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Keywords

Three-period gender-based OLG model, life expectancy, poverty, Côte d'Ivoire

JEL Classification

I25, J16, O41

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Gender Equality, Economic Growth and Poverty in Côte d'Ivoire: A Quantitative Analysis*

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In this paper, we develop a three-period gender-based Overlapping Generations (OLG) model of economic growth for Côte d'Ivoire by endogenizing life expectancy and linking growth and poverty. We then calibrate the model using the country-specific data to illustrate the role of public policies in the model, and its implications for long-term growth, gender equality, and poverty in Côte d'Ivoire. To this end, we discuss three sets of quantitative experiments: broad-based development policies (increase in education spending and infrastructure investment, and governance reform), gender-based policies (reduction in gender bias in the market place, increase in women's bargaining power, and reduction in family bias against girls' education), and a composite reform program (combination of pro-growth, pro-gender policies). Overall, our findings suggest that Côte d'Ivoire could achieve better growth and poverty outcomes if the country could implement a composite reform program that includes comprehensive development and gender-based policies.

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*We are grateful to Pierre-Richard Agénor for providing us with some guidance on developing the theoretical model. However, any errors that remain are our sole responsibility. The appendix is available upon request.

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1 Introduction

According to the World Bank's latest estimates, Côte d'Ivoire is the 3^{rd} biggest economy among the ECOWAS and has the 9^{th} biggest economy of the Sub-Saharan Africa. As for GDP per capita, the country ranks 3^{rd} and 12^{th} among the ECOWAS and the Sub-Saharan African countries, respectively. Despite its strong economic performance over the last years, the country has, however, experienced gender disparities in many aspects, including access to education and healthcare. Indeed, opportunities to attend school at any level are particularly limited for girls. For instance, according to the estimates based on data from the 2018-19 EHCVM household survey, while the probability of completing lower education is 13.1 percent for boys, it is only 8.7 percent for girls. In fact, this probability is even lower in rural areas for girls; the probability of completing lower secondary school is 6.7 percent in comparison with a completion rate of 12.5 percent in urban areas. However, the probability of attending school is lower for children of parents with no educational attainment. For example, the probability of children who cannot complete the primary school is 72 percent if their father did not complete the primary school either, and this becomes more significant for girls; the probability of girls with less than primary education ranges from 51.7 percent to 76.4 percent. Besides, the fertility rate remains high among women with no formal education and living in urban areas: it ranges from 5.9 to 6.6. According to data from the 2011-12 DHS, pregnancy-related deaths are very high in the country due to a number of reasons, including lack of financial means and distance to the nearest health centre. Women are also more vulnerable than men to other diseases, such as anemia and HIV infection. Not only do women face constraints in terms of access to education and healthcare, but they also experience gender-based discrimination in different dimensions, such as decision-making power, domestic violence, and child marriage among others. Based on the same data source, while only 35 percent of women take part in health decisions, 42 percent of women do not even have any say in household decisions. Although the country has made a significant progress in closing the gender gap in labor force participation, women's labor force participation rate still remains low in urban areas. Besides, employment opportunities are not large enough to respond to the labor force for men and women alike but, according to data from the 2018-19 EHCVM household survey, in 2018 the unemployment rate for females was higher at 7.2 percent in comparison to an unemployment rate of 5 percent for males. While 35.8 percent and 52.2 percent of women are self-employed in agriculture and non-agricultural sectors, respectively, only 12.1 percent of women in employment are wage workers. However, these gaps in employment between men and women are also reflected in the gender wage gap in the country. Such that, according to the estimates by the World Bank, using data from the 2018-19 EHCVM household survey, it ranges from 33.9 percent to 47.9 percent.

In summary, all these figures clearly suggest that there are gender disparities in many aspects in Côte d'Ivoire and this has important implications for long-term growth, gender equality, and poverty. For example, if women are less educated, they will have less say not only in health decisions but also in the allocation of family resources within the household, especially towards children. Due to gender-based social norms, girls are, however, the ones who are mostly affected by a mother's intra-household bargaining power, which depends on their relative level of human capital. In other words, a mother's bargaining power has important consequences for girls' ability to accumulate human capital in childhood, their productivity and capacity to generate income, and therefore their bargaining power in adulthood. Besides, women with a lower level of education will tend to have more children, which, however, poses health risks, such as pregnancy-related deaths for mothers and their children and also creates a hidden barrier to their own human capital formation. Less-educated women will also be at risk of being less informed about the health issues they may face at any stages of life. Indeed, as noted earlier, in Côte d'Ivoire, women are more vulnerable than men to other diseases, such as anemia and HIV infection. However, all these factors are important to explain persistence in gender inequality.

