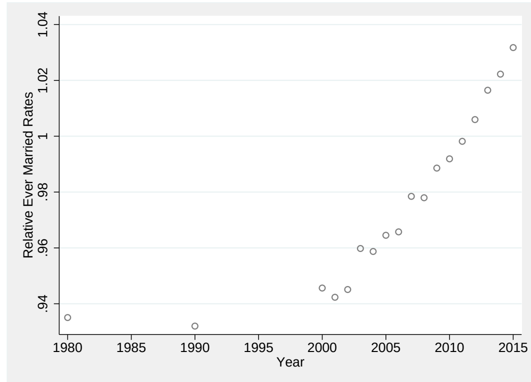


Figure 11: The left panel shows the fraction of women with at least a college degree who are currently married relative to fraction of other women who are currently married. The right panel shows the fraction of women with at least a college degree who have ever been married relative to fraction of other women who have ever been married. The data is from the US census and ACS. The sample is comprised of white, non-Hispanic women aged 35–44.

as the rich increased their fertility. These facts challenge the standard theory according to which rising inequality should make 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. Without marketization the model yields a quantitatively significant biased estimate of inequality's impact on education through differential fertility. Going from the standard theory to the one with marketization implies an increase of just under 3 percentage points of college attainment. This is equivalent to more than one-quarter of the rise in college completion between white non-Hispanic non-immigrant Americans born in 1950 and 1980.

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/hour, as per Bernie Sanders, would imply an increase in the cost of market goods of about 21 percent. This increase would have a significant detrimental effect on the labor supply and fertility women, with high income women responding much more than lower income women.

We have ended with a discussion on the insights our theory has for the literatures of the economics of childlessness and marital sorting. We have shown that since 1990, childlessness rates have been dramatically decreasing among highly educated women, while no change has been observed among less educated women. This is consistent with the differential effect of rising income inequality, through marketization in mitigating high opportunity cost of raising kids for high income women. Finally, we have argued that the rise in income inequality through marketization makes high income women more valuable in the marriage market. This is because marketization weakens the tradeoff between consumption and large family. These are promising avenues for future research.

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A Data

We employ the 1980 Census and the American Community Survey (ACS) 2010 (Ruggles, Alexander, Genadek, Goeken, Schroeder and Sobek 2010) for measuring incomes, fertility and work hours of each spouse and inferring wages for non-working females. 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, $I^{year}_{f,i}, I^{year}_{m,i}, w^{year}_{f,i}, w^{year}_{m,i}, hours^{year}_{f,i}, n^{year}_{i}, hours^{1980}_{m}$ for each decile $i \in [1, 2, ...10]$ 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 for wages and working at least 35 hours 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 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, $hours^{1980}_{m}$ (~2,300 hours 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. Because our model does not allow for male hours variation across time or deciles, this method ensures that any such variation is reflected in the purchasing power of couples.

We infer the data counterpart of $w_{f,i}$ as $I_{f,i}^{year}/hours_{f,i}^{year}$.[33]

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 to 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 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.

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 house-

[33]Note that if 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.

hold 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.

Finally, we use the childcare module of the Survey of Program Participation and Income (SIPP) to estimate relative uses of market substitutes.[34] Our index measures 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.

B Proofs

B.1 Existence and Uniqueness of the Solution to the Household Problem

Proposition 1 *The necessary and sufficient condition for existence of a unique solution to the household's problem is* $\frac{\beta\theta}{\alpha} < 1$.

Proof. The household's optimization problem can be written as follows:

$$\max_{e \geqslant 0} U(e) = -\ln\left(\frac{p_n}{p_e} + e\right) + \frac{\beta\theta}{\alpha}\ln(e + \eta)$$

[34] We use the 1990 childcare module as a proxy for the 1980 index of marketization, as this is the earliest available data.

There is a possibility that $U(e)$ is unbounded above, and therefore the household's problem has no solution. We can write the objective function as follows:

$$U(e) = \ln\left(\frac{(e+\eta)^{\frac{\beta\theta}{\alpha}}}{\frac{p_n}{p_e}+e}\right)$$

Taking the limit as $e \to \infty$,

$$\begin{aligned}
\lim_{e\to\infty} U(e) &= \ln\left(\lim_{e\to\infty}\frac{(e+\eta)^{\frac{\beta\theta}{\alpha}}}{\frac{p_n}{p_e}+e}\right) \\
&= \ln\left(\lim_{e\to\infty}\frac{\frac{\beta\theta}{\alpha}(e+\eta)^{\frac{\beta\theta}{\alpha}-1}}{1}\right) = \begin{cases} \infty & \frac{\beta\theta}{\alpha} > 1 \\ 1 & \frac{\beta\theta}{\alpha} = 1 \\ -\infty & \frac{\beta\theta}{\alpha} < 1 \end{cases}
\end{aligned}$$

