A General Equilibrium Model for Gender and Income Inequality

by Vivian Malta, Angelica Martinez, Lisa Kolovich, Marina Mendes Tavares

Work in Progress
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Abstract

We quantitatively investigate the gender and distributional impact of government policies aimed to promote gender equality. We extend a standard overlapping generation models to capture barriers that females face to participate in the labor market during their life. We use this model to quantify the impact of education reform on female labor force participation in Senegal. We show that the increase in girls’ primary education explains half of the increase in female labor force participation between 2006 and 2011.

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Keywords: Labor Force Participation, Development

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Introduction

Gender equality can play a significant role in promoting economic stability by boosting economic productivity and growth, enhancing economic resilience, and reducing income inequality. It has been shown that high levels of inequality can impair the future pace and sustainability of growth.\(^2\) Inequality hurts specially women, as they constitute the majority in the lower levels of the income distribution and face more financial constraints, asset ownership barriers, social, cultural and even sometimes legal discrimination, besides having more time restrictions due to their important role in child rearing, organizing the house, and taking care of the elderly.

In this context, we develop a micro-founded overlapping generations model that allows one to analyze the impacts of policies on both aggregate and distributional levels of income and gender. In this framework, females face different barriers to their development over the life-cycle, starting from early education, passing through the costs of taking care of the home and the family, and through discrimination in the labor market. This type of framework is suited to run fiscal and gender-related policy experiments, such as changes in the tax code, in cash transfer programs, in government-funded education, in female work regulation, in childcare subsidies, in family and social costs from having a job and in general anti-gender-based discrimination policies. With this framework we can examine the resulting impacts on economic growth, on income distribution, on (some) fiscal costs and gains, on labor force participation and on human capital formation. Impacts can be assessed for different income levels, for women vs. men, and for older vs. younger generations.

We use this model to quantify the importance of education in the increase in female labor force participation in Senegal between 2005 and 2015. During this period, female labor force participation increased from 35 percent to 45 percent, supported by increases in females’ education and health. Females’ primary education completion rates increased from 28 percent to 43 percent and females’ secondary education completion rate from 11 to 20 percent. In the same period, infant mortality decreased by half, and the use of contraception expanded from 11 percent of females to 23 percent in 2015. The model is calibrated to the Senegalese economy, using both micro and macro data. This includes statistics such as: the size of formal and informal sectors relative to GDP; the proportions of labor force employed in the formal and informal sectors; the country’s income distribution; rules regarding taxation and government tax collection; government expenditure on education; distribution of education across the population; female labor force participation (relative to males’); gender wage gaps in formal and informal sector; earnings returns from education and from work experience; and family consumption patterns.

We find that the increase in primary education explains half of the increase in female labor force participation during this period, contributing to higher economic growth and lower income inequality. Higher levels of primary education increase the return from participating in the labor force leading many women to join the labor force. These females mostly join the

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\(^2\) Ostry, Berg and Tsangarides (2014) and Dabla-Norris et al (2015) are papers that establish the connection between inequality and economic growth.
informal sector contributing to higher economic growth and lower levels of inequality. The increase in secondary education also contributed to the increase in female labor force participation, but at a much lower extent. The increase in secondary education impacted mostly females that already participate in the labor market and now equipped with higher levels of education switched from informal to formal jobs.


The paper is divided in four sections. In the first section, a brief background about Senegal is presented. In section II the model is presented, section III contains the explanation of the calibration, and section IV the main results. Section V concludes the paper.

I. Background On Senegal

Senegal female labor force participation has increased dramatically in the last decade, from 35 percent in the beginning of the 2000s to 45 percent 2010s (panel 1). Female labor force participation in Senegal is still low and below the average in Sub-Saharan Africa, however the gains made in the 2010s have helped Senegal to get closer to the Sub-Saharan Africa average, which has been stagnated during the same period.

The beginning of 2000s are also a period of economic and development gains in Senegal. Senegal GDP per capita grew on average 1.03 percent between 2005 and 2015, while in the Sub-Saharan region, GDP per capita increased by 2.16 percent. This period was marked by increase in exports and large investment in infrastructure, health and education.

