Interdependence of Technology and Women's Rights in Macro-Development Dynamics

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Abstract

Does technology adoption depend on the politics of women's rights? Can this interdependence explain the developmental trap that pushes many international migrants to face a cultural clash concerning women's rights, causing a political backlash against such migration and women's empowerment in their host countries? First, higher per capita income via globalization and free trade has reduced child mortality and boosted population growth in many developing countries like India and Brazil. Still, it hasn't improved women's welfare significantly, especially in rural areas. Capitalism thrives there with cheap physical labor from a large pool of unskilled men and children due to low opportunity costs for sustaining high fertility with no education scaffolded with low women's rights. Consequently, business leaders have little incentive to adopt brain-intensive technology there. Also, growth led by brawn-biased technology, like plow-based agriculture, forestry, and mining, offers little employment opportunities for women, creating a vicious circle. Second, institutions for improving women's rights and brain-intensive industries that reward women for their comparative advantage in skills, like finance and software engineering, sustain each other in most industrialized countries. However, their world population share is tiny and shrinking. This sustainability concern of the industrialized countries and the economic opportunities for women in countries growing wealth with brain-intensive technology imply a politically polarizing international migration crisis. We address these macroeconomic issues by broadening the conceptual framework of the unified growth theory developed by Galor (2011) and others by considering factors affecting male-female differences in productivity, participation rate, and education. Here, family decision rules reflect male bias due to technology's brawn bias and gender-discriminating

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social norms. The model produces endogenous interdependence between technology and social norms, for which we find evidence in Alesina et al. (2013) and Xue (2024).

Keywords: Gender-Biased Technology, Social Discrimination against Women, Endogenous Fertility, Quantity-Quality Tradeoff, and Demographic Transition.

1 Introduction

Claudia Goldin's 2023 Nobel lecture motivates us to explore the role of institutions and technology in shaping how society values women's welfare. From the seminal work of Alesina *et al.* (2013), we learn how brawn-intensive technology shapes social norms against women. Subsequently, Gupta *et al.* (2022) claim that groups whose ancestors frequently faced war (arguably a brawn-intensive technology) for survival tend to have relatively conservative social norms that glorify motherhood and high fertility. In contrast, we note from recent work by Xue (2020) how relatively brain-intensive technology (such as textile) works to increase the value of women in her family. At the same time, we also note that two hundred years of technological diffusion since the first industrial revolution has yet to make a significant dent in most developing countries which have a dismal record of low women's rights. Bénabou *et al.* (2022) found a robust negative relationship between religiosity and patents per capita. To the extent the religiosity index also signals a cultural bias against women's equal rights as men, this finding support the hypothesis that a society with low women's rights may resist adoption of brain-intensive technology. A question arises naturally: do low women's rights sustain a high fertility and low-skill economy to discourage innovations of brain-intensive (advanced) technology while brawn-intensive (primitive) technology incentivizes low women's rights to create a developmental trap?

Moreover, some of the countries with significantly low economic rights for women are resource-rich, such as Saudi Arabia and Iran. Some, such as Brazil and India, grew their per capita income via international trade. Child mortality decreased, and life expectancy increased. According to conventional wisdom, such as Cervellati and Sunde (2015), those changes should lead to a sustained skill-biased technological change, which should promote women's participation by arguments established by Galor and Weil (1996) with supporting evidence offered by Rendall (2010 and 2013), and a cultural shift toward women's empowerment, following the argument of Fernandez (2013).[1] At the same time, a large volume of literature summarized in Tertilt et al.(2022) and the seminal work of Doepke and Tertilt (2009) and Fernandez (2014) popularize the enlightenment hypothesis under which higher levels of income, by itself, makes men care sufficiently more about their daughters and grand-daughters to feel less competitive with their spouses. Consequently, per capita income growth tilts the tradeoff over time in favor of greater women's rights. Doepke et al. (2012) further help build a virtuous circle of growth and women's welfare by modeling improved women's rights as catalysts of economic development.

Consequently, two macro-developmental facts that exist in plain sight pose a puzzle. First, the fact that a large number of countries with improved health and low infant mortality but with low women's rights continue to specialize heavily in brawn-intensive technology to sustain its high levels of per capita income. Second, economies which operate brain-intensive tech-

[1]Fernandez (2013) highlights the role of women's market participation in changing social attitudes toward women and norms.

nology not only have a significantly higher per capita income than those operating a brawn-intensive technology, but their world population share is tiny and shrinking, facing the "empty planet trap" discussed by Jones (2022), causing a growing per capita income inequality across countries. A declining population with increasing relative prosperity is unsustainable without international migration. However, such migration invites a clash of culture concerning women's rights and political polarization in the host countries where a conservative culture promotes higher fertility to make up for less migration from poorer countries. These two developmental facts remain relatively unexplored and poses a puzzle to the conventional wisdom of a virtuous circle of economic growth and women's welfare.

So, in this paper we explore an alternative theoretical explanation for these developmental phenomena. However, we do that by integrating the unified growth theoretical framework of Galor (2011) with a political theory of women's rights by taking a cue from Esteban and Ray's (2008) model of conflicts. Our expanded model offer a hypothesis that a political struggle is sometimes necessary for improving institutions for women's rights. Htun and Weldon (2012) provide evidence for such an alternative hypothesis. Moreover, in recent studies by Kanbeer (2016), Folbre (2020), and Santos Silva and Klasen (2021) we note that a male backlash could follow women's empowerment, raising threats of crime against women (see Adams-Prass *et al.* 2022), which deter women's participation in the market economy according to Chakraborty et al. (2018), Broker (2021, 2022) and Amaral et al. (2023). We find these evidence-based ideas strengthens the conclusions of our theoretical model.

In the model, adult men and women work, save for retirement, and raise children as couples when young with no experience. After gathering work and family experience, they retire from normal work as elderly adults but spend time to improve the welfare of the next generation either with a team of business innovators or with a team of social workers who participate in politics to influence institutions for women's rights. Each family consists of a man, a woman, and their children, but not their parents, who live on their past savings. Each family belongs to a political group of a distinct culture, conservative or progressive, corresponding to their production technology, specific to their residential locations, rural or urban, respectively. Business and social leaders do not communicate because our model's business leaders speak science while social workers speak religions. Families assign welfare weights on the male-to-female utility and the utility from the number (proxying for implicit benefits from child labor) and quality of children based on the parameters set by the group's business and social leaders. Men and women have different technology-specific productivity. Relative productivity of women to men, and the family's opportunity of increasing the number of child labor with no education, increases if the group switches from a brawn-intensive to a brain-intensive technology. Further, the welfare weight on women's utility relative to other components (including fertility and child labor) is higher for the group that uses a brain-intensive (rather than a brawn-intensive) technology and a better institution for women's rights.

The group's attitude toward women and girl children defines culture in our model. It varies with social norms that reflect women's comparative advantage in the production technology and the effectiveness of institutions in administering women's equal rights as men by eliminating crime that deter women's economic engagement. Those norms influence the family's optimal decision rules.[2] However, political conflicts and their policy outcomes change social norms to

[2]Field *et al.* (2021) report how women's financial control impacts gender norms. From a field experiment in India, Field *et al.* (2010) note that social norms upheld by traditional institutions limit female engagement in business ventures.

affect those family decision rules which have significant implications for fertility and children's education and that, in turn, have significant impact on the long-term macro-development dynamics. Thus, our model illustrates how politics of women's rights alter the economic tradeoff affecting the family's fertility decisions is critical to our understanding of the long-term human evolutionary dynamics.[3]

We model the family's decision-making process in a way that follows the idea of Chiappori (1988). Consistent with an internally Pareto-efficient arrangement, constrained by the contemporary social norms, the family arrives at its welfare weights for the individual outcomes affecting its members, and its optimizing decision rules follow from that aggregate welfare function. The family decision rules determine its value as functions of technology, women's rights, and the women's participation rate determined by the extent of male backlash in the economy.

Families belonging to groups with a lower weight on women's utility relative to men and the number of children and a higher male backlash against working women incentivize higher fertility and lower expenditure on children's education. The resulting factor-endowment bias toward physical vis-a-vis mental labor incentivizes the group's business leaders to choose relatively brawn-intensive technology. Similar arguments establish that a group that values its women more incentivizes its business leaders to adopt a more brain-intensive technology. At the same time, groups operating primarily on brawn-intensive technology incentivize the social leaders to make a political choice favoring relatively low women's rights that make the economy relatively abundant in large numbers of unskilled male and child labor. On the other hand, a group operating primarily on brain-intensive technology generates political incentives for social leaders to build institutions for improved women's rights necessary to populate the economy with fewer workers but with higher quality, measured by a higher level of education.

Consequently, without migration and cultural assimilation across groups, along the line discussed in Bisin and Verdier (2001), our model would explain why globalization facilitates population growth and blocks the adoption of labor-saving, skill-biased technology in economies with lower women's rights. It would also motivate the rationale for how the resulting divergence in per capita income between these two cultures triggers a migration crisis involving a clash of cultures and the subsequent political backlash from the vested interest groups against cultural assimilation.

Galor and Mountford (2008) provided an alternative scenario that can also serve as the objective basis of a similar worldwide political conflict. In that scenario, access to the international goods market triggers countries with different skilled-to-unskilled labor ratios to specialize in brawn-intensive or brain-intensive technologies. Also, our story of different cultural types reproducing at different rates and characterizing the population, technology, and income dynamics is comparable to Galor and Michalopoulos (2012). However, in their model, the non-entrepreneurial types gain an evolutionary advantage to stop the growth engine of the advanced economies, thereby facilitating a global convergence of living standards. That optimistic scenario contrasts the story where social norms that undermine women's welfare blocks technological progress, and yet has an evolutionary advantage, causing a diverging living standard worldwide, trigerring an international migration crisis, in the absence of cultural assimilation.

Further, recent Indian experience provides some empirical validation for this hypothesis. In 2006, there was a state government led initiative to usher a directed technological change by

[3]For examples of how policies improve social norm to enhance the family-evaluation of its women members, see Beaman, *et al.* (2009) and Maitra and Rosenblum (2022).

inviting TATA with a tax incentive to build a nano factory in Singur, West Bengal, a rural agrarian economy. There were no plans to offer alternative sources of employment to a large pull of unskilled agricultural workers displaced by the plan. The local community resisted because people considered a labor-saving advanced technology unsuitable for creating jobs for male workers without the necessary skills to operate it. Also, skilled engineers and managers did not want to move there because their families and children required strong institutions for women's rights. Subsequently, not only the plan failed, but also the state government lost power to the opposition who led the resistance movement.[4]

Thus, our model offers an alternative scenario of the evolutionary dynamics of the technology described in Cervellati and Sunde (2015) by connecting them to the politics of women's rights and their evolution addressed in Doepke *et al.* (2012), Fernandez (2014), and Tertilt *et al.* (2022). It also provides an alternative story of evolutionary dynamics to complement Galor and Moav (2001) and Galor and Moav (2002) by focussing on how social attitudes toward women may direct how technology evolves. It also offers a different perspective to re-examine the idea emphasized in de la Croix and Vander Donct (2010) that if an economy is stuck in a "corner equilibrium" where women specialize fully giving birth and taking care of children because of a self-enforcing mechanism, then improving women's rights or lowering gender earning gap would do little to change anything, and qualifies that claim.

Summing up, this paper contributes to the literature with an illustrative theoretical example to shed light on four contemporary developmental challenges. First, the model's long-term macro development dynamics characterize how, in the absence of a political struggle for women's rights, resilient social institutions with Conservative (patriarchal) cultural norms suppress women's rights to boost fertility and thereby create an abundant supply of workers with no skill to block technological progress, despite the arrival of industrial revolution two centuries ago. Capitalism thrives there nonetheless by relying on cheap, unskilled labor with brawn-intensive technology, causing high gender inequality, instead of using more advanced labor-saving, brain-intensive technology. Second, it explains why the business community finds incentives to adopt brain-intensive technology in societies with adequate women's rights. Capitalism demands higher skills but fewer workers, while equal institutional rights for men and women encourage couples to have fewer children with higher education and skills. Consequently, it creates an economic condition for migrants from impoverished economies with a culture hostile to women to help sustain the shrinking world population share of the affluent economies, creating an objective basis for a political conflict. Third, a strong political movement to change institutions for women's rights may be critical to technological advancement in countries stuck in a developmental trap. Fourth, the male backlash against institutional changes favoring women's rights raises threats against working women and causes economic waste. A new policy insight emerges. Technology transfer as a developmental aid may only succeed with a simultaneous improvement in institutions for women's rights and other policies to redress male backlash.

In what follows, Section 2 presents our theoretical model and describes the family decision rules and the model's outcome by taking technology and institutions for women's rights exogenously given. Section 3 describes the interdependent evolution of technology and institutions of of women's rights involving social choices without political conflicts. Section 4 extends that analysis by allowing migration across two cultures, cultural assimilation and politics of women's

[4]Ghatak *et al.* (2013) recorded this history but focussed on the economic hardship of the poorly compensated farmers.

rights. Section 5 presents a quantitative analysis of the model calibrated to the real-world data based on simulations. Section 6 adds concluding remarks, followed by the appendix, which includes algebra and supplementary simulations.

2 The Model

We consider an economy made of rural and urban sectors characterized by "brawn-intensive" and "brain-intensive" production technology, respectively. We model each sector within an overlapping generational framework in which men, women and families belong to a location-specific cultural group: conservative (rural) and progressive (urban). Each person lives for three periods, first passively as a child, then as a working adult, and finally as a retired elderly adult. A couple is made up of two young adults, a man (m) and a woman (w) who form a family when young, have children and educate them. A family consists of a couple and their children. It weighs a couple's wellbeing with a full commitment to it's cultural group's social norms that determine the welfare weights assigned to the various components of the family utility. Those norms depend on women's comparative advantage in the existing technology and the institutions of women's rights. Young adults allocate their time 100% for working and raising children, save for the old age, beginning with zero non-human initial wealth. Elderly adults behave altruistically to improve the welfare of the future generations. They live on past saving, leave no bequests, and engage with their peers to influence technology and institutions for women's rights.

Each family takes the technology and institutions as given to determine a set of decision rules for consumption, fertility and children's education as functions of the relevant state variables. Those decision rules yield the indirect utility of the representative family for each group, which we call the group's welfare, as functions of the sector-specific technology and institutions for women's rights.

The community of elderly people are randomly divided into two non-cooperative interest groups: (i) technology developers or business innovators and (ii) moral police or social institution developers. They develop their interests only in their second period of life based on their idiosyncratic work-life experience in their first period. These two groups speak two different languages: science and religion. Consequently, they do not cooperate. Business leaders adopts technology for the next generation given the institutions for women's rights so as to maximize the group welfare for the next generation. Social leaders engage in the politics of women's rights to determine the institutions governing the women's rights.

Next, we describe the economic environment that determines the welfare of the representative family belonging to each group for exogenously given technology and women's rights.

2.1 Production Technology

Galor and Weil's (1996) idea of women's comparative advantage in a relatively brain-biased technology, supported by Rendall's (2013) evidence, meets Galor's (2011) knowledge-based technological factor productivity (TFP) in this model's specification of technology.

Our technology replaces physical capital modelled in Galor and Weil (1996) with a human capital index, h, which reflects health or physical stength and education or skill. It complements physical and mental tasks differently to characterize technology which asymmetrically treats male and female human capital because of their evolutionary difference in the brawn to brain

endowment ratio. A similar gender-specific bias arises also in the original Galor and Weil's (1996) model. We assume that the production process requires two types of tasks. One primarily requires brain (B) or mental labor. The other primarily requires physical strength (PH). Personal human capital complements brain in augmenting mental labor more than augmenting physical labor.

Following Galor (2011), we assume that the economy's output is a function of a time invariant unit of land, Z, the technological factor productivity (*TFP*), A_t, and the production technology satisfies constant returns to scale with respect to *TFP*-augmented land, A_tZ, and human capital augmented effective labor, H_t, such that the economy's output, Y_t, produced in period t, satisfies

$$Y_t = (A_tZ)^{1-\alpha}H_t^{\alpha},\ H_t = h_tL_t,\ 0 < \alpha < 1, \tag{1}$$

where we identify the number of families, L_t, with the employment level and define h_t as the average efficiency index of the male-female labor supply from each family such that:

$$h_t = \left(b\left(\sum_{k=m,w} l_k^B * h_{k,t} \right)^{\alpha} + (1-b)\left(\sum_{k=m,w} l_k^{PH} * h_{m,t} \right)^{\alpha} \right)^{1/\alpha}, \tag{2}$$

where the parameter b denotes the brain-biasedness of technology, and for $k = m,\ w$, l_k^B and l_k^{PH} are two indicator variables which take the values 0 or 1 such that $l_k^B = 1$, if k performs tasks primarily using "brain (B)", otherwise $l_k^B = 0$, and $l_k^{PH} = 1$, if k performs tasks primarily using physical strength (PH), otherwise $l_k^{PH} = 0$. Both types of tasks are necessary for completing the production process. Following Galor and Weil (1996), we assume that in the labor market only men (not women) supply the tasks that primarily require physical strength. In other words, $l_m^{PH} = 1$ and $l_w^{PH} = 0$.[5]

By (2), h_t varies with b in a way such that we can write $h_t = h_t(b)$. In other words, the average output per family, $y_t \equiv Y_t/L_t$, generated from the technology for the representative family satisfies:

$$y_t = (h_t(b))^{\alpha}\left(\frac{A_tZ}{L_t}\right)^{1-\alpha} = (h_t(b))^{\alpha}\, z_t^{1-\alpha},\ \text{where, } z_t \equiv \frac{A_tZ}{L_t}. \tag{3}$$

In a competitive market, operating under the technology described by (1) - (3), in each period t, the representative profit-maximizing firm pays each factor its marginal product such that for $k = m, w$, such that $w_{k,t} = \frac{\partial y_t}{\partial h_{k,t}}$, $r_t = \frac{\partial y_t}{\partial z_t}$, and with equal division of land rent, the income of the man and the woman of each family is given by

$$y_{k,t} = w_{k,t}h_{k,t} + r_tz_t/2,\ k = m, w, \tag{4}$$

[5]We do not model home production where women engage in tasks requiring physical strength. Our formulation here is closer to Cervellati and Sunde (2015) and Rendall (2018) which replaces physical capital with human capital.

and z_t denotes the average land-holding per family, augmented by TFP, A_t. With a convenient assumption that the land rent, r_t, does not depend its size, the constant returns to scale set up of the per capita production technology allows the competitive market outcome for the representative family with the average land-holding, z_t, implies product exhaustion: $y_t = \sum_{k=m,w} (w_{k,t}h_{k,t} + r_t z_t/2) = \sum_{k=m,w} y_{k,t}$.

2.1.1 *Male-Biased Technology*

Gender-specific differences in the marginal product of human capital, which equals its competitive market price, $w_{k,t}$, vary with the technology's brain-biasedness parameter b. For a self-employed we capture this technology-specific gender difference in the productivity factor as $A_{k,t} = z_{k,t}(b)A_t$ by equating the income from self-employment and the competitive market income as follows:

$$y_{k,t} = h_{k,t}^{\alpha} \left(z_{k,t}(b)z_t\right)^{1-\alpha} = \left(z_{k,t}(b)\right)^{1-\alpha} h_{k,t}^{\alpha} z_t^{1-\alpha}, \ k = m, w, \tag{5}$$

and

$$y_t = \sum_{k=m,w} y_{k,t}. \tag{6}$$

Equality of y_t, given by (3) and (6) imply the following relationship that implicitly defines the two gender-specific technological productivity factors, $z_{k,t}(b)$, $k = m, w$:

$$h_t(b) = \left(\sum_{k=m,w} z_{k,t}^{1-\alpha}(b) h_{k,t}^{\alpha} \right)^{1/\alpha}, \tag{7}$$

where (2) defines $h_t(b)$. We now define the *male bias of technology* (m_T) by the male-to-female technological productivity ratio as follows:

$$m_{T,t} = \frac{z_{m,t}(b)}{z_{w,t}(b)} > 1. \tag{8}$$

By comparing (2) and (7), we get the following result about the *male-biasedness,* m_T, of technology, defined by (8).

Lemma 1: *If, per unit of production time, each working man performs tasks, requiring both brain and physical labor such that* $l_m^B = l_m^{PH} = 1$, and *each working woman performs tasks requiring brain alone such that* $l_w^B = 1$ *and* $l_w^{PH} = 0$, *then the following inverse relationship between* $m_{T,t}$ *and* b holds:

$$m_{T,t} = \left(\frac{1}{b}\right)^{1/(1-\alpha)} = m_T(b). \tag{9}$$

Proof. See Appendix.

Thus, the technological male bias, m_T, in productivity varies inversely as a continuously differentiable function of the its brain-biasedness indicator, b.

