A Note on Contraception, Social Norms and Growth*

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Abstract

We introduce contraceptives and social norms in an overlapping-generations growth model of fertility and human capital. Parents can use costly modern contraceptives to control their family size and each household's fertility decision is influenced by the decisions made by others. Given the number of children born, parents decide how much education to provide and how much to save out of their income. We characterize the local dynamics of a stable steady-state equilibrium. Around this steady-state, family planning interventions, which reduce the price of modern contraceptives, decrease fertility and increase human and physical capital. The effects of family planning interventions are larger when reproductive externalities are stronger.

KEYWORDS: education, contraception, social norms, income
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1 Introduction

Family planning interventions can have large effects on fertility outcomes, as previously shown by several micro studies (e.g., Kearney and Levine, 2009; Miller, 2010; Joshi and Schultz, 2013). With easier and cheaper access to contraception, parents have fewer children and educate them more. A more educated and productive populace can lead to higher aggregate levels of development (see Cavalcanti, Kocharkov, and Santos, 2021). Moreover, there is evidence of reproduction externalities and effects of social norms on

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fertility decisions (e.g., Dasgupta, 2000; Fernández and Fogli, 2009). This paper provides a theoretical framework to answer the novel question of whether family planning interventions are more effective in the presence of social norms.

To answer this question, we develop an overlapping-generations model of fertility and human capital with costly fertility control and reproductive externalities, describing social norms. We characterize the economic dynamics of a local stable steady-state equilibrium in which fertility decreases with human and physical capital accumulation. We then show that family planning interventions (or innovations in contraceptive methods) decrease fertility and increase human capital and income levels. Further, we show that the effects of family planning interventions are stronger when reproductive externalities are larger. This happens due to a feedback effect in the population. As more and more people respond to the intervention by cutting the number of children, others follow suit.

There is a long tradition in economics to investigate the link between the economic and the demographic processes (cf., Barro and Becker, 1989; Galor and Weil, 2000; de la Croix and Doepke, 2003; Baudin, de la Croix, and Gobbi, 2018). According to this literature, parents decrease their family size and invest more in each child when income rises, since the opportunity cost to raise a child increases with wages. This quantity-quality trade-off depends on the income elasticity of the quantity and quality of children, as explained in Doepke (2015). In general, when income and substitution effects cancel each other (e.g., log utility), then fertility is independent of income. Our model can generate a negative relationship between fertility and income even in the presence of a log utility. In our formulation, as income rises, modern contraceptive methods become relatively cheaper and therefore fertility decreases.

Although Becker (1960) already discussed in detail the importance of contraceptive methods in controlling family size, this is largely neglected in the macro growth literature.[1] An exception is Cavalcanti, Kocharkov, and Santos (2021). Relative to our previous paper, we add social norms in fertility behaviour, which has been pointed out as an important factor in the reduction of fertility during the demographic transition (cf., Munshi and Myaux, 2006; Fernández and Fogli, 2009; de Silva and Tenreyro, 2020). On the other hand, in this paper, we do not analyze distributional aspects of fertility since we work with a representative agent model nor do we model unwanted fertility as shocks. We do this to better focus on the role of social norms. Moreover, we analyze family planning interventions in this scenario and show that such interventions are stronger in the presence of social norms.[2]

Finding a proper empirical measurement of social norms about fertility is not easy. Fernández and Fogli (2009) explore the role of culture for current economic outcomes of women such as labor-force participation and fertility. In particular, they show that current completed fertility in a sample of second-generation immigrants to the U.S. is positively

[1]This is in contrast with the empirical micro literature, which shows strong effects of family planning interventions on fertility and children outcomes (cf., Schultz, 2008).

[2]Moreover, the model in Cavalcanti, Kocharkov, and Santos (2021) can only be solved numerically and only quantitative exercises are provided. Quantitative analysis are very useful in economics but the underlying mechanisms behind the quantitative results are, sometimes, not easy to be interpreted.

correlated with past total fertility rate (TFR) in the country of origin of the parents. Moreover, the correlation becomes stronger for females in ethnically-clustered neighborhoods, signalling the presence of social norms about fertility.