To address some of these issues, we develop a three-period gender-based Overlapping Generations (OLG) model of economic growth for Côte d'Ivoire. The model we present in this paper dwells on a series of contributions by Agénor (2012, 2017, 2020), Agénor and Canuto (2015), Agénor et al. (2014, 2021), and Agénor and Agénor (2020). However, we extend these contributions by endogenizing life expectancy and linking growth and poverty. We then calibrate the model using the country-specific data to illustrate the role of public policies in the model, and its implications for long-term growth, gender equality, and poverty in Côte d'Ivoire. To this end, we discuss three sets of quantitative experiments: broad-based development policies, gender-based policies, and a composite reform program (combination of pro-growth and pro-gender policies), as further discussed later. The paper has been organised in the following way. While Section 2 presents the model, Section 3 provides a detailed discussion of the model calibration. Section 4 discusses public policies in detail. Finally, Section 5 concludes.

2 The Model

In this section, we present a three-period, childhood (period $t-1$), adulthood (period t) and old age (period $t+1$), gender-based OLG model of economic growth for Côte d'Ivoire. In what follows family preferences, home production, market production, human capital accumulation, government activities, bargaining power and gender bias in the family, the savings-investment balance, the adult survival rate, the link between growth and poverty, and balanced growth equilibrium are discussed in detail.

2.1 Family Preferences

A mother's time allocated to market activity, $\varepsilon_t^{f,W}$, is

$$\varepsilon_t^{f,W} = 1 - \varepsilon_t^{f,P} - \varepsilon_t^{f,E} - n_t \varepsilon_t^{f,R}, \tag{1}$$

where $\varepsilon_t^{f,P}$ time allocated by women to home production, $\varepsilon_t^{f,E}$ time allocated to human capital accumulation, $\varepsilon_t^{f,R} \in (0,1)$ units of child rearing time so $n_t \varepsilon_t^{f,R}$ is the total amount of time allocated to child rearing given that n_t is the number of children each couple produces; it is, however, assumed that half of them are sons and the other half are daughters so that the gender balance can hold.

It is assumed in what follows that $\varepsilon_t^{f,W} \geq 1 - \varepsilon_m^{f,P}$, where $\varepsilon_m^{f,P} \geq 0$ is the minimum amount of time that women must allocate to household chores in the family.

Using a similar notation, men's time allocation is constant over time and is given by

$$\varepsilon^{m,W} = 1 - \varepsilon^{m,P} - \varepsilon^{m,E}. \tag{2}$$

The family's utility can be written as follows:

$$U_t = \varkappa_t U_t^f + (1 - \varkappa_t) U_t^m, \tag{3}$$

where U^j is partner j's utility function and $\varkappa_t \in (0,1)$ is a weight parameter that helps measure the wife's bargaining power in the household decision process.

The sub-utility functions are given by, with $j = f, m$,[1]

$$U_t^j = \eta_C^j \ln c_t^{t-1} + \eta_Q \ln Q_t + \eta_N^j \ln n_t \tag{4}$$

$$+\eta_G(\chi_t \ln e_t^{f,C} + \ln e_t^{m,C}) + \eta_E^j \ln e_t^{f,A} + \frac{p_t}{1+\rho} \ln c_{t+1}^{t-1},$$

where $c_t^{t-1} = c_t^{f,t-1} + c_t^{m,t-1}$ ($c_{t+1}^{t-1} = c_{t+1}^{f,t-1} + c_{t+1}^{m,t-1}$) is the family's total consumption in adulthood (old age), Q_t consumption of the home good, $e_t^{j,C}$ is child j's human

[1] It is assumed that children's consumption is included in the family's consumption and that the home good is not consumed in old age.

capital, $e_t^{f,A}$ unit of human capital for females, $\rho > 0$ the discount rate, and $p_t \in (0,1)$ the probability of survival from adulthood to old age. Coefficient η_C^j measures the relative preference for today's consumption, η_E^j the relative preference for women's education, η_N^j the relative preference for the number of children, and η_Q the family's relative preference for the home-produced good. We also have the following the restrictions: $\eta_C^f < \eta_C^m$, $\eta_E^f > \eta_E^m$, and $\eta_N^f < \eta_N^m$, which imply that men attach more importance than women to current consumption, and prefer higher children than women, but they are less concerned about women's education[2]. In addition, both men and women attach equal importance to the consumption of the home good (measured by η_Q) and to the education of their children (measured by η_G, the altruism parameter). However, as in Agénor (2020), there is a gender bias in parental preferences for the human capital of girls, which can be captured by the parameter χ_t, and this parameter is therefore assumed to be less than 1.