2.1.2 *Gender Inequality in Potential Earning*

By (7), the average family income, y_t, given by (3) equals the total potential lifetime income, y_t, of the representative family.[6]

By (8), (5), and *Lemma 1,* in each period t, each family's potential lifetime income, y_t, and the gender earning inequality, $I_{y,t}$, measured by the male to female lifetime income ratio minus one vary as a function of the male-biasedness, m_T, of technology as follows:

$$y_t = (z_t z_{w,t})^{1-\alpha} (h_{w,t}^{\alpha} + m_{T,t}^{1-\alpha} h_{m,t}^{\alpha}),$$

and

$$I_{y,t} \equiv \frac{y_{m,t}}{y_{w,t}} - 1 = m_T^{1-\alpha} \left(\frac{h_{m,t}}{h_{w,t}}\right)^{\alpha} - 1 = \left(\frac{1}{b}\right) \left(\frac{h_{m,t}}{h_{w,t}}\right)^{\eta} - 1 \tag{10}$$

Therefore, by (10), a more brain-biased technological advancement and a lower human capital gap between men and women represent the two channels through which the gender income inequality decreases in this economy.

Next, we model human capital using the functional form explored in Lagerlöf (2006) and Galor (2011) but introduce gender difference in human capital accumulation due to gender difference in the marginal cost of providing children with education.

2.2 Human Capital Technology

The adult-age human capital, $h_{k,\,t+1}$, at date $t+1$ of the date t child $k = m, w$ increases with child's education $e_{k,t+1}$, decreases with knowledge growth because vintage education becomes obsolete such that

$$h_{k,\,t+1} = h(e_{k,t+1}, g_{t+1}) = B \left[\frac{e_{k,t+1} + \theta\tau}{e_{k,t+1} + \theta\tau + g_{t+1}}\right],\ k \in \{m, w\},\ B > 0. \tag{11}$$

where $e_{k,t}$ denotes the date t parents' choice of education for their son ($k = m$) or daughter ($k = w$), and g_{t+1} denotes the knowledge growth rate between date t and $t+1$. The parameters τ and θ concern health capital due to early childhood care: $0 < \tau < 1$ denotes the time women spend for giving birth and early childhood care and θ determines the quality of that nurturing which positively influences the child's mental capability.[7] The data matching parameter B proxies for the efficiency of the education technology.

[6] We thank Professor Diego Restuccia for asking us to establish this equivalence.

[7] From Heckman and Masterov (2007), we find evidence to make a case for the productivity-enhancing effect of pre and post-natal (maternal) early childhood care in the form of higher human capital.

2.3 Population and TFP (Knowledge) Growth

In every generation t, the economy consists of a continuum of families with measure L_t. The average number of offsprings, o_t, which come with equal number of boys (m) and girls (w), as in de la Croix and Vander Donckt (2010), per family determines the family population growth dynamics:

$$L_{t+1} = 0.5 L_t o_t. \tag{12}$$

The working adults interact to find solutions to technological constraints. The number of working adults and their average education level in period t partly determine the outcome of those social interactions. A larger volume of nonrival knowledge from those interactions implies a higher *TFP*, A_{t+1} for everyone in period $t+1$. Therefore, the population density, proxied by, L_t, and the average education, e_t, measured by the weighted average of men's and women's education, $e_{k,t}$, $k = m, w$, determine the growth rate of knowledge or technology, g_{t+1} up to a point. Beyond that point, *TFP* growth increases only with the advancement of technology, measured by the increase in its relative brain-biasedness, b, which disproportionately increases marginal product of human capital that engages brain (l_k^B) compared to physical strength (l_k^{PH}), $k = m$, w.

In particular, we assume

$$g_{t+1} = [e_t + \theta\tau] a(L_t), \tag{13}$$

where, e_t denotes the average education level of the adult men and women at date t such that

$$e_t = 0.5(e_{m,t} + e_{w,t}), \tag{14}$$

where the parameter τ measures the fraction of potential worklife mothers must forgo for each childbirth, and the parameter θ captures the impact of maternal care (pre-natal and post-natal) and early-childhood nourishment and training per unit of time on the adult-age communication ability. Thus, the term $\tau\theta$ proxies for the impact of childcare time, τ, and quality, θ, on the children's health that enhances their adult-age human capital and communication capability and hence future knowledge spillover in the macroeconomy. The function $a(L_t)$ captures the impact of population density on TFP growth due to knowledge spillover which has an upper bound as follows:

$$\begin{aligned} a(L_t) &= \min\{\Psi L_t,\ D\Psi^*\},\ D \geqslant 1. \qquad (15) \\ \Psi &> 0,\ \Psi^* = \Psi^*(m_T) > 0,\ \Psi^{*\prime} < 0, \end{aligned}$$

where the parameter D captures a potential impact of diffusion of knowledge developed outside the macroeconomy on the effectiveness of indigenous technology in promoting knowledge growth.[8]

The assumption that $\Psi^{*\prime} < 0$ parallels a critical assumption in Cervellati and Sunde (2005 & 2015) as well as Diebolt and Perrin (2019). It is regarding the impact of their model's physical to mental productivity ratio, which corresponds to our model's m_T statistic, on growth. In a way, this impact captures the role of directed and skill-biased technological changes that mark the distinctive characteristic of technology growth in the later phase of economic development. By *Lemma 1*, m_T, varies inversely with female to male human capital ratio and the relative productivity share of mental vis-a-vis physical labor, b. Therefore, by this assumption, the knowledge-based growth rate would be higher when the technology's brain-biasedness, b, and female to to male human capital ratio is higher. However, it occurs only when the population level exceeds a minimum threshold, $L_t > \widehat{L} \equiv \frac{D\Psi^*}{\Psi}$ for directed technological innovation. This threshold, $\widehat{L}$, increases when the knowledge diffusion parameter D increases during the phase of globalization, slowing down indigenous innovation. Thus, it follows from (13) - (15):

$$g_{t+1} = g(L_t,\ e_t,\ m_T) \tag{16}$$

where nonrival knowledge drives the land productivity or the overall technological factor productivity (TFP), A_t, at the endogenously determined growth rate, g_{t+1}, which we describe later, such that

$$A_{t+1} = (1 + g_{t+1})A_t. \tag{17}$$

2.4 Women's Rights Institutions

From Iyer et al. (2012), we learn that a rise in women's political representation and the resulting improvements in the social, legal and judicial institutions for upholding women's rights empowers women. We measure the partial impact of those institutions on social norms by the fraction, $0 \leq \sigma_I \leq 1$, of men's rights that women enjoy on average in a society.

We assume that the economy has two distinct cultural groups (e.g., rural and urban) with two distinct political prerences for the choice of women's rights institutions. We provide a microfoundation of the group's preference for women's rights after describing the optimization exercise of the individual family. We show how the political choice of women's rights institution, σ_I, involving group leader who maximize the indirect utilities of their representative families, rationalizes how different developmental stages and different technologies with significantly different male-biasedness, m_T, shape the differences in social norms regarding the prefenrence of

[8] Jones (2022a) noted that modelling knowledge growth based on the indigenous population alone ignores the relevance of knowledge diffusion across countries for understanding global technological development. Our specification implies, in addition, that the population size needs to be sufficiently large, $L_t \geqslant \frac{D\Psi^*}{\Psi}$, to benefit from this diffusion from abroad through a significant volume of social interactions. It also captures barriers to technology diffusion due to geography, politics and trade restrictions.

women's rights, or social status of women, among different groups operating different technology due to different geographical or historical reasons.[9]

Following the description of the optimization exercise of the representative family, which takes the women's social status in the group, determined by its male-biased technology and institutions, m_T and σ_I, as given, we describe how the business and social leaders of each group choose the group's technology and institutions for women's rights for the next generation.[10]

2.5 Family Preference

In the spirit of Chiappori (1988), the representative family assigns welfare weights to individual components that family-members care about, reflecting a Pareto efficient allocation within the family under the constraints imposed by the existing social norms of the economy.

2.5.1 *Social Status of Women (σ)*

We assume that the welfare weight the family assigns to its adult female vis-a-vis male member's utility depends on the women's social status, σ, which depends on the contemporary gender bias in technology, m_T, and institution for women's rights, σ_I, as follows:

$$\sigma = \frac{\sigma_I}{m_T}. \tag{18}$$

From Beaman *et al.* (2009) we note that when communities elect female representatives, attitude toward women improves in their families. The study by Field *et al.* (2021) documents how strengthening women's financial control over family budget impacts gender norms about her status in the family. Findings of Doepke *et al.* (2020) and Christopherson *et al.* (2022) indicate that legal reforms to improve institutions for women's rights, σ_I, can empower women and thereby enhances their status, σ, within the family.

From the study of Field *et al.* (2010), we learn how the impact of social norms arising from women's religious and caste backgrounds contribute to their limited access to information, which, in turn, limits women's business activities. We then infer from Field, *et al.* (2021) how social norms influence a typical family's evaluation of women's welfare and son preference.

Further, from Ho (2016) and Damjanovic and Selvaretnam (2018), and other studies we conclude that as women's comparative advantage in the production technology increases, that is, as the technology's male bias, m_T, decreases, women's status in the family improves.

2.5.2 *Family Preference Construction*

In each generation t, the personal utility of each adult $k = m, w$, from consumption, $c_{1k,t}$ and c_{2k}, for the period (1) when working as young worker or self-employed and (2) after retirement as elderly person, respectively, determines the personal lifetime utility, $u_{k,t}$, without any time discounting such that

[9] Influential work by Alesina et al. (2013) motivated this theory.

[10] It turns out that a coordination failure between the business and social leaders can result in multiple equilibria, creating a distribution of culture characterizing the group's technology and women's rights. We add a separate section afterward to address the task of nation-building to integrate different groups via the politics of technology adoption and women's rights.

$$u_{k,t} = \ln c_{1k,t} + \ln c_{2k,t} = \ln c_{k,t}, \tag{19}$$

where $c_{k,t} = (c_{1k,t})(c_{2k})$.[11] Given, the period t personal utility $u_{k,t}$ of an adult $k = m,\ w$, the family aggregates the working couple's utility, $U_{C,t}$, consistent with the contemporary social status, σ_t, of women in their group as follows:

$$U_{C,t} = \ln c_{m,t} + \sigma_t \ln c_{w,t}, \tag{20}$$

where, (18) determine σ_t.

Further, we assume that the social norms are such that the family cares about the number of offsprings, $o_t > 0$ irrespective of their gender. We suggest that this component of preference proxies for a hidden utility benefit from unpaid child labor.[12] Moreover, as in Hiller (2014), the family cares about the average quality of its offsprings at their adult-age, measured by their period $t+1$ average human capital, $h^k_{t+1,}$ but evaluating it differently for sons ($k = m$) and daughters ($k = w$).[13]

Thus, being guided by the underlying social norms, the representative family assigns the welfare weights to various factors that adds to its utlity, $U_{F,t}$, which satisfies

$$U_{F,t} = U_{C,t} + \sum_{k=m,\ w} \gamma_{k,t} \ln[h_{k,\ t+1}] + \rho \ln[o_t]\ ,\ \gamma_{k,t} > 0,\ \rho > 0. \tag{21}$$

where $U_{C,t}$ satisfies (20), ρ and $\gamma_{k,t}$, $k = m,\ w$, denote the family's welfare weights on the number and the average human capital of all sons and all daughters, respectively.[14]

2.6 Family Budget

By (3) - (7), we determine the date t representative family's potential income, y_t, which equals what the working couple pull together out of their potential lifetime income, $y_{k,t}$, for each young adult, $k = m, w$.

[11] We make this simplifying assumption, in the spirit of Cervellati et al (2023) and many others, to avoid life cyle related issues which are extraneous in a study of long-run growth and development.

[12] Bhalotra et al. (2019) examined the issue of son bias in parental preference and the resulting outcome of female feticide in some developing countries. However, considering the tractability of the model's outcome, we leave that very pertinent issue for future research.

[13] Hiller and Touré (2021), Doepke and Tertilt (2019), and Prettner and Strulik (2017) are noteworthy examples of a parallel literature that focuses on bargaining and the intrinsic male-female difference in the attitude toward children. We take a different route here by focussing on how social norms impact economic development causing diversity.

[14] The difference between γ_m and γ_w potentially captures parents' estimate of the differential marginal products of human capital between men and women.

2.6.1 Barriers to Women's Participation

Two additional factors influence women's lifetime income, $y_{w,t}$. First, in the spirit of the recent study by Kleven et al. (2019), we assume that each birth brings one child at a time and compels the woman to forgo a fraction τ of her lifetime earning. The idea is similar to de la Croix and Donckt (2010) where they define it as the "time cost of rearing a child, which can be interpreted as the time required to rear and nurse children just to keep them alive" and helps explain the key assumption in Erosa et al. (2022) which allows gender differences in home production responsibility because they asymmetrically bear this cost.

Second, we assume that the physical threat due to patriarchal male backlash against working women, lowers women's participation such that a fraction p of all women don't work. We model it as if the representative family faces a friction that forces it to forgo a fraction p of its adult woman member's lifetime income.[15]

The family can partially control with their choice of the number, o, of offsprings the total cost $\tau y_{w,t} o$ of childbirth. However, they must accept the "social penalty", $py_{w,t}$, as an implicit tax on their lifetime family income due to crime against working women in the economy. Later, we describe how the level of crime against women varies with the intensity of political struggle for improving women's rights and the resulting male backlash. Therefore, the date t disposable income, $y_{p,t}$, of the representative family satisfies

$$y_{p,t} = y_t - py_{w,t}, \tag{22}$$

where (5) and (6) define the woman's potential income, $y_{w,t}$ and the potential income, y_t, for her family.

The family allocates its disposable income, $y_{p,t}$, for the lifetime consumption, $c_{m,t}$ and $c_{w,t}$ of the man and woman, for buying $e_{k,t+1}$ units of education for each son ($k = m$) and daughter ($k = m$), and a' units of food for each of their o_t number of children to keep them alive. We assume that each unit of education cost one unit of educator's time, and the educator is equally likely to be a man or a woman but from the same culture. Consequently, the price of one unit of education equals the average labor productivity, $0.5y_t$, at date t. We model social discrimination against girl's education as a social tax that augments the price of girl's education at a rate $q > 0$ per unit of $e_{w,t+1}$.

Therefore, it follows from (22) that the representative family's budget constraint satisfies:

$$c_{m,t} + c_{w,t} + [a' + 0.5y_t(e_{m,t+1} + e_{w,t+1}(1+q)) + \tau y_{w,t}]o_t \leqslant y_t - py_{w,t} \equiv y_{p,t}, \tag{23}$$

where, y_t satisfies (6) and $y_{p,t}$ denotes family income net of women's income lost due to socio-cultural barriers against women. Social norms that lower σ relative to ρ, a parameter proxying the utility benefits from child labor, complements the benefits brawn-intensive technology that lowers the opportunity cost of children, measured in terms of women's income lost.

Following the UGT framework, there is a minimum level of consumption, $\widetilde{c}$, necessary for survival. It implies a subsistence constraint:

[15] Erosa *et al.* (2022) linked gender earning inequality to exogenous gender differences in participation constraints leading to productivity differences.

$$c_{k,t} \geqslant \widetilde{c},\ k \in \{m, w\}. \tag{24}$$

2.7 The Representative Family's Optimization Problem

The representative family's optimal choice problem is to maximize (21) subject to the budget and subsistence constraints, (23) and (24), respectively. In other words, the decision rules for the representative family of generation t satisfy the following optimization exercise:

$$\begin{aligned} &\underset{((c_{k,t},\, e_{k,t+1},\, \mu_{2kt},\, \mu_{3kt})_{k=m,w},\, o_t\ \mu_{1t})}{Maximize} [U_{F,t}(c_{m,t}, c_{w,t}, e_{m,t+1}, e_{w,t+1}, o_t) \\ &-\mu_{1t}(c_{m,t} + c_{w,t} + (a' + 0.5y_t(e_{m,t+1} + e_{w,t+1}(1+q)) + \tau y_{w,t})o_t - y_{p,t}) \\ &-\sum_{k\,=\,m,\,w} \left(\mu_{2k,t}\left(c_{kt} - \widetilde{c}\right) + \mu_{3k,t}\left(h_{k,t+1} - h(e_{k,t+1}, g_{t+1})\right)\right), \end{aligned} \tag{25}$$

where μ_{jt}, $j = 1, 2, 3$ denote the Lagrange multipliers, $h(e_{k,t+1}, g_{t+1})$ satisfies (11), (22) define y_{pt}, and by (21),

$$U_{F,t}(c_{m,t}, c_{w,t}, e_{m,t+1}, e_{w,t+1}, o_t) = \ln c_{m,t} + \sigma_t \ln c_{w,t} + \sum_{k=m,\,w} \gamma_k \ln[h_{k,\,t+1}] + \rho \ln[o_t]\ .$$

We assume zero child mortality and non-stochastic lifetime to avoid inessential details and describe the First Order Conditions (FOC) of (25) in the Appendix.[16]

Given the parameter proxying for subsistence consumption, $\widetilde{c} > 0$, we define two time-varying thresholds of income $\widetilde{y}_t$ and $\widetilde{\widetilde{y}}_t$, where

$$\widetilde{y}_t = \widetilde{c}\left(1 + \frac{1+\rho}{\sigma_t}\right) > \ \widetilde{\widetilde{y}}_t = 2\widetilde{c}. \tag{26}$$

and, the families survive if and only if $y_{p,t} > \widetilde{\widetilde{y}}$. However, a lower valuation of women raises the threshold for subsistence income while lower women's participation rate, $1 - p$, reduces the disposable income, $y_{p,t}$ of the couple without children. The following lemma characterizes the representative family's decision rules when the subsistence constraint is not binding.

Lemma 2*: If $y_{p,t} > \widetilde{y}$, that is, if the subsistence constraint is not binding, the above optimization exercise (25) yields the following decision rules for consumption, fertility, and the*

[16]Lagerlöf (2003) and Cervellati and Sunde (2005, 2015) are noteworthy examples of models in UGT which made important contributions showing how child mortality and life expectancy impact longterm economic growth.

tradeoff between the number and the quality (or education) of sons and daughters, the quantity-quality tradeoff:

Consumption:

$$c_{m,t} = \frac{y_{m,t} + (1-p)y_{w,t}}{1+\sigma_t+\rho};\ c_{w,t} = \sigma_t c_{m,t}. \tag{27}$$

Fertility:

$$o_t = \frac{\rho c_{m,t}}{[a' + 0.5y_t(e_{m,t+1} + e_{w,t+1}(1+q_t)) + \tau y_{w,t}]} \tag{28}$$

Quantity-Quality Tradeoff:

$$o_t[a'/y_t + 0.5(e_{m,t+1} + e_{w,t+1}(1+q_t)) + \tau\left(\frac{1}{2+I_{y,t}}\right)] = \left(\frac{\rho}{1+\sigma_t+\rho}\right)\left(\frac{y_{p,t}}{y_t}\right). \tag{29}$$

Further, if $\widetilde{y} > y_{p,t} > \widetilde{\widetilde{y}}$,

$$c_{m,t} = \frac{\widetilde{c}}{\sigma_t},\ c_{w,t} = \widetilde{c},\ \text{where } \sigma_t = \frac{\sigma_{I,t}}{m_T} < 1, \tag{30}$$

and

$$o_t = \frac{(1-\widetilde{c}(1+1/\sigma_t))\left(\frac{y_{p,t}}{y_i}\right)}{[a'/y_t + 0.5(e_{m,t+1} + e_{w,t+1}(1+q_t)) + \frac{\tau}{2+I_{y,t}}]}. \tag{31}$$

Proof. See Appendix.

We interpret (28)–(31) as conditions through which institutions for women's rights, $\sigma_{I,t}$, and gender-biased technology-induced gender inequality of income index, $I_{y,t}$, affects the quantity-quality tradeoff along the development paths. Interestingly, more women's rights increase fertility when subsistence conditions are binding but lower fertility when not binding. Note $\frac{y_{w,t}}{y_i} = \frac{1}{2+I_{y,t}}$ and $\frac{y_{p,t}}{y_i} = 1 - \frac{p}{2+I_{y,t}}$.[17] If we assume that a lower crime rate against women raises their average life expectancy, and hence increases the family's disposable income, $y_{p,t}$, given y_t, then by (31), fertility decreases. This results resembles de la Croix and Vander Donckt (2010) with one important caveat. An improvement in women's rights increases fertility.

Next, we characterize the optimal decision rules for children's education: $e_{k,t+1}$ for $k = m$ and w but with a simplifying assumption (which we relax later) that $p = 0$. Here we will see that a lower family weight, $\sigma = \frac{\sigma_I}{m_T}$, on women's consumption, due to the underlying environmental conditions defined by technology and institutions for women's rights causes a higher gender inequality, $I_{y,t}$, of income and that corresponds to higher fertility and lower education.

