Recent Demographic Developments in a Quantity-Quality Framework

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Abstract

This paper contributes to explaining recent demographic developments using basic economic theory. In particular, I rely on a household production approach (Becker, 1965) on one hand, and the the quantity vs quality model of fertility (going back to Becker and Lewis, 1973) on the other hand. The quantity-quality framework is crucial to understand recent demographic trends despite arguments to the contrary. In particular, I show that when fathers' and mothers' human capital are complements in the production of child quality, and when the optimal level of child quality is sufficiently high, the long-observed negative relationship between income and fertility reverses. Also, the level of involvement in child quality production by respective parents can partly explain differences in fertility in rich countries precisely when optimal child quality is high.

1 Introduction

This paper aims to understand recent trends in fertility. In particular, one puzzle related to fertility is the reversal of the previous trend of higher income and more educated households having lower fertility. In a number of rich countries, now an opposite trend seems to emerge. Another puzzle is that while traditional theories might predict that fertility declines would be less pronounced in countries with more traditional gender roles, what we find is that more "conservative" countries often have as large or even larger decreases in fertility. Examples include Japan and Italy.

Several hypotheses have been put forward to explain these puzzles. The more promising ones include the attempts of Doepke and Kinderman (2019), Doepke et al (2023), as well as a very recent working paper by Claudia Goldin (2024). Dopeke and Kindermann, as well as Doepke et al in particular posit that couples have to agree on the number of children they produce. As both parents need to partake in the production of children, there is a certain "veto power" over whether to have children as well as how many children to have. Having children comes with a "motherhood penalty", especially in countries where most of the childcare responsibilities are borne by women. The lower wages women

face after having children in turn influence their bargaining power within their respective marriages. The main innovation of Doepke ad Kindermann is taking into account this dynamic tradeoff. Of course, if men can commit to a certain sharing rule in their marriages, this tradeoff is not present, for women will receive the same share of the marital surplus before and after having children. Alternatively, men can promise to take over some of the childcare responsibilities. However, Doepke and Kindermann work with a model where commitment is limited. Thus, after deciding on the number of children and how the amount of childcare is allocated between mothers and fathers, fathers can renege on their promise to take up a larger share of childcare responsibilities, which in turn hurts the labor market opportunities of mothers.

In the present paper, unlike Doepke and Kindermann and Doepke et al, I follow closely the collective framework developed by Chiappori (1992) and assume that, after households are formed, there is full cooperation, including over time periods. I do so partly in order to show that some of the relevant facts can be explained without resorting to a non-cooperative framework, and also because models assuming commitment and an associated efficient division of labor within households in general have a good empirical track record.

My framework includes the following features. Households produce child quantity and child quality. Following Becker and Lewis (1973), I do not specify the utility function over quantity and quality. There is, at the same time, a tradeoff between the quantity and quality of children, which works through the budget constraint, as in Becker and Lewis (1973). I depart from the Becker-Lewis framework only by specifying the production function of producing child quantity and child quality.

Child quality is produced by using education as well as household-specific human capital. The skills of men and women are complements, thus if one member of the household, such as the man, do not possess enough of the latter, child quality suffers.

At the same time, we have evidence that the power of women in marriages has increased substantially during the past several decades (Chiappori and Meghir, 2015). Because women place a higher weight on children as family goods, when female empowerment is more substantial, changes in fertility as a response to the several developments analyzed in the present paper are also more substantial.

Goldin (2024)'s observation, namely that fertility crises occur more when economic growth, and hence a possible disconnect between inherited skills and norms and new economic realities is large, is replicated in my model. Unlike in Goldin, I do not make assumptions about women and men being differentially open to new ideas.Here everyone might be open to the same extent, however, one may not have adequate parenting skills.

The division of labor between mother and father in my model is efficient and the result of cooperative household decisions, given the existing parenting skills of the respective partners. Traditional roles play a role in my analysis as they do in the approach stressing "separate spheres" bargaining (Lundberg and Pollak, 1996), but they do not ever lead to inefficiency ex post; on the other hand, they do limit adaptation to changing circumstances.