The family's budget constraints for period t and $t+1$ are given by

$$c_t^{t-1} + m_t + s_t = (1 - \theta^R n_t)(1 - \tau) w_t, \tag{5}$$

$$c_{t+1}^{t-1} = [(1 + r_{t+1}) s_t] / p_t, \tag{6}$$

where $\tau \in (0,1)$ is the tax rate on wages, m_t spending on the market good used to produce the home good, s_t family savings, θ^R the share of family income allocated to each child, r_{t+1} the rental rate of private capital, and w_t gross wage income of the family, defined as

$$w_t = \varepsilon_t^{f,W} e_t^{f,A} w_t^f + \varepsilon^{m,W} e_t^{m,A} w_t^m, \tag{7}$$

where $e_t^{f,A}$ ($e_t^{m,A}$) unit of human capital for females (males) and w_t^f (w_t^m) effective market wage per unit of time worked for females (males).

[2]These assumptions are well documented in the literature; see, for instance, UNICEF (2007), World Bank (2011), and Doepke and Tertilt (2019).

Combining (5) and (6), the family's consolidated budget constraint is thus

$$c_t^{t-1} + m_t + \frac{p_t c_{t+1}^{t-1}}{1 + r_{t+1}} = (1 - \theta^R n_t)(1 - \tau) w_t. \tag{8}$$

Families maximize (3) subject to (1), (2), (4), and (8), as well as (9), (14), and (15) below, with respect to c_t^{t-1}, c_{t+1}^{t-1}, $\varepsilon_t^{f,P}$, $\varepsilon_t^{f,R}$, $\varepsilon_t^{f,E}$, m_t, and n_t; $\varepsilon_t^{f,W}$ is then solved residually from (1).

2.2 Home Production

Home production, Q_t, involves combining both men's and women's time allocated to household chores with infrastructure services and market goods. For tractability, use of the market good enters linearly in the home production technology:

$$Q_t = [\varepsilon_t^{f,P} + \zeta_Q (\frac{K_t^I}{K_t^P})]^{\pi^Q} (\varepsilon^{m,P})^{1-\pi^Q} m_t, \tag{9}$$

where K_t^I is the stock of public capital in infrastructure, K_t^P the aggregate stock of private capital, $\pi^Q \in (0,1)$, and $\zeta_Q > 0$ is a coefficient that measures the degree of efficiency in the use of infrastructure services.

2.3 Market Production

Each firm i produces a single nonstorable good, using male effective labor, $L_t^{m,i}$, and female effective labor, $L_t^{f,i}$, where $L_t^{i,j} = \varepsilon_t^{j,W} E_t^{j,A} N_t^{i,j}$ (with $E_t^{j,A}$ denoting *average* human capital in adulthood for $j = f, m$), private capital, $K_t^{P,i}$, and public infrastructure. Public capital is subject to congestion and it is assumed to be proportional to the aggregate private capital stock, $K_t^P = \int_0^1 K_t^{P,i} di$[3].

Assuming a constant returns to scale in private inputs, the production function of individual firm i takes the form

$$Y_t^i = (\frac{K_t^I}{K_t^P})^{\alpha} (L_t^{f,i})^{\beta^f} (L_t^{m,i})^{\beta^m} (K_t^{P,i})^{1-\beta^f-\beta^m}, \tag{10}$$

[3] See Agénor (2012) for further discussion.

where $\beta^f, \beta^m \in (0,1)$ and $\alpha > 0$.

As in Agénor (2020), female workers are assumed to be subject to discrimination from all employers due to the entrenched gender stereotypes and norms. But doing so involves a cost, because discrimination is illegal. This cost is, however, assumed to be proportional, at the rate $\phi^i \in (0,1)$, to the female wage bill for simplicity purposes.

Assuming full depreciation of physical capital, firm i's profits are thus defined as

$$\Pi^Y_{i,t} = Y^i_t - (1+\phi^i_t)w^f_t L^{f,i}_t - w^m_t L^{m,i}_t - (1+r^i_t)K^{P,i}_t.$$

Using (10), and the definition of $L^{j,i}_t$, profit maximization with respect to $N^{f,i}_t$, $N^{m,i}_t$ and $K^{P,i}_t$ gives

$$\varepsilon^{f,W}_t E^{f,A}_t w^f_t = b^i \frac{\beta^f Y^i_t}{N^{f,i}_t}, \quad \varepsilon^{m,W} E^{m,A}_t w^m_t = \frac{\beta^m Y^i_t}{N^{m,i}_t}, \quad r_t = (1-\beta^f-\beta^m)\frac{Y^i_t}{K^{P,i}_t} - 1, \quad (11)$$

where $b^i = 1/(1+\phi^i) \in (0,1)$, the parameter to capture gender discrimination.