The first step used chain rule of limits, and the second step used L'Hospital's rule since we have a limit of the form $\frac{\infty}{\infty}$. Intuitively, $\frac{\beta\theta}{\alpha}$ is the weight on quality in the utility function. When this weight is very high, it is possible that the household would like to choose $e \to \infty$ and $n \to 0$, which makes the problem unsolvable. Thus, in order to make the objective function bounded above, we have to impose the restriction $\frac{\beta\theta}{\alpha} \leqslant 1$.

Case 1: $\frac{\beta\theta}{\alpha} = 1$

$$\begin{aligned}
U(e) &= -\ln\left(\frac{p_n}{p_e}+e\right) + \ln(e+\eta) \\
U'(e) &= -\frac{1}{\frac{p_n}{p_e}+e} + \frac{1}{e+\eta}
\end{aligned}$$

In this case, the solution to the household's problem is as follows:

$$\begin{aligned}
\frac{p_n}{p_e} &> \eta \Rightarrow U'(e) > 0 \;\; \forall e, \text{i.e. } U(e) \text{ is monotone increasing, } e^* \to \infty \\
\frac{p_n}{p_e} &< \eta \Rightarrow U'(e) < 0 \;\; \forall e, \text{i.e. } U(e) \text{ is monotone decreasing, } e^* = 0 \\
\frac{p_n}{p_e} &= \eta \Rightarrow U'(e) = 0 \;\; \forall e, \text{i.e. } U(e) \text{ is constant, } e^* \in (-\infty, \infty)
\end{aligned}$$

Case 2: $\frac{\beta\theta}{\alpha} < 1$

In this case, the first order necessary condition for interior maximum is $U'(e^*) = 0$:

$$\begin{aligned}
U(e) &= -\ln\left(\frac{p_n}{p_e} + e\right) + \frac{\beta\theta}{\alpha}\ln(e+\eta) \\
U'(e) &= -\frac{1}{\frac{p_n}{p_e} + e} + \frac{\frac{\beta\theta}{\alpha}}{\eta + e} = 0 \\
\frac{\eta + e}{\frac{p_n}{p_e} + e} &= \frac{\beta\theta}{\alpha} \\
e\left(1 - \frac{\beta\theta}{\alpha}\right) &= \frac{\beta\theta}{\alpha}\frac{p_n}{p_e} - \eta \\
e^* &= \frac{\frac{\beta\theta}{\alpha}\frac{p_n}{p_e} - \eta}{1 - \frac{\beta\theta}{\alpha}}
\end{aligned}$$

The second order sufficient condition for e^* to be a local maximizer is:

$$\begin{aligned}
U''(e^*) &< 0 \\
\frac{1}{\left(\frac{p_n}{p_e} + e^*\right)^2} - \frac{\frac{\beta\theta}{\alpha}}{(\eta + e^*)^2} &< 0 \\
\left(\frac{\eta + e^*}{\frac{p_n}{p_e} + e^*}\right)^2 &< \frac{\beta\theta}{\alpha}
\end{aligned}$$

Using the first order condition:

$$\begin{aligned}
\left(\frac{\beta\theta}{\alpha}\right)^2 &< \frac{\beta\theta}{\alpha} \\
\frac{\beta\theta}{\alpha} &< 1
\end{aligned}$$

Thus, $\frac{\beta\theta}{\alpha} < 1$ guarantees that a solution to the household's problem exists, and the first order necessary condition is a local maximum. Moreover, since the critical point is unique, the local maximum must also be the unique global maximizer. ■

B.2 Proof of U-Shape

Proposition 2 *Let* $p_n = \frac{1}{A}\left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1-\phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}}$. *We have the following properties:*

(i). Let $\partial p_n/\partial w_f$ *be the marginal effect of* w_f *on* p_n*. This marginal effect is positive, a monotone decreasing function of* w_f*, and* $\lim_{w_f\to\infty} \partial p_n/\partial w_f = 0$.

(ii). Let $\mathcal{E}_{p_n,w_f}$ *be the elasticity of* p_n *with respect to* w_f*. This elasticity is* $0 < \mathcal{E}_{p_n,w_f} < 1$*, a monotone decreasing function of* w_f*, and* $\lim_{w_f\to\infty} \mathcal{E}_{p_n,w_f} = 0$.