Finally, a novelty of my approach is that it connects recent theoretical and empirical work with the Beckerian quantity vs quality framework. According to Doepke et al and others, the Beckerian model cannot fully (or even partially) account for the recent puzzling trends in fertility. I argue to the contrary that the quantity-quality model is crucial in understanding the recent trends. As in standard quantity-quality models, I assume that the budget constraint creates an interaction between quantity and quality. It turns out that, without saying anything about the preferences, this assumption coupled with a small set of auxiliary assumptions, generate predictions consistent with what the data show. In particular, my model predicts that at some point the relationship between education (and income) and fertility becomes positive. Furthermore, even under full commitment, men lacking childcare skills is a major stumbling block not only toward greater "equality" but also toward higher fertility.

One key feature of my model is that I introduce co-parenting into the quantity-quality framework. As alluded to above, having two parents in the model presents us with novel predictions regarding the relationship between income and fertility, as well as the relationship between fertility and the division of childcare responsibilities.

The remainder of the paper is built as follows. First, I present empirical evidence on recent trends in fertility. Then, I outline my theoretical framework, after which I analyze two problems: the relationship between income and fertility, and pre-investments in parenting skills by men and women. Finally, I summarize how my framework helps account for various recent trends in fertility.

1.1 Recent demographic developments

We seem to live in an age of demographic decline. Populations in almost all countries are aging; that is partly positive news, given it means individuals live longer. However, parallel to the greater longevity trend there is a decline in birth rates (Figure 1). The decline is especially pronounced in rich countries (Figure 2); in many of these countries the fertility rate is now below the replacement level (2). Furthermore, there is a puzzle accompanying these developments: in OECD countries the long-term negative relationship between income and fertility has been stalling and even reversing (Figure 3). Another puzzle is why some countries with seemingly traditional gender roles do especially poorly when it comes to reproducing their population, while in countries where fathers take part in a larger share of childcare responsibilities, fertility is higher (see Figure 4). Additionally, the highly educated now have more children (Figure 5), and they also spend more time with them (Figure 6).

2 Formal analysis

In the following I turn to formal analysis. Let us consider a household characterized by the collective household model (Chiappori, 1992). An important feature of this type of model is that household production choices are made