In a symmetric equilibrium, and given that men and women are in equal numbers in the adult population ($N^m_t = N^f_t$), the first two equations in (11) give the wage ratio as

$$\frac{\varepsilon^{f,W}_t E^{f,A}_t w^f_t}{\varepsilon^{m,W} E^{m,A}_t w^m_t} = b(\frac{\beta^f}{\beta^m}), \quad (12)$$

which implies that, other things being equal, the wage difference between males and females will be larger as the parameter b becomes smaller.

Given that all firms are identical, and that their number is normalized to 1, $K^P_t = K^{P,i}_t \; \forall i$, and from (10) and the definition of $L^j_t = \varepsilon^{j,W}_t E^{j,A}_t N^j_t$, aggregate output is

$$Y_t = \int_0^1 Y^i_t di = (k^I_t)^\alpha (\frac{\varepsilon^{f,W}_t E^{f,A}_t N^f_t}{K^P_t})^{\beta^f} (\frac{\varepsilon^{m,W} E^{m,A}_t N^m_t}{K^P_t})^{\beta^m} K^P_t, \quad (13)$$

where $k^I_t = K^I_t / K^P_t$ is the public-private capital ratio.

2.4 Human Capital Formation

Human capital in childhood depends on a mother's human capital, $E_t^{f,A}$, government spending on education per child, $\varphi_E G_t^E / n_t 0.5 N_t$, where $0.5N_t$ measures the number of families and $\varphi_E \in (0,1)$ is an efficiency indicator, public-private capital ratio[4], the amount of time mothers allocate to child rearing; however, they allocate a smaller fraction, $0.5\chi_t$, of their rearing time to their daughters due to gender-related social norms, where χ_t is the gender bias parameter in parental preferences and $\chi_t < 1$, as noted earlier. As a result, human capital in childhood is as follows:

$$e_t^{m,C} = (E_t^{f,A})^{1-\nu_1} (\frac{\varphi_E G_t^E}{n_t 0.5 N_t})^{\nu_1} [(1 - 0.5\chi_t) \varepsilon_t^{f,R}]^{\nu_2} (k_t^I)^{\nu_3}, \tag{14}$$

$$e_t^{f,C} = (E_t^{f,A})^{1-\nu_1} (\frac{\varphi_E G_t^E}{n_t 0.5 N_t})^{\nu_1} (0.5\chi_t \varepsilon_t^{f,R})^{\nu_2} (k_t^I)^{\nu_3}, \tag{15}$$

where $\nu_1 \in (0,1)$ and $\nu_2, \nu_3 > 0$.

Human capital in adulthood of an individual born at t is determined by human capital in childhood and the amount of time that they choose to invest in the acquisition of skills:

$$e_{t+1}^{j,A} = e_t^{j,C} (\varepsilon_{t+1}^{j,E})^{\nu_4}, \tag{16}$$

where $\nu_4 > 0$.

Dividing (15) by (14) yields

$$\frac{e_t^{f,C}}{e_t^{m,C}} = (\frac{0.5\chi_t}{1 - 0.5\chi_t})^{\nu_2}, \tag{17}$$

which can be substituted in (16) to give

$$\frac{e_{t+1}^{f,A}}{e_{t+1}^{m,A}} = (\frac{0.5\chi_t}{1 - 0.5\chi_t})^{\nu_2} (\frac{\varepsilon_{t+1}^{f,E}}{\varepsilon^{m,E}})^{\nu_4}. \tag{18}$$

Equation (18) has important implications for a reduction in gender bias; an increase in χ_t or in women's time allocated to own education raises a girl's human capital later in life relative to a boy's human capital.

[4] See Agénor (2011, 2012, Chapter 2).

2.5 Government

It is assumed that the government spends on education (G_t^E) and infrastructure investment (G_t^I), which are both productive types of public spending, as well as on unproductive items (G_t^U) and that it finances its expenditures by taxing the wage income of adults. Its services are provided at no charge. Besides, the government cannot issue debt, and therefore there is a balanced budget:

$$G_t = \sum G_t^h = \tau(w_t^f L_t^f + w_t^m L_t^m). \tag{19}$$

Shares of spending are all assumed to be constant fractions of government revenues:

$$G_t^h = \upsilon_h \tau(w_t^f L_t^f + w_t^m L_t^m), \tag{20}$$

where $h = E, I, U$.