[17] $\frac{y_{w,t}}{y_i} = \frac{1}{1+y_{m,t}/y_{w,t}}$. Then it follows from (10)), which implies that $y_{m,t}/y_{w,t} = 1 + I_{y,t}$. Similarly, by (22) $\frac{y_{p,t}}{y_i} = 1 - \frac{p}{1+y_{m,t}/y_{w,t}}$.

Define $v_k = \frac{\gamma_k}{\rho}$, $k = m, w$ and the gender inequality in earning, $I_{y,t} \equiv \frac{y_{m,t}}{y_{w,t}} - 1$ and $I_{\max} \equiv 2v_m/\theta$.

Lemma 3*: If $v_m = \frac{\gamma_m}{\rho} > 1$ and $I_{y,t} < I_{\max}$, there exists $\widehat{g}_{m,t+1} = \frac{(\theta\tau)^2}{\frac{\gamma_m}{\rho}[2a'/y_t + (e_{w,t+1}(1+q_t)) + 2\tau\left(\frac{1}{2+I_{y,t}}\right)] - \theta\tau}$ such that $g_{t+1} > \widehat{g}_{m,t+1}$ implies that $e_{m,t+1} > 0$, and if $e_{w,t+1} = 0$,*

$$e_{m,t+1} = \max\{0,\ 0.5(v_m - 1)g_{t+1} + \sqrt{(\tau\theta - 0.5(v_m - 1)g_{t+1}))^2 + E_m(y_t,\, I_{y,t})g_{t+1} - (\theta\tau)^2} - \tau\theta\}, \tag{32}$$

where,

$$E_m(y_t,\, I_{y,t}) = \left(2v_m\left(a'/y_t + \tau\left(\frac{1}{2+I_{y,t}}\right)\right) - \theta\tau\right),$$

and, if $e_{m,t+1} = 0$, and $e_{w,t+1} > 0$, then

$$e_{w,t+1} = \max\{0,\ 0.5(v_w - 1)g_{t+1} + \sqrt{(\tau\theta - 0.5(v_w - 1)g_{t+1}))^2 + E_w(y_t,\, I_{y,t})g_{t+1} - (\theta\tau)^2} - \tau\theta\}, \tag{33}$$

where,

$$E_w(y_t,\, I_{y,t}) = \left(\frac{2v_w}{(1+q_t)}\left(a'/y_t + \tau\left(\frac{1}{2+I_{y,t}}\right)\right) - \theta\tau\right).$$

Also, there exists a time-varying threshold $\widehat{g}_{w,t+1} = \frac{(\theta\tau)^2}{2\frac{\gamma_w}{\rho}\left(\frac{a'}{y_t} + 0.5e_{m,t+1} + \tau\left(\frac{1}{2+I_{y,t}}\right)\right) - \theta\tau} > 0$ such that if $g_{t+1} < \widehat{g}_{w,t+1}$, $e_{w,t+1} = 0$, and $\gamma_m > (1+q)\gamma_w$ implies that if $g_{t+1} < \widehat{g}_{m,t+1}$, then $\widehat{g}_{w,t+1} > \widehat{g}_{m,t+1}$.

Otherwise, if $g_{t+1} > \max\{\widehat{g}_{w,t+1},\ \widehat{g}_{m,t+1}\} \equiv \widehat{g}_t$, *then the family's date t allocations for education of each son ($e_{m,t+1}$) and each daughter ($e_{m,t+1}$), such that $0 < e_{m,t+1},\ e_{w,t+1} < 1$, satisfy*:

$$\frac{(e_{m,t+1} + \theta\tau)\,(e_{m,t+1} + \theta\tau + g_{t+1})}{(e_{w,t+1} + \theta\tau)\,(e_{w,t+1} + \theta\tau + g_{t+1})} = \frac{\gamma_m(1+q_t)}{\gamma_w}, \tag{34}$$

and

$$(e_{w,t+1} + \theta\tau)\,(e_{w,t+1} + \theta\tau + g_{t+1}) = \frac{2\gamma_w g_{t+1}}{\rho(1+q)}(0.5\,(e_{m,t+1} + (1+q)e_{w,t+1}) + a'/y_t + \tau/(2+I_{y,t})). \tag{35}$$

Proof: See Appendix.

Lemma 3 implies a useful corollary as follows: if, as in Galor (2011) and Lagerlöf (2006), for both $k = m, w$, $v_k = 1$, that is, $\gamma_k = \rho$, $a' = 0$ (a child's survival requires no additional consumption goods), and for all t, $q_t = 0$, (no social discrimination or crime against women at the place of education), $I_{y,t} = \frac{y_{m,t}}{y_{w,t}} - 1 = 0$ (no gender inequality in earning for either cultural group), then by (32) & (33) reduce to

$$e_{t+1} = \max\{0,\ \sqrt{g_{t+1}\tau(1-\theta)} - \theta\tau\}, \tag{36}$$

and if $e_{m,t} = e_{w,t} = 0$, $I_{y,t} = 0$, $\widehat{g} = \frac{\theta^2\tau}{(1-\theta)}$, as in Lagerlöf (2006, p. 123), except θ here corresponds to his parameter "ρ".

2.7.1 The Value Function of the Family

Let the period t state variable vector be $X_t \equiv (L_t,\ A_t,\ g_t,\ h_{m,t},\ h_{w,t})$. Under a stationary environment with a time-invariant ratio of $h_{m,t}$ to $h_{w,t}$, by *Lemma 1*, m_T is a function of b. Next, given X_t and the statistics m_T, σ_I and p, denoting indicators of the technology's male-biasedness, institutionalized women's rights, and missing fraction of young adult women in production due to male backlash against working women, respectively, we define the maximum possible utility that the date t representative family achieves by solving (25) as its indirect utility, $V_{F,t}$ as follows:

$$V_{F,t} = V_{F,t}(m_T,\ \sigma_I,\ p;\ X_t). \tag{37}$$

2.8 Equilibrium

Given the period t macroeconomic state variable vector, $X_t \equiv (L_t,\ A_t,\ g_t,\ h_{m,t},\ h_{w,t})$ and vector of the group-specific factors (m_T, σ_I, p) that the family treats as parameters, (26) - (35), characterize its optimal decision rules and welfare, measured by the value function, given by (37). The sequential decision rules for fertility, $\{o_t\}$, and education $\{(e_{k,t})_{k=m,w}\}$ and the environmental dynamics described by (11) - (17) coupled with technology described by (1) - (6), help generate a set of first order difference equations to characterize the dynamical system for the state variables, $X_{t+1} = f(X_t)$.[18]

2.8.1 Balanced Growth State

This sequence of the vector of state variables eventually converges to a quasi-steady-growth state characterized by strictly positive constants: $e_{k,t} = e_k$, $k = m, w$, $o_t = o$, and $g_t = g$, while y_t grows at a stationary rate, g_y and the population of families, L_t, grows at a rate $(0.5o - 1)$. Consequently, at this state we face an extreme outcome depending on the value of o.

Moreover, by (10) and (11), it follows that human capital $h_{k,t+1}$ of men ($k = m$) and women ($k = n$), and gender earning inequality, $I_{y,t}$, converge to $h_k > 0$, $k = m, w$, and $I_y > 0$, respectively. Consequently, it follows from (6) and (12) that the growth rate of the average family income converges to $g_y = (1 - \alpha)(1 + g - 0.5o)$.

[18]Note the state variables h_t and g_t together help us determine e_t using (11). We need e_t to determine g_{t+1} via () and e_{t+1} via ()-().

2.8.2 Malthusian Trap and Modern Growth State

The condition $g = 0.5o - 1$ coupled with the condition that $e_k = 0$ for both $k = m, w$ yield the well-known *Malthusian Trap* where population growth induces diminishing returns to land and increasing returns to knowledge and TFP proportionately to offset each other so that the ratio of A_t to L_t remains time invariant. Consequently, the per capita income as well as the average family income, y_t, remains stuck in the *Malthusian Trap.* Interestingly, this model can lead to such trap multiple times and even with positive education if education is insufficient to grow human capital faster than its rate of obsolescence due to knowledge growth while the ratio of A_t to L_t remains constant. However, if $g - (0.5o - 1) > 0$, the model exhibits the *Modern Growth* state.

Further, we conclude from (29), that a sufficiently low time-cost, τ, of child-birth or a sufficiently high desire to have children, ρ, such that $\rho > \frac{2\tau}{1-\tau}$ implies $o \geqslant 2$, and rules out the steady state with negative population growth rate.

Moreover, the specific transitional path and the value of the steady states, $g - (0.5o - 1)$, depend on the initial degree of male bias in technology, m_T, and the initial social attitude toward women, measured by the initial institutional rights of women, σ_I, relative to men. A relatively male-biased initial technology, i.e., a higher m_T, by (10) corresponds to a higher degree of gender inequality in earning, $I_{y,t}$ while a lower social valuation of women's welfare, i.e., a lower σ_I, tilts the quantity-quality tradeoff against children's education. Consequently, by (29) and (31), its population growth rate $0.5o_t - 1$ increases.

2.8.3 Gender Inequality in Income, Education and Fertility Dynamics

The model's gender inequality in education, $e_m/e_w - 1$, human capital, $h_m/h_w - 1$,earning, $I_y \equiv y_m/y_w - 1$, and welfare $V_m/V_w - 1$ arise from no intrinsic differences in talents or attitudes, but from multiple environmental factors related to nature, technology, institutions, and politics, all of which except the profile of the political mindset in the local population are endogenous in our model. This inequality evolves in different phases as a part of economic development.

Lemmas 2 and **3** show that in each period t, the gender inequality in earning, $I_{y,t}$, positively affect fertility, and negatively affect education of both sons and daughters. This negative effect of gender inequality on education works through two channels. First, it raises the thresholds, $\widehat{g}_{m,t+1}$ and $\widehat{g}_{w,t+1}$ for the TFP growth rate, g_{t+1}, above which a positive investment in education is optimal for the son and the daughter, respectively. Second, along the transition path for economic development, a higher gender inequality in earning implies a lower parental investment in education for both sons and daughters.

For a low level of L_t, the economy's y_t and $I_{y,t}$ remain constant, $g_{t+1} < \widehat{g}_t$ (defined in **Lemma 3**) and the time series sequences $\{e_{k,t+1}\}_{k=m,w}$ equals zero. However, as **Lemma 3** describes, at a sufficiently high TFP growth rate, g_{t+1}, $e_{k,t+1} > 0$ and $I_{y,t} > 0$. Further, as the sequences $\{e_{k,t+1},\ g_{t+1},\ I_{y,t}\}$ converges to a steady balanced growth state, $\{e_k > 0,\ g_{t+1} > 0,\ I_{y,t} \geqslant 0$. However, the transitional dynamics describe an uneven path which causes the thresholds, $\widehat{g}_{m,t+1}$ and $\widehat{g}_{w,t+1}$ to fluctuate and that implies the possibility of a sudden decrease followed by a sudden increase in the average education level arising from the net impact of income and substitution effect even in this deterministic set up. Further, by (29), these fluctuations transmit corresponding fluctuations in o_t dynamics as well. Consequently, the dynamic sequence of optimal investment in children's education, $e_{k,t+1}$, $k = m, w$, and the optimal number of offspring involve fluctuations. However, once both $e_{m,t+1}$ and $e_{w,t+1}$ grow

steadily and the inequality, $I_{y,t}$, does not rise faster than the growth rate of $e_{k,t+1}$, $k = m, w$, then g_{t+1} increases while $\widehat{g}_{k,t+1}$ decreases. Consequently, we can sustain the positive investment in children's education.

These dynamics of inequality and education make a significant impact on fertility through (29) in a way that supplements the well-known findings of de la Croix and Doepke (2003) for the gender-neutral macroeconomic model. Here we add a gender lens to conclude that a higher gender inequality of earning capability, due to the higher male-biasedness in technology, tilts the quantity-quality tradeoff in favour of more people with less average quality. Interestingly, by (16), this tilt by a higher income inequality could enhance growth if the population level is below its critical threshold, $\widehat{L}$, contrary to what the earlier gender-neutral case studies concluded.

3 Interdependent Evolution of Technology and Women's Rights

In each generation, influential business and social leaders emerge from the elderly population. The business leaders collaborate to share the fixed cost of building a public infrastructure for the most appropriate technology in the form of a nonrival knowledge base that is freely accessible by everyone in the economy. The most appropriate technology for the economy is the one that maximizes the indirect utility, $V_{F,t}(m_T, \sigma_I, p; X_t)$, of the representative family in state X_t to maximize its social acceptance at date t, given the existing institution for women's rights, σ_I, and the missing working women index, p. The social leaders motivate changes in the institutions for women's rights, which triggers changes in social norms.

3.1 Technology adoption

Following Chari and Hopenhayn (1991), we assume business leaders choose from a menu of technology that includes a variety of vintages and those which exist only in blueprint. In each period t, given the state variable vector, X_t, the environmental indicators for women, σ_I and p, and a set, M_t, of technology indicator b that implies its intrinsic male bias, m_T, described by *Lemma 1*, the business leaders collectively choose the optimal technology, $m^{opt}_{T,t}(\sigma_I, p; X_t)$, from the menu of technology available, $M_t \equiv \{m_T : m^{\max}_T, ..., m^{\min}_{T,t} > 0\}$ such that

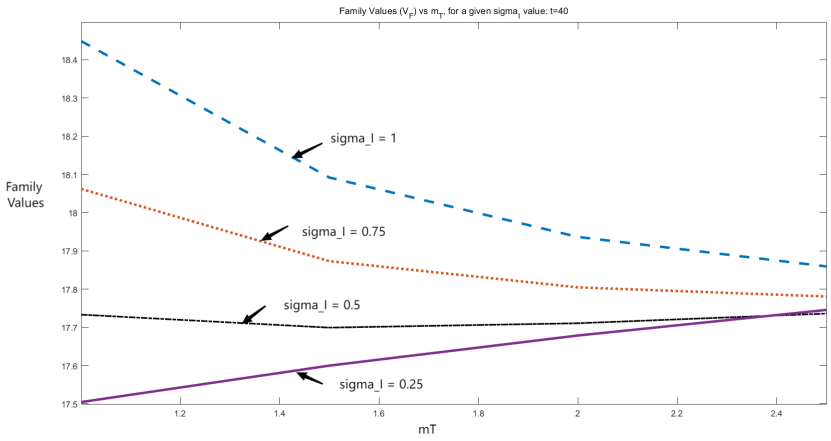
$$m^{opt}_{T,t}(\sigma_I, p; X_t) = \underset{m_T \, \epsilon M_t}{\arg\max} V_{F,t}(m_T; \sigma_I, p, X_t) \tag{38}$$

We assume $m^{\max}_T$ as the initial technology parameter and $m^{\min}_{T,t}$ as a time varying exogenous variable. Further, the value of $\sigma^{\max}_{I,t}$ may reflect the underlying political economy.[19]

In general, the curvature of $V_{F,t}(.; \sigma_I, p, X_t)$ depends on σ_I and p while X_t acts as a shift factor. A high value of σ_I, which indicates strong women's rights institutions, coupled with low crime rate, p, economy implies that technological advancement, by lowering

[19]Chari and Hopenhayn (1991) motivated the rationale for using "the vintage technology" even when more advanced technologies are available, and suppose $m^{\max}_T$ denotes the lower bound for such technology. On the other extreme, at each date t, the most advanced technology, $m^{\min}_{T,t}$, would reflect the condition of the economy at that date. The value of $m^{\min}_T$ is likely to drop as the economy transits from the periods of no education to positive education.

Figure 1a



m_T and, equivalently, increasing its brain-biasedness, b in (2), is optimal, since $V'_{F,t}(m_T; \sigma_{I,high}, p_{low}\cdot, .) < 0$. In contrast, a low value of σ_I and high crime rate, p, economy implies technology regression or a choice of relatively brawn-biased technology with a higher value of m_T, since $V'_{F,t}(m_T; \sigma_{I,low}, p_{high}\cdot, .) > 0$. Consequently, the value of σ_I and p play a critical role in determining $m^{opt}_{T,t}(\sigma_I, p; X_t)$. The following figures illustrate that.

Figure 1a indicates that for low enough σ_I such as $\sigma_I = 0.25$, $V_{F,40}$ increases with m_T. So, the business leaders would not choose to advance technology by lowering m_T. They would do that even if they have knowledge about it because they fear causing social distress and repercussions that would jeopardize their business interest.

Conditions (10) and (28) – (31) imply that higher m_T (regression of technology) increases gender income inequality, $I_{y,t}$, both of which raise fertility but lowers education. By (15), at low level of population, $L < \widehat{L} \equiv \frac{D\Psi^*}{\Psi}$, the level of technology grows with L. Therefore, by (11), human capital declines due to insufficient education to keep up with new knowledge generated through human interactions. However, by (10), the marginal product of a more brawn-intensive technology (higher m_T) would help raise the average family income of a population with low human capital. At the same time, low σ_I complement the impact of higher m_T, by tilting the optimal balance in favor of quantity and against quality through (29).

In other words, the business leader acts as a Ramsey planner here. Moreover, the leader's net indirect-utility benefit from adopting a relatively brawn-intensive (higher m_T) technology is higher with conservative social norms that lower the ratio of σ to ρ, which measures the utility tradeoff between higher women's welfare (consumption) and hidden utility benefit from child labor. Further, a higher m_T increases gender inequality in income, and that, in turn, lowers the opportunity cost of increasing the number of children and child labor with no education. Therefore, brawn-intensive technology (higher m_T) is optimal for a society with conservative social norms due to weaker institutions for women's rights (lower σ_I). Similar arguments help establish the opposite scenario where a progressive society with stronger institutions for women's rights prefers a relatively brain-intensive technology.

3.2 Evolution of Women's Rights

The social leaders take the existing technology as given and determine the best institutions for women's rights and thus influence the social norm index, σ, that influences how families influence women's welfare in (20). In real worlds, these decision makers are typically Ramsey planners, such as, religious leaders or government regulators of a religious society build appropriate institutions to implement the optimal women's rights, $\sigma_{I,t}^{opt}$, that maximizes the welfare, $V_{F,t}(m_T, \sigma_I, p; X_t)$ of the average family, given m_T, p; X_t, to ensure social acceptance. Suppose a menu of social institutions, $S_t \equiv \{\sigma_I : \sigma_{I,t}^{\min} < \sigma_I \leqslant \sigma_{I,t}^{\max}\}$ available from history.[20] The date t social leaders cooperatively choose their optimal institutions for women's rights, $\sigma_{I,t}^{opt}(m_T, p, X_t)$, considering social acceptance, given m_T, p; and X_t, such that

$$\sigma_{I,t}^{opt}(m_T, p, X_t) = \arg\max_{\sigma_I \epsilon S_t} V_{F,t}(\sigma_I;\ m_T, p, X_t) \tag{39}$$

However, the business and social leaders cannot coordinate because they speak different languages, namely, science and religion. The business leaders take the institutions governing women's rights, σ_I as given while choosing the most appropriate technology, m_T, for the economy that would be socially acceptable. The social leaders take the technology, m_T, as given and choose the most appropriate social institutions for women's rights that fits the underlying technological environment. The equilibrium occurs when both choices are mutually consistent. We explore the outcome of one such aggregate consistency condition. We define the aggregate consistency condition for this non-coordinated outcome in a way that resembles Nash Equilibrium as follows:

Given the period t state variable vector, X_t, and the family value, $V_{F,t}(m_T, \sigma_I)$, which is the indirect utility, defined by (37), a pair $(m_{T,t}^*, \sigma_{I,t}^*)$ is an equilibrium pair if and only if the following two fixed point conditions hold:

$$m_{T,t}^{opt}(\sigma_{I,t}^{opt}(m_{T,t}^*)) = m_{T,t}^*, \tag{40}$$

and

$$\sigma_{I,t}^{opt}(m_{T,t}^{opt}(\sigma_{I,t}^*)) = \sigma_{I,t}^*, \tag{41}$$

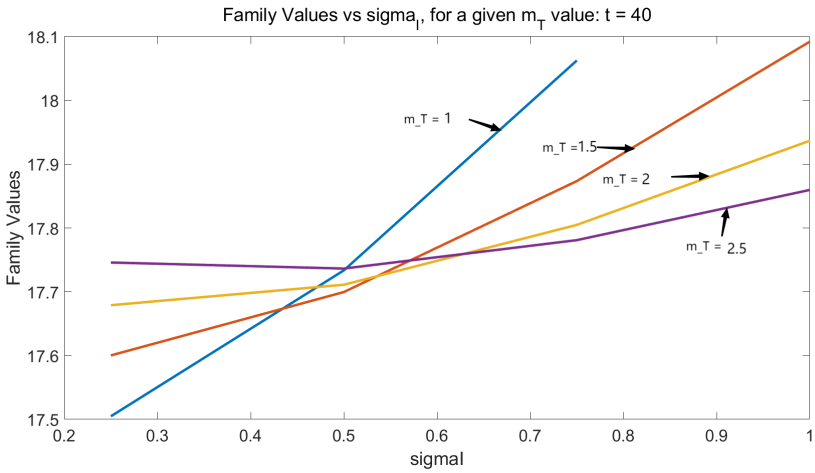
where, for any given period t, the optimal rules $\sigma_{I,t}^{opt}(m_T)$ and $m_{T,t}^{opt}(\sigma_I)$ satisfy (38).