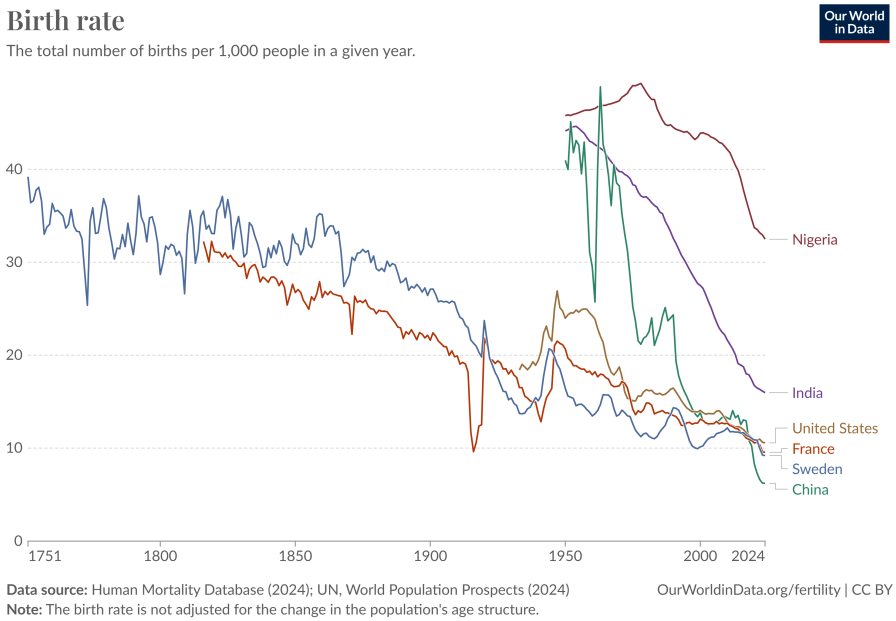


Figure 1: The global fertility decline. Source: Our World in Data

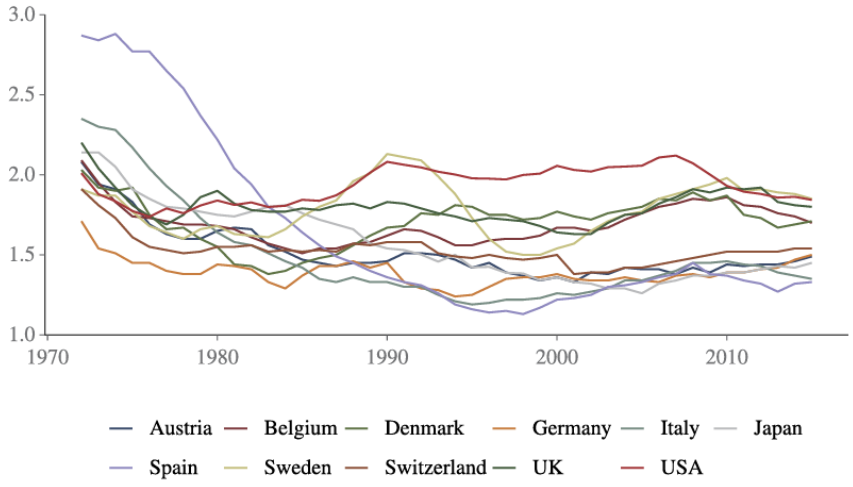


Figure 2: Fertility in a set of developed countries. Source: Doepke et al, 2023

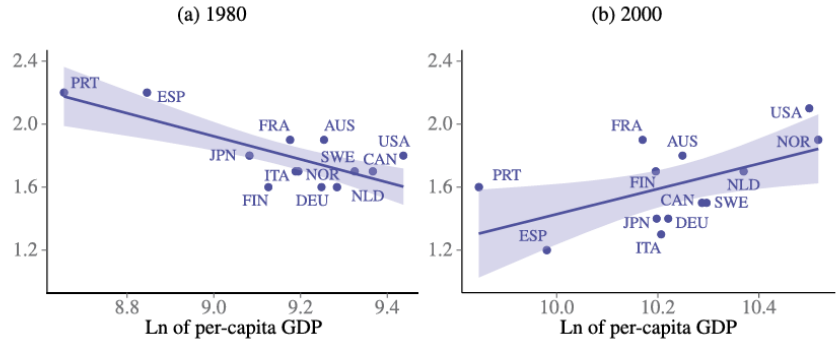


Figure 3: Income and fertility. Source: Doepke et al, 2023

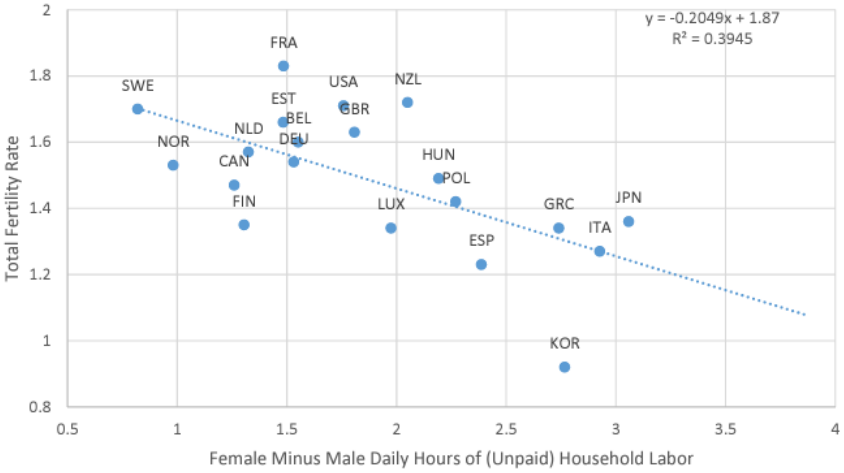


Figure 4: The division of childcare responsibilities and fertility. Source: Doepke et al, 2023