Proof. (i). We can rewrite p_n as

$$p_n = \frac{1}{A}\left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1-\phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}} = \frac{1}{A}\left[\alpha_1 w_f^{\sigma} + \alpha_2 p_m^{\sigma}\right]^{\frac{1}{\sigma}}$$

where

$$\alpha_1 = \alpha^{\frac{1}{1-\rho}}, \alpha_2 = (1-\alpha)^{\frac{1}{1-\rho}}, \sigma = \frac{\rho}{\rho-1} = \eta - 1 < 0$$

and $\eta \equiv \frac{1}{1-\rho}$ is the elasticity of substitution between the two inputs t_f and t_b in the production function. Recall that p_n is the marginal cost function, derived from the home production cost minimization problem. It is well known that if production function is CES, the marginal cost function also has CES form.

$$\begin{aligned}\frac{\partial p_n}{\partial w_f} &= \frac{1}{A}\left[\alpha_1 w_f^{\sigma} + \alpha_2 p_m^{\sigma}\right]^{\frac{1}{\sigma}-1} \alpha_1 w_f^{\sigma-1} \\ &= \frac{1}{A}\left[\alpha_1 + \alpha_2 \left(\frac{p_m}{w_f}\right)^{\sigma}\right]^{\frac{1-\sigma}{\sigma}} \alpha_1 > 0\end{aligned}$$

Notice that since $\sigma < 0$, and $\frac{1-\sigma}{\sigma} < 0$, the above expression is decreasing in w_f.

We can also demonstrate this by taking the second derivative:

$$\begin{aligned}
\frac{\partial^2 p_n}{\partial w_f^2} &= \frac{1}{A}\left\{\left(\frac{1}{\sigma}-1\right)\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-2}\alpha_1^2\sigma w_f^{2\sigma-2}+\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-1}\alpha_1(\sigma-1)\,w_f^{\sigma-2}\right\}\\
&= \frac{1}{A}\left\{(1-\sigma)\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-2}\alpha_1^2 w_f^{2\sigma-2}+\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-1}\alpha_1(\sigma-1)\,w_f^{\sigma-2}\right\}\\
&= \frac{1}{A}\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-1}\alpha_1 w_f^{\sigma-2}(1-\sigma)\left\{\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{-1}\alpha_1 w_f^\sigma-1\right\}\\
&= \frac{1}{A}\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-1}\alpha_1 w_f^{\sigma-2}(1-\sigma)\left\{\frac{\alpha_1 w_f^\sigma}{\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma}-1\right\}<0
\end{aligned}$$

The first term in the curly brackets is a fraction smaller than 1, and $1-\sigma>0$. Thus, we proved that $\partial p_n/\partial w_f>0$ and is monotone decreasing in w_f, i.e. p_n is increasing in w_f at diminishing rate. Also notice that

$$\begin{aligned}
\lim_{w_f\to\infty}\frac{\partial p_n}{\partial w_f} &= \frac{\alpha_1}{A}\lim_{w_f\to\infty}\left[\alpha_1+\alpha_2\left(\frac{p_m}{w_f}\right)^\sigma\right]^{\frac{1-\sigma}{\sigma}}\\
&= \frac{\alpha_1}{A}\lim_{y\to\infty}y^{\frac{1-\sigma}{\sigma}}=0
\end{aligned}$$

where $y=\left[\alpha_1+\alpha_2\left(\frac{p_m}{w_f}\right)^\sigma\right]$ and $\lim_{w_f\to\infty}y=\infty$.

(ii). The elasticity of p_n with respect to w_f is given by:

$$\begin{aligned}
\mathcal{E}_{p_n,w_f} \equiv \frac{\partial p_n}{\partial w_f}\frac{w_f}{p_n} &= \frac{\frac{1}{A}\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}-1}\alpha_1 w_f^{\sigma-1}w_f}{\frac{1}{A}\left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}}}\\
&= \left[\alpha_1 w_f^\sigma+\alpha_2 p_m^\sigma\right]^{-1}\alpha_1 w_f^\sigma\\
&= \alpha_1\left[\alpha_1+\alpha_2\left(\frac{p_m}{w_f}\right)^\sigma\right]^{-1}>0
\end{aligned}$$

The above is a positive and monotone-decreasing function of w_f, with

$$\begin{aligned}\lim_{w_f\to\infty}\mathcal{E}_{p_n,w_f} &= \alpha_1 \lim_{w_f\to\infty}\left[\alpha_1+\alpha_2\left(\frac{p_m}{w_f}\right)^{\sigma}\right]^{-1} \\ &= \alpha_1 \lim_{y\to\infty} y^{-1} = 0\end{aligned}$$

where $y = \left[\alpha_1+\alpha_2\left(\frac{p_m}{w_f}\right)^{\sigma}\right]$ and $\lim_{w_f\to\infty} y = \infty$. ■