In general, there are multiple equilibria. Consequently, economic history, which includes the period t vector of state variables, X_t, which, in turn, depends on values of the pair $(m_{T,t-1}, \sigma_{I,t-1})$. Also, given the equilibrium pair (m_T^*, σ_I^*), the vector of state variables, X_t, and the family decision rules $\{(c_{k,t}(m_{T,t}^*, \sigma_{I,t}^*),\ e_{k,t+1}(m_{T,t}^*, \sigma_{I,t}^*))_{k=m,w},\ o_t(m_{T,t}^*, \sigma_{I,t}^*)\}$, which satisfy (27) - (35), determine the next period's state variable vector X_{t+1}, which determine the equilibrium vector of technology and institutions $(m_{T,t+1}^*,\ \sigma_{I,t+1}^*)$ for period $t+1$.

Lemma 4: There exist four reals, $\sigma_{High}^* > \sigma_{Low}^* > 0$, and $m_{High}^* > m_{Low}^* > 0$ such that (i) if $\sigma_I < \sigma_{Low}^*$, and $m_T > m_{High}^*$ then then $\frac{\partial V_F}{\partial m_T} > 0$; (ii) if $\sigma_I > \sigma_{High}^*$, and $m_T < m_{Low}^*$, then

[20] One would reasonably expect via the intergenerational altruism channel that the value of $\sigma_{I,t}^{\max}$ to increase as the economy transits from a period of no educated women to one when all women have some education.

Figure 1b



$\frac{\partial V_F}{\partial m_T} < 0$. Further, (i) if $m_T < m^*_{Low}$, and $\sigma_I > \sigma^*_{High}$, then $\frac{\partial V_F}{\partial \sigma_I} > 0$; (ii) if $m_T > m^*_{High}$, and $\sigma_I < \sigma^*_{Low}$, then $\frac{\partial V_F}{\partial \sigma_I} > 0$.

Proof. Appendix

Using the baseline parameter values presented in **Table 1** later in the Numerical Section, we illustrate the above lemma with numerical illustrations through Figures 1a,b. **Figure 1a** describes, for $t = 40$, how $V_{F,t}(m_T; \sigma_{I,t})$ changes as m_T changes for a given σ_I which varies as the shift parameter. **Figure 1b** describes how the same $V_{F,40}$ varies as a function of σ_I while m_T varies as the shift parameter.

Figure 1b indicates that for high enough m_T such as $m_T = 0.25$, for all $\sigma_I < 0.5$, the family value $V_{F,40}$ decreases as σ_I increases. So, the religious leaders would not choose to reform institutions for women's rights to raise σ_I. They would do that even if they have knowledge about it because they fear causing social distress and male backlash that would jeopardize the underlying religious harmony that uphold the fabric of family decisions.

If the technology is sufficiently brawn intensive (m_T is high), then gender income inequality, I_y, would be high and demand for education would be low. However, the optimal number of children would be high. Under this objective condition for a successful business operation, a push for improving institution for women's rights (higher σ_I) would be counter-productive because, by (29), a higher σ_I would lower optimal fertility, provided $y_{p,t} > \widetilde{y}$.

On the other hand, when the population size exceeds its critical threshold described in (15), $L < \widehat{L} \equiv \frac{D\Psi^*}{\Psi}$, technology advancement (lower m_T) increases TFP growth rate and demand for education. Improving institution for women's rights (higher σ_I) would be complementary to that process for raising the welfare of the average household, V_F, in the economy. Consequently, the social leaders choose to raise σ_I when m_T falls below a critical threshold.

In period $t = 40$, **Figure 2a** describes the social choice of women's rights institution, $\sigma_I^{opt}(m_T)$, conditional on the technology index, m_T, or, the social leaders' *best response* to the business leaders' choice of technology, while **Figure 2b** describes the business leaders' optimal choice of technology, $m_T^{opt}(\sigma_I)$, conditional on the institution of women's rights, σ_I, or the business leaders' *best response* to the social leaders' choice of institutions for women's rights.

Figure 2a

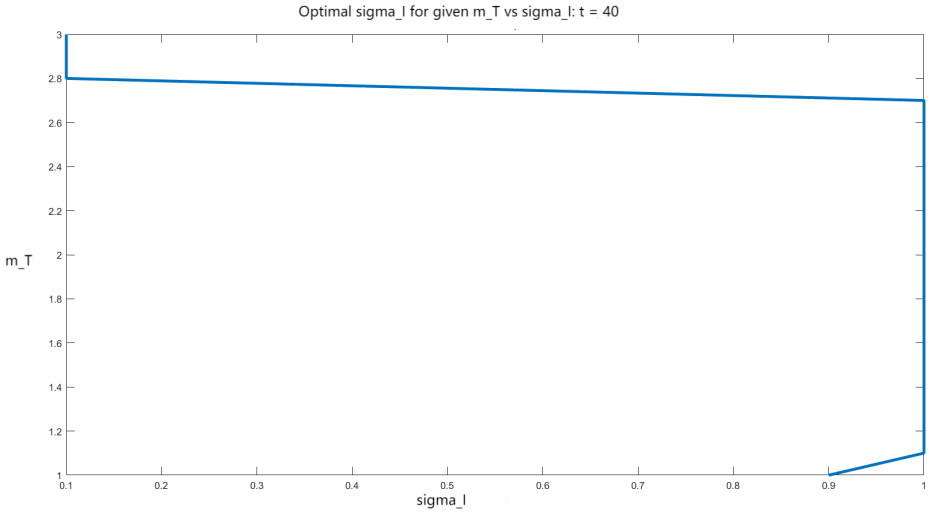


Figure 2b

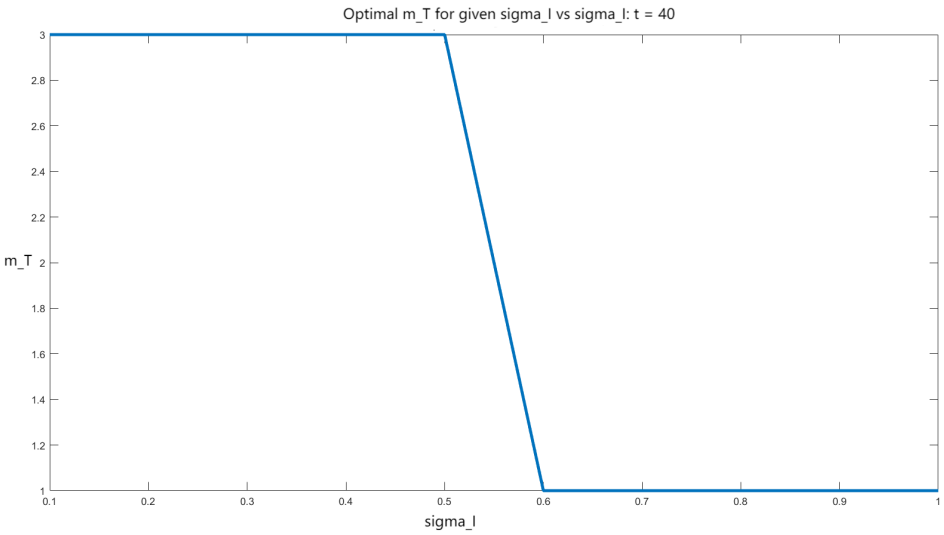


Figure 3

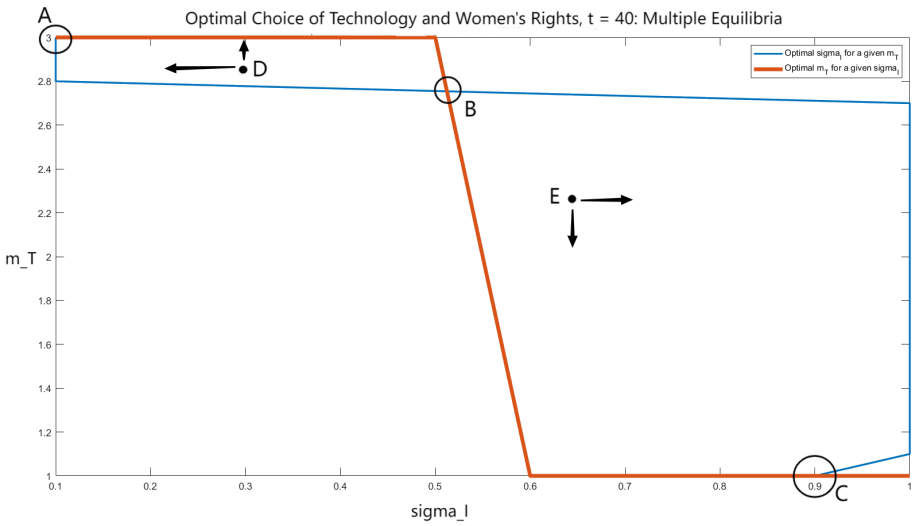


Figure 3 describes the dynamics of technology and institutional choices. There are 3 equilibria in this case indicated by points **A**, **B** and **C. A** and **C** are stable equilibria while **B** is unstable. However, as the vector of state variables, X_t, changes the *best response* profiles change and that alters potential numbers of equilibria. Typically, during the Malthusian era, characterized by sufficiently low values of the state variables, L_t, A_t, g_t, only **A** satisfies the two equilibrium conditions (40) - (41). Eventually if the if the economy has a successful demographic transition, only **C** satisfies the equilibrium conditions. Moreover, the initial conditions matter. If the economy is at **D** it will move to **A** next period while if it is at **E**, it will move to **C** in the next period.

Lemma 5: *In general, there are multiple pairs of* (m_T, σ_I) *that satisfy the above equilibrium condition with at least one and two or more locally stable equilibria in the early stages od development. The initial condition matters for determining the long-run evolutionary dynamics of technology and women's rights.*

Proof. Appendix.

Proposition 1. *Early stages of economic development exhibit multiple outcomes of technology and women's rights such that the degree of male bias of technology,* m_T*, and the index for women's institutional rights relative to men,* σ_I*, are negatively related.*

Proof. Appendix.

Figures 1-3 illustrates **Lemmas 4** and **5** and **Proposition 1** follows from them and **Figure 4** illustrates that.

The possibility of multiple equilibria implies that an economy may accommodate multiple cultural groups using multiple technology types. Without a loss of generality, we focus on an economy with two cultures: (1) conservative using a rural (brawn-intensive) technology and (2) progressive using an urban (brain-intensive) technology. In the next section we examine the population dynamics of this two culture economy when we allow inter-group interractions to

model rural-urban or international migration. Here an economy may refer to a country divided into rural-urban sectors or the world economy divided into developed and developing countries.

4 An Economy of Two Cultures

Suppose that the economy has two distinct groups (e.g., rural and urban) which operates different technologies with significantly different male-biasedness, (and hence different brain-biasedness, by *Lemma 1*), for geographical or historical reasons. Further, assume that the institutions for women's rights, σ_I, and social norms, σ, differ because of technological differences in a way that satisfies (39) and (18). Consequently, the economy consists of two types of families: conservatives (C) and progressives (P), distinguished by their respective social norms, σ_j, $j = C$ and P such that $\sigma_C << \sigma_P$.

4.1 Population Dynamics

Without migration across groups, the population share of the conservatives, $n_{C,t}$, changes over time as follows:

$$n_{C,t+1} = \frac{n_{C,t} o_t^C(m_{TC},\ \sigma_{IC})}{n_{C,t} o_t^C(m_{TC},\ \sigma_{IC}) + (1 - n_{C,t}) o_t^P(m_{TC},\ \sigma_{IP})}, \tag{42}$$

where $o_t^j(m_{Tj},\ \sigma_{Ij})$, $j = C, P$ satisfies (29) and (31).

Beyond subsistence, by operating under a combination of weaker institutions for women's rights (lower σ_I) and a more male-biased technology, by (29), conservatives opt for a higher fertility rate and lower education levels, which incentivizes the conservative business leaders to choose relatively brawn (physical labor) intensive technology, which further increases gender inequality and the relative size of the unskilled laborforce. Consequently, the population dynamics described in (42) imply that the population share of the conservatives increases over time and significant differences of per capita income and standard of living emerges in this economy with dual outcome. There are four possible ways a stable distribution of cultural types distinguished by social norms can emerge.

First, suppose that at each date t, an x_t fraction of the conservative population, $x_t n_{C,t} L_t$, leave their impoverished economy to join the relatively affluent economy but with progressive culture in search of better quality of life. However, that leads to cultural change in a way that resembles the cultural dynamics discussed in Bisin and Werdier (2001). Consequently, without any loss of generality we assume that the fertility rate of the immigrant coincides with that of the average fertility of the progressive group, $o_{P,t}$, the transitional dynamics (42) after accommodating this migration would imply a stable distribution of two groups if and only if x_t satisfies

$$x_t = n_{C,t}(1 - n_{C,t})(o_{C,t} - o_{P,t}). \tag{43}$$

Second, suppose that to prevent such migration as a group survival response, the conservatives value daughter's education more than before so that γ^w improves. Consequently, through

the quantity - quality tradeoff, described in (29), the conservative culture encourages fewer children, $o_{C,t}$, and higher education for their daughters, and x_t decreases.

Third, suppose that the surviving progressives are sufficiently richer than the conservatives such that $y_{P,t} >> y_{C,t}$, and the cost of child's consumption including health, a', is higher in a richer country. By (29), it implies a smaller gap in the fertility rates of the two groups, $(o_{C,t} - o_{P,t})$, which implies, by (43), a lower migration rate of x_t.

Fourth, suppose that the survival instinct among the progressives kick in a backlash effect against women's rights and their valuation of women, σ_I^P, decreases through institutional changes such as making abortion illegal. It also implies a boost in fertility, $o_{P,t}$, and lower need for migration from the conservative population for survival. Further, to prevent infiltration of culture that undermines institutions for ensuring equal rights of men and women they discourage intergroup marriages to lower x_t directly by building "walls". If the fall in migration, x_t, equals the rise in the value of $n_{C,t}(1-n_{C,t})o_{P,t}$ due to a larger number of offsprings, $o_{P,t}$, growing up in the progressive culture, then also we would observe a stable distribution of culture. We may identify these types of survival response as a progressive men's backlash against women's rights.

In reality, all four survival modes exist, and the data reflects what the Nature selects. Moreover, we can calibrate x_t by matching the steady state fertility differences between the two groups, given a stable cultural distribution, indexed by the share, n_c, of conservative culture in the world population.

With open border policy ensuring free mobility across lands, by (12), (17), (6) and (16) a higher population density and a lower average education in the globalized macroeconomy due to lower family evaluation of women in the conservative families, $\sigma_{C,t}$, negatively affect the welfare of the progressive families through the knowledge diffusion channel, especially in the later stages of economic development. Consequently, as a part of a nation-building exercise, the progressive group has the incentive to politicize women's rights to improve institutions that implement these rights universally to mitigate this negative impact. We address that politics of women's rights next.

4.2 Politics of Women's Rights

The discussion on the population dynamics motivates a political extension of this otherwise neoclassical model. We assume that as a part of the nation building exercise, the two cultural groups form two political parties engage in a contest for controlling the administrative bodies of institutions that govern women's rights. The mechanism involves a political contest between two political actors (leaders), with two conflicting preference orderings over women's rights institutions, σ_I.

Better institutions for women's rights, σ_I, by (18) and (20) change the social norms and, hence, the family evaluation of women's welfare, respectively, to influence the family decision rules. By (27), that lowers the consumption-share of the working male member of the family. Such loss of gender-rents could arguably trigger backlash among some men against women's empowerment to form a conservative group and invests in resources to resist such change. Some women may also join them under the influence of religions and other sociological factors. In response, a political group primarily led by women attracts investments from like-minded people which may also include men to fight a political contest for acquiring administrative power to change institutions for improving women's rights.

The cultural distribution of population plays a critical role in determining the outcome of the contest to control the institutions of women's rights. By (43), the migrants from economies with low women's rights to affluent economies, sustain a stable population share there. However, it also changes the politics of women's rights by altering the period t distribution of cultural types, $n_{C,t}$ and $n_{P,t}$, and political preferences in both the indigent and affluent economies.

At each period t, the Conservative (C) leader's most preferred outcome, $\sigma_{IC,t}$ and the Progressive leader's most preferred outcome, $\sigma_{IP,t}$ satisfy (39). The outcome of the political contest in period t for governing the next period's minimal women's rights institutions in which the party i wins, $\sigma_{I,t+1}$, is not deterministic but subject to stochastic noise in the political system. However, it differs from the most preferred outcome, $\sigma_{Ii,t}$, of the winning party $i = C$ or P.[21] We assume that the winner of the administrative power over institutions for women's rights can move the status quo toward their ideal. However, administrative and legal frictions in changing social institutions cause a temporary difference between the winning party i's most preferred option, $\sigma_{Ii,t}$, and the actual outcome, $\sigma_{I,t+1}$ such that, subject to the individual rationality constraint that $\sigma_{IC,t} \leqq \sigma_{I,t+1} \leqq \sigma_{IP,t}$, $i = C$, P, it satisfies

$$\sigma_{I,t+1} = \sigma_{I,t} + \eta(\sigma_{Ii,t} - \sigma_{I,t}), \text{ if } i = C, P \text{ wins.} \tag{44}$$

where $1 > \eta > 0$, denote the parameter for administrative frictions to changes to women's rights.

If for some period t, $\sigma_{IC,t} > \sigma_{I,t}$, via natural evolution over economic development through the intergenerational altruism and income channels mentioned in Tertilt et al (2022), by (44), then women's rights improve ($\sigma_{I,t} < \sigma_{I,t+1}$). However, if $\sigma_{IC,t} < \sigma_{I,t}$, then the political channel through which the Progressive party seizes the control over administering changes in the institutions would be necessary for improving women's rights. We treat women's rights institutions, σ_I, as a public good.

4.2.1 Political Power

The relative measure of political support changes over time though population dynamics, (42), and migration, (43), due to changes in the relative cultural influence in a similar spirit as in Fernández (2013). In particular, if there is a skill-biased technological change that increases the productivity share of mental labor (lower m_T) in which women enjoy a comparative advantage, women's relative productivity increases, which increases the potential benefits for everyone in a regime with greater women's rights. The popularity of the Progressive party increases through migration from the conservative group as n_C declines and n_P increases.

4.2.2 Alienation

A social change creates conditions whereby one group finds itself alienated by the outcome that prevails in society relative to its preferred outcome. In the spirit of Esteban and Ray (2008), for

[21] We determine the probabilistic outcome of that political contest based on a pure strategy Nash equilibrium of contest success strategy, by using a Dixit (1987) type contest success probability, which is only partially manipulable due to the inherently noisy mechanism, following the original idea of Tullock (1980).

each group $i = C, P$, we measure the "alienating distance," δ_i, by the welfare loss that group i suffers when the political process implements its opponent's preferred outcome such that

$$\delta_i = V_i(\sigma_{Ii},\ X) - V_i(\sigma_{Ij\neq i},\ X), \tag{45}$$

where $X = (L,\ A,\ g;\ m_T)$ denotes the state variables characterizing the macroeconomy.

4.2.3 Political Contribution

The leaders of each political party i collect $r_{i,\ i\in\{C,\ P\}}$ units of rent as subscription from each couple. The maximum amount, $r_{\max}$, a leader can collect from each member is limited by what the member can afford from their limited family-allocation of lifetime consumption.