Myong, Park, and Yi (2020) take a different approach. First, they document that even though marriage rates in East Asian countries are one of the highest in the world, fertility is one of the lowest. Furthermore, almost all births occur within marriage. They hypothesize that these patterns are historically shaped by social norms imposed by Confucianism: females bear entirely the childcare tasks within marriage and out-of-wedlock births are stigmatized. These two social norms are embedded in a structural model of fertility. The results point that, while the gender-biased child care norm indeed influences the low fertility rate of married women, the out-of-wedlock birth norm does not play such a large role for the childlessness of single females.

In a similar fashion, Iftikhar (2018) explores the influence on fertility of social norms about the acceptable number of children in Pakistan. First, the reduced-form relations between past average completed fertility and current fertility by education and ethnicity are estimated. Second, a structural model of fertility and quantity-quality trade-offs is disciplined to generate the same relations by indirect inference. The results point out that around 40% of the fertility dispersion is accounted for by social norms.

Myong, Park, and Yi (2020) and Iftikhar (2018) augment the quantitative model of Baudin, De La Croix, and Gobbi (2015) by introducing social norms about fertility and/or childlessness. The main advantage of this framework is the explicit modelling of the extensive and intensive margin of fertility. In contrast, here we pose a simple quantity-quality model of fertility and family planning in which social norms are injected and the analytical properties of the model with respect to the fertility social norm and family planning polices are derived. Our model allows us to discuss analytically the role of social norms in the implementation of family planning policies.

Strulik (2017) studies how cheaper and more effective contraception can lead to higher growth as individuals switch from traditional to modern contraception (see also Fernández-Villaverde, Greenwood, and Guner, 2014). Prettner and Strulik (2017) also study the interplay of contraception and norms (religious beliefs). We add to these papers by analyzing how powerful family planning interventions impact the economy in the presence of social norms.

2 Model

2.1 Demographics and endowments

Individuals live for three periods: childhood, young adulthood, and old adulthood. Children do not make any economic decisions, but they can acquire skills. Young adults have one unit of productive time and are endowed with skills that they acquire during their childhood. They make the relevant economic decisions, including investment decisions. Old adults do not work and simply consume their savings.

2.2 Production

The consumption good is produced with a technology that uses capital, K, and efficiency units of labor, L, as inputs, such that:[3]

$$Y = AK^{\alpha}L^{1-\alpha},\ \alpha \in (0,1),\ A > 0. \tag{1}$$

Capital depreciates fully after use. Let w be the wage rate and let R be the rental price of capital. Profit maximization implies that inputs are paid according to their marginal productivity, such that:

$$w = (1-\alpha)AK^{\alpha}L^{-\alpha}, \tag{2}$$
$$R = \alpha AK^{\alpha-1}L^{1-\alpha}. \tag{3}$$

2.3 Households

Fertility: Couples can have up to $N > 0$ children, and they can control their family size, n, by investing in contraceptive use, such that:

$$n = N - \theta q,\ \theta > 0, \tag{4}$$

where $q \geq 0$ is the investment in contraception and θ is related to the efficiency of contraception on birth control. Contraception is costly and the relative price of contraception is $\phi_q \geq 0$.

Human capital: Parents invest in the education of their children, $e \geq 0$, such that the human capital of their children is given by

$$h' = h(e) = e^{\zeta},\ \zeta \in (0,1). \tag{5}$$

Investment in education is in terms of the consumption good. Children are also time consuming. Each child takes a fraction $\chi \in (0,1)$ of her parents' time endowment. We assume that parents are able to provide some hours in the labor market even when they have the maximum amount of children, i.e., $\chi N < 1$.