Proposition 3 *At the interior solution for education good, i.e. when $e^* > 0$, the optimal fertility n^* is a U-shape function of w_f.*

Proof. The optimal education good (when it is interior, $e^* > 0$) is given by

$$e^* = \frac{p_n}{p_e}\frac{\beta\theta}{\alpha} - \eta$$

In this case, the optimal fertility is

$$n^* = \left(1-\frac{\beta\theta}{\alpha}\right)\frac{\alpha}{1+\alpha}\left(\frac{w_f+w_m}{p_n-\eta p_e}\right)$$

where

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

Since p_n is increasing in w_f, interiority of e^* is equivalent to $w_f \geqslant \underline{w_f}$, where $\underline{w_f}$

is some minimal w_f at which $e^* = 0$:

$$\begin{aligned}
e^* &= \frac{p_n}{p_e}\frac{\beta\theta}{\alpha} - \eta = \frac{\frac{1}{A}\left[\alpha_1 w_f^\sigma + \alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}}}{p_e}\frac{\beta\theta}{\alpha} - \eta = 0 \\
\left[\alpha_1 w_f^\sigma + \alpha_2 p_m^\sigma\right]^{\frac{1}{\sigma}} &= A\frac{\alpha}{\beta\theta}\eta p_e \\
\alpha_1 w_f^\sigma &= \left[A\frac{\alpha}{\beta\theta}\eta p_e\right]^\sigma - \alpha_2 p_m^\sigma \\
\underline{w_f} &= \left\{\frac{\left[A\frac{\alpha}{\beta\theta}\eta p_e\right]^\sigma - \alpha_2 p_m^\sigma}{\alpha_1}\right\}^{\frac{1}{\sigma}}
\end{aligned}$$

Notice that $p_n \to \frac{\alpha}{\beta\theta}\eta p_e$ as $w_f \searrow \underline{w_f}$.

We are interested in $sign\left(\frac{\partial}{\partial w_f}n^*\right) = sign\left(\frac{\partial}{\partial w_f}\left(\frac{w_f+w_m}{p_n-\eta p_e}\right)\right)$ on $w_f \geqslant \underline{w_f}$, i.e. the sign of

$$\frac{\partial}{\partial w_f}\left(\frac{w_f + w_m}{p_n - \eta p_e}\right) = \frac{(p_n - \eta p_e) - (w_f + w_m)\frac{\partial p_n}{\partial w_f}}{(p_n - \eta p_e)^2} \tag{17}$$

First, we show that $\frac{\partial}{\partial w_f}n^* < 0$ as $w_f \searrow \underline{w_f}$.

$$\begin{aligned}
\overset{*}{\lim_{w_f \searrow \underline{w_f}}} \frac{\partial}{\partial w_f}\left(\frac{w_f + w_m}{p_n - \eta p_e}\right) &= \lim_{w_f \searrow \underline{w_f}} \frac{\left(\frac{\alpha}{\beta\theta}\eta p_e - \eta p_e\right) - (w_f + w_m)\frac{\partial p_n}{\partial w_f}}{\left(\frac{\alpha}{\beta\theta}\eta p_e - \eta p_e\right)^2} \\
&= \frac{-\left(1 - \frac{\alpha}{\beta\theta}\right)\eta p_e - (w_f + w_m)\frac{\partial p_n}{\partial w_f}}{\left(\frac{\alpha}{\beta\theta}\eta p_e - \eta p_e\right)^2} < 0
\end{aligned}$$

Next, we show that the numerator of (17) is a monotone increasing function of w_f, which is positive for w_f large enough. This will prove that n^* is a U-shape function of w_f.

$$\begin{aligned}\frac{\partial}{\partial w_f}\left(\frac{w_f + w_m}{p_n - \eta p_e}\right) &= \frac{p_n - w_f \frac{\partial p_n}{\partial w_f} - w_m \frac{\partial p_n}{\partial w_f} - \eta p_e}{(p_n - \eta p_e)^2} \\ &= \frac{p_n - p_n \frac{\partial p_n}{\partial w_f}\frac{w_f}{p_n} - w_m \frac{\partial p_n}{\partial w_f} - \eta p_e}{(p_n - \eta p_e)^2} \\ &= \frac{p_n\left(1 - \mathcal{E}_{p_n, w_f}\right) - w_m \frac{\partial p_n}{\partial w_f} - \eta p_e}{(p_n - \eta p_e)^2},\end{aligned}$$