Combination of equations (19) and (20) therefore yields

$$\sum \upsilon_h = 1. \tag{21}$$

The stock of public capital in infrastructure is

$$K_{t+1}^I = \varphi_I G_t^I, \tag{22}$$

where $\varphi_I \in (0, 1)$ is an indicator of efficiency of spending on infrastructure[5], and full depreciation is assumed for simplicity.

2.6 Bargaining Power and Family Gender Bias

The relative bargaining power of women is assumed to be a function of the relative wages of husbands and wives[6]:

$$\varkappa_t = \varkappa_m\left(\frac{\varepsilon_t^{f,W} E_t^{f,A} w_t^f}{\varepsilon^{m,W} E_t^{m,A} w_t^m}\right)^{\mu_B}, \tag{23}$$

[5] See Agénor (2012, Chapter 2) for a discussion.

[6] See Quisumbing (2010) and Doss (2013) for a discussion of the evidence on the determinants of women's bargaining power. Note that because it is *average* values that matter, bargaining power is taken as given in solving the family's optimization problem.

where $\varkappa_m > 0$ measures the autonomous component of women's bargaining power and $\mu_B \geq 0$ a parameter that measures the sensitivity of that variable to relative wages.

Substituting (12) in (23) yields

$$\varkappa_t = \varkappa_m [b(\frac{\beta^f}{\beta^m})]^{\mu_B}, \tag{24}$$

which indicates that gender discrimination in the labor market (a low value of b) has a direct impact on bargaining dynamics in the family; it benefits men, in the sense that it mitigates the influence of their wives on family decisions.

While gender bias in the market place is taken as given, gender bias in the family against girls' education is endogenously related, as in Agénor (2020), to women's bargaining power:

$$\chi_t = \min \{\chi_m \varkappa_t^{\mu_G}, 1\}, \tag{25}$$

where $\chi_m > 0$ and $\mu_G \geq 0$.

As noted earlier, women are more concerned than men about the education of their daughters so women with a stronger bargaining power play an important role in girls' educational outcomes. Besides, mothers allocate more rearing time to their daughters, which in turn improves their human capital in adulthood, thereby mitigating the gender gap in education. Indeed, this specification corroborates the findings of earlier studies, such as Doss (2013).

2.7 Savings-Investment Balance

Let us define N_t as the number of adults alive in period t;

$$N_t = n_{t-1} 0.5 N_{t-1}, \tag{26}$$

where n_{t-1} is the number of children per family born in the previous period and $0.5N_{t-1}$ is the number of families in $t-1$.

The savings-investment balance requires that tomorrow's private capital stock is equal to today's savings in period t by adult workers born in $t-1$. Given that s_t is savings per family, that the number of families at t is $0.5N_t$, and that $N_t^f = N_t^m$,

$$K_{t+1}^P = 0.5N_t s_t = 0.5(N_t^m + N_t^f)s_t = N_t^f s_t. \tag{27}$$

2.8 Adult Survival Rate

The survival rate from adulthood to old age, p_t, is taken to depend on the public-private capital ratio:

$$p_t = p_m + \bar{p}(\frac{k_t^I}{1+k_t^I})^{\nu_S}, \tag{28}$$

with $\nu_S > 0$. The underlying view is that greater access to infrastructure allows individuals (both men and women) to have better access to health services, as documented in the literature (see Agénor (2012, Chapter 3)). With better roads, for instance, it is easier to get to medical facilities. Thus, public capital also generates an externality in terms of health outcomes[7]. The relationship between the survival rate and the public-private capital ratio is concave, with, in addition, $p_0 = p_m$, and $\lim_{k_t^I \to \infty} p_t = p_m + \bar{p} \leq 1$[8].

2.9 Link with Poverty

To assess in a simple manner the impact of the policy experiments reported below on poverty in Côte d'Ivoire, the formula estimated by Ravallion (2004) for a large group of developing countries is used. Formally, the rate of change of the poverty rate, γ_{POV}, is linked to the growth rate of output per capita, through the formula

$$\gamma_t^{POV} = -9.33(1-GINI)^3(\frac{1+\gamma_t^Y}{1+\gamma_t^P}) - 1, \tag{29}$$

[7] It could also be assumed that it is average human capital, $(E_t^{f,A})^{\varkappa_t}(E_t^{m,A})^{1-\varkappa_t}$, weighted by bargaining power, that affects the survival rate. See Agénor (2012, Chapter 3) for a discussion of alternative functional forms.