Preferences and optimal decisions: Consumption of couples during the young adulthood period is denoted by c_y, while c_o' denotes consumption of the couple in the next period, when old. Preferences of households are represented by:

$$U(c_y, c_o', n, h') = \log(c_y) + \beta \log(c_o') + \gamma \log(n) + \xi \log(h') + \psi\left(\frac{n-\bar{n}}{\bar{n}}\right), \tag{6}$$

[3] We will abstract from the subscript t to denote the time period and use the convention that object $'$ stands for future variables.

where β, γ, ξ and ψ are positive numbers.[4] The variable $\bar{n}$ is the average fertility in society and describes social norms in reproduction behavior.[5]

Let s denote savings during the young adulthood period. The problem of the couple is to choose c_y, c'_o, q, s, and e to maximize (6) subject to (4), (5), and the following budget constraints:

$$c_y + s + \phi_q q + en = wh(1 - \chi n), \tag{7}$$

$$c'_o = R's. \tag{8}$$

Equation (7) states that consumption plus savings and expenditures on contraception[6] and education equals income. Equation (8) implies that old couples consume their savings from the young adulthood period. Whenever $q > 0$, then the equations which describe the solution of this problem after imposing the symmetric equilibrium condition that $n = \bar{n}$

[4]The way we embed social norms in preferences is based on the idea of conformism (e.g., Dasgupta, 2000). A positive ψ implies that it is more costly to reduce fertility in a society in which fertility is relatively high and there is peer pressure for high fertility rates. Since our focus is on the role of family planning interventions, we believe that this form of social norms better represents the issue we investigate.

[5]Given the linearity assumption of the fertility function on contraception, then the social norm on fertility can also be written in terms of contraceptive usage. Using Equation (4) into Equation (6), then the social norm term of the utility function becomes

$$\psi \left(\frac{\theta(\bar{q} - q)}{\bar{n}} \right),$$

where $\bar{q}$ is the average use of contraception. Our qualitative results would go through if we had a more general utility, such as

$$U(c_y, c'_o, n, h') = \log(c_y) + \beta \log(c'_o) + \gamma \log(n) + \xi \log(h') + \psi_n \left(\frac{n - \bar{n}}{\bar{n}} \right) + \psi_q \left(\frac{\bar{q} - q}{\bar{n}} \right).$$

In this case, we would replace ψ by $\psi_n + \frac{\psi_q}{\theta}$ in our analytical solution. If we assume more general functional forms for social norms, then we lose the analytical tractability of the model and we would need to solve it numerically.

[6]This is the relative price of modern contraceptives. This includes not only the monetary value of modern contraceptive methods but also any non-monetary barrier (e.g., access and availability) to use them.

are:[7]

$$c_y = \frac{1}{(1+\beta+\gamma+\psi)}\left(wh - \frac{\phi_q}{\theta}N\right), \tag{9}$$

$$s = \frac{\beta}{(1+\beta+\gamma+\psi)}\left(wh - \frac{\phi_q}{\theta}N\right), \text{ and } c_o' = R's, \tag{10}$$

$$e = \frac{\xi\zeta}{(\gamma+\psi-\xi\zeta)}\left(wh\chi - \frac{\phi_q}{\theta}\right), \tag{11}$$

$$q = \frac{N}{\theta} - \frac{(\gamma+\psi-\xi\zeta)}{\theta(1+\beta+\gamma+\psi)}\left(\frac{wh - \frac{\phi_q}{\theta}N}{wh\chi - \frac{\phi_q}{\theta}}\right), \tag{12}$$

$$n = \frac{(\gamma+\psi-\xi\zeta)}{(1+\beta+\gamma+\psi)}\left(\frac{wh - \frac{\phi_q}{\theta}N}{wh\chi - \frac{\phi_q}{\theta}}\right). \tag{13}$$

We make the following assumption:

Assumption 1: Let $N\chi < 1$ and $\frac{(\gamma+\psi-\xi\zeta)}{(1+\beta+\gamma+\psi)\chi} < N$.