The large investment in education with increases in enrollment rates of boys and girls during this period has supported the economic growth. In the last decade, primary education completion rates almost doubled for girls, reaching 45 percent in 2016. For boys, the gains were less dramatic but still substantial: primary education completion rate rose from 37 to 43 percent in the same period. Regarding secondary education, progress was made, but female completion rate is only 6 percent, compared to 9 percent for boys. Although important gains were made during the 2000s and despite education being, by law, free and compulsory until 16, average years of schooling in Senegal is still only 3.3 years, compared to almost 5 years in Sub-Saharan Africa.

Gender gaps in education can have negative consequences for economic growth, and development (see e.g. King and Hill, 1991). Corroborating the international empirical evidence, the 2011 Senegal’s household survey (ESPS II) shows a stark negative correlation between education and fertility rates among women in (panel 1). Women with more years of education have lower fertility rates, higher earnings, and therefore can provide better life conditions and future for each of their kids.
In addition, Senegal, supported by the Millennial Development Goals agenda, experienced an improvement in many health indicators: infant mortality decreased by half from 68 per 1000 births in 2000 to 34 in 1000 births in 2016; the use of contraception was also broadened from 11 percent of females between 15 to 49 years old in 2005 to 23 percent in 2015. Access to drinking water and managed sanitation also improved during this period, freeing women’s time from managing drinking water and taking care of sick children to work.
Panel 1: Some Statistics from Senegal
I. The Environment

We construct an overlapping generations (OLG) model in which heterogenous agents live in a small open economy for three periods and die at the end of the third period. Each generation consists in a continuum of agents. Individuals initially differ from each other by age, gender, initial endowment and access to the savings market. Individuals with higher initial endowments can save and borrow at a given interest rate \( r^* \). In this economy, in the first period, a household is comprised by a man and a woman – husband and wife – and two kids. In period 2 and 3 the household is comprised only by husband and wife. Husband and wife make all the decisions together, including labor supply, consumption and savings/borrowing (richer households only). In terms of labor choices, they decide husband’s labor supply in the formal and/or informal sector and women’s female labor force participation and, in the case of participation, how much time she is going to work in the formal and informal sector.

In the first period of life, each household give birth to two children. All agents die at the end of period 3 to maintain a constant population over time. Husband and wife decide together which sector to work and how much to consume of each of the two types of goods in the economy (formal and informal goods). Education for kids are provided by the government, and the amount of education is not equal across gender and initial endowments. In the next two periods, kids have grown, left their parents’ households, and started their own family, so that the initial household has now only the husband and the wife. Households that do not have access to financial markets (hand-to-mouth households) continue to choose how much labor to supply and how much to consume. Meanwhile, richer households also choose how much to save or borrow in period 2, and do not work in period 3 – only spending their life-time savings in consumption. Whenever women supply labor (in either period), there is a utility cost incurred by the family. This cost relates to the difficulty of coordinating multiple household activities, such as home production and rearing children. For some countries, this cost can also be interpreted as social and cultural barriers for the woman and her family when she works outside.

Production in the formal sector is made through capital and labor, while the informal sector uses only labor. The formal sector in this economy is modeled as a representative firm that hires both male and female effective hours of labor and rent capital at rate \( r^* \) from the rich households or from abroad, to produce the formal good. Besides being produced domestically, formal goods can be importated from abroad. They can serve as formal goods consumption, education or capital investment.

Women suffer discrimination in the workplace when working in both formal and informal sectors, and this is captured, respectively, by parameters \( \phi_{fo} \) and \( \phi_{inf} \) multipliyng the production functions. This discrimination refrains women from achieving their full salary and career potential.

The government collects labor income tax, consumption tax and corporate tax and spends on education, in formal goods and in cash-transfers. The government has access to external financial market and finance its debt by borrowing at interest rate \( r^* \).

Preferences
Households maximize utility over their three periods of life and discount the future at rate $\beta$. We assume that households have log-linear preferences over consumption of formal goods ($c_{t}^{fo}$) and informal goods ($c_{t}^{inf}$) and disutility over total female labor supply ($l_{t}^{f}$):

$$u(c_{t}^{fo}, c_{t}^{fo}, c_{t}^{fo}) = \xi_{fo} \log(c_{t}^{fo}) + \xi_{inf} \log(c_{t}^{inf}) - \xi_{l}^{f} I(l_{t}^{f} > 0),$$

where $\xi_{l}$ is the parameter that describes the utility cost for families when females enter the labor market (total labor supply greater than zero), $\xi_{fo}$ preference over formal goods consumption (excluding kids’ education), and the remaining fraction $\xi_{inf}$ on the preference over informal goods consumption, and subscripts $t$ refers to time.