By (19), the family allocates the lifetime consumption equally between the working age and the retired life, and that the elderly couples finance any political contribution from their predetermined consumption allocation. So, the maximum contribution a retired elderly couple can make equals half of their average lifetime consumption determined in the previous period.[22] Therefore, it follows from (27) that in each period t, each party leader i faces a constraint on their rents as follows:

$$r_{i,\max}(t) = \frac{0.5(1+\sigma_{Ii,\ t-1})y^i_{t-1}}{1+\sigma_{Ii,\ t-1}+\rho} = r(\sigma_{Ii,\ t-1},\ y^i_{t-1}),\ i = C, P. \tag{46}$$

The leaders also care about the indirect utility cost each member's subscription from forgone consumption. However, in each period t, they impute the political cost of each member's subscription, $r_{i,t}$, according to their respective party i's preferred value function $V_i(r_{i,\max}(t) - r_{i,t})$, predetermined under the period $t-1$ status quo women's rights $\sigma_{I,\ t-1}$, $i = C, P$. Therefore, the political cost $C_i(.)$ of member subscription of $r_{i,t}$ that the leader i considers satisfies

$$C_i(r_{i,t}) = V_i(r_{i,\max}(t),\ X_t) - V_i(r_{i,\max}(t) - r_{i,t},\ X_t). \tag{47}$$

4.2.4 Hostility Surrounding Women's Rights

In each period, t, each group leader of the ith party first collects a subscription or rent $r_{i,t,\ i\in\{C,\ P\}}$ from each of the party's n_i members and invests the total collection, $n_i r_{i,t}$, to influence the media with hostile messages against other group. We assume, following the idea explored in Dixit (1987), that a party's probability of winning the contest for changing the institutions for women's rights increases with the group's share $\lambda_{i,t}$ of total expenditure on hostility, H_t, toward the other groups in the economy, where

$$\lambda_{i,t} = \frac{n_i r_{i,t}}{H_t},\ \text{where, } H_t = \sum_{i=C,\ P} n_i r_{i,t}. \tag{48}$$

[22] It's straightforward to derive $r_{\max} = 0.5(c_m + c_w)$ from the family optimization exercise (25) subject to (19): $\ln c_k = \ln c_{1,k}, + \ln c_{2,k}$, 1 = young, and 2 = old, for both $k = m, w$.

However, following the idea of Tulloock (1980), we also note that human history always brings a stochastic factor from the underlying political system that is independent of a party's share of political contribution. Consequently, the party leader's subjective probability of success does not depend on that white noise but coincides with the group's share $\lambda_{i,t}$, $i = C,\ P$ of total political expenditure in the economy.

4.2.5 The Party Leader i's Objective Function and the Optimization Exercise:

The outcome $\sigma_{I,\ t+1,\ i}$, given by (44), if the party i wins remains apriori random to the contestants with the winning probability, $\lambda_{i,t}$, given by (48). Consequently, in each the period t, given the macroeconomic fundamental state variables, X_t, the party leader chooses the optimal subscription rate or rent, $r_{i,t}$, for each member to maximize the expected profit, $E\Pi_{i,t}$, which satisfies

$$\begin{aligned} E\Pi_{i,t} &= \lambda_{i,t}(V_i(\sigma_{I,\ t+1,\ i},\ X_t) - V_i(\sigma_{I,t},\ X_{\sigma_{I,t}})) + (1-\lambda_{i,t})(V_i(\sigma_{I,\ t+1,\ j},\ X_t) \\ &\quad -V_i(\sigma_{I,t},\ X_{\sigma_{I,t}})) - C_i(r_{i,t}) \end{aligned} \tag{49}$$

By (44), (45) and (47), it simplifies to

$$E\Pi_{i,t} = \lambda_{i,t}\eta\delta_{i,t} + V_i(\sigma_{I,\ t+1,\ j},\ X_t) - (V_i(r(\sigma_{Ii,\ t-1},\ y^i_{t-1})) - V_i(r(\sigma_{Ii,\ t-1},\ y^i_{t-1}) - r_{i,t}),\ i = C,\ P. \tag{50}$$

In each period t, the leader of party i chooses the optimal subscription, $r_{i,t}$, for each member, $i = C,\ P$, so as to maximize the expected profit $E\Pi_{i,t}$, given by (50), subject to (45) and (47).

Next, by plugging each group i's optimal σ_i that satisfies (39) into (37), and the Envelope theorem, we determine the marginal cost of contribution, $\frac{\partial V_i(r(\sigma_{I,\ t-1},\ y_{t-1})-r_{i,t})}{\partial r_{i,t}}$.

The group i's optimal contribution r_i chosen by the leader of the party $i = C,\ P$, satisfies the following First Order Conditions of profit maximization[23]:

$$\frac{\partial E\Pi_{i,t}}{\partial r_{i,t}} = \lambda_{i,t}\frac{\partial\widetilde{\delta}_{i,t}}{\partial r_{i,t}} + (1-\lambda_{i,t})\frac{n_i\widetilde{\delta}_{i,t}}{H_t} + \frac{\partial V_i(r(\sigma_{I,\ t-1},\ y_{t-1}) - r_{i,t})}{\partial r_{i,t}} = 0, \tag{51}$$

where $\widetilde{\delta}_{i,t} = \eta\delta_{i,t}$, (44) and (45) describe η and $\delta_{i,t}$, respectively, with $X = X_t$.

$$\frac{\partial V_F(\sigma_i)}{\partial r_{i,t}} = \left(\frac{\partial V_i}{\partial(r(\sigma_{I,\ t-1},\ y_{t-1}) - r_{i,t}))}\right)\left(\frac{\partial(r(\sigma_{I,\ t-1},\ y_{t-1}) - r_{i,t})}{\partial r_{i,t}}\right) = \frac{-1}{r(\sigma_{I,\ t-1},\ y_{t-1}) - r_{i,t}} \tag{52}$$

$$\frac{\partial E\Pi_{i,t}}{\partial r_{i,t}} = (1-\lambda_{i,t})\frac{n_i\widetilde{\delta}_{i,t}}{H_t} - \frac{1}{r(\sigma_{I,\ t-1},\ y_{t-1}) - r_{i,t}} = 0,\ i = P, C. \tag{53}$$

[23]

$$\frac{\partial\lambda_i}{\partial r_i} = \frac{\partial}{\partial r_i}\left[\frac{n_i r_i}{H}\right],\ \frac{Hn_i - n_i r_i\left[\frac{\partial H}{\partial r_i}\right]}{H^2} = \frac{n_i(1-\lambda_i)}{H}$$

Lemma 6: In each period t, for any arbitrarily given $0 < n_C < 1$ and $n_P = 1 - n_C$, there exist two reals, $0 < r_{P,t}^{\max} < \infty$ and $0 < r_{C,t}^{\max} < \infty$, such that (i) iff $r_{P,t} \leqslant r_{P,t}^{\max}$, $\frac{\partial E\Pi_{C,t}}{\partial r_{C,t}}|_{r_{C,t}=0} \geqslant 0$, (ii) iff $r_{C,t} \leqslant r_{C,t}^{\max}$, $\frac{\partial \Pi_{P,t}}{\partial r_{P,t}}|_{r_{P,t}=0} \geqslant 0$, and there exists a locally stable and unique solution to (51) such that $r_{i,t} \geqslant 0$, $i = C, P$.

Proof. See Appendix.

Therefore, it follows from (37) - (53) that the Nash equilibrium of the optimal strategy vector $(r_{C,t}, r_{P,t})$ and the party i's likelihood of success, $\lambda_{i,t}$, in period t, satisfies the following function:

$$\lambda_{i,t} = \Lambda_i(X_t;\ \sigma_{I,\min,t-1},\ \sigma_{IC},\ n_C), \tag{54}$$

where the critical cultural and social parameters σ_{IC}, σ_{IP}, n_C, describing the most preferred measure of women's rights institutions, σ_I, for the conservative (C), and progressive (P) party, and the political power, measured by the population share of the membership for the conservative party, respectively.

Further, we conclude from (37) - (54) that the optimal rent, $r_{i,t}^*$, that the party leader $i = C, P$ extracts from each member satisfies:

$$r_{i,t}^* = r(X_t;\ \sigma_{I,\min,t-1},\ \sigma_{IC}, n_C) \tag{55}$$

4.2.6 Male Backlash and Barriers to Women's Participation

In the spirit of Esteban and Ray's (2008) modelling of conflicts and violence, we determine the equilibrium index of hostility, H^*, for and against improving women's rights institutions, σ_I as the same as the weighted sum of the optimal subscriptions, $r_{i,t}^*$, for political expenditure related to misogyny:

$$H_t^* = \sum_{i=C,P} n_{i,t} r_{i,t}^*. \tag{56}$$

We assume that these political conflicts and related propaganda for and against improved rights for women fuels misogyny that raises hostility against working women in the macroeconomy. Further, we assume that a fraction p of the female population disengages from production because of safety concern due to misogynistic attacks.[24]

[24]The increase in hostility against women in Iran and Afghanistan is an example of how the political conflicts surrounding women's rights raise safety concerns for women in public. The current abortion controversy in the US could also provide another example of increased hostility against women as a negative externality of a political fight for power between the conservative and progressive parties.

From a panel data analysis of women's getting sick from sexual violence based on newly available data from the National Institutes of Health publication by Borumandnia et al. (2020), presented in Table 2 in Appendix B indicate that GDP per capita and some measures of women's rights are lower, while the other indicators raise misogyny-related crimes. We interpret them as a combination of deterrence and backlash effects. We assume that the hostility index proxies this backlash effect because it increases with the resources conservatives spend and then spend more when the progressives spend more. With that assumption, guided by the regression results, we conclude that p increases with the backlash effect, proxied by the hostility index, H, and decreases with the per capita income, y, which proxies for law and order and women's rights institutions, σ_I, which act as the deterrent against male backlash such that:

$$p_{t+1} = p(y_t, H_t^*, \sigma_{I,t+1}, n_{C,t}) = \max\{0, \frac{H_t^*}{y_t + H_t^*} - d\sigma_{I,t+1}\},\ d > 0. \tag{57}$$

By (6), (44), and (54) - (57), it follows:

$$p_{t+1} = P(X_t;\ \sigma_{I,t-1},\ \sigma_{IC},\ n_C) \tag{58}$$

The variable p_t indicate the crime rate due to male-backlash against women's empowerment and, by assumptions, measures also the fraction of female population it deters from engaging with the production technology.

4.2.7 The Outcome of the Political Contest

If the political actors have too little understanding of the mechanism of the political change, the outcome of the political contest would depend more on the noise from the stochastic factors or historical accidents beyond the scope of this model. However, following Tullock's (1980) idea, we suggest that if the noise is negligible, and arbitrarily small, then the winning chance for the party with higher expenditure share, $\lambda_{i,t}$, would approach certainty, notwithstanding the belief of both parties that success is a random outcome. The actual outcome remains stochastic reflecting the historical noise about the underlying political mechanism. Moreover, we assume that the decision rules are holds ex ante and there are no learnings ex post.

4.3 Evolutionary Transitional Dynamics

Given the initial period, $t = 0$, productivity of women, z_w, the initial level of population, L_0 and the initial human capital stock of the working men and women, h_{k0}^j, $k = m, w$, for each group $j = C, P$, the initial TFP, A_0, and its growth rate, g_1, in each period, $t = 0$, 1, 2, ..., the representative family j's decision rules (27) - (35) determine for $k = m, w$ consumption, $c_{k,t}^j$, the number, o_t^j, and education, $e_{k,t+1}^j$, of their children by solving the optimization problem (25) as functions of the social norm for the family's evaluation, σ_t, of women's welfare as per the rule given by (18). Given those decision rules, each group j chooses the optimal vector $\varkappa_t^j$ of technology and institutions for women's rights, $m_{T,t}^j$, and $\sigma_{I,t}^j$, respectively, to satisfy (38) – (41) under Scenario 1 or (38) and (44) under Scenario 2. The date t political process, when operative (Scenario 2), determines the minimum value of women's rights for the next period, $\sigma_{I,t+1}^{\min}$, for the whole economy and the resulting crime rate, p_{t+1} due to male backlash.

We characterize the macroeconomy in each period t state with two state vectors: $X_t \equiv (A_t,$ $L_t,\, g_t, n_{c,t}, p_t, \sigma_{I,\min,t})$ and $h_t \equiv (h^j_{m,t}, h^j_{w,t})$, $j = C,\, P$ and summarize the evolutionary dynamics of technology and culture, $\varkappa^j_t \equiv (m^j_{T,t},\, \sigma^j_{I,t})$, $j = C, P$, as follows:

$$\varkappa^j_{t+1} = \phi^j(\varkappa^j_t;\ X_t,\ h_t),\ j = C, P, \tag{59}$$

where the vector $(\varkappa^j_t)_{j=C,P} \equiv \varkappa_t$ satisfies (38), and the period t knowledge spillover index, $m_{T,t}$, affecting the TFP growth rate in (16) evolves as follows:

$$m_{T,t} = n_{c,t} m^C_{T,t} + (1 - n_{c,t}) m^j_{T,t}. \tag{60}$$

We can now summarize the complete dynamical system in terms of the vector of state variables: $(X_t, n_{c,t}, p_t, \sigma_{I,t})$ and $E_t \equiv (e^j_{m,t}, e^j_{w,t})_{j=C,P}$, for which (12), (17), (**??**), (6), (10), (16), (37), (27) - (35), and (37) - (48) provide the parametric specifications, beginning with the TFP level, A_t:

$$A_{t+1} = [1 + g(e_t,\, L_t,\ m_{T,t},\ p_t)]A_t = A(X_t),$$

where (60) describes $m_{T,t}$ and (14) describes e_t. The TFP growth rate, g_{t+1} is given by

$$g_{t+1} = g(e_t, L_t, m_{T,t}\ p_t) = g(X_t),$$

male (m) and female (w) education $(e_{k,t+1})_{k=m,w}$, and the population level, L_t

$$e^j_{k,t+1} = \phi_j(e^j_{m,t},\ e^j_{w,t};\ \varkappa^j_{t-1},\ X_t),\ j = C, P.$$

and

$$L_{t+1} = \phi_L(X_t, E_t; \varkappa_t)L_t = L(X_t).$$

By (44), (54) and the crime rate due to male backlash, (57), it follows:

$$\sigma_{I,\min,t+1} = S(X_t)$$

and

$$p_{t+1} = P(X_t).$$

However, only through simulations we can explore how the endogenous evolution of technology and culture alters the macroeconomic outcomes.

Numerical simulations help us uncover how the endogenous evolution of technology and culture alters the macroeconomic outcomes.

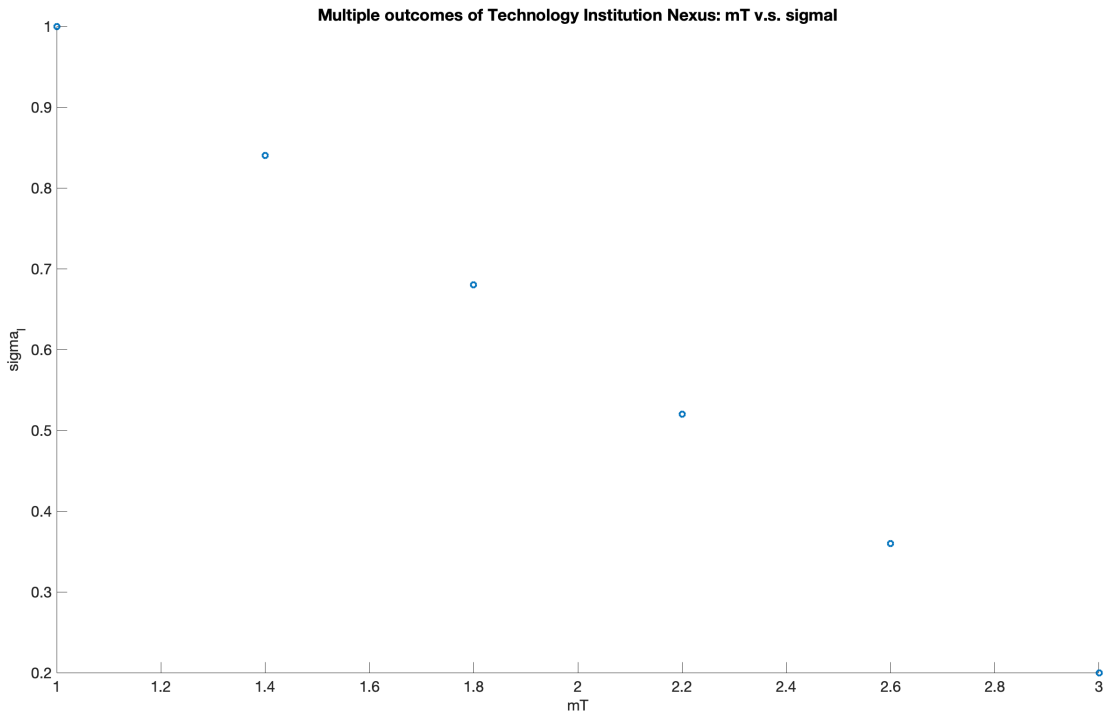
5 Numerical Simulations

We describe the numerical values of the parameter in the baseline case below in Table 1. We follow Lagerlöf's (2006) strategies in generating the baseline economy other than finding values for gender specific variables to match data on gender inequality in earning and education. The parameter τ marks a noteworthy departure. It denotes the fraction of lifetime income which the mother (as opposed to parents) sacrifices for each child. In other words, the childbirth does not cost the father any income loss. Further, there is a separate food consumption or fixed survival cost, a', per child which comes out of the family budget.

Table 1

Parameters	**Interpretation**	**Value**
α	Labor share	0.6
τ	Fixed time cost for motherhood	0.2
a'	Fixed food cost for children	0.0001
θ	Educational part of τ	0.879
Ψ^*	Scale effect parameter above threshold population	9.17
ψ	Scale effect parameter below threshold population	1
ρ	Weight on fertility in family utility	0.552
γ_m	Weight on son's human capital in family utility	0.85
γ_w	Weight on daughter's human capital in family utility	0.705
$\widetilde{c}$	Subsistence consumption	2
p	fraction of women absent from the laborforce	0
q	religious barrier to girl's education	0
$z_{w,0}$	Initial productivity of women	1
B	Efficiency of the education technology	1
Endogenous Variables	**Interpretation**	**Value**
e^*	Education, modern growth	0.075
g^*	Technology (TFP, z) growth, modern growth	2.3
o^*	Fertility, modern growth	2
$\widehat{L}$	Threshold population	1.35
$I_y = \left(\frac{y_{m,t}}{y_{w,t}} - 1\right)^*$	Gender inequality in earning (gender earning gap)	0.1
$I_e = \left(\frac{e_{m,t}}{e_{w,t}} - 1\right)^*$	Gender Inequality in education	0.9
Initial Conditions	**Interpretation**	**Value**
o_0	Initial fertility	2
L_0	Initial population	0.0673
z_0	Initial technology	14.77
$h_{m,0}$, $h_{w,0}$	Initial human capital	1, 1
g_0	Initial technology growth	0
y_0	Initial per-family income	17.37
$\sigma_{I,0}$	Initial Institution for women's (relative to men's) rights	0.2
$m_{T,0} \equiv \frac{z_{m,0}}{z_{w,0}}$	Initial male bias in technology	3

Figure 4



5.1 The Simulation Algorithm

Given the period $t = 0, 1, 2...$, state of the macroeconomy, $X_t \equiv \{L_t, A_t, g_t\}$ and the parental education vector, $h_t \equiv \{(h_{k,t})_{k=m,w}\}$, by (5), (6), (10), and (13) – (16), we determine y_t, $I_{y,t}$ and g_{t+1}. Then, by (32) - (35), we determine $(e_{k,t+1})_{k=m,w}$, by (27) - (31), we determine $(c_{k,t})_{k=m,w}$, and o_t, and by (11), $h_{t+1} \equiv \{(h_{k,t+1})_{k=m,w}\}$. Next, by (37) – (38), we determine the vector of technology and women's rights institutions $(m_{T,t}, \sigma_{I,t})$ that satisfy (40) and (41) to determine completely the next period's state vector, X_{t+1} and h_{t+1}.

Figure 4 includes 3-panels which describe together how technology and institutions for women's rights for the baseline economy evolves over time. The first panel displays that without any institutional restrictions to ensure equal rights for women and men, the appropriate technology has high male bias (m_T) and that, in turn, may create a developmental trap due to the absence of a sufficiently strong political movements that improve institutions for women's rights. However, in period $t = 89$, the political momentum of the progressives significantly exceeds the conservatives to tilt the balance favoring institutional changes to improve women's rights (higher σ_I), and the business leaders respond by adopting relatively brain-biased technology (lower m_T) to eliminate the developmental trap.