The assumption that $N\chi < 1$ implies that even when fertility is at its maximum ($q = 0$), couples still supply a positive number of hours to the labor market. The second part of the assumption implies that when the price of modern contraceptive methods is zero ($\phi_q = 0$), then fertility is lower than the case in which there is no investment in modern contraceptive methods ($q = 0$).

Observe that when ϕ_q goes to zero then fertility does not depend on labor income (wh). This is because when income rises the opportunity cost (time cost) of having more children rises (substitution effect), but since children are a normal good, then the income effect induces parents to have more children. With log-utility these two effects cancel each other out, and when $\phi_q = 0$ then fertility does not depend on income—see Equation (13).[8] This is explained in Doepke (2015) and Jones, Schoonbroodt, and Tertilt (2010). When ϕ_q is positive then there is a negative association between fertility and income, as reported in the data. In this case richer parents can increase the intensity of their use of contraceptive methods in order to control family size.

Notice that whenever the price of modern contraceptives falls then fertility decreases and this relationship is stronger for a higher ψ, which measures how social norms affect reproduction behavior.

Proposition 1. *Let Assumption 1 be satisfied, then for a given wage rate w and when $q > 0$, we have that $\frac{\partial n}{\partial \phi_q} > 0$ and $\frac{\partial\left(\frac{\partial n}{\partial \phi_q}\right)}{\partial \psi} > 0$.*

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[7] When $q = 0$, we have that $n = N$, $c_y = \frac{wh(1-\chi N)}{1+\beta+\xi\zeta}$, $s = \beta c_y$, $c_0' = R's$ and $e = \frac{\xi\zeta}{(1+\beta+\xi\zeta)}\frac{wh(1-\chi N)}{N}$.

[8] Technically, our utility function is not purely a log-utility since we have the last term in (6) that controls the social norms. The critical assumption for income not to matter for fertility with free contraception is that social norms is represented in a relative fashion (i.e. $n/\bar{n}$).

Proof. See Appendix A.

When the price of contraception falls, it becomes cheaper to lower the number of children. As more people do this, others follow suit due to the social norms. With stronger social norms (higher ψ), this feedback becomes more powerful.

One can argue that it is not necessary to explicitly add investment in contraceptives into a standard quantity-quality fertility model because parameter χ, which corresponds to the time cost of children, could capture that investment. Better access to contraceptives could be translated into a rise in parameter χ such that it would raise the quality of children (e) as well as reduce their quantity (n). In fact, the proportional changes in n and e due to a proportional variation in χ have opposite signs but equal magnitude. A fall in the price of contraceptives (ϕ_q) generates not only different quantitative but also qualitative effects. Indeed, a fall in ϕ_q also increases e and reduces n, but observe that parameter χ does not affect the consumption-saving decision, while the price of contraceptives does. In addition, family planning interventions which reduce the price of contraceptives have strong effects on the quantity and quality of children when income levels are low. Proposition 2 summarizes these findings.

Proposition 2. *Let Assumption 1 be satisfied and define $\epsilon_{z,\chi}$ and ϵ_{z,ϕ_q} as the elasticity of variable $z \in \{n, e\}$ with respect to χ and ϕ_q, respectively. Then whenever $q > 0$, we have that:*

(i) $\frac{\partial e}{\partial \chi} > 0$, $\frac{\partial n}{\partial \chi} < 0$ *and* $\frac{\partial s}{\partial \chi} = 0$. *Moreover,* $r_\chi = \frac{|\epsilon_{n,\chi}|}{\epsilon_{e,\chi}} = 1$.

(ii) $\frac{\partial e}{\partial \phi_q} < 0$, $\frac{\partial n}{\partial \phi_q} > 0$ *and* $\frac{\partial s}{\partial \phi_q} < 0$. *Moreover,* $r_{\phi_q} = \frac{\epsilon_{n,\phi_q}}{|\epsilon_{e,\phi_q}|} = \frac{wh(1-N\chi)}{wh - \frac{\phi_q}{\theta} N}$ *and* $\frac{\partial r_{\phi_q}}{\partial (wh)} < 0$.