[8] Note also that because it is *average* female human capital that matters in (28), the survival probability is taken as given in solving the family's optimization problem, as noted earlier.

where γ_t^Y is the growth rate of output, γ_t^P the growth rate of the population, and $GINI \in (0,1)$ the Gini coefficient. Therefore, the term $-9.33(1-GINI)^3$ measures the growth elasticity of poverty. From that formula, the *level* of poverty can be derived, for a given initial level.

2.10 Balanced Growth Equilibrium

As in Agénor (2017, 2020), a competitive equilibrium in this economy is: prices $\{w_t^m, w_t^f, r_{t+1}\}_{t=0}^{\infty}$, family consumption and spending on market goods for home production, $\{c_t^{t-1}, c_{t+1}^{t-1}, m_t\}_{t=0}^{\infty}$, female time allocation $\{\varepsilon_t^{f,E}, \varepsilon_t^{f,P}, \varepsilon_t^{f,R}\}_{t=0}^{\infty}$, physical capital stocks $\{K_{t+1}^P, K_{t+1}^I\}_{t=0}^{\infty}$, female and male human capital stocks $\{E_{t+1}^{f,A}, E_{t+1}^{m,A}\}_{t=0}^{\infty}$, a constant tax rate, and constant spending shares such that, given initial physical and human capital stocks $K_0^P, K_0^I > 0$ and $E_0^{f,A}, E_0^{m,A} > 0$, families maximize utility subject to their time and budget constraints, firms producing the market good maximize profits, markets clear, and the government budget is balanced. Also, in equilibrium, $e_t^j = E_t^j$, for $j = f, m$. A balanced growth equilibrium is a competitive equilibrium in which c_{t+1}^{t-1}, c_{t+1}^{t-1}, m_t , Q_t, K_{t+1}^P, K_{t+1}^I, $E_{t+1}^{f,A}$, $E_{t+1}^{m,A}$ grow at the constant, endogenous rate $1+\boldsymbol{\gamma}$, the rate of return on private capital r_{t+1} is constant, and women's time allocation and bargaining power, and the survival rate, are all constant.

As can be seen from the Appendix, once the model is solved analytically, the public-private capital ratio is given by

$$k_{t+1}^I = \frac{\varphi_I \upsilon_I \tau}{(1-\tau)\sigma_t(1-\theta^R n_t)}, \tag{30}$$

where σ_t is the family's propensity to save, defined as

$$\sigma_t = \frac{p_t/(1+\rho)\eta_t^C}{\eta_t + p_t/(1+\rho)\eta_t^C} < 1, \tag{31}$$

with

$$\eta_t = 1 + \frac{\eta_Q}{\eta_t^C} > 1. \tag{32}$$

Women's time allocation to home production, child rearing, own education, and market work, as well as the fertility rate are given by, as long as $k_t^I \leq k_t^{I,C}$,[9]

$$\varepsilon_t^{f,P} = \left\{1 + \frac{\eta_Q \pi^Q \Lambda_t^1}{\Lambda_t^2}\right\}^{-1} \left\{\frac{\eta_Q \pi^Q \Lambda_t^1}{\Lambda_t^2} - \zeta_Q k_t^I\right\}, \tag{33}$$

$$\varepsilon_t^{f,R} = \eta_G \nu_2 (\frac{\chi_t + 1}{n_t}) \Lambda_t^1 (\frac{1 - \varepsilon_t^{f,P}}{\Lambda_t^2}), \tag{34}$$

$$\varepsilon_t^{f,E} = \eta_t^E \nu_4 \Lambda_t^1 (\frac{1 - \varepsilon_t^{f,P}}{\Lambda_t^2}), \tag{35}$$

$$\varepsilon_t^{f,W} = 1 - \varepsilon_t^{f,P} - \varepsilon_t^{f,E} - n_t \varepsilon_t^{f,R}, \tag{36}$$

$$n_t = \frac{1}{\theta^R} \frac{\Lambda_t^3 - 1 - (b\beta^{fm})^{-1}}{\Lambda_t^3}, \tag{37}$$

where $k_t^{I,C}$ is a threshold level given by

$$k_t^{I,C} = \frac{1}{\zeta_Q} \left\{\frac{\eta_Q \pi^Q \Lambda_t^1}{\Lambda_t^2} - (1 + \frac{\eta_Q \pi^Q \Lambda_t^1}{\Lambda_t^2}) \varepsilon_m^{f,P}\right\},$$