Human Capital

Each family is born with initial ability $\varepsilon \sim \text{lognormal}(0, \sigma^2)$ which is assumed to be passed deterministically throughout generations. We discretize the lognormal distribution so that households are divided into 100 percentiles. Human capital formation starts at birth and evolves according to the individual’s initial ability $\varepsilon$, education provided by the government, and the amount of labor supplied in the previous period. In period 1, human capital is given by:

$$h_{1} = \varepsilon(e^{i}(\varepsilon))^{\alpha_{e}} \text{ where } i \in \{f, m\}$$

and where education $e^{i}(\varepsilon)$ depends on the gender and initial ability. In periods 2 and 3, human capital accumulation for men and women depends on the labor supply decision in the previous period:

$$h_{t}^{i} = \begin{cases} (1 + g_{t})h_{t-1}^{i}, & \text{if } l_{t-1}^{i} > 0 \\ h_{t-1}^{i}, & \text{if } l_{t-1}^{i} = 0 \end{cases} \text{ where } i \in \{f, m\} \text{ and } t \in \{2,3\}.$$

If the man or woman did not participate on the labor market in their previous period, their human capital is constant, while if they participate human capital grows at a rate $g_{t}$.

Technologies

Formal Markets – Formal goods are produced by a representative firm using effective labor supplied by individuals and capital in a Cobb-Douglas production function. The formal goods production function is given by:

$$y^{fo} = z^{fo} \left(L^{m,fo} + \phi_{fo} L^{f,fo}\right)^{\alpha_{fo}} (K)^{1-\alpha_{fo}}$$

where $z^{fo}$ is the formal sector productivity, $K$ is the total capital, $\alpha_{fo}$ is the factor share, and $L^{m,fo}$ is the total effective labor units hired for male’s workers and $\phi_{fo} L^{f,fo}$ is the total effective labor units hired for female’s workers and $\phi_{fo}$ is the parameter capturing the discrimination against women that reduces their labor efficiency and wages.
Informal Markets – The production of informal goods is made by households using effective hours of labor:

\[ y^m, inf_t (e) = z^m, inf_t [l^m, inf_t (e)h^m_t (e)]^{\alpha_{inf}} \]

\[ y^f, inf_t (e) = \phi_{inf}z^m, inf_t [l^f, inf_t (e)h^f_t (e)]^{\alpha_{inf}} \]

and where \( z^inf \) is the informal sector productivity, \( \alpha_{inf} \) is the factor share, \( l^inf_t h^f_t \) is the total effective labor units which is product of labor hours \( l^inf_t \) multiplied by the individual’s human capital \( h^f_t \), and \( \phi_{inf} \) is the parameter capturing the discrimination against women that reduces their labor efficiency and earnings in the informal sector.

Optimization Problems

Households Problem – A hand-to-mouth household maximizes life-time utility subjective to the budget constraints:

\[
\begin{align*}
\max_{\{c^o_t(e), c^m, inf_t(e), l^f, fo_t(e), l^m, inf_t(e), l^m, fo_t(e)\}} & \quad u_t(c^o_t(e), c^m, inf_t(e), l^f_t(e)) + \beta u_{t+1}(c^o_{t+1}(e), c^m, inf_{t+1}(e), l^f_{t+1}(e)) \\
& + \beta^2 u_{t+2} \left(c^o_{t+2}, c^m, inf_{t+1}, l^f_{t+2}(e)\right)
\end{align*}
\]

subjected to

\[
\theta_t \left((1 + \tau^c_t) c^o_t(e) + p_{inf} c^m, inf_t(e)\right) \leq B_t(e) \quad \text{where budget } B_t(e) \text{ is given by in period } t = 1
\]

\[
\begin{align*}
B_t(e) = \begin{cases} 
(1 - \tau^f) w^f l^f, fo_t(e) h^f_t(e) + (1 - \tau^m) w^m l^m, fo_t(e) h^m_t(e) + p_{inf} \left(y^m, inf_t(e) + y^f, inf_t(e)\right), & \text{if } l^f_t(e) > 0 \\
(1 - \tau^m) (w^m l^m, fo_t(e) h^m_t(e)) + p_{inf} y^m, inf_t(e), & \text{if } l^f_t(e) = 0
\end{cases}
\end{align*}
\]