Proof. See Appendix A.

2.4 Closing the Model

Let P denote the number of young adult households such that $P' = nP$. In equilibrium, demand equals supply in all markets. In the labor market this means that $L = P(1 - \chi n)h$, and in the capital market, $K' = Ps$. Let k denote physical capital per young household. In equilibrium with $q > 0$ it can be shown that $h' = Dk'^{\zeta}$ with $D = \left(\frac{\xi\zeta}{\beta}\right)^{\zeta} > 0$, and $w(k) = (1-\alpha)D^{-\alpha}Ak^{\alpha(1-\zeta)}(1-\chi n(k))^{-\alpha}$. When $q = 0$, we also have that $h' = Dk'^{\zeta}$, and $w(k) = (1-\alpha)D^{-\alpha}(1-\chi N)^{-\alpha}k^{\alpha(1-\zeta)}$. In addition,

$$n(k) = \min\left\{N, \frac{(\gamma + \psi - \xi\zeta)}{(1+\beta+\gamma+\psi)}\left(\frac{(1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha} - \frac{\phi_q}{\theta}N}{(1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha}\chi - \frac{\phi_q}{\theta}}\right)\right\}. \tag{14}$$

Then the following proposition summarizes the fertility choice and our main results.

Proposition 3. *Let Assumption 1 be satisfied. Then it can be shown that* $n(k) \in \left(\frac{(\gamma+\psi-\xi\zeta)}{(1+\beta+\gamma+\psi)\chi}, N\right]$ *and* *(i) there exists a $\underline{k} > 0$ such that if $k \leq \underline{k}$, then $n(k) = N$; and if $k > \underline{k}$, then $n(k) < N$; in addition, $\frac{\partial \underline{k}}{\partial \phi_q} > 0$ and $\frac{\partial \underline{k}}{\partial \psi} > 0$;*

(ii) for $k > \underline{k}$ fertility is decreasing with capital accumulation, i.e., $n'(k) < 0$;

(iii) for $k > \underline{k}$ fertility decreases with family planning interventions which reduce the price of modern contraceptives, i.e., $\frac{\partial n(k)}{\partial \phi_q} > 0$; and the effects of family planning interventions on fertility is stronger for higher reproductive externality ψ, i.e., $\frac{\partial\left(\frac{\partial n(k)}{\partial \phi_q}\right)}{\partial \psi} > 0$.

Proof. See Appendix A.

Part (i) of Proposition 3 shows that, for extremely low levels of development, individuals are too poor to use contraception and fertility is at its maximum. After a certain threshold of development is reached ($\underline{k}$), people start using contraception and fertility declines. The richer the economy becomes, the lower is the fertility level (part (ii)). This happens since, as people become richer, contraception becomes relatively cheaper. Finally, part (iii) shows that family planning interventions are more powerful in the presence of social norms due to the feedback from one individual's decisions onto others.

We can also see these results graphically. Figure 1 displays how the fertility rate changes with physical capital stock in an economy without reproductive externality (gray solid line) and with reproductive externality (black solid line). Fertility is higher in an economy with reproductive externalities for any level of capital stock above $\underline{k}(\psi = 0)$. When fertility starts to fall with capital levels, then the slope is steeper in an economy with a positive ψ. Therefore, for any $k \geq \underline{k}(\psi)$, family planning interventions that decrease the price of contraceptives have stronger effects on fertility in the presence of social norms in fertility, as can be seen by the vertical difference between the solid line and the dashed line in these two economies—one displayed by gray lines ($\psi = 0$) and the other displayed by black lines ($\psi > 0$).

