Economic Growth and Evolution of Gender Equality*

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Abstract

We present an evolutionary growth model where the degree of gender equality evolves towards the value maximising social output. It follows that a woman's bargaining power should depend positively on her relative productivity. When man is more productive it is socially efficient to give him a larger compensation as it would stimulate his effort. We consider multisector economy, where woman is relatively more productive in a human-capital incentive sector. The relative gender labour productivity depends on the level of physical and human capital. When an economy is less developed, physical strength plays a key role in production thus, total output is greater when the man gets a larger share. Our model shows that an economy richer in natural resources would have lower investment in human capital, which in turn reduces the woman's share of the output. As society develops and accumulates physical and human capital, the woman becomes relatively more productive, which drives the output maximising social norm towards gender equality. We also investigate economic consequences of premature gender equality. It turns that in the short run such policy may be detrimental for production and accumulation of physical capital; however it could stimulate larger investment in human capital. As a result, an economy with gender equality can outperform an economy where gender balance of power maximises social output, although in the short run, it can lag behind.

Key Words: evolution of social norms, gender equality, structural change.

JEL: C72, C73, D13, J16, O41, O43

*Acknowledgements: We thank Christian Siegel, Wenya Cheng, Bishnu Gupta, Helmut Rainer, Antonio Parlavecchio, seminar participants at GRAPE conference and University of St Andrews, especially David Ulph, Paola Manzini, Radoslaw Stefanski and Ian Smith for helpful comments and discussions. The usual disclaimer applies.

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1 Introduction

Gender balance of power in a society is regulated by many institutions such as religious traditions, legal systems and social norms. These institutions not only vary across countries but can also change over time. Our paper proposes a growth model explaining the evolution of gender equality.

We use a popular assumption that social institutions evolve towards the largest probability of survival. This idea was formulated by behavioural biologists (Hamilton 1964, Levin and Kimer, 1974) and has been accepted and developed by economists (Frank, 1998; Bergstrom, 1995; Alger and Weibull, 2010, 2012). Ceteris paribus, a society which produces larger economic output can afford a stronger defence and will survive in a hostile environment with a greater probability. Its institutions are also more attractive for imitation by other communities. Therefore, it is reasonable to assume that social norms evolve towards those which maximise social output. We apply that concept to explain the evolution of gender balance of power. See Giuliano (2017) for an overview of empirical literature on differences in gender roles such as labourforce participation, fertility, education, marriage, domestic violence etc., which indicate women's position within the family, in the work place and in society has been rising. There is a significant decrease in the gender wage gap (Blau, 1998; Edin and Richardson, 2002; Goldin, 2006; Mulligan and Rubinstein, 2008; Heathcote *et al*, 2010). The legal rights of women have improved, including earning, inheritance rights and divorce conditions (Geddes and Lueck, 2002; Doepke and Tertilt, 2009; Fernandez, 2014). These trends are accompanied by growing participation of women in the formal labour market (Fernandez, 2013) and their share of national political positions (Alesina *et al.* 2013). Figure 1 shows the recent trend in the ratio of female to male labour force participation for selected countries according to the world bank data[1].

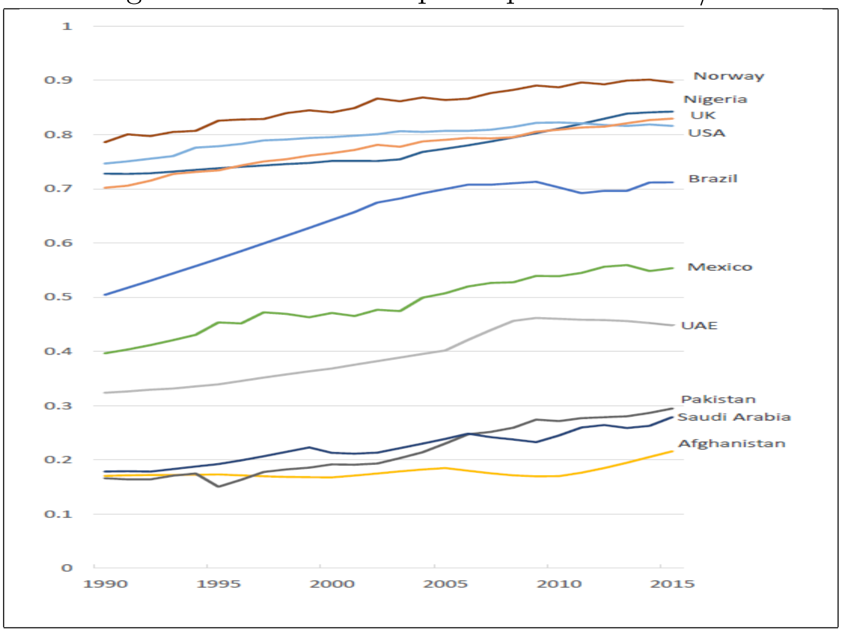
Basu (2006), Rainer (2008) and Iyigun and Walsh (2007) assume a woman's bargaining power depends on the relative amount of income she contributes to the household. Similarly, De la Croix and Vander Donckt (2010) assume that the bargaining power within a household depends on the earning abilities of the spouses and in particular, relative earning abilities of women will be higher in economies with a larger human capital intensive sector. These papers justify those assumptions by positive relations between higher human capital/ productivity and better outside option. We follow the same approach when modelling intra-household bargaining, but provide an alternative hypothesis to the assumptions. In our model, it is the total society which makes the decision about gender power. We adopt the idea that institutional design of the society develops towards maximisation of the social output to increase the probability of survival and external cultural influence of that particular society. To some extent, we justify the assumptions of Iyigun and Walsh (2007) and De la Croix and Vander Donckt (2010) about the endogeneity of gender bargaining power. In our paper female bargaining power is a proxy for institutional design which, defines the woman's outside option conditional on her human capital. Evolution of the divorce law or increasing social intolerance to domestic violence are examples of the change of the outside options for women, which we do not model for the sake of tractability. We prove that if the social norms are designed in a way that maximises the social output, then the bargaining power of the woman should be proportional to her share of the family production.