where $\mathcal{E}_{p_n, w_f}$ is the elasticity of p_n with respect to w_f. Proposition 2 proves that $0 < \mathcal{E}_{p_n, w_f} < 1$, $\frac{\partial p_n}{\partial w_f} > 0$, both $\mathcal{E}_{p_n, w_f}$ and $\frac{\partial p_n}{\partial w_f}$ are monotone decreasing functions of w_f, and $\lim_{w_f \to \infty} \mathcal{E}_{p_n, w_f} = \lim_{w_f \to \infty} \frac{\partial p_n}{\partial w_f} = 0$. Thus, $p_n\left(1 - \mathcal{E}_{p_n, w_f}\right) - w_m \frac{\partial p_n}{\partial w_f} - \eta p_e$ is a monotone increasing function of w_f, and

$$\begin{aligned}\lim_{w_f \to \infty} \frac{\partial}{\partial w_f}\left(\frac{w_f + w_m}{p_n - \eta p_e}\right) &= \lim_{w_f \to \infty} \frac{p_n\left(1 - \mathcal{E}_{p_n, w_f}\right) - w_m \frac{\partial p_n}{\partial w_f} - \eta p_e}{(p_n - \eta p_e)^2} \\ &= \lim_{w_f \to \infty} \frac{p_n - \eta p_e}{(p_n - \eta p_e)^2} = \frac{1}{p_n - \eta p_e} > 0\end{aligned}$$

The last inequality follows from interior solution $n^* > 0$.

In summary, we proved that $\frac{\partial}{\partial w_f} n^* < 0$ as $w_f \searrow \underline{w_f}$, and $\frac{\partial}{\partial w_f} n^*$ is a monotone increasing function w_f, and for large enough w_f the derivative $\frac{\partial}{\partial w_f} n^*$ is positive. Thus, the derivative $\frac{\partial}{\partial w_f} n^*$ changes sign on $w_f \geqslant \underline{w_f}$ only once, and n^* is a U-shape function of w_f, for $w_f \geqslant \underline{w_f}$. ■

C Education Robustness

There has been increasing interest in rising returns to education and rising education costs in the literature. We have so far abstracted from these issues, using the empirical relationship between income and college attainment in 1980 in order to control for changing education rates over time, instead focusing on differential fertility. Is it possible, however, that changes in college returns and costs could be driving changes in differential fertility? In principle, rising education costs could lead to more fertility through a quantity-quality tradeoff, potentially yielding changing patterns fertility by income. This effect might be mitigated by rising returns to education.

We now allow both the college premium, as described in (1), and education costs (p_e) to change over time. The time dependent parameters $p_{e,t}$ and ω_t capture the increase in the price of education and the rise in the college premium. The only other change we make to the setup of the model is that we replace (2) with:

$$u = \ln(c + \bar{c}) + \alpha \ln(n) + \tilde{\beta} \ln(w). \tag{18}$$

That is, we introduce a constant $\bar{c}$ into the consumption function. This allows for non-homotheticity.[35]

Relative to the calibration strategy described in Section 3, we only need to describe three things: how p_e changes over time; how ω is calibrated; how $\bar{c}$ is identified.

Beginning with p_e, we normalize $p_{e,1980} = 1$ as before. Although education expenditures map into all possible education-related expenditures per child, we take the stand that college education cost changes accurately describe general changes over time. We therefore choose to proxy the increase in the price of education by the increase in the effective price of college. Using institutional survey data available through the National Center for Education Statistics, we obtain that an annual cost of a public 4-year college is approximately \$6,400. This includes tuition and room & board, net of grants and scholarships. This quantity for the most recent year available is \$7,887, an increase of a 22%. We thus set $p_{e,2010} = 1.22$. ω in our model captures the lifetime return to college. This is different from the lifetime college premium which simply refers to the observed difference between the earnings of college graduates and other workers. Hendricks and Leukhina (2017) measure the role of ability selection in lifetime earn-

[35]The calibration sets $\bar{c}$ close to 0 in the benchmark model, so we do not include it in the analysis there.

ings premium (for the 1980 high school graduates) to be approximately a half of the observed college premium. The remaining half is the average return to college. Hence, we calibrate the return to college in 1980 and 2010 to the half of the observed cross-sectional lifetime premium (measured from the 1980 Census and 2010 ACS). Thus, we set $\omega^{1980} = 1.25$ and $\omega^{2010} = 1.40$). Finally, as the model is already greatly overidentified, $\bar{c}$ does not need extra moments for identification. We recalibrate the rest of the parameters as before. The calibrated parameters are as follows:

Parameter	Interpretation	Value
α	Weight on # children	0.15
β	Weight on quality of children	0.22
θ	Exponent π	0.60
b	Scaling	1.82
η	Basic edu.	0.47
ϕ	Share of mother's time	0.92
ρ	Elasticity wife/m	0.63
$\bar{c}$	Consumption constant	25.81
A_{1980}	TFP child production, 1980	4.30
A_{2010}	TFP child production, 2010	0.7 % annual growth
$p_{m,1980}$	Price of market substitutes 1980	1
$p_{m,2010}$	Price of market substitutes 2010	1.6% Annual decrease
$p_{e,1980,2010}$	Cost of education	1, 1.22
$\omega_{1980,2010}$	Returns to college degree	1.25, 1.40

Notice that the change in the price of is somewhat lower than in the benchmark exercise while the pace of technological advancement (A) is somewhat faster. The other parameters are quite similar.

The results are quite similar. In the model, college attainment due to differential fertility rises modestly, by 0.4 percentage points, but when recalculating holding the cost of marketization constant, this statistic falls by 1.4 percentage points, leading to a total bias from ignoring marketization of 1.8 percentage points. While this result is somewhat weaker than the benchmark results, it is still quantitatively meaningful.

D Normalization of Parameters

D.1 Normalizing p_e

Notice that in our model we can normalize $p_e = 1$ (or any other value), without affecting other meaningful quantities which are mapped to the data. At the interior solution we have

$$\begin{aligned} e^* &= \frac{p_n}{p_e}\frac{\beta\theta}{\alpha}\ln(\omega) - \eta \\ p_e e^* &= p_n \frac{\beta\theta}{\alpha}\ln(\omega) - p_e\eta \end{aligned}$$

The last equation shows that scaling up p_e by any factor, requires reducing e^* and η by the same factor to keep the product $p_e e^*$ unchanged, e.g. $\forall\varepsilon > 0$

$$\begin{aligned} p_e e^* &= p_e \varepsilon \frac{e^*}{\varepsilon} \\ p_e \eta &= p_e \varepsilon \frac{\eta}{\varepsilon} \end{aligned}$$

Only the product $p_e e^*$ enters the solution for n, so the solution to n will not change due to the scaling above. Finally, although e itself is meaningless, the quantity $\pi(e)$ is used to target college attainment rates in the data. However, the parameters inside $\pi(\cdot)$ can be scaled as follows, to keep it unchanged:

$$\pi\left(\frac{e}{\varepsilon}\right) = \ln\left(b\varepsilon^\theta\left(\frac{e}{\varepsilon} + \frac{\eta}{\varepsilon}\right)^\theta\right) = \ln\left(b(e+\eta)^\theta\right) = \pi(e)$$

Thus, the solution to the model, in terms of n and $\pi(e)$, is invariant to the following transformation of parameters:

$$\tilde{p}_e = p_e\varepsilon, \tilde{\eta} = \frac{\eta}{\varepsilon}, \tilde{b} = b\varepsilon^\theta, \tilde{e} = \frac{e}{\varepsilon} \;\; \forall\varepsilon > 0$$

D.2 Normalizing p_m

In this section we show that we can normalize p_m to any value, without affecting the key variables: p_n, t_f and mp_m. The solution to p_n from the cost minimization problem can be rewritten as follows:

$$\begin{aligned} p_n &= \frac{1}{A}\left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1-\phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}} \\ &= \left[A^{\frac{\rho}{1-\rho}} \phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + A^{\frac{\rho}{1-\rho}} (1-\phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{\rho-1}{\rho}} \end{aligned}$$

First we show that when scaling p_m by $\varepsilon > 0$, we can find adjustments to A and ϕ to keep p_n unchanged:

$$\begin{aligned} \tilde{A}^{\frac{\rho}{1-\rho}} \tilde{\phi}^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + \tilde{A}^{\frac{\rho}{1-\rho}} \left(1-\tilde{\phi}\right)^{\frac{1}{1-\rho}} (p_m \varepsilon)^{\frac{\rho}{\rho-1}} &= A^{\frac{\rho}{1-\rho}} \phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + A^{\frac{\rho}{1-\rho}} (1-\phi)^{\frac{1}{1-\rho}} p_m^{\frac{\rho}{\rho-1}} \\ \left[\tilde{A}^{\frac{\rho}{1-\rho}} \tilde{\phi}^{\frac{1}{1-\rho}} - A^{\frac{\rho}{1-\rho}} \phi^{\frac{1}{1-\rho}}\right] w_f^{\frac{\rho}{\rho-1}} &= \left[A^{\frac{\rho}{1-\rho}} (1-\phi)^{\frac{1}{1-\rho}} - \tilde{A}^{\frac{\rho}{1-\rho}} \left(1-\tilde{\phi}\right)^{\frac{1}{1-\rho}} \varepsilon^{\frac{\rho}{\rho-1}}\right] p_m^{\frac{\rho}{\rho-1}} \end{aligned}$$