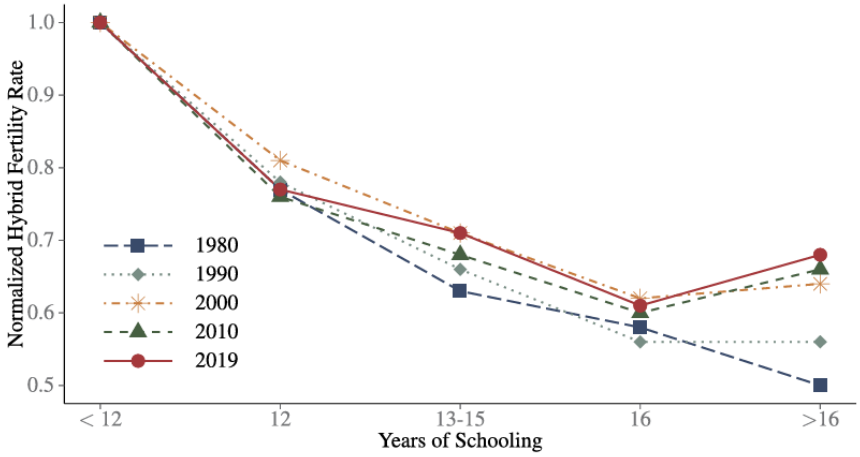


Figure 5: Schooling and fertility. Source: Doepke et al, 2023

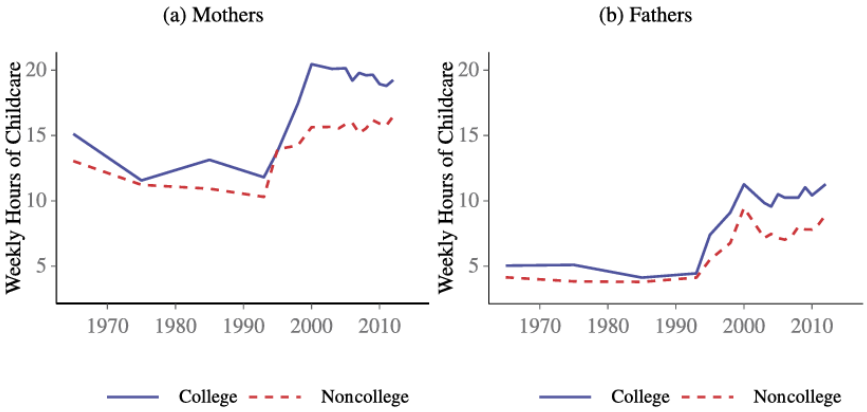


Figure 6: Schooling and the intensity of childcare

cooperatively and hence are efficient. Consumption of household goods occurs according to the "power" enjoyed by the respective household members. I assume that, in particular, women value the quality of children more than men, an assumption driven by a wide range of empirical evidence. Household members consume a composite private good with a price of 1, as well as child quantity (n) and child quality (q), the latter two as public (family) goods.

In the case of child quantity, only the time of woman household members is productive, given that only women can give birth. On the other hand, the inputs of males and females are assumed to be, on net, complements in the production of child quality. The full price of child quantity can be written as $t_n w_f n + (aw_f + bw_m)nq$, while the full price of child quality is $(aw_f + bw_m)nq + (aw_f + bw_m)q$. Both have a fixed element, as well as a shared one, exhibiting an interaction between the quantity and quality of children. In this I follow the literature sparked by Becker and Lewis (1973). a and b are input coefficients that determine the amount of female and male time units necessary to produce one unit of child quality (assuming that a and b are consistent with cost-minimization), while t_f is the time input of a woman bearing a child. Later I will introduce different forms of human capital as influencing these coefficients.

As a or b changes, the relative shadow prices of male and female inputs change. While the envelope theorem implies that such changes will not affect indirect utility via already optimized variables, the shift in relative productivity affects the cost of producing both n and q. Complementarity in child quality production dampens substitution effects by maintaining a balance between male and female inputs, ensuring that efficiency gains in one input benefit the production of q and n.

Now consider preferences. The utility function is

$$U = \mu_f u_f(C_f, n, q) + (1 - \mu_f) u_m(C_m, n, q), \tag{1}$$

where μ_f is the Pareto-weight of women, and C_f and C_m are the private consumption of the female and male household member, respectively. The function is maximized with respect to the following budget constraint:

$$C_f + C_m + t_n w_f n + (aw_f + bw_m)nq + (aw_f + bw_m)q = w_f T_f + w_m T_m. \tag{2}$$

w_f and w_m are female and male wages, respectively, while T_f and T_m are the time available to women and men, respectively.