and

$$\eta_t^h = \varkappa_t \eta_h^f + (1 - \varkappa_t) \eta_h^m = \eta_h^m + \varkappa(\eta_h^f - \eta_h^m), \quad h = C, E, N \tag{38}$$

together with

$$\Lambda_t^1 = \frac{1}{\eta_t \eta_t^C} (1 - \sigma_t)[1 + (b\beta^{fm})^{-1}] > 0,$$

$$\Lambda_t^2 = 1 + \Lambda_t^1 [\eta_t^E \nu_4 + \eta_G \nu_2 (\chi_t + 1)] > 1,$$

$$\Lambda_t^3 = 1 + (b\beta^{fm})^{-1} + [\eta_t^N - \eta_G \nu_2 (\chi_t + 1)] \Lambda_t^1.$$

Equation (33) holds as long as $\varepsilon_t^{f,P} > \varepsilon_m^{f,P}$. Through η_t^C, η_t^E and η_t^N, the bargaining parameter $\varkappa_t$ affects the fertility rate, women's time allocation, and the savings rate.

Note that, given the restrictions discussed earlier, $\eta_C^f < \eta_C^m$, and $\eta_N^f < \eta_N^m$, $d\eta_t^h / d\varkappa_t < 0$, $h = C, N$. Similarly, with $\eta_E^f > \eta_E^m$, $d\eta_t^h / d\varkappa_t > 0$.

[9] In the steady-state, the condition $n \geq 2$ is also assumed; population size converges to zero otherwise.

Let $x_t^f = K_t^P / E_t^f N_t^f$ denote the private capital-female effective labor ratio, which can be expressed in the following way:

$$x_{t+1}^f = \Lambda_t^5 (k_t^I)^{-\nu_3+\alpha(1-\nu_1)} (\varepsilon_t^{f,W})^{\beta^f(1-\nu_1)} (x_t^f)^{(1-\beta)(1-\nu_1)} (\frac{0.5\chi_{t-1}}{1-0.5\chi_{t-1}})^{-\beta^m \nu_2 (1-\nu_1)}, \quad (39)$$

$$\times (\frac{\varepsilon_t^{f,E}}{\varepsilon^{m,E}})^{-\beta^m \nu_4 (1-\nu_1)} (0.5\chi_t \varepsilon_t^{f,R})^{-\nu_2} (\varepsilon_{t+1}^{f,E})^{-\nu_4},$$

where $\beta = \beta^f + \beta^m$, and

$$\Lambda_t^4 = [\frac{(1-\tau)\sigma_t(1-\theta^R n_t)[b+(\beta^{fm})^{-1}]\beta^f}{n_t^{1-\nu_1} 0.5}][\varphi_E \upsilon_E \tau (b + \frac{1}{\beta^{fm}})\beta^f]^{-\nu_1},$$

$$\Lambda_t^5 = \Lambda_t^4 (\varepsilon^{m,W})^{\beta^m(1-\nu_1)},$$

with $\beta^{fm} = \beta^f / \beta^m$.

As can also be seen from the Appendix, the steady-state growth rate of output is given by

$$1 + \boldsymbol{\gamma} = \tilde{\Lambda}^6 (\tilde{k}^I)^\alpha (\tilde{\varepsilon}^{f,W})^{\beta^f} (\tilde{x}^f)^{-\beta} (\frac{0.5\tilde{\chi}}{1-0.5\tilde{\chi}})^{-\beta^m \nu_2} (\frac{\tilde{\varepsilon}^{f,E}}{\varepsilon^{m,E}})^{-\beta^m \nu_4}, \quad (40)$$

where, from (23) and (25),

$$\tilde{\varkappa} = \varkappa_m [b(\frac{\beta^f}{\beta^m})]^{\mu_B}, \qquad \tilde{\chi} = \chi_m \tilde{\varkappa}^{\mu_G}, \quad (41)$$

$$\tilde{\Lambda}^6 = (\varepsilon^{m,W})^{\beta^m} (1-\tau)\tilde{\sigma}(1-\theta^R \tilde{n})(b + \frac{1}{\beta^{fm}})\beta^f,$$

from (30),

$$\tilde{k}^I = \frac{\varphi_I \upsilon_I \tau}{(1-\tau)\tilde{\sigma}(1-\theta^R \tilde{n})}, \quad (42)$$

and $\tilde{x}^f$ is the steady-state solution obtained by setting $\Delta x_{t+1}^f = 0$ in (39):