Since w_f and p_m are fixed at arbitrary values, we have the following system with $\tilde{A}$ and $\tilde{\phi}$:

$$\begin{aligned} \tilde{A}^{\frac{\rho}{1-\rho}} \tilde{\phi}^{\frac{1}{1-\rho}} &= A^{\frac{\rho}{1-\rho}} \phi^{\frac{1}{1-\rho}} \\ \tilde{A}^{\frac{\rho}{1-\rho}} \left(1-\tilde{\phi}\right)^{\frac{1}{1-\rho}} \varepsilon^{\frac{\rho}{\rho-1}} &= A^{\frac{\rho}{1-\rho}} (1-\phi)^{\frac{1}{1-\rho}} \end{aligned}$$

Dividing through, and solving for $\tilde{\phi}$:

$$\begin{aligned} \frac{\tilde{A}^{\frac{\rho}{1-\rho}} \left(1-\tilde{\phi}\right)^{\frac{1}{1-\rho}} \varepsilon^{\frac{\rho}{\rho-1}}}{\tilde{A}^{\frac{\rho}{1-\rho}} \tilde{\phi}^{\frac{1}{1-\rho}}} &= \frac{A^{\frac{\rho}{1-\rho}} (1-\phi)^{\frac{1}{1-\rho}}}{A^{\frac{\rho}{1-\rho}} \phi^{\frac{1}{1-\rho}}} \\ \left(\frac{1-\tilde{\phi}}{\tilde{\phi}}\right)^{\frac{1}{1-\rho}} &= \left(\frac{1-\phi}{\phi}\right)^{\frac{1}{1-\rho}} \varepsilon^{\frac{\rho}{1-\rho}} \\ \frac{1-\tilde{\phi}}{\tilde{\phi}} &= \left(\frac{1-\phi}{\phi}\right) \varepsilon^{\rho} \\ \tilde{\phi} &= \frac{1}{1+\left(\frac{1-\phi}{\phi}\right)\varepsilon^{\rho}} = \frac{\phi}{\phi + (1-\phi)\,\varepsilon^{\rho}} \in [0,1] \end{aligned}$$

Notice that if $\varepsilon = 1$, then $\tilde{\phi} = \phi$. If $\varepsilon > 1$, then $\tilde{\phi} < \phi$, which does not make sense. Finally, solving for $\tilde{A}$ gives

$$\begin{aligned}
\tilde{A}^{\frac{\rho}{1-\rho}} &= A^{\frac{\rho}{1-\rho}} \left(\frac{\phi}{\tilde{\phi}}\right)^{\frac{1}{1-\rho}} = A^{\frac{\rho}{1-\rho}} \left[\phi + (1-\phi)\,\varepsilon^{\rho}\right]^{\frac{1}{1-\rho}} \\
\tilde{A} &= A\left[\phi + (1-\phi)\,\varepsilon^{\rho}\right]^{\frac{1}{\rho}}
\end{aligned}$$

Thus, scaling p_m by a factor $\varepsilon > 0$, and adjusting the share parameter and productivity as above, keeps p_n fixed.

Now, we express t_f and m in terms of p_n

$$(Ap_n)^{\frac{1}{\rho-1}} = \left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1-\phi)^{\frac{1}{1-\rho}}\, p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{1}{\rho}}$$

Plug the bracketed term into t_f and m

$$\begin{aligned}
t_f^n &= \frac{\left(\frac{\phi}{w_f}\right)^{\frac{1}{1-\rho}}}{A\left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1-\phi)^{\frac{1}{1-\rho}}\, p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{1}{\rho}}} n = \frac{\left(\frac{\phi}{w_f}\right)^{\frac{1}{1-\rho}}}{A\,(Ap_n)^{\frac{1}{\rho-1}}} n = \frac{\left(\frac{\phi}{w_f}\right)^{\frac{1}{1-\rho}} \phi^{\frac{1}{\rho-1}}}{A^{\frac{\rho}{\rho-1}} \phi^{\frac{1}{\rho-1}} p_n^{\frac{1}{\rho-1}}} \\
m &= \frac{\left(\frac{1-\phi}{p_m}\right)^{\frac{1}{1-\rho}}}{A\left[\phi^{\frac{1}{1-\rho}} w_f^{\frac{\rho}{\rho-1}} + (1-\phi)^{\frac{1}{1-\rho}}\, p_m^{\frac{\rho}{\rho-1}}\right]^{\frac{1}{\rho}}} n = \frac{\left(\frac{1-\phi}{p_m}\right)^{\frac{1}{1-\rho}}}{A\,(Ap_n)^{\frac{1}{\rho-1}}} n = \frac{\left(\frac{1}{p_m}\right)^{\frac{1}{1-\rho}}}{A^{\frac{\rho}{\rho-1}} (1-\phi)^{\frac{1}{\rho-1}}\, p_n^{\frac{1}{\rho-1}}}
\end{aligned}$$