We can now move to finish the solution of the model. The condition that equilibrates the capital market implies that

$$k' = G(k) = \begin{cases} \dfrac{\beta(1-\alpha)D^{-\alpha}A(1-\chi N)^{-\alpha}k^{\alpha+\zeta(1-\alpha)}}{(1+\beta+\xi\zeta)N} & \text{for } k \leq \underline{k}, \\[2ex] \dfrac{\beta\left((1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha}\chi - \frac{\phi_q}{\theta}\right)}{\gamma+\psi-\xi\zeta} & \text{for } k > \underline{k}. \end{cases} \tag{15}$$

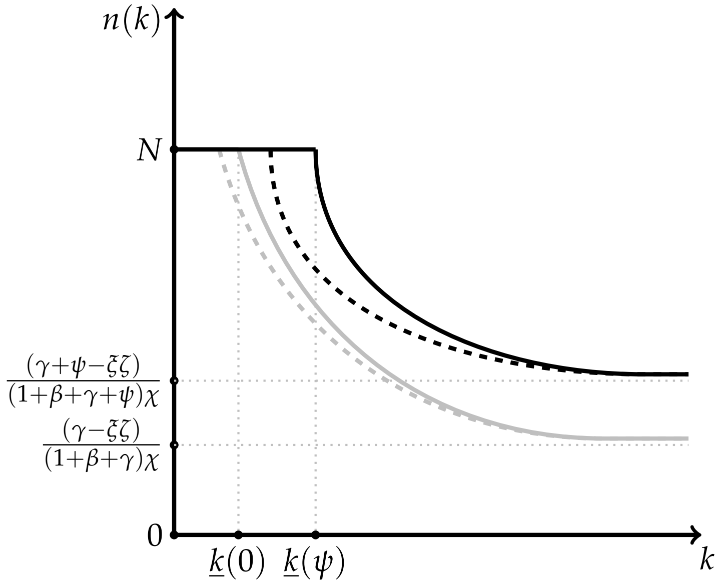
We also have that

$$h' = Dk'^{\zeta}, \tag{16}$$

and human and physical capital are positively related.

Proposition 4. ***(Existence and uniqueness of equilibrium path)*** *For a given initial capital stock k_0, let h_0 be given by (16); then the dynamic system of difference equations (14)–(16) has a unique trajectory (solution).*

Figure 1: Fertility and capital levels



Note: Fertility and physical capital stock for two economies: one without reproductive externality ($\psi = 0$) - gray lines; and another with reproductive externality ($\psi > 0$) - black lines. The dotted lines correspond to the case of family planning interventions which reduce ϕ_q for these two economies

Proof. See Appendix A.

Given the path for n, k, and h, we can find consumption and investment decisions (9)–(11), as well as investment in contraceptive methods. Asymptotically, the system may diverge to infinity, converge to a zero, or converge to a non-zero steady-state equilibrium. Observe that when $k < \underline{k}$, we have that $\frac{\partial G(k)}{\partial k} > 0$, $\frac{\partial^2 G(k)}{\partial k^2} < 0$, and $lim_{k \to 0} \frac{\partial G(k)}{\partial k} = \infty$. Therefore, the system does not converge to a zero steady-state. If $\underline{k}$ is sufficiently large,[9] then there will be a locally stable steady-state $k_N^* = G(k_N^*)$ in which $n(k) = N$. In this case, there is no investment in modern contraceptive methods ($q = 0$), and therefore family planning interventions do not have any effect on the long-run level of the capital stock, i.e, k_N^* is independent of ϕ_q. However, whenever $\underline{k} < k_N^*$, then it can be shown that there exists a locally stable steady-state equilibrium $k^* > \underline{k}$ such that fertility decreases with capital accumulation, and family planning interventions have long-run effects on capital accumulation and output. This is summarized in the following proposition.