Figures 5a1 indicates that the GDP per capita (proxied by the average family income) remains stuck in a poverty trap during the Malthusian era when population grows for about 90 periods, each period lasting 20 annual years, before it takes off. **Figure 5a2** indicates how the gender inequality in earning or the *gender wage gap* varies over time. Interestingly, the earning gap remains constant with a low value during the Malthusian era even when the degree of male

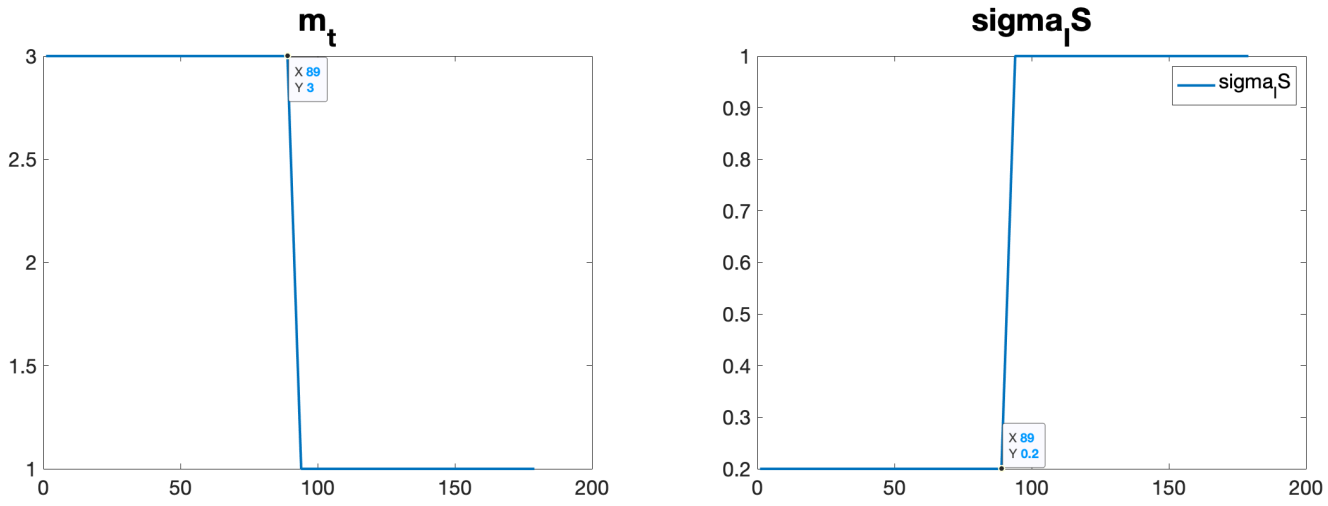

m_t
X 89
Y 3
sigma_lS
sigma_lS
X 89
Y 0.2

Figure 5a1

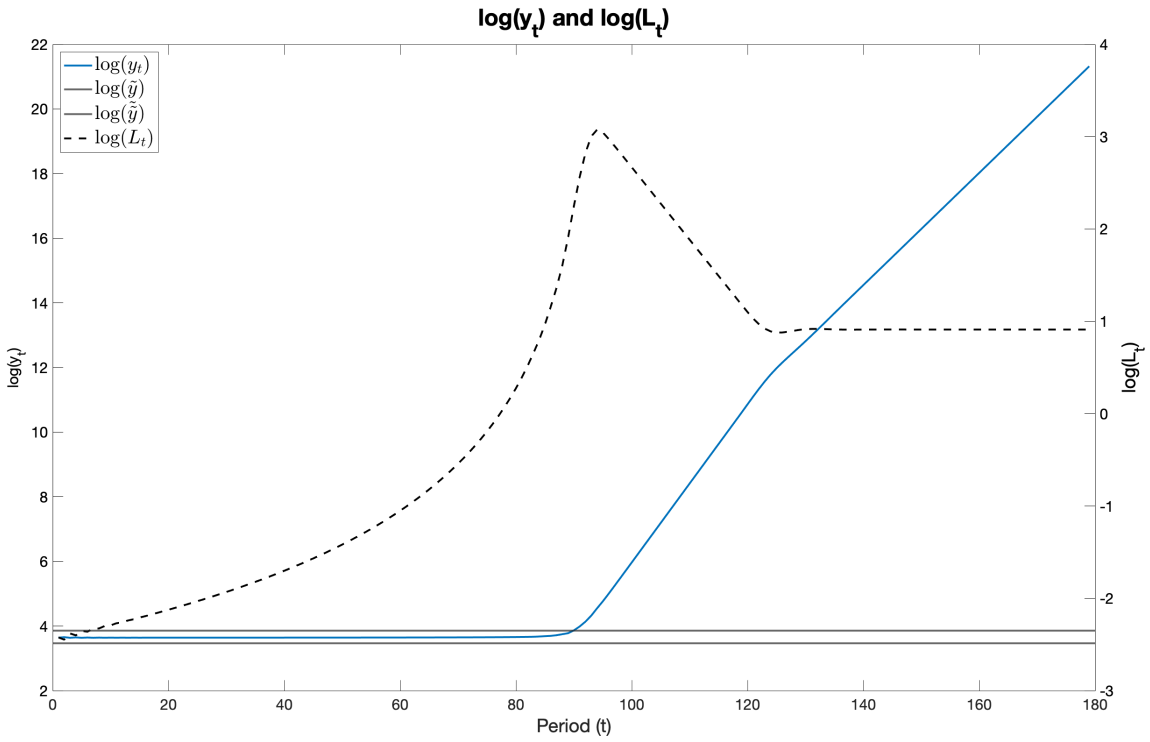

log(y_t) and log(L_t)
log(y_t)
log(ỹ)
log(ỹ)
log(L_t)
log(y_t)
log(L_t)
Period (t)

Figure 5a2

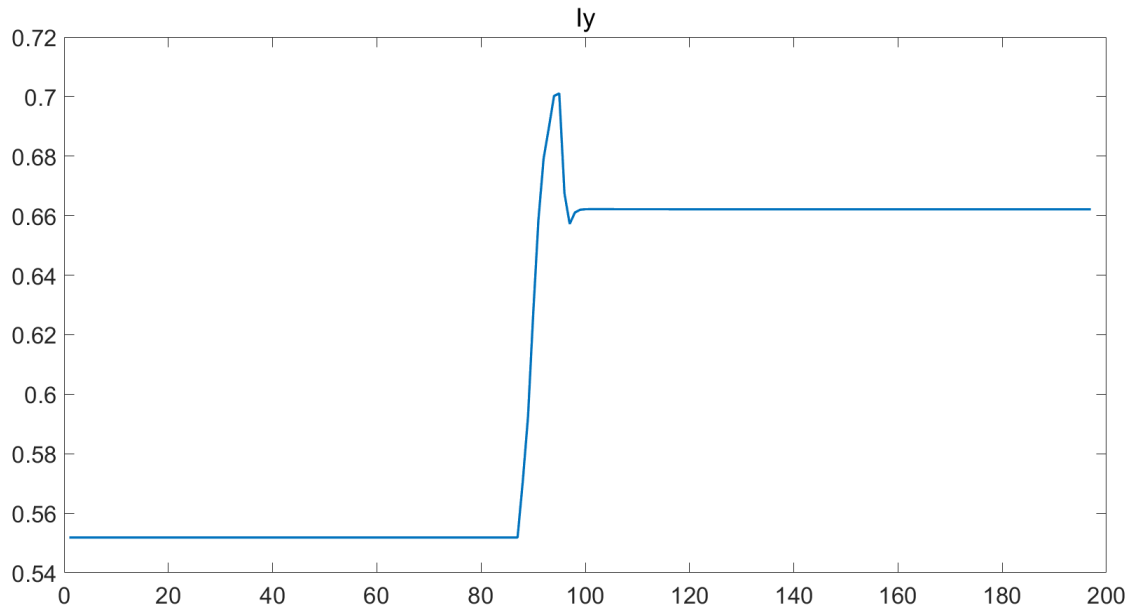


Figure 5b

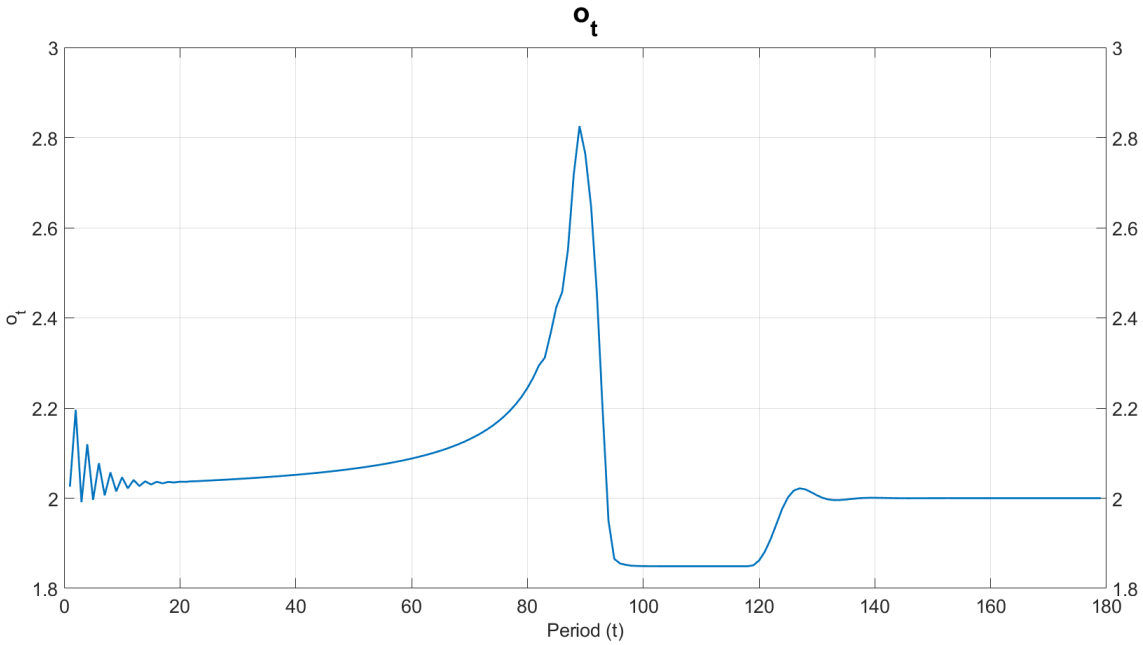


Figure 5c

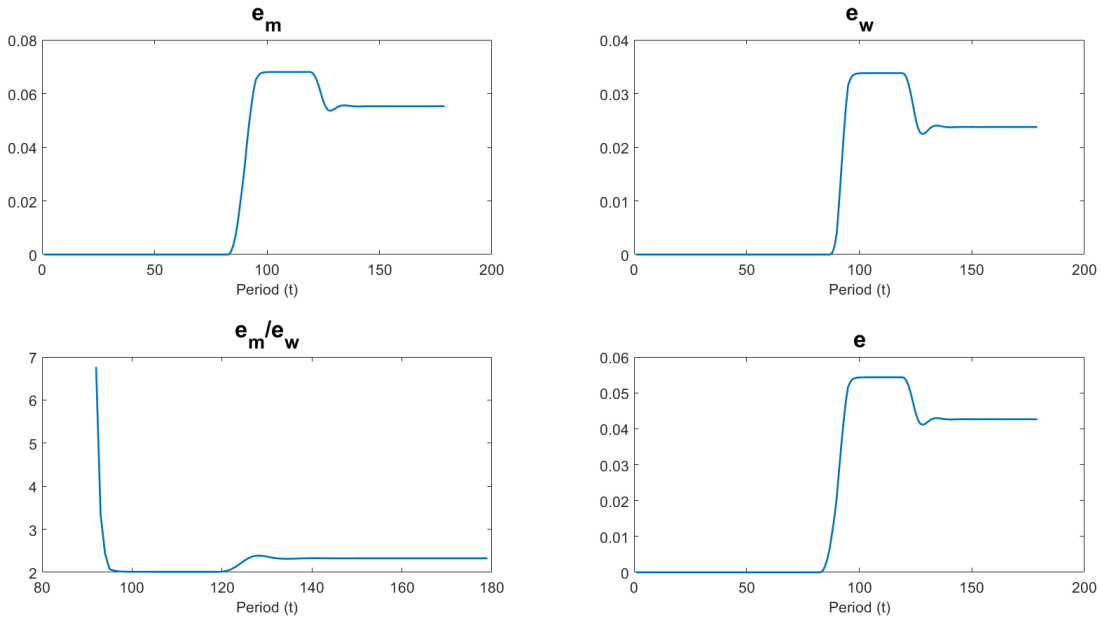


Figure 5d

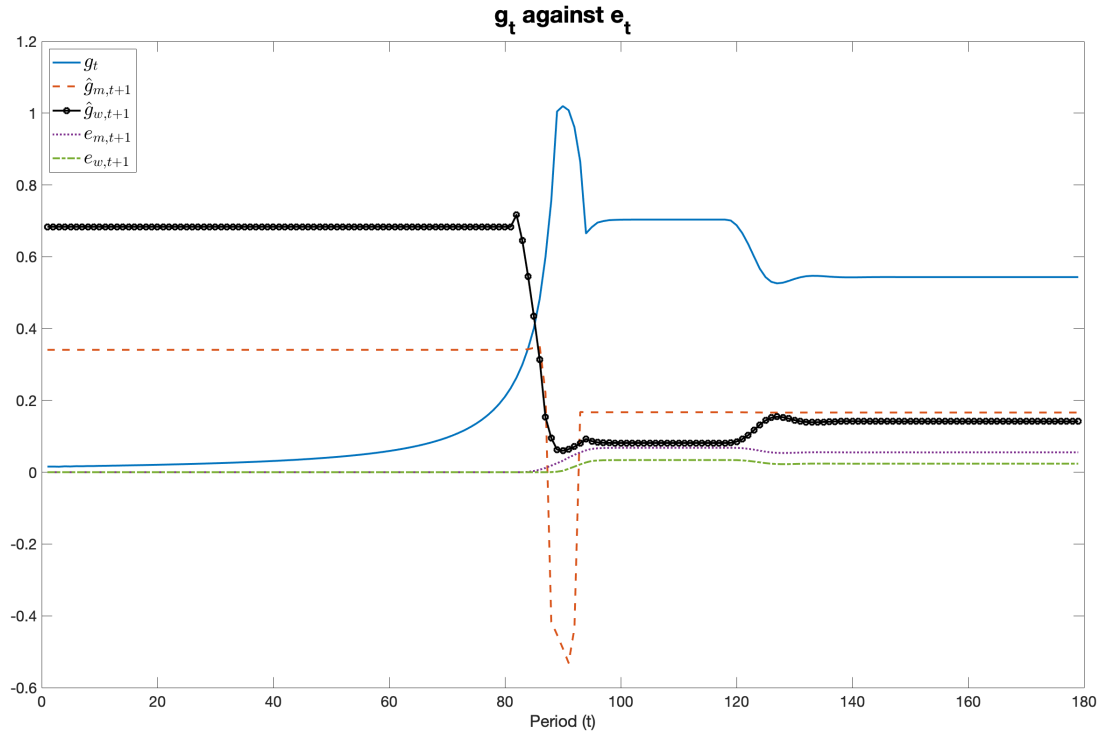
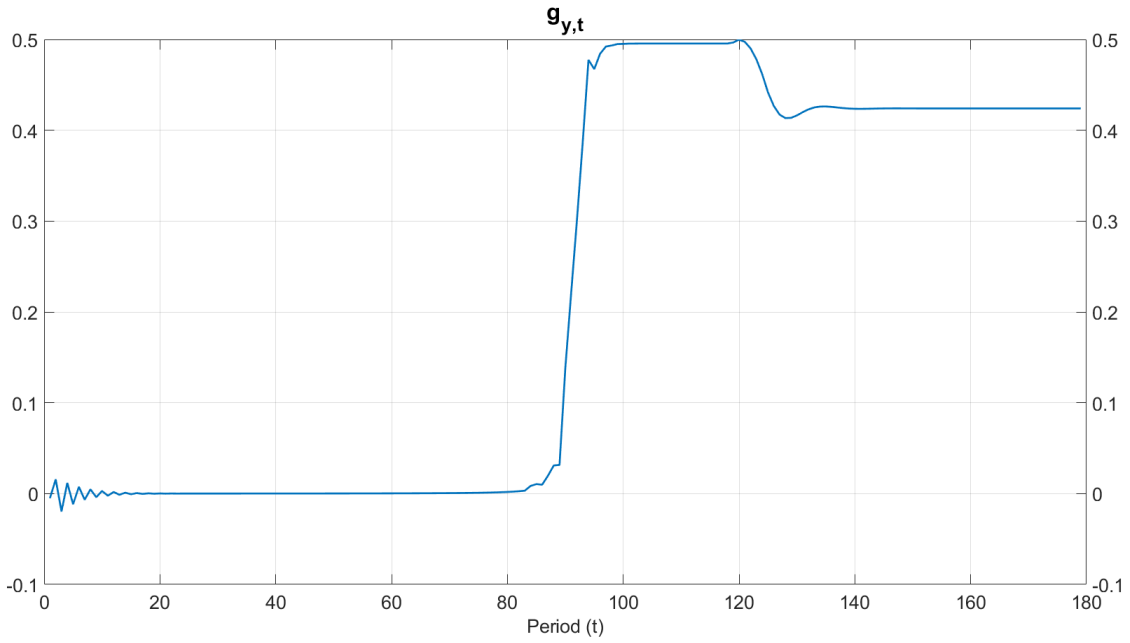


Figure 5e



bias is significantly large, $m_T = 3$ and increased sharply when technology advanced, captured by a decline in m_T, and the consequent increase in the demand for human capital encouraged families to invest in education while cutting back on the number of children, displaying the quantity-quality tradeoff (see **Figures 5b - 5c**).

Figure 5b indicates that following a large fluctuations in the initial period (as noted by Lagerlöf, 2006) due to high frequency of changes in the dominance of the income and substitution effects at a low level of family income, the economy experiences rapid population growth until around period $t = 90$ when the demographic transition sets in before the population growth rate reaches a steady state from the period $t = 98$ onward. **Figures 5c-d** illustrates **Lemma 3** to indicate that the TFP growth rate, g_t, was not sufficiently high until the period $t = 85$ to generate sufficient demand for human capital necessary for the family to invest in their children's education. Further, the male-biased technology implies that the son's education starts before the daughter. However, as the gender bias in technology drops from period $t = 87$, the gender gap in education, e_m/e_w steadily declines before converging around $t = 98$.

Figure 5e indicates the 20-year long period growth rate of the average family income (y_t) converges between 0.4 and 0.5, which is equivalent to an annual growth rate of about 2%.

5.2 An Example: Conservative versus Progressive

Finally, we discuss an example to illustrate how social leader's attitude toward women affect the macroeconomic outcome along the process of economic development. In Figures 6 a, b, present two contrasting scenarios to illustrate the power of conservative politics in changing the course of economic history. The main idea is that a dominant political group can trigger a process of change in how the economy administer the functioning of the institution for women's rights.

Figure 6a corresponds to a case of conservative culture where institutions for women's rights deteriorates under the administration of a conservative religious group who took over power in a country like Iran or Afghanistan. Following the Taliban takeover, the institutions for women's rights steadily decreased.

Figure 6b corresponds to a case of culture dominated by the progressives like Europe where, following the Black Death, the female laborforce participation increased significantly. That development changed the social mindset and politics over time favorably toward women from conservative to progressive, following Fernandez's (2013) idea of gradual cultural change. In this simulation we keep the initial values or the status quo (S) of women's rights institution indicator, $\sigma_{IS} = 0.4$.

Next, we describe how the macroeconomy evolves under these two histories of culture. **Figure 7** contrast the outcome of these two diametrically opposite cultures of how a society values women on the macroeconomy.

The evolution of population (in logarithms), gender earning gap, $I_y \equiv \frac{y_m - y_w}{y_m}$, gender bias in technology, $m_T \equiv \frac{z_m}{z_w}$, and the TFP growth rate, g, over time in that order of presentation.

The figures indicate that in the conservative scenario, such as Iran, the population reaches a higher level and begins its demographic transition at a later date, almost 30 periods or about 600 years later if we interpret the model's period as 20 years of the working adults' lifetime.

Gender inequality in income, I_y, remained similar during the initial periods but dropped significantly more under the progressive culture as technology advanced. It happened because the technology remained relatively brawn-intensive (higher m_T) in the conservative country. The gender bias in technology (m_T) seems to stop declining after reaching 1.4 while it reaches 1.2 in the progressive country. We explain this difference by referring to the sharp difference in the endogenous outcomes of women's rights between the two scenarios.

A significantly higher level of women's rights in Europe following the Black Death triggered a demographic transition and the quantity-quality tradeoff hundreds of years before other conservative countries.

The growth rate of TFP in a progressive country relies more on education and less on population. Consequently, the growth rate of TFP would be higher with lower m_T, which values mental labor more than physical labor.

The modern era TFP growth rate reaches a higher level in the progressive country because the conservative country gets stuck with a relatively brawn-intensive technology that has a higher value of m_T, and we model the modern era TFP growth rate to be higher if the operating technology is relatively brain intensive. Such objective reality triggers international migration from conservative countries to progressive ones.