The FOCs are

$$\mu_f u'_f(C_f) + (1 - \mu_f) u'_m(C_m) = \lambda, \tag{3}$$

$$\mu_f u'_f(n) + (1 - \mu_f) u'_m(n) = \lambda(t_f w_f + (aw_f + bw_m)q), \tag{4}$$

and

$$\mu_f u'_f(q) + (1 - \mu_f) u'_m(q) = \lambda(aw_f + bw_m)(1 + n). \tag{5}$$

Notice, among else, the following: There is a tradeoff between the quantity and quality of children. This is not surprising given that I follow closely the framework set up by Becker and Lewis (1973). However, also notice that when either a or b is higher; which can be interpreted to be a result of a lack of (general or specific parental) skill by either the male or female part of the household, *both* the optimal amount of child quality and child quantity is lower. This is also a direct consequence of the interaction between quantity and quality through their multiplicatively entering the budget constraint. This theoretical result is consistent with empirical findings, as presented in Figure 4.

The model seems to account for several changes in fertility over the last 100 years. First, it is steeped in the quantity vs quality tradition, so it is consistent with the long-standing negative relationship between income and fertility. However, by introducing complementarity between the inputs of fathers and mothers, it also accounts for the reversal of that relationship. In particular, the more important is quality as opposed to quantity, the more it will matter how well mothers *and* fathers are equipped with parenting and other skills (I will say more about this in the next subsections).

2.1 The role of market-oriented human capital and the reversal of the income-fertility relationship

Market-oriented human capital (that is, education) is, while mainly oriented toward the market sector, also productive in the household (Becker and Murphy, 2007). In particular, assume that $a'(H_f) < 0$ and $b'(H_m) < 0$, that is, the level of parental education makes parents' time more productive in the production of child quality. At the same time, $w'_f(H_f) > 0$ and $w'_m(H_m) > 0$. That is, an increase in general market-oriented human capital has two counteracting effects. First, by increasing wages, it increases the opportunity cost of child-rearing. However, it also lowers the shadow price of child rearing through its direct effect on the input coefficients a and b.

I further assume interaction between female and male human capital. Formally, assume that $a_{H_f H_m} > 0$ and $a_{H_m H_f} > 0$. The complementarity between male and female inputs reflects the synergistic effect of joint parental engagement. Activities like reading or teaching benefit from both parents having higher human capital, as one parent's actions amplify the other's contributions. This mechanism distinguishes the model from traditional quantity-quality models that often focus only on inputs by one (unisex) parent. One exception is Del Boca et al (2014) who assume a Cobb-Douglas relationship between inputs in the production of child quality. They, however, do not focus on the quantity-quality interaction.

Now consider the dynamics in this revised model of the quantity-quality interaction. First, a higher H_f or H_m decreases the cost of both quantity and quality. According to equations (4) and (5) this increases q more than n when n is still large and q small. This in turn increases the shadow price of n, leading to less n and in turn to more q. This is all in keeping with the Beckerian quantity-quality tradition.

However, as I will show, a reversal in the traditional relationship between education and income on one hand, and fertility on the other hand, will be To see this, consider more formally the effects of female human capital on the right-hand sites of Eq. (4) and (5) (the effect of male human capital is symmetric). The former is expressed with the derivative

$$t_f w'_f(H_f) + (a'(H_f)w_f + aw'_f(H_f) + b'(H_f)w_m)q, \tag{6}$$

while the latter is

$$(a'(H-f)w_f + aw'_f(H_f) + b'(H_f)w_m)(1+n). \tag{7}$$

Suppose now that $a'(H_f)w_f + aw'_f(H_f) + b'(H_f)w_m)q < 0$.

As n falls and q increases, there will come a point from which

$$\begin{aligned}\big|(a'(H_f)w_f + aw'_f(H_f) + b'(H_f)w_m)q - t_f w'_f(H_f)\big| > \\ \big|(a'(H_f)w_f + aw'_f(H_f) + b'(H_f)w_m)(1+n)\big|.\end{aligned} \tag{8}$$

In this case the increase in education (and consequently: income) increases n more than q, thus leading to *higher* fertility. Intuitively, human capital and the interaction between parental education levels decreases the shadow price of both quantity and quality, but once quality is very high, it has a disproportionate effect on the cost of *quantity*, due to the quantity-quality interaction in the budget constraint, and this effect can dominate the indirect effect education have through wages.