Proposition 5. *Let Assumption 1 be satisfied and $\underline{k} < k_N^*$. Then there exists at least one locally stable steady-state equilibrium for capital per young household, $k^* = G(k^*)$, such that in the neighbourhood of k^*, fertility decreases with capital accumulation, and family planning interventions, which reduce the price of modern contraceptives, increase the steady-state level of capital,*

[9] For instance if the relative price of contraceptive methods is too high; see Equation (17).

i.e., $\frac{\partial k^*}{\partial \phi_q} < 0$. *In addition, the higher is the reproductive externality (higher* ψ*) the higher is the steady-state fertility and the lower is the steady-state level of capital, i.e.,* $\frac{\partial k^*}{\partial \psi} < 0$.

Proof. See Appendix A.

Since human capital and physical capital are associated by Equation (16), then it is trivial to show the following result.

Corollary 1. *Let Assumption 1 be satisfied; then human capital increases with physical capital accumulation. If* ϕ_q *is sufficiently small (or* ψ *is sufficiently large) such that* $\underline{k}(\phi_q, \psi) < k^*_{\mathrm{N}}$*, then* $\frac{\partial h^*}{\partial \phi_q} < 0$ *and* $\frac{\partial h^*}{\partial \psi} < 0$.

Proof. See Appendix A.

Notice that the steady-state level of capital per young household, k^*, depends on the parameters of the model and therefore it can lie at any point on the horizontal axis in Figure 1. Hence, the impact of family planning interventions (the gap between the solid and dotted lines) also depends on the exogenous parameters that contribute to determine how rich the economy is.

Taking Proposition 5 and Corollary 1 together, we have that economies with a higher degree of social norms in fertility end up with lower physical and human capital levels. Decreasing the price of contraception leads to lower fertility and more accumulation of both human and physical capital. This latter effect is quantitatively more powerful when social norms are stronger. As contraception becomes cheaper, individuals lower fertility. Due to social norms, others follow suit.

3 Conclusion

In this paper we present a model that is able to replicate the negative relationship between fertility and income through the intensity in the use of modern contraceptive methods. The main mechanism is that, as income rises, then modern contraceptives become relatively cheaper and fertility decreases. We show the local dynamics of a stable steady-state equilibrium and characterize how family planning interventions affect fertility, human capital, physical capital and income levels around this equilibrium. We use this framework to study the effects of family planning interventions on fertility in the presence of social norms. Our results show that the effects of such interventions on fertility are stronger when the reproductive externality is larger. Finally, changes in social norms relative to reproductive behavior can trigger a fall in fertility, which can be amplified with better access to modern contraceptives.

To keep the model tractable, we naturally made some simplifying assumptions. One assumption was that the economy is populated by homogeneous agents. Solving such a representative agent model allows us to clarify the role of family planning interventions in the presence of social norms. However, this necessarily prevents us from studying issues that arise with heterogeneous agents. For instance, modeling men and women separately would allow the study of gender gaps in fertility, a feature of developing countries as shown by Field, Molitor, Schoonbroodt, and Tertilt (2016). To do this, an assumption on intra-household decisions has to be made. The possibility of enriching our model in this dimension is left for future research.

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Appendix

A Proofs

Proof of Proposition 1

Proof. Take the partial derivatives of Equation (13) with respect to ϕ_q and then take the partial derivative of the derived equation with respect to ψ. *Q.E.D.*

Proof of Proposition 2

Proof. For the partial derivative, simply use equations (10), (11), and (13) and take the corresponding partial derivatives with respect to χ and ϕ_q. For the elasticities, take the logarithm on both sides of equations (11) and (13) and differentiate either with respect to χ and ϕ_q. *Q.E.D.*