and

\[
\begin{align*}
l^f_t(e) = l^f, fo_t(e) + l^f, inf_t(e) \\
y^m, inf_t(e) = z^m, inf_t [l^m, inf_t(e)h^m_t(e)]^{\alpha_{inf}} \\
y^f, inf_t(e) = \phi_{inf}z^m, inf_t [l^f, inf_t(e)h^f_t(e)]^{\alpha_{inf}}
\end{align*}
\]

\[ h^2_t(e) = \varepsilon(e^{ji})^{\alpha_e}, \quad \text{where } e^{ji} \text{ is education provided by the government and } i \in \{m, f\}, \]

and for period \( t = 2, 3 \):

\[
\begin{align*}
h^m_t(e) &= (1 + g_t) h^m_{t-1}(e) \\
h^f_t(e) &= \begin{cases} 
(1 + g_t) h^f_{t-1}(e), & \text{if } l^f_{t-1} > 0 \\
h^f_{t-1}(e), & \text{if } l^f_{t-1} = 0
\end{cases} \\
l^{f, fo}_t &\in [0, 1], \quad i \in \{m, f\} \\
l^{i, inf} &\in 1 - l^{i, fo}, \quad i \in \{m, f\} \\
\theta_t &= \begin{cases} 
\theta, & \text{if } t = 1 \\
1, & \text{otherwise}
\end{cases}
\]

where \( \theta \) captures the cost in consumption terms of having small children.
The difference between rich households’ and hand-to-mouth households’ maximization problems are: (i) rich households have access to financial markets and can borrow and save at an exogenous interest rate $r^*$; and (ii) rich households do not work in period 3, only using their life-time savings to consume.

**Formal Sector** - A representative firm hires both male and female effective hours of labor, $L_{m,fo}$ and $\phi_{fo} L_{f,fo}$, and capital, $K$ to produce the formal good. The firm maximization problem is given by:

$$\max_{\{L_{f,fo}, L_{m,fo}, K\}} (1 - \tau^k) z^{fo} (L_{m,fo} + \phi_{fo} L_{f,fo})^{\alpha_{fo}} (K)^{1-\alpha_{fo}} - (w^{m} L_{m,fo} + w^{f} L_{f,fo}) - (r + \delta) K$$

(2)

**Government Budget Constraint** - The government taxes consumption $\tau^c$, female (formal) labor income $\tau^f$, male (formal) labor income $\tau^m$, and firms’ revenues $\tau^k$. The revenue from each source is given by:

Revenue from consumption taxes:

$$R^c = \tau^c \sum_{i=1}^{100} c_{t}^{fo}(\epsilon_i) + c_{t}^{inf}(\epsilon_i) + c_{t}^{inf}(\epsilon_i) .$$

Revenue from labor income:

$$R^w = \sum_{t=1}^{3} \tau^m \sum_{i=1}^{100} w^{m} t_{i}^{m,fo}(\epsilon_i) h_{t}^{m}(\epsilon_i) + \tau^f \sum_{i=1}^{100} w^{f} t_{i}^{f,fo}(\epsilon_i) h_{t}^{f}(\epsilon_i).$$

Revenue from corporate taxes:

$$R^k = \tau^k z^{fo} (L_{m,fo} + \phi_{fo} L_{f,fo})^{\alpha_{fo}} (K)^{1-\alpha_{fo}}.$$ 

Government spends its revenue on formal goods (total expenditure on formal good equals to $G$), on education, $E$, and on government transfers $CT$. The government has access to external financial market and can borrow $D$ to satisfies its expenditure. The government budget constraint is given by:

$$D_{t+1} = R^c_t + R^k_t + R^w_t - Et - CT t - (1 + r^*) D_t$$

**Stationary Equilibrium**

A stationary equilibrium is a vector of allocations for each type of household

$$\{[c_{t}^{fo}(\epsilon_i), c_{t}^{inf}(\epsilon_i), t_{t}^{f,fo}(\epsilon_i), t_{t}^{inf}(\epsilon_i), t_{t}^{m,fo}(\epsilon_i), t_{t}^{m,inf}(\epsilon_i), h_{t}^{m}(\epsilon_i), h_{t}^{f}(\epsilon_i)]_{t=1}^{100} \}$$

and for the competitive firm

$$\{L_{f,fo}, L_{m,fo}, K\},$$

such that given competitive prices $\{w^{f}, w^{m}, p^{inf}\}$, the interest rates $\{r^*\}$ and government policies $\{\tau^c, \tau^m, \tau^f, \tau^k, CT, E\}$, the vector of allocations and prices solve:
i) Households solve their optimization problem (1)