Figure 6a [Afghanistan]

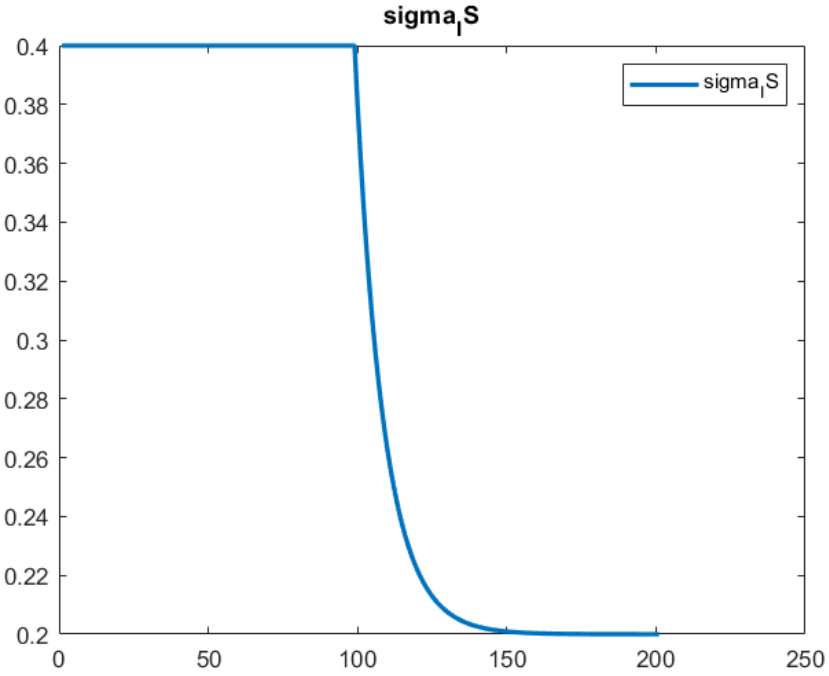


Figure 6b [Europe]

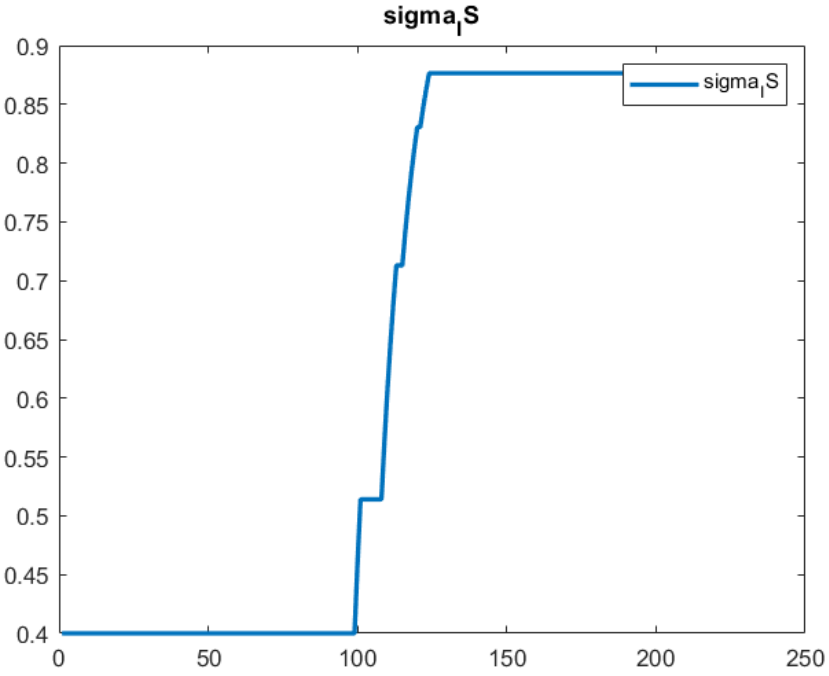
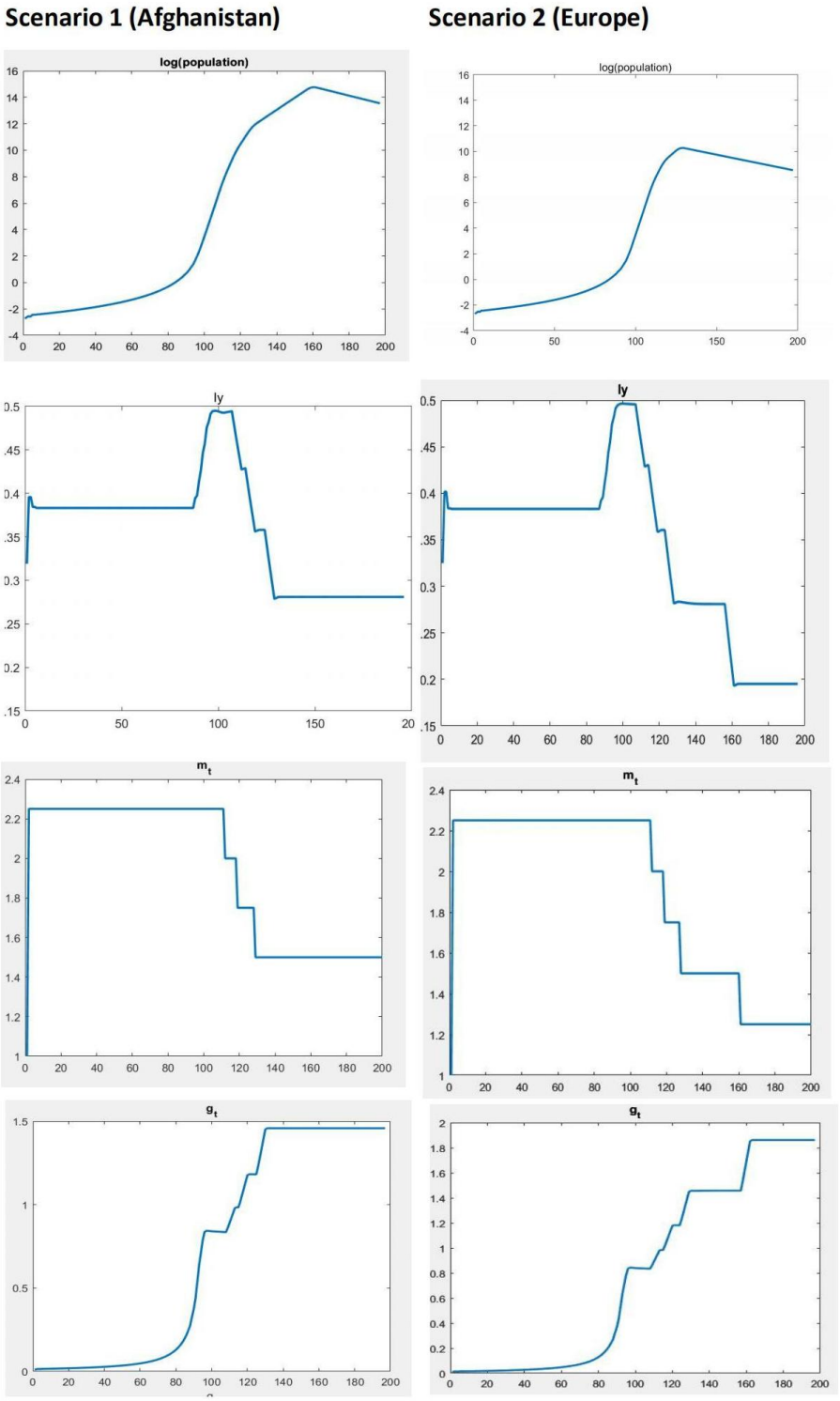


Figure 7


Scenario 1 (Afghanistan)
Scenario 2 (Europe)
log(population)
log(population)
ly
ly
m_t
m_t
g_t
g_t

6 Concluding Remarks

This paper broadens Galor's (2011, 2022) Unified Growth Theoretical (UGT) framework by considering four complementary gender lenses: women's comparative advantage in relatively brain-intensive technology, social norms that instil systematic discrimination against women in the formulation of the family decision rules, politics of women's rights, and male backlash that deters women's engagement in productive activities. In that expanded framework, we understand how the interdependent evolution of technology and institutions for women's rights causes multiple developmental outcomes and how that, in turn, explains why two economies with identical parameters may follow significantly diverse evolutionary paths based on their distinctive political history related to the institutions of women's rights.

It includes a theoretical example like Lagerlöf's (2006) quantification of the UGT model of Galor (2011) but with four gender lenses. The example characterizes the long-term macroeconomic evolutionary dynamics that shed light on a contemporary developmental puzzle: why two hundred years of technological diffusion since the first industrial revolution has yet to make a significant dent in most developing countries while the developed countries continue to grow in affluence but shrink in their world population share.

In the expanded UGT model with four gender lenses, like other UGT models, in the early stages of development, when fertility rates are high and the average education level is low, the economy benefits from a greater supply of people and manual power. However, in the expanded model, this is necessary to maximize the economic welfare of the average household, supported by relatively brawn-intensive technology and weak institutions of women's rights that sustain a high crime level to deter women's engagement with production technology. Consequently, in the later phase of economic development, business leaders find that economic progress with technological advancement requires stronger institutions for women's rights. However, progressive (progress-minded) leaders cannot implement those changes without succeeding in a political conflict against conservative leaders who benefit from the status quo that yields gender-based rents. Thus, the macroeconomy faces a coordination problem that requires a social planner. Political conflicts play a critical role in economic development when the real world finds no such planner.

With this result, the paper offers an alternative hypothesis to the conventional wisdom of a virtuous circle in which economic development improves women's rights with no political conflicts, promoting growth and further development. It does that by identifying specific parametric conditions in an economy, which is used for illustration when the politics of women's rights play a critical role in determining the course of economic development.

By modelling a political contest between two cultural groups with opposing attitudes toward women, it sheds light on factors that influence the adoption of technology and institutional rights for men and women and fuel misogyny-led crime due to male backlash against women's empowerment that deters women's market participation. The social choice of technology and institutions and their implications for the barriers to women's market participation exhibit local complementarity. The resulting non-linearity and duality of outcomes allow politics to play a role in determining the course of history.

For impoverished countries stuck in a developmental trap, which the model characterizes, the political hypothesis for improving women's rights and its associated male backlash may play a critical role. Thus, this paper increases the relevance of the plethora of empirical evidence that has emerged since Htun and Weldon's (2012) seminal work, including those on male backlash

to women's empowerment, which Santos Silva and Klasen (2021) summarized in an influential article.

Moreover, by modeling male backlash as a catalyst to heighten crime against women, it links crime and development in a way that adds value to the recent findings of Chakraborty et al. (2018), Broker (2021, 2022), Amaral *et al.* (2023), Adams-Prass *et al.* (2022), and others, which document how crime deter women's participation in the market economy.

The paper's main contribution is an introduction to a new theoretical rationale that justifies why the interdependent evolution of technology and institutions for women's rights matters in explaining the diversity in economic development. It demonstrates with an example how such interdependence gives rise to multiple macro-developmental outcomes and when politics play a critical role in determining the chosen path of economic history. This theory may help explain why a large section of the world remains stuck, till today, with primitive technology and meager women's rights, while the share of the world population with equal rights for women and men and advanced technology is small and shrinking over time. The other related contribution is working out a numerical example highlighting the standard of living gap between two groups of the world population with two distinct institutions for women's rights and then explaining why this gap has been alarmingly growing.

This paper also illuminates an emerging worldwide macro developmental challenge: why the world with primitive technology and meager women's rights has a significantly larger population share than the world with equal rights for women and men and advanced technology. Future studies should focus on why this gap in population shares and the standard of living between these two sections of the world population has been alarmingly growing, causing political conflicts and migration crises worldwide.

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8 Appendix A (Technical Details)

This section includes the proofs of various lemmas.

Proof of Lemma 1.

We omit the time subscript t, which is unnecessary. By (2), (3) and (7).

$$\frac{\partial y/\partial h_m}{\partial y/\partial h_w} = \frac{(\partial y/\partial h)(\partial h/\partial h_m)}{(\partial y/\partial h)(\partial h/\partial h_w)} = \frac{1}{b}\left(\frac{h_m}{h_w}\right)^{\alpha-1}. \tag{61}$$

Next, by (8), $m_T = z_m/z_m$. Therefore, by (5) and (6),

$$\frac{\partial y/\partial h_m}{\partial y/\partial h_w} = \left(\frac{z_m h_w}{z_w h_m}\right)^{1-\alpha} = m_T^{1-\alpha}\left(\frac{h_m}{h_w}\right)^{\alpha-1}. \tag{62}$$

By comparing (61) and (62), we complete the proof of Lemma 1. □

Proof of Lemma 2.

The First Order Conditions (FOC) of (25):

$c_{m,t}$:

$$\frac{1}{c_{m,t}} = \mu_{1t} \tag{63}$$

$c_{w,t}$:

$$\frac{\sigma_t}{c_{w,t}} = \mu_{1t} \tag{64}$$

o_t :

$$\frac{\rho}{o_t} = \mu_{1t}\left[0.5y_t\left(e_{m,t+1} + e_{w,t+1}\left(1+q\right)\right) + a' + \tau y_{w,t}\right], \text{where}$$

$$y_t = y_{m,t} + y_{w,t}$$

It follows:

$$\frac{\rho}{o_t} = \frac{1}{c_{m,t}} \left[0.5 y_t \left(e_{m,t+1} + e_{w,t+1} \left(1+q\right)\right) + a' + \tau y_{w,t}\right] \tag{65}$$

$$\rho c_{m,t} = \left[0.5 y_t \left(e_{m,t+1} + e_{w,t+1} \left(1+q\right)\right) + a' + \tau y_{w,t}\right] o_t \tag{66}$$

λ_t :

$$c_{m,t} + c_{w,t} + \left[0.5 y_t \left(e_{m,t+1} + e_{w,t+1} \left(1+q\right)\right) + a' + \tau y_{w,t}\right] o_t = y_{p,t}. \tag{67}$$

It follows from (63) - (64)

$$c_{m,t} + \sigma_t c_{m,t} + \rho c_{m,t} = y_{p,t} \tag{68}$$

Hence,

$$c_{m,t} = \frac{y_{p,t}}{1 + \sigma_t + \rho}. \tag{69}$$

$$c_{w,t} = \sigma_t c_{m,t} \tag{70}$$

$$\begin{aligned} o_t &= \frac{\rho c_{m,t}}{[a' + 0.5 y_t (e_{m,t+1} + e_{w,t+1}(1+q)) + \tau y_{w,t}]} \\ &= \frac{\rho \left(\frac{y_{p,t}}{y_i}\right)}{(1+\sigma_t+\rho)[\frac{a'}{y_t} + 0.5(e_{m,t+1} + e_{w,t+1}(1+q)) + \tau \left(\frac{1}{1+I_{y,t}}\right)]}, \end{aligned} \tag{71}$$

where, $I_{y,t} = \frac{y_{m,t}}{y_{w,t}} - 1$ and $\left(\frac{y_{p,t}}{y_i}\right) = \left(1 - \frac{p}{2+I_{y,t}}\right)$.

The daughter's education, $e_{w,t+1}$:

$$\frac{\gamma_w}{h_{w,t+1}} \cdot \frac{\partial h_{w,t+1}}{\partial e_{w,t+1}} = \lambda_t \left[0.5 y_t \left(1+q\right) \mathbf{o}_t\right] \tag{72}$$

μ_{3t} : Human Capital: it follows from (11)

$$\frac{\partial h_{k,t+1}}{\partial e_{k,t+1}} = h_{k,t+1} \left(\frac{g_{t+1}}{\left(e_{k,t+1} + \theta\tau\right)\left(e_{k,t+1} + \theta\tau + g_{t+1}\right)}\right), \ k = m, w. \tag{73}$$

It follows from (72) - (73):

$$\frac{\gamma_w}{h_{w,t+1}} \cdot h_{w,t+1} \cdot \frac{g_{t+1}}{\left(e_{w,t+1} + \theta\tau\right)\left(e_{w,t+1} + \theta\tau + g_{t+1}\right)} = \frac{1}{c_{m,t}} \left[0.5 y_t \left(1+q_t\right) \mathbf{o}_t\right] \tag{74}$$

$$\frac{\gamma_w g_{t+1}}{(e_{w,t+1}+\theta\tau)\,(e_{w,t+1}+\theta\tau+g_{t+1})} = \frac{y_t\,(1+q)\,o_t}{2c_{m,t}} \tag{75}$$

From (69), the quantity-quality tradeoff for the daughter's education follows:

$$(e_{w,t+1}+\theta\tau)\,(e_{w,t+1}+\theta\tau+g_{t+1})\,o_t = \frac{2\gamma_w g_{t+1} c_{m,t}}{y_t\,(1+q)} = \frac{2\gamma_w g_{t+1}}{(1+q)\,(1+\sigma_t+\rho)}. \tag{76}$$

The son's education, $e_{m,t+1}$:

$$\frac{\gamma_m}{h_{m,t+1}} \cdot \frac{\partial h_{m,t+1}}{\partial e_{m,t+1}} = \lambda_t\,[0.5 y_t o_t] \tag{77}$$

From (73), it follows:

$$\frac{\gamma_m}{h_{m,t+1}} \cdot h_{m,t+1} \cdot \frac{g_{t+1}}{(e_{m,t+1}+\theta\tau)\,(e_{m,t+1}+\theta\tau+g_{t+1})} = \frac{y_t}{2c_{m,t}} o_t \tag{78}$$

and from (69), the quantity-quality tradeoff for the son's education follows:

$$(e_{m,t+1}+\theta\tau)\,(e_{m,t+1}+\theta\tau+g_{t+1})\,o_t = \frac{2\gamma_m g_{t+1}}{(1+\sigma_t+\rho)} \tag{79}$$

Dividing (79) by (76), yields:

$$\frac{(e_{m,t+1}+\theta\tau)\,(e_{m,t+1}+\theta\tau+g_{t+1})}{(e_{w,t+1}+\theta\tau)\,(e_{w,t+1}+\theta\tau+g_{t+1})} = \frac{\gamma_m(1+q)}{\gamma_w}. \tag{80}$$

and from (76) and (71) follows:

$$(e_{w,t+1}+\theta\tau)\,(e_{w,t+1}+\theta\tau+g_{t+1}) = \frac{2\gamma_w g_{t+1}(a' + 0.5 y_t(e_{m,t+1}+e_{w,t+1}(1+q)) + \tau y_{w,t})}{\rho(1+q)(y_{m,t}+y_{w,t})} \tag{81}$$

Given state variable vector X_t, (80) - (81) reduce to 2 x 2 difference equations of the form: $e_{k,t+1} = E(e_{k,t};\, X_t)$. Also, given X_t, by (11), we determine $e_{k,t}$. □

Proof of Lemma 3.
If $\frac{\partial L}{\partial e_{w,t+1}} < 0$, $e_{w,t+1} = 0$. In other words, if

$$\begin{aligned} \frac{\gamma_w g_{t+1}}{\theta\tau\,(\theta\tau+g_{t+1})} - \frac{1}{c_{m,t}}\,[0.5 y_t\,(1+q)\,\mathbf{o}_t] &< 0,\ e_{w,t+1} = 0. \\ \frac{\gamma_w g_{t+1}}{\theta\tau\,(\theta\tau+g_{t+1})} &< \frac{y_t\,(1+q_t)\,o_t}{2c_{m,t}} \end{aligned}$$

From (69) and (71), it follows:

$$\frac{\gamma_w g_{t+1}}{\theta\tau\left(\theta\tau+g_{t+1}\right)} < \frac{\rho(1+q_t)}{[a'+0.5e_{m,t+1}+\tau\left(\frac{y_{w,t}}{y_t}\right)]} \tag{82}$$

$$g_{t+1} < \frac{(\rho\theta)^2}{\gamma_w(\frac{a'}{y_t}+0.5e_{m,t+1}+\tau\left(\frac{y_{w,t}}{y_t}\right))} = \widehat{g}_{w,t+1}. \tag{83}$$

$$\tag{84}$$

$$g_{t+1} < \frac{(\tau\theta)^2}{\frac{2\gamma_w}{(1+q)\rho}(\frac{a'}{y_t}+0.5e_{m,t+1}+\tau\left(\frac{y_{w,t}}{y_t}\right))-\theta\tau} = \widehat{g}_{w,t+1}. \tag{85}$$

The gender inequality in earning, $I_{y,t} \equiv \frac{y_{m,t}}{y_{w,t}} - 1$, varies inversely with $\frac{y_{w,t}}{y_t}$, since $y_t = y_{m,t} + y_{w,t}$. We note from simulations that $e_{m,t+1} + \tau\left(\frac{1}{1+I_{y,t}}\right)$ converges to a steady state but its transition path is uneven which causes $\widehat{g}_{w,t+1}$ to fluctuate. Consequently, the optimal investment in daughter's education, $e_{w,t+1}$, involves fluctuations, in general. However, once both $e_{m,t+1}$ and $e_{w,t+1}$ grow steadily such that the gender inequality in earning, $I_{y,t}$, does not decline faster than the growth rate of $e_{m,t+1}$, then g_{t+1} increases while $\widehat{g}_{w,t+1}$ decreases, and we can sustain the positive investment in daughter's education, once it is positive.