There are several theoretical models explaining the evolution of women's rights and labour force participation. According to Fernandez (2014), women liberalisation is facilitated through men being willing to grant more rights to their daughters. Doepke and Tertilt (2009) show how women's rights increase with higher returns to education and a wife's

[1] https://data.worldbank.org/

exclusive ability to educate children. Geddes and Lueck (2002) exploit the relationship between women's rights and their incentives to invest in productive effort and human capital accumulation. They investigate the male's choice between two institutions: *patriarch regime*, when only man's utility is maximised and *equal rights* regime. Our model on the other hand, allows for a continuous spectrum of women's rights in society measured as women's bargaining power over social income and, shows that the relative earning ability of the woman should depend on the structural composition of the social output. Our paper aims to explain the evolution of gender equality and relate it to economic growth and structural change in the production technology. Since we assume bargaining power within a household is determined by social norms which evolve towards maximising social output, these have an impact on the productive efforts of men and women. When the man is more productive, it is efficient to give him a larger share in the division of household product. If social norms are designed to maximise total output, the relative bargaining power of women should increase with their relative productivity. In modelling the endogeneity of gender power, our paper complements Echevarria and Merlo (1999), where parents make decisions about the educational investment in their sons and daughters to maximise total utility of the family, given the institutional design with endogenous gender power.

Figure 1. Labour force participation Female/Male

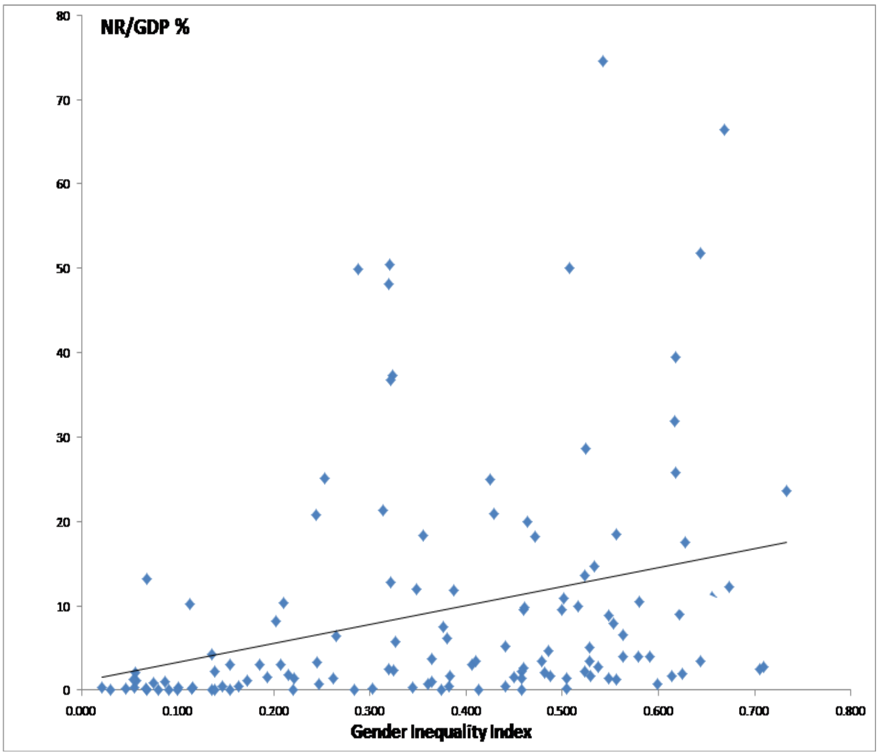


The production process in our model consists of three sectors: natural resources extraction, and two sectors which exploit physical and human capital respectively. Man's relative productivity is very high in resource extraction but it declines as physical capital accumulates. We assume a woman's productivity in the human capital intensive sector is not less than that of a man. The human capital/service sector relies on intellect and creativity. This sector includes child rearing, because these activities are creative in nature requiring high intensive human capital. The level and composition of the three production sectors change over time. In the early days of civilization, male physical strength was very important in resource extraction. As technology improved, relative productivity of men declined, incentivising women to participate in the labour market and educate themselves. That in turn increases the investment in human capital which improves total productivity, generating further structural changes in production technology favourable to women. We show that as long as human capital productivity is the same for both men and women, gender balance of power will eventually converge to equality.

Our theoretical model is consistent with recent empirical literature about the factors that are statistically significant in explaining gender inequality. According to Mulligan and Rubinstein (2008) and Heathcote *et al* (2010), the decrease in the wage gap should be attributed to the higher return to investment in human capital and also to the drift in technology towards those sectors where women have comparative advantages. Kury *et al* (2004) compare domestic violence across Europe and find the variation is explained by economic conditions. Rendall (2013, 2015) show that the structural changes in the labour market, requiring less brawn and more service oriented skills, have decreased the gender gap in the labour market participation. Alesina *et al.* (2013) find a male's relative productivity in the pre-industrial period explains the variation in gender inequality today.