ii) Formal Sector firm solves its problem (2)

iii) Informal Sector clears:

$$
\sum_{t=1}^{3} \sum_{i=1}^{100} c_t^{inf}(\varepsilon_i) = \sum_{t=1}^{3} \sum_{i=1}^{100} (y_t^{inf}(\varepsilon_i) + y_t^{m,inf}(\varepsilon_i))
$$

iv) Formal Labor Market Clears:

$$
\sum_{i=1}^{100} l^{m,fo}(\varepsilon_i) = L^m,fo \quad \text{and} \quad \sum_{i=1}^{100} l^{f,fo}(\varepsilon_i) = L^{f,fo}
$$

v) Government Budget Constraint is satisfied:

$$
D_{t+1} = R_t^x + R_t^k + R_t^w - Et - CT_t - (1 + r^*)D_t
$$

vi) Current Account holds:

$$
D_{t+1} - D_t = (X_t - M_t) - r^*D_t
$$

Sources of Gender Inequality

The main sources for gender inequality in the model are the utility cost a family incurs when the wife has a job, the different education levels provided by the government, and the discrimination faced by women in the labor market.

The disutility incurred by the family when a woman supplies labor relates to the difficulty in coordinating multiple household activities, such as home production and rearing children, whenever she works outside, and cultural preferences of having women staying at home.

Besides the utility cost, the parameter $\phi$ in both formal and informal production functions relates to the discrimination women face in the labor market, either in the form of lower earnings per hour (given the same human capital, the so-called wage gap) or in the form of less productivity due to the difficulty in navigating in the labor market and not realizing their full potential. The discrimination in the workplace diminishes the potential for return on women, so that, even though they have the same experience and education, they achieve and earn less.
We call discrimination as any form of unjust or prejudicial treatment between women and men. In the labor market the different treatment may affect women's productivity, their earnings and their career. The literature points to many reasons why women's productivity can be smaller than men's, given the same initial characteristics, such as education and occupation. As pointed by Becker (1985) and Albanesis & Olivietti (2009), when women carries most of the responsibility in taking care of children and the house, they imprint less effort at work. Alos, many studies (e.g., Blau and DeVaro 2007, Cobb-Clark 2001) find that women are less likely to be promoted, all else equal. Another reason for lower productivity is a reluctance of discriminatory customers or clients to buy goods or services provided by women. This makes women less productive in terms of revenue brought in, thus depressing their relative wages. For instance, Azmat and Ferrer (2015) find that female lawyers are less productive than male lawyers: if corporate clients only want male lawyers, billable hours and number of new clients (their measures of productivity) will reflect this discrimination against women. Productivity differences between female-owned and male-owned businesses are often explained by differences in access to and use of productive resources. According to WB 2012, among African firms in urban areas, the median female-owned firm in the formal sector has 2.5 times less start-up capital than the median male-owned firm, but it has 5 times more start-up capital than the median female-owned firm in the informal sector. The publication also shows differences in males and females' productivity in rural areas for many countries. Kilic et al (2014) shows that female-managed plots in Malawi are on average 25% less productive, and a large part of the differential comes from difficulty of females in hiring male labor.

Added to different levels of education for males and females with different innate ability shocks, these three sources of gender inequality in the model create different outcomes for men and women in terms of labor force participation, the choice of formal versus informal jobs and hours dedicated to them, and earnings.

II. Calibration

The model is calibrated to match Senegal (2011). The data used in the calibration has annual frequency and most of the parameters are calibrated jointly so that the model matches the moments from the data. The model period is 18 years, so that hand-to-mouth agents work from 18 to 72 years of age and die at 72. Savers stop working at 54 and use their savings to consume. Since all agents live and die at 72 years of age, the measure of households at each period must be equal to 1/3 (i.e., $\mu_1 = \mu_2 = \mu_3 = 1/3$).