By (18), (10), (11), and the the family's optimization exercise (25), the evolution of gender inequality, $I_{y,t}$, depends on how gender bias in technology, $m_{T,\,t}$, and institution of women's rights, $\sigma_{I,t}$, governing the value of women's wellbeing in the family, σ_t, and social discrimination against women at work and in education, proxied by p_t and q_t, respectively. Thus,

If there are no separate consumption allocation for children, no son bias ($\gamma_w = \gamma_m = \gamma$), $\rho = \gamma$, and men and women equally bear the child-birth related cost, and no gender difference in education such that $e_{m,t+1} = e_{w,t+1} = 0$, as in Lagerlöf (2006), then the condition (82) reduces to $\widehat{g} = \frac{\theta^2}{(1-\theta)}$.

$$\begin{aligned} g_t &< \frac{\rho\theta^2}{(\gamma-\rho\theta)} = \widehat{g}. \\ \widehat{g} &= \frac{\theta^2}{(1-\theta)}, \text{ if } \rho = \gamma. \end{aligned} \tag{86}$$

By (**??**) and (**??**), a_2 decreases with y_w. We note that $a_2 = \tau$ in Galor (2011) and Lagerlöf (2006) which assumed that men and women equally share the child-bearing cost and resources consumed by a child is included in the adult's consumption and, hence, $a' = 0$. In our model, if $e_k = 0$, $k = m, w$, $y_m = (m_T(1+p))^{1-\alpha}\, y_w$, and $y_m + y_w > \widetilde{\widetilde{y}}$. Therefore, $y_w > \frac{\widetilde{\widetilde{y}}}{(1+(m_T(1+p))^{1-\alpha})} = y_{w,\min}$. It implies that $a_2 < a_{2,\max} = \frac{2\left(a'/y_{w,\min}+\tau\right)}{\gamma+1}$, which, in turn, implies that $g_m \geq \widehat{g}_m = \frac{(\theta\tau)^2}{\gamma_m a_{2,\max}-\theta\tau}$. In other words, if $g < \widehat{g}_m \leq g_m$, $e_m = 0$, and $e_m > 0$ implies that $g > \widehat{g}_m$. □

Proof of Lemma 4

$$V_{F,t}(m_T,\ \sigma_I) = \ln c_{m,t} + \frac{\sigma_I}{m_T}\ln\left(\frac{\sigma_I}{m_T}c_{m,t}\right) + \sum \gamma_k \ln h_{k,t+1}\left(m_T,\ \sigma_I\right) + \rho \ln o_t\left(m_T,\ \sigma_I\right), \quad (87)$$

$$= (1+\frac{\sigma_I}{m_T})\ln c_{m,t} + \frac{\sigma_I}{m_T}\ln\frac{\sigma_I}{m_T} + \sum \gamma_k \ln h_{k,t+1}\left(m_T,\ \sigma_I\right) + \rho \ln o_t\left(m_T,\ \sigma_I\right),$$

and differentiating $V_{F,t}$ w.r.t. m_T we get,

$$\frac{\partial V_{F,t}}{\partial m_T} = (1+\frac{\sigma_I}{m_T})\left(\frac{1}{c_{m,t}}\frac{\partial c_{m,t}}{\partial m_T}\right) - \frac{\sigma_I}{(m_T)^2}\left(1+\ln\frac{\sigma_I}{m_T}+\ln c_{m,t}\right) + \sum \gamma_k \frac{\partial \ln h_{k,t+1}}{\partial m_T} + \rho\frac{\partial \ln o_t}{\partial m_T}$$

where,

$$c_{m,t} = \frac{y_{p,t}(m_T)}{1+\frac{\sigma_I}{m_T}+\rho},\ y_{p,t}\left(m_T\right) = \left(\frac{z_w A_t Z}{L_t}\right)^{1-\alpha}\left[h_{m,t}^{\alpha} m_T^{1-\alpha} + (1-p)h_{w,t}^{\alpha}\right],\ I_{y,t}(m_T) \equiv m_T^{1-\alpha}\left(\frac{h_{m,t}}{h_{w,t}}\right)^{\alpha} - 1$$

$$\ln o_t\left(m_T,\ \sigma_I\right) = \ln\rho + \ln\left(\frac{1-\frac{p}{2+I_y(m_T)}}{1+\frac{\sigma_I}{m_T}+\rho}\right) - \ln\left[a'/y_t(m_T) + 0.5\left(e_{m,t+1}+(1+q)\,e_{w,t+1}\right) + \frac{\tau}{2+I_{y,t}(m_T)}\right]$$

$$y_{p,t}(m_T) = y_t(m_T), \text{ if } p=0, \text{ and (5) – (10) describe } y_t(m_T) \text{ and } I_{y,t}(m_T).$$

Case: $e_{k,t+1} > 0$, $k = m, w$.

$$\frac{\partial \ln o_t}{\partial m_T} = \frac{1}{c_{m,t}}\left(\frac{\partial c_{m,t}}{\partial m_T}\right) - \frac{-\frac{a' y_t'(m_T)}{y_t(m_T)^2} + 0.5\left[\left(x_{m,t+1}+(1+q)\,x_{w,t+1}\right)\right] - \frac{\tau I_{y,t}'(m_T)}{(2+I_{y,t}(m_T))^2}}{a'/y_t(m_T) + 0.5\left(e_{m,t+1}+(1+q)\,e_{w,t+1}\right) + \tau/(2+I_{y,t}(m_T))},$$

where,

$$x_{k,t+1} \equiv \frac{\partial e_{k,t+1}}{\partial m_T},\ k = m, w.$$

Some Notations:

$A_{k,t+1} \equiv e_{k,t+1} + \theta\tau$, $a_{1,t+1} \equiv \frac{R(2A_{w,t+1}+g_{t+1})}{2A_{m,t+1}+g_{t+1}}$, $R \equiv \frac{\gamma_m(1+q)}{\gamma_w}$, $b_{1,t+1} \equiv \frac{\rho(1+q)(2A_{w,t+1}+g_{t+1})}{\gamma_w g_{t+1}} - (1+q)$, $c_{1,t+1} \equiv \left(\frac{1-\alpha}{m_T}\right)\left(\frac{a' y_{m,t}(m_T)}{y_t(m_T)^2} + \frac{\tau I_{y,t}(m_T)}{(2+I_{y,t}(m_T))^2}\right)$,

where, by (13) - (16), $g_{t+1} = g_{t+1}(m_T,\ \sigma_I)$.

Then by differentiating (34) - (35) and apply the Implicit Function Theorem, we derive the following results:

$$x_{m,t+1} = \frac{a_{1,t+1}c_{1,t+1}}{a_{1,t+1}-b_{1,t+1}};\ x_{w,t+1} = \frac{c_{1,t+1}}{a_{1,t+1}-b_{1,t+1}}.$$

Note that for all $t = 0, 1, 2..$, $a_{1,t+1}$ and $c_{1,t+1} > 0$. Therefore, the necessary and sufficient condition for $x_{k,t+1} \equiv \frac{\partial e_{k,t+1}}{\partial m_T} < 0$, for both $k = m, w$, is $a_{1,t+1} < b_{1,t+1}$, or equivalently, $e_{m,t+1} + \theta\tau > 0.5 g_{t+1}(\frac{\gamma_m - \rho}{\rho})$.

$$\frac{\partial V_{F,t}}{\partial m_T} = \left(1+\rho+\frac{\sigma_I}{m_T}\right)\left(\frac{1}{c_{m,t}}\frac{\partial c_{m,t}}{\partial m_T}\right) - \frac{\sigma_{I,t}}{(m_T)^2}\left[\ln\left(\frac{\sigma_I c_{m,t}}{m_T}\right)+1\right] + g_{t+1}(m_T,\,\sigma_I)\sum \gamma_k \frac{h_{k,t+1}}{e_{k,t+1}} x_{k,t+1} \quad (88)$$

$$-\rho\frac{-\frac{a' y_t'(m_T)}{y_t(m_T)^2}+0.5\left[\left(x_{m,t+1}+(1+q)\,x_{w,t+1}\right)\right]-\frac{\tau I_{y,t}'(m_T)}{(2+I_{y,t}(m_T))^2}}{a'/y_t(m_T)+0.5\left(e_{m,t+1}+(1+q)\,e_{w,t+1}\right)+\tau/(2+I_{y,t}(m_T))},$$

where, $x_{k,t+1} \equiv \frac{\partial e_{k,t+1}}{\partial m_T}$, $k = m, w$, and

$$\frac{1}{c_{m,t}}\frac{\partial c_{m,t}}{\partial m_T} = \frac{(1-\alpha)(1+\rho)+\frac{\sigma_I}{m_T}\left(1+(1-\alpha)\frac{y_{m,t}(m_T)}{y_t(m_T)}\right)}{(1+\rho)m_T+\sigma_I}.$$

We assume that an advancement of technology (lower m_T) increases returns to education and, hence, $x_{k,t+1} \equiv \frac{\partial e_{k,t+1}}{\partial m_T} < 0$.[25] It implies that the first and the last term of (88) are positive while the second and the third terms are negative. Next, we note that if g_{t+1} and σ_I are sufficiently small then the first and fourth terms dominate the second and third terms to ensure that $\frac{\partial V_{F,t}}{\partial m_T} > 0$. If the economy is stuck at the Malthusian trap such that $g_{t+1} = 0$, but $y_C > \frac{1}{e}$, then we can prove that there exists a $\sigma_I^{low} \equiv \frac{m_T(1+\rho)}{e\left(y_C-\frac{1}{e}\right)} > 0$ such that if $\sigma_I < \sigma_I^{low}$, then $1+\ln\left(\frac{\sigma_I c_{m,t}}{m_T}\right) < 0$, which implies $\frac{\partial V_{F,t}}{\partial m_T} > 0$. □

Next, differentiating $V_{F,t}$, given by (87), w.r.t. σ_I we get,

$$\begin{aligned}\frac{\partial V_{F,t}}{\partial \sigma_I} &= \frac{\partial}{\partial \sigma_I}\left[\ln y_t(m_T) - \ln\left(1+\frac{\sigma_I}{m_T}+\rho\right)\right] \\ &+\frac{\sigma_I}{m_T}\frac{\partial}{\partial \sigma_{\mathrm{I}}}\left[\ln\frac{\sigma_I}{m_T}+\ln y_t(m_T) - \ln\left(1+\frac{\sigma_I}{m_T}+\rho\right)\right] \\ &+\ln c_{w,t}\cdot\frac{1}{m_T}+\sum\gamma_k\frac{\partial \ln h_{k,t+1}}{\partial \sigma_I}+\rho\frac{\partial \ln o_t}{\partial \sigma_I}.\end{aligned}$$

$\Leftrightarrow$

$$\frac{\partial V_{F,t}}{\partial \sigma_I} = \frac{\ln\left(\frac{\sigma_I m_T^{-\alpha}\left(\frac{A_t X}{L_t}\right)^{1-\alpha}\left(m_T(p+1)\left(\frac{e_{m,t}+\theta\tau}{e_{m,t}+g_t+\theta\tau}\right)^{\alpha}+m_T^{\alpha}(p+1)^{\alpha}\left(\frac{e_{w,t}+\theta\tau}{e_{w,t}+g_t+\theta\tau}\right)^{\alpha}\right)}{(1+\rho)(m_T\rho+m_T+\sigma_I)}\right)}{m_T} < 0$$

implies

$$m_T(1+p)\left(\frac{e_{m,t}+\theta\tau}{e_{m,t}+g_t+\theta\tau}\right)^{\alpha}+m_T^{\alpha}(1+\rho)^{\alpha}\left(\frac{e_{w,t}+\theta\tau}{e_{w,t}+g_t+\theta\tau}\right)^{\alpha} < \frac{(1+\rho)m_T^{\alpha}(m_T(1+\rho)+\sigma_I)}{\sigma_I\left(\frac{A_t X}{L_t}\right)^{1-\alpha}}$$

[25] We find that in our model specification $\frac{\gamma_m}{\rho} < 1+\frac{2}{D\Psi^*}$ implies $x_k < 0$, for $k = m, w$.

implies

$$\begin{aligned} m_T &< \frac{m_T^{\alpha}(m_T(1+\rho)+\sigma_I)}{2\sigma_I\left(\frac{A_tX}{L_t}\right)^{1-\alpha}\left(\frac{e_{m,t}+\theta\tau}{e_{m,t}+g_t+\theta\tau}\right)^{\alpha}}. \qquad (89)\\ &\Leftrightarrow \\ 2\sigma_I\left(\frac{A_tX}{L_t}\right)^{1-\alpha}\left(\frac{e_{m,t}+\theta\tau}{e_{m,t}+g_t+\theta\tau}\right)^{\alpha} &< m_T^{\alpha}(1+\rho)+\frac{\sigma_I}{m_T^{1-\alpha}} \equiv Z(m_T). \end{aligned}$$

Note: $Z(m_{T,t})$ is a $U-$shaped function of m_T and $Z'(m_{T,t})=0$, if $m_T=m_T^*$, where

$$m_T^* = \frac{(1-\alpha)\sigma_I}{\alpha(1+\rho)}. \qquad (90)$$

A smaller σ_I implies a lower value for m_T^*. If for some $m_T^{High} > m_T^*$, (89) holds, then for all if $m_T > m_T^{High}$, $\frac{\partial V_{F,t}}{\partial \sigma_I} < 0$. $\square$

The Political Leader's Optimization Exercise

Proof of Lemma 5: For notational simplicity, we omit the subscript t for this contemporaneous analysis. Note that, by (45), $\frac{\partial d_i}{\partial r_i}=0$ and, by (49), $\Pi_i(.)$ is strictly concave. Also, $C_i''(r_i)>0$, and $\frac{\partial \Pi_i(r_i,X_C,X_P)}{\partial r_i}|_{r_i=0} \gtrless 0$, $i=C,\,P$.

For $i=C$:

$$\frac{\partial \Pi_C(r_C,X_C,X_P)}{\partial r_C} = (1-\frac{n_Cr_C}{n_Cr_C+n_Pr_P})\frac{n_Cd_C}{n_Cr_C+n_Pr_P} - \frac{1}{c_m^*-r_C} = 0 \qquad (91)$$

so for $\frac{\partial \Pi_C}{\partial r_C}|_{r_C=0} > 0$,

$$\frac{n_Cd_C}{n_Pr_P} > \frac{1}{c_m^*}$$

Or, equivalently,

$$r_P < \frac{n_Cd_Cc_m^*}{n_P} = r_P^{\max} \qquad (92)$$

For $i=P$:

$$\frac{\partial \Pi_P(r_P,X_C,X_P)}{\partial r_P} = (1-\frac{n_Pr_P}{n_Cr_C+n_Pr_P})\frac{n_Pd_P}{n_Cr_C+n_Pr_P} - \frac{1}{c_w^*-r_P} = 0 \qquad (93)$$

so for $\frac{\partial \Pi_P}{\partial r_P}|_{r_P=0} > 0$,

$$\frac{n_Pd_P}{n_Cr_C} > \frac{1}{c_w^*}$$

Or, equivalently,

$$r_C < \frac{n_Pd_Pc_w^*}{n_C} = r_C^{\max} \qquad (94)$$

□

Appendix B [An Empirical Exercise]

Table 2 follows:

Table 2
Evidence of Conservative Backlash Against Women's Rights

VARIABLES	(1) OLS val_Rate	(2) RE val_Rate	(3) FE val_Rate
Female_suffrage_flag	7.481***	-1.077**	-1.095**
	(1.802)	(0.538)	(0.541)
Economic_rights	-18.005***	0.819	0.904
	(0.923)	(0.807)	(0.813)
Political_rights	-7.523***	2.676***	2.669***
	(1.340)	(0.791)	(0.791)
Labor_rights	4.188***	2.299***	2.285***
	(0.929)	(0.619)	(0.619)
Univ_stand_women	6.980***	1.667	1.684
	(1.605)	(1.082)	(1.087)
GDP_pc	-24.627***	-9.362***	-9.146***
	(1.352)	(1.630)	(1.634)
Constant	3,609.719***	2,816.227***	2,789.734***
	(205.867)	(148.245)	(102.907)
Observations	5043	5043	5043
Adjust R-squared	0.1903		
Within R-squared		0.1451	0.1451
Year fixed effect	No	Yes	Yes
County fixed effect	No	No	Yes

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Robust-heteroskedasticity standard errors in parentheses for columns (2) & (3). Standard errors in parentheses for column (1). This table is based on data for the period 1990-2019 and covers 178 countries and territories.

#Val Rate refers to the medical record of the number of women per 100,000 who suffered sickness from sexual violence.

Sexual Violence (SV) is defined as any sexual act or any attempt to obtain a sexual act through violence or coercion, which, according to WHO, encompasses a variety of situations, namely rape or marital infidelity, rape by strangers, sexual abuse, sexual or physical abuse of those with disabilities, sexual abuse of children, forced marriage and child marriage, denial of the right to use contraceptive equipment or prevention of sexually transmitted diseases as well as forced abortion.

RE (Random Effects) & FE (Fixed Effects): Both RE and FE models, while considering the individual effects, show a negative correlation between female suffrage rights and Val_Rate. Such a difference from the OLS model suggests potential omitted variable bias in the OLS results. The FE model is beneficial for controlling unobserved time-invariant characteristics.

Other rights like Political_rights, Labor_rights, and Economic_rights also significantly influence Val_Rate but show different magnitudes and directions of effect across models. Particularly, the GDP_per_capita coefficient is consistently negative across all models, suggesting that as GDP per capita increases, the Val_Rate tends to decrease, holding other factors constant.

Conclusion: An increase in GDP per capita and Female Suffrage both decrease sexual violence while Labor and Political Rights increase it. The impact of GDP per capita through improved law and order and other public infrastructure prevents crimes against women. Interestingly, increased women's rights have ambiguous effects on sexual violence. While Female Suffrage mitigates it, increased labor and political rights increase it. We interpret the source of this difference as the relative dominance of the deterrence versus backlash effect.

Data Description

Variables	Description	Source
Female_suffrage_flag	female suffrage index	"The Economics of Women's Rights," Journal of the European Economic Association, Volume 20, Issue 6, December 2022, Pages 2271–2316. (https://doi.org/10.1093/jeea/jvac059).
Economic_rights	women's economic rights index	
Political_rights	women's political rights index	
Labor_rights	women's body rights index	
Univ_stand_women	universal right to stand for election index	
val_Rate	Number of females per 100,000 population diagnosed due to sexual assault	The Institute for Health Metrics and Evaluation
GDP_pc	GDP per capita (constant 2015 USD), in 1000s	WDI database

***These women's rights indicators come from the database published by Tertilt et al. (2022): https://tertilt.vwl.uni-mannheim.de/research.php#Womensrights. We thank Professor Michele Tertilt for emailing me the above link for the data.**

Table 2A

	(1) val_Rate	(2) val_Rate	(3) val_Rate
Female_suffrage_flag	11.59***	-0.419	-0.423
	(4.05)	(-0.93)	(-0.94)
Econ_rights (Sig_E)	-12.36***	0.788	0.853
	(-11.66)	(0.84)	(0.90)
Pol_rights (Sig_P)	-10.38***	3.779***	3.767***
	(-6.48)	(4.32)	(4.31)
Labor_rights (Lab_E)	8.849***	2.984***	2.954***
	(7.99)	(3.81)	(3.77)
Univ_stand_women (Sig_U)	1.470	-1.686	-1.681
	(0.52)	(-1.12)	(-1.11)
GDP_pc	-50.01**	-13.18*	-12.49
	(-2.96)	(-2.03)	(-1.90)
GDPPC2	2260.1***	108.7**	102.9**
	(9.88)	(2.85)	(2.68)
GDPPC3	-1053.3***		
	(-7.59)		
Sig_E_GDP	-806.4***	-67.05	-62.15
	(-5.38)	(-0.54)	(-0.49)
Sig_P_GDP	530.4***	-156.4**	-156.6**
	(3.47)	(-2.85)	(-2.86)
Sig_L_GDP	-360.4**	-120.0*	-119.9*
	(-2.72)	(-2.13)	(-2.13)
Sig_U_GDP	303.5	292.3***	292.3***
	(1.69)	(4.32)	(4.27)
sigma_B_GDP	-624.6*	8.201	3.442
	(-2.51)	(0.24)	(0.10)
_cons	3565.5***	2997.1***	2969.3***
	(7.67)	(15.41)	(18.03)
N	5043	5043	5043

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$