$$\tilde{x}^f = \left\{ \tilde{\Lambda}^5 (\tilde{k}^I)^{-\nu_3+\alpha(1-\nu_1)} (\tilde{\varepsilon}^{f,W})^{\beta^f(1-\nu_1)} (\frac{0.5\tilde{\chi}}{1-0.5\tilde{\chi}})^{-\beta^m \nu_2 (1-\nu_1)}, \right. \quad (43)$$

$$\left. \times (\frac{\tilde{\varepsilon}^{f,E}}{\varepsilon^{m,E}})^{-\beta^m \nu_4 (1-\nu_1)} (0.5\tilde{\chi}\tilde{\varepsilon}^{f,R})^{-\nu_2} (\tilde{\varepsilon}^{f,E})^{-\nu_4} \right\}^{1/\Pi},$$

with

$$\Pi = 0 < [1 - (1 - \beta)(1 - \nu_1)] < 1,$$

which is a necessary condition for the transition equation (39) to be stable, together with $\beta < 1$ and $\nu_1 \in (0, 1)$, as noted earlier.

As can be inferred from the first equation in (41), because the degree of gender bias (as measured by b) is constant, women's bargaining power is also constant; as a result, as implied by the second equation in (41), gender bias in the family against girls' education is also constant.

3 Calibration

We use a number of data sources in calibrating the model for Côte d'Ivoire: the *World Development Indicators* (WDI) database of the World Bank, data from the 2018-19 EHCVM household survey, data from the 2019 Country Report by the International Monetary Fund (IMF), as well as both theoretical and empirical papers where necessary.

For households, the annual discount rate is set at 0.03, which implies that the discount factor is equal to 0.97 on a yearly basis. A 20-year period in an OLG framework yields an intergenerational discount rate of $0.97^{20} = 0.544$.

The family savings rate for Côte d'Ivoire, σ, can be proxied by gross domestic saving for the nongovernment sector as a share of GDP over the period 2016-19, as defined in the IMF Country Report No. 19/366 (Table 1); this gives 19.4 percent.

The gross fertility rate (number of births per woman) is multiplied by the child survival probability so that the (effective) fertility rate, n, can be obtained. According to WDI data, the gross fertility rate over the period 2011-18 is 4.8. The child survival probability is $1 - 0.092 = 0.908$, where 0.092 is the number of deaths of children under five per 1,000 live births over the same period according to WDI data. Therefore, the (effective) fertility rate is $4.8 \cdot 0.908 = 4.4$.

To calibrate the adult survival rate, p, we first estimate the probability of death. According to WHO's latest estimates, in 2016 in Côte d'Ivoire the probability of dying between ages 15 and 60 was an average of 0.398[10]. The survival rate can therefore be measured as $p = 1 - 0.398 = 0.602$.

Based on data from the 2018-19 EHCVM household survey for Côte d'Ivoire, the proportion of total household income spent on children (aged between 0 and 18) is estimated to be 40.6 percent, which corresponds to $n\theta^R$ in our model. As noted earlier, $n = 4.4$; thus, θ^R (the share of family spending on each child) can be estimated as 0.406/4.4, that is, $\theta^R = 0.092$.

To estimate women's time allocation, we rely on Blackden and Wodon (2006), Agénor et al. (2014), and Charmes (2015). Time spent by women in household chores, market work, and education is estimated at 40 hours, 35 hours, and 12 hours per week, respectively. However, in calculating total time available in a week, we also consider time spent sleeping and time spent on personal care and leisure, which are both subtracted from raw time. As a result, weekly time available is $168(7 \cdot 24$ hours a day$) - 56(7 \cdot 8$ hours a day$) - 14(7 \cdot 2$ hours a day$) = 98$ hours. The proportion of total time spent by women in home production, market work, and education can be then estimated as follows: $\varepsilon^{f,P} = 40/98 = 0.408$, $\varepsilon^{f,W} = 35/98 = 0.357$, and $\varepsilon^{f,E} = 12/98 = 0.122$. Given these estimates, the total proportion of time devoted to rearing time can be estimated as $n\varepsilon^{f,R} = 1 - 0.408 - 0.357 - 0.122 = 0.113$, implying that (given that $n = 4.4$, as noted earlier) the proportion of time spent on each child is $\varepsilon^{f,R} = 0.026$.

Men's time allocation is calibrated so that they spend three-fourths of their available time in market work (in line with the data for Sub-Saharan Africa reported by Blackden and Wodon (2006, Table 3.13)) and allocate the rest to household chores and education. Men are also assumed to allocate the same amount of time as women

[10] See http://apps.who.int/gho/data/node.main.11?lang=en.