Preferences. Households have log-linear preferences over formal and informal goods and disutility over female labor supply ($L_f$). The weight of the consumption goods ($\xi_{fo}$ and $\xi_{inf}$) in the utility function are determined given the amount of informal GDP, the tax on formal goods consumption ($\tau_c$) and the government formal goods purchases ($G$) and expenditure on education ($E$). Using national accounts data, we calibrate $G$ to be 5.2 percent of GDP for Senegal. Given this, we find $\xi_{inf} = 43.4$ percent and $\xi_{fo} = 56.6$ percent. We calibrate $\xi_{\ell}$, the parameter that describes the family disutility when women enter the labor market ($L_f > 0$) to match total female labor force participation in each country as proportion to male’s labor.
force participation, which was 0.6 for Senegal in 2011. We set the discount factor $\beta$ to 0.96 annually, which is a commonly used value in the literature, and the parameter $\theta$ is set to 2, using OECD’s modified scale calculations for increase in household consumption when 5 kids are added in the household$^3$, five being the average number of kids in Senegal’s households.

**Production.** We normalize the price of formal sector to 1. The productivity $z_{inf}$ is calibrated to match the share of informal production on GDP, of 45% according to national accounts correction for 2014, while the productivity of the informal sector $z_{fo}$ is normalized to one. We calibrate firm’s discrimination parameter $\phi$ in both formal and informal sectors to match the female-male net wage ratio in each sector. For Senegal, in the formal sector the parameter is set to 0.86 and to 0.70 in the informal sector. We calibrate $a^{inf}$ to match the share of informal labor in total labor in Senegal, which is 14% according to 2011 Household’s survey data. We find the parameter to be 0.6.

**Initial Endowments** We set 100 initial shocks/endowments, that follow a log normal distribution. We calibrate the variance of the shock to match Senegal’s Gini coefficient of income inequality, which we find to be 0.628 using 2011 Household Survey.

**Human Capital Formation Function.** We calibrate the parameter of the curvature of the human capital function $\alpha^e$ to 0.2, which we find by regressing log of education on log hourly wages, using control variables.

**Fiscal Policy.** Income tax is found by applying 2011’s tax rules on average income from work in each percentile of Senegal’s income distribution. According to our calculations, the bottom 50% of Senegal income distribution don’t need to pay taxes in the formal sector. For percentiles 51st to 100th, we smooth the resulting tax rates through an exponential function. Tax on consumption $\tau^c(\cdot)$ is set to 18 percent for Senegal, using Deloitte’s 2012 report on Senegal$^4$. We calibrate taxes on companies’ revenues (\tau^v) to match total revenue collection in corporate taxes in Senegal (1.45% of GDP), resulting in a 2.7% rate.

**International interest rate.** We calibrate real interest rate in Senegal to match the relative size of the formal sector, which is 55% of GDP. This is done because the formal sector is the only sector that uses capital in this economy (which is a tradable formal good). We find it to be 4.5% per year.

In Table 8, we report the calibration values and respective moments, and Table 9 reports the parametrization values.

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### Table 8: Calibration

<table>
<thead>
<tr>
<th>Parameter of the model</th>
<th>Value calibrated</th>
<th>Statistic to match in the data</th>
<th>Value in the model</th>
<th>Value in the data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Deviation of Income Distribution</td>
<td>1.44</td>
<td>Gini coefficient (income)</td>
<td>0.63</td>
<td>0.63</td>
</tr>
<tr>
<td>( \xi_l )</td>
<td>0.088</td>
<td>Female over male’s labor force participation</td>
<td>0.60</td>
<td>0.60</td>
</tr>
<tr>
<td>( \alpha^{inf} )</td>
<td>0.6</td>
<td>Share of formal labor force</td>
<td>0.23</td>
<td>0.14</td>
</tr>
<tr>
<td>( \phi_{fo} )</td>
<td>0.86</td>
<td>Female’s over male’s per hour wage in the formal sector</td>
<td>0.74</td>
<td>0.74</td>
</tr>
<tr>
<td>( \phi_{inf} )</td>
<td>0.70</td>
<td>Female’s over male’s per hour wage in the informal sector</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>( \tau^v )</td>
<td>2.7%</td>
<td>Government Revenues on corporate taxes (as % of GDP)</td>
<td>1.5%</td>
<td>1.5%</td>
</tr>
<tr>
<td>( e_t ) and ( e_m )</td>
<td>0.088</td>
<td>Government Expenditure on education as % of GDP(^5)</td>
<td>6.2%</td>
<td>6.2%</td>
</tr>
<tr>
<td>( \tau^s )</td>
<td>4.5% per year</td>
<td>Size of formal sector (as % of GDP)</td>
<td>56%</td>
<td>55%</td>
</tr>
</tbody>
</table>