Meanwhile, the derivatives of the full price functions with respect to q and n are $\lambda(aw_f + bw_m)$ for both. This relationship is driving the tradeoff between quantity and quality.

Now consider what happens once the income-fertility relationship turns positive. As n increases, it does not induce a corresponding increase in human capital, so the right-hand side of equation (5) increases and thus quality goes back down. This in turn lowers the right-hand side of (4), leading to yet more n. The negative correlation between n and q is restored until the household economy reaches a steady state.

To sum up, the interaction between quantity and quality, for a while, leads to a negative relationship between parental human capital (and hence income) and the number of children. At some point, however, q becomes sufficiently large and n sufficiently small so that (provided the complementary between parental inputs in the production of child quality is sufficiently strong) the right-hand side of equation (4) increases more with an increase in maternal and/or paternal human capital than the right hand side of equation (5). We arrive at the new, positive relationship between education and income on one hand, and fertility on the other hand. However, this positive relationship is not sustainable in the long-run without reinforcement in the growth of female and male human capital, as the increase in n pushes down quality over time.

The new, positive income-fertility relationship is observed between OECD countries (see Figure 3), and there are studies (e.g. Kolk, 2022) that suggest the reversal can be observed even at the individual level, notably among

higher income and highly educated cohorts. This is consistent with Figure 5 and my predictions which would point to highly educated couples, expecting high-quality children, as sources of a potential positive relationship between income and fertility.

Note that a similar dynamic applies to the evolution of (co-)parental skills and fertility. First, as fathers take on a more active role as parents, it decreases the shadow price of child quality more than that of quantity, and this in turn raises the endogenous shadow price of the quantity of children. Once q reaches a certain threshold, a more "equal" division of parental tasks starts to increase, rather than decrease, fertility.

2.2 Parenting skills

Apart from a general education, parents also have more specific skills related to parenting. Here I endogenize the accumulation of such parenting skills.

Let ρ_f and ρ_m be the female and male investments in parenting skills. Let the total cost of investments be simply ρ_f and ρ_m, respectively. Both male and female parenting skills affect the parental input of the other parent, just as in the case of general human capital.

Investments are made prior to the matching phase. This means that men (women) do not take into account the contribution their investments make to the time input of women (men). With that in mind, I derive the first-order conditions.

Private optimum

The FOCs with respect to female investment are

$$\mu_f u'_f(n)\Big(- \frac{n^* w_f}{(aw_f + bw_m)^2 q^*}\Big)a'(\rho_f) = 1 \tag{9}$$

for child quantity and

$$\mu_f u'_f(q)\Big(- \frac{q^* w_f}{(aw_f + bw_m)^2 (1+n)}\Big)a'(\rho_f) = 1 \tag{10}$$

for child quality.

The same FOCs for males are

$$(1-\mu_f) u'_m(n)\Big(- \frac{n^* w_m}{(aw_f + bw_m)^2 q^*}\Big)b'(\rho_m) = 1 \tag{11}$$

and

$$(1-\mu_f) u'_m(q)\Big(- \frac{q^* w_m}{(aw_f + bw_m)^2 (1+n)}\Big)(a'(\rho_m + b'(\rho_m) = 1. \tag{12}$$

Quantity-quality tradeoff

From the FOCs we obtain

$$\frac{u'_f(n)}{u'_f(q)} = \frac{(q^*)^2 w_f}{(1+n)} \tag{13}$$

and

$$\frac{u'_m(n)}{u'_m(q)} = \frac{(q^*)^2 w_m}{(1+n)}. \tag{14}$$

The tradeoff between the quantity and the quality of children continues to hold.

Social optimum

Now consider the problem of a "social planner" who, unlike the men and women in my model, takes into account the effect of female parental skills on male skills and vice versa. In the following I derive the first-order conditions of the *social* optimization problem.