Proof of Proposition 3

Proof. Let $N\chi < 1$, then when $n(k) < N$ and using the Implicit Function Theorem (IFT) we can show that

$$n'(k) = -\frac{\left[\frac{(\gamma+\psi-\xi\zeta)}{(1+\beta+\gamma+\psi)}(\alpha+\zeta(1-\alpha))(1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)-1}(1-\chi n(k))^{-\alpha}\frac{\phi_q}{\theta}(1-\chi N)\right]/X(n(k))^2}{1+\left[\frac{(\gamma-\xi\zeta)}{(1+\beta+\gamma)}\alpha(1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha-1}\frac{\phi_q}{\theta}(1-\chi N)\right]/X(n(k))^2} < 0,$$

where $X(n(k)) = \left((1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha}\chi - \frac{\phi_q}{\theta}\right)$. Moreover,

$$\frac{\partial n(k)}{\partial \phi_q} = \frac{\left[\frac{(\gamma+\psi-\xi\zeta)}{(1+\beta+\gamma+\psi)}(1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha}\frac{1}{\theta}(1-\chi N)\right]/X(n(k))^2}{1+\left[\frac{(\gamma-\xi\zeta)}{(1+\beta+\gamma)}\alpha(1-\alpha)D^{-\alpha}Ak^{\alpha+\zeta(1-\alpha)}(1-\chi n(k))^{-\alpha-1}\frac{\phi_q}{\theta}(1-\chi N)\right]/X(n(k))^2} > 0.$$

and $\frac{\partial\left(\frac{\partial n(k)}{\partial \phi_q}\right)}{\partial \psi} > 0$. In addition, $\lim_{k\to\infty} n(k) = \frac{(\gamma+\psi-\xi\zeta)}{(1+\beta+\gamma+\psi)\chi}$. Notice that Equation (14) defines a critical value $\underline{k}(\phi,\psi) > 0$:

$$\underline{k} = \left(\frac{N\phi_q(1+\beta+\xi\zeta)(1-\chi N)^{\alpha}}{\theta(1-\alpha)D^{-\alpha}A((1+\beta+\gamma+\psi)N\chi-(\gamma+\psi-\xi\zeta))}\right)^{\frac{1}{\alpha+\zeta(1-\alpha)}}, \tag{17}$$

We have that $n(k) = N$ for any $k \leq \underline{k}$ and $n(k) < N$ for any $k > \underline{k}$. In order to see this, observe that without the upper bound in the fertility choice, $n(k)$ would go to infinity as k would be sufficiently small such that $n(k)\chi$ would tend to 1. Therefore, given the continuity of $n(k)$, we have that there exists a $\underline{k} > 0$ such that $n(\underline{k}) = N$. Using the IFT we can show that $\frac{\partial \underline{k}}{\partial \phi_q} > 0$. Similarly, the IFT and Assumption 1 imply that $\frac{\partial \underline{k}}{\partial \psi} > 0$. *Q.E.D.*

Proof of Proposition 4

Proof. Given k_0 and the fact that h_0 is given by (16), we can use (14) to find $n(k_0)$, which is unique given that $n(k)$ is non-increasing and continuous in k. Then, we can use Equations (15) and (16) to find $k_1(k_0)$ and $h_1(k_0)$, respectively; and so on. *Q.E.D.*

Proof of Proposition 5

Proof. If $\underline{k} < k_N^*$, then for any $k > \underline{k}$ it can be shown that $\frac{\partial G(k)}{\partial k} > 0$, and $\lim_{k\to\infty} \frac{\partial G(k)}{\partial k} = 0$. This implies that $k' = G(k)$ has to cross (at least once) the 45 degree line ($k' = k$) from above, and this defines $k^* = G(k^*)$ with $G'(k^*) \in (0, 1)$, which is locally stable. Fertility thus decreases with capital accumulation. Moreover, we can easily show that $\frac{\partial k^*}{\partial \phi_q} < 0$. Using the IFT we can show that $\frac{\partial n(k^*)}{\partial \psi} > 0$ and $\frac{\partial k^*}{\partial \psi} < 0$, completing the proof. *Q.E.D.*

Proof of Corollary 1

Proof. This follows directly from Equation (16) and Proposition 5. *Q.E.D.*