\(^5\) The total amount over GDP is then divided between boys and girls of each percentile of the income distribution using years of education of girls and boys for each percentile of the income distribution, found through the 2011 household survey.
Table 9: Parametrization

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human capital growth rate</td>
<td>0.28</td>
</tr>
<tr>
<td>$\alpha^e$</td>
<td>0.20</td>
</tr>
<tr>
<td>$\alpha^{fo}$</td>
<td>0.63</td>
</tr>
<tr>
<td>Consumption tax rate</td>
<td>18%</td>
</tr>
<tr>
<td>Income tax rates</td>
<td></td>
</tr>
<tr>
<td>E_GDP</td>
<td>0.01</td>
</tr>
<tr>
<td>G_GDP</td>
<td>0.052</td>
</tr>
<tr>
<td>beta</td>
<td>0.96</td>
</tr>
<tr>
<td>theta</td>
<td>2.0</td>
</tr>
<tr>
<td>weight informal goods</td>
<td>0.434</td>
</tr>
<tr>
<td>weight formal goods</td>
<td>0.566</td>
</tr>
</tbody>
</table>
III. Results

We perform two experiments to quantify the importance of education in the increase in female labor force participation in Senegal from 2006 to 2011. First, departing from 2011, which is our baseline year, we reduce primary education to the 2006 level and analyze the impact on female labor participation, gender wage gap, inequality, and growth. Second, departing from 2011, we reduce secondary education to the 2006 level and analyze the impact on the same variables.

Increase in primary education - Increasing the spending in primary education increases the productivity of females in the lower end of the income distribution. Many girls that were not finishing primary education in 2006 now finish in 2011 and participate in the labor force by joining the informal sector. The increase in primary education explains half of the increase in female labor force participation between 2006 and 2011.

The increase in primary education has also a positive impact on the distribution of income. The Gini coefficient decreases by 3 gini points from 66 to 63, explained by low income females that start participating in the labor force and contributing financially to their households. The increase in education helps to explain the decline on the gender wage gap, in the data gender wage gap decreased from 0.69 to 0.64 from 2009 to 2017 according to Leopold (2017) and Hausmann (2009), the model predicts that the increase in primary education accounts for 30 percent of this decline.

Regarding the economy, the increase in education has a positive impact on GDP growth that increases by 3 percent. This effect is due to the increase in the labor productivity of the work force and demand effects, aggregate consumption increases by 2.2 percent. Taking into consideration the impact on expenditure and on revenue the net cost of the policy is 2.7 percent of GDP per year.

Increase in secondary education - The increase in secondary education leads to an increase in the productivity of females many of them are already working in the informal sector, and now they switch to the formal sector. Female labor force participation increases by 5 percent. This reform has a larger impact in reducing the gender wage gap, because increases the return of females already working in the labor force and reduce the return of males, some low productive males switch from formal to informal jobs.

The increase in secondary education has a small impact on inequality increasing it by 0.3 gini points. The increase in inequality is due to the fact that more high/medium income families are benefiting from the increase in secondary education. More secondary education has also a larger impact on economic growth generating a 4 percent increase in growth. The reform boosts the productivity of the workers that work to the formal sector, which is the most productive sector of the economy generating higher levels of economic growth. Overall the net cost of the reform is 1.3 percent of GDP, lower than the primary education reform.

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6 Unfortunately, there is no data on income inequality that we could compare the predictions of the model to the data. The only data available is on consumption inequality.
because the reform generates higher revenue from the labor income taxes and because of the lower initial cost.

IV. Conclusions

We develop a micro-founded overlapping generation model that allows to analyze the impacts of policies on both aggregate and distributional levels of income and gender inequality. In this framework females face different barriers to their development over the life-cycle, starting from early education, passing through the cost of child bearing, and lately through discrimination in the labor market. We use this model to quantify the impact of increases in primary and secondary education in female labor force participation in Senegal.

We find that the increase in primary education explains half of the increase in female labor force participation in Senegal between 2005 and 2015, contributing to higher economic growth and lower income inequality. Higher levels of primary education increase the return of participating in the labor force leading many women to join the labor force. These females mostly join the informal sector contributing to higher economic growth and lower levels of inequality. We find that to a lower extend the increase in secondary education also contributed to the increase in female labor force participation. The increase in secondary education impacted mostly females that already participate in the labor market and now equipped with higher levels of education switch from informal to formal jobs.