The FOCs with respect to female investment are

$$\mu_f u'_f(n)\Big(- \frac{n^* w_f}{(aw_f + bw_m)^2 q^*}\Big)(a'(\rho_f) + b'(\rho_f)) = 1 \tag{15}$$

for child quantity and

$$\mu_f u'_f(q)\Big(- \frac{q^* w_f}{(aw_f + bw_m)^2 (1+n)}\Big)(a'(\rho_f) + b'(\rho_f)) = 1 \tag{16}$$

for child quality.

The same FOCs for males are

$$(1-\mu_f) u'_m(n)\Big(- \frac{n^* w_m}{(aw_f + bw_m)^2 q^*}\Big)(a'(\rho_m) + b'(\rho_m)) = 1 \tag{17}$$

and

$$(1-\mu_f) u'_m(q)\Big(- \frac{q^* w_m}{(aw_f + bw_m)^2 (1+n)}\Big)(a'(\rho_m) + b'(\rho_m)) = 1. \tag{18}$$

Consider now the following. The net externality male investments have on female input can be written as

$$(1-\mu_f) u'_m(n)\Big(- \frac{n^* w_m}{(aw_f + bw_m)^2 q^*}\Big) a'(\rho_m) > 0. \tag{19}$$

Notice that as μ_f, that is, the power of women within the household, increases, the externality term decreases. It also decreases in female and male wages, with female wages playing a disproportionate role.

An implication of the model is that as the gender wage gap between men and women narrows, men internalize their contribution to child-rearing to a greater extent. The same is true when women are empowered relative to men in the household.

Men initially may have worse parental skills due to social norms or by women optimally accumulating a higher level of parental skills because of their traditionally lower earnings and corresponding lower cost of time. Once this pattern is established, men may remain "low-skilled" in parenting by following the examples set by earlier generations. As shown, the dynamic changes as women start closing the gender wage gap and also achieve greater power within households.

3 Accounting for recent demographic trends

Let us review how the arguments presented in this article account for a number of recent demographic trends.

First, my model predicts that as the optimal level of child quality increases, the negative relationship between education and income on one hand, and fertility on the other hand, can turn to positive. This is driven by the effect of education on the efficiency of parenting and the interaction between male and female human capital in parenting. Figures 5 and 6 indicate that this is at least an important part of the story.

Another consequence of a higher optimal child quality is that the presence or lack of effective co-parenting becomes important not only for child quality, but also for child *quantity*. This is because of the interaction between quantity and quality in determining the cost of both quantity and quality. As parenting becomes more efficient, the cost of both the quality and the quantity of children decreases. The effect on quantity (i.e. fertility) increases as quality increases. Thus, the model helps explain why there is now a positive relationship between fertility and a more equal sharing of childcare responsibilities (Figure 4).

My results can be compared and contrasted to the findings of Doepke and Kindermann (2019). Unlike in their model, in my framework household members do not face commitment problems. There is, however, still room for disagreement over the number of children (which plays a crucial role in Doepke and Kindermann). To see this, consider again Equation (4). If women have a stronger preference for child quality than men do, then an additional child has a higher shadow price in a state of the world where the woman's preferences dominate, while it has a lower shadow price when men have more bargaining power, for then the couple chooses a lower level of child quality, lowering the cost of child quantity. The more "deficient" men are in childcare skills (which translates to a higher b), the larger is the disagreement between men and women over the number of children.

Absent from Doepke and Kindermann, but present in my analysis is the prediction that the higher is the optimal child quality, the more likely it is that the negative relationship between income (and education) and fertility turns positive. Figure 5 indicates that reversal occurs among the *very* highly

educated, which lends credence to my theory, for the production of child quality is highly intensive in parental human capital.

4 Conclusions

This paper contributes to explaining recent demographic developments using basic economic theory. In particular, I relied on a household production approach (Becker, 1965) on one hand, and the the quantity vs quality model of fertility (starting with Becker and Lewis, 1973), on the other hand. Using this framework I showed that if female and male inputs (and in particular, female and male human capital) are complements in producing child quality, the relationship observed throughout the 20th century between income and fertility (namely, that higher incomes drive down fertility) can and at one point is reversed, when child quality reaches a certain level. Also, lack of parenting skills by one of the parents (typically, the father) can account for differences in fertility among rich countries precisely when child quality is sufficiently high. My paper shows that the quantity-quality model is still powerful in explaining recent demographic trends.

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