We showed that the term $A^{\frac{\rho}{\rho-1}} \phi^{\frac{1}{\rho-1}}$ is unchanged due to scaling of p_m, which means that t_f is unchanged. However, the term $A^{\frac{\rho}{1-\rho}} (1-\phi)^{\frac{1}{1-\rho}}$ increases by a factor of $\varepsilon^{\frac{\rho}{1-\rho}}$. Thus, the effect of scaling p_m by a factor of $\varepsilon > 0$, and adjusting A and ϕ to keep p_n constant, gives:

$$mp_m = \frac{\left(\frac{1}{p_m \varepsilon}\right)^{\frac{1}{1-\rho}} (p_m \varepsilon)}{A^{\frac{\rho}{\rho-1}} (1-\phi)^{\frac{1}{\rho-1}}\, \varepsilon^{\frac{\rho}{1-\rho}} p_n^{\frac{1}{\rho-1}}} = \frac{p_m^{\frac{\rho}{1-\rho}} \varepsilon^{\frac{\rho}{1-\rho}}}{A^{\frac{\rho}{\rho-1}} (1-\phi)^{\frac{1}{\rho-1}}\, \varepsilon^{\frac{\rho}{1-\rho}} p_n^{\frac{1}{\rho-1}}} = \frac{p_m^{\frac{\rho}{1-\rho}}}{A^{\frac{\rho}{\rho-1}} (1-\phi)^{\frac{1}{\rho-1}}\, p_n^{\frac{1}{\rho-1}}}$$

Notice that ε cancels out, and therefore does not affect mp_m.

Table 2: The Effect of the Minimum Wage on the Wage in Industries Associated with Home Production Substitutes

Dependent Variable: The Real Wage										
	OLS					2SLS				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Minimum Real Wage	0.764***	0.771***	0.770***	0.665***	0.648***	0.747***	0.645***	0.550**	0.632**	0.582**
	(0.059)	(0.053)	(0.063)	(0.058)	(0.056)	(0.169)	(0.133)	(0.267)	(0.248)	(0.247)
State FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No	Yes	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 F-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
R^2	0.258	0.259	0.259	0.372	0.372	0.258	0.258	0.259	0.372	0.372

Notes: 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.

Table 3: 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	-0.026	-0.006	-0.020	0.039	0.022	0.040	-0.523***	-0.655***	-0.608***	-0.478**	-0.378*	-0.398*
	(0.087)	(0.070)	(0.066)	(0.049)	(0.054)	(0.053)	(0.183)	(0.252)	(0.232)	(0.214)	(0.222)	(0.240)
Year FE	Yes	No	No	No	No	No	Yes	No	No	No	No	No
Region$\times$ 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
1^{st} stage F statistic	–	–	–	–	–	–	15.73	24.42	24.55	24.68	24.76	24.92
Obs.	86,414	86,414	86,414	86,414	86,414	86,414	86,414	86,414	86,414	86,414	86,414	86,414
R^2	0.013	0.015	0.046	0.256	0.291	0.309	0.012	0.014	0.046	0.255	0.290	0.309

Notes: 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 4: 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	0.010	0.005	0.002	-0.008	-0.011	-0.124	-0.124	-0.045	0.022	-0.071	-0.041
	(0.034)	(0.030)	(0.027)	(0.026)	(0.026)	(0.026)	(0.115)	(0.148)	(0.122)	(0.121)	(0.122)	(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
1^{st} stage F statistic	–	–	–	–	–	–	15.28	25.11	25.19	25.44	25.32	25.63
Obs.	100,927	100,927	100,927	100,927	100,927	100,927	100,927	100,927	100,927	100,927	100,927	100,927
R^2	0.014	0.015	0.067	0.159	0.201	0.210	0.013	0.015	0.067	0.159	0.201	0.210

Notes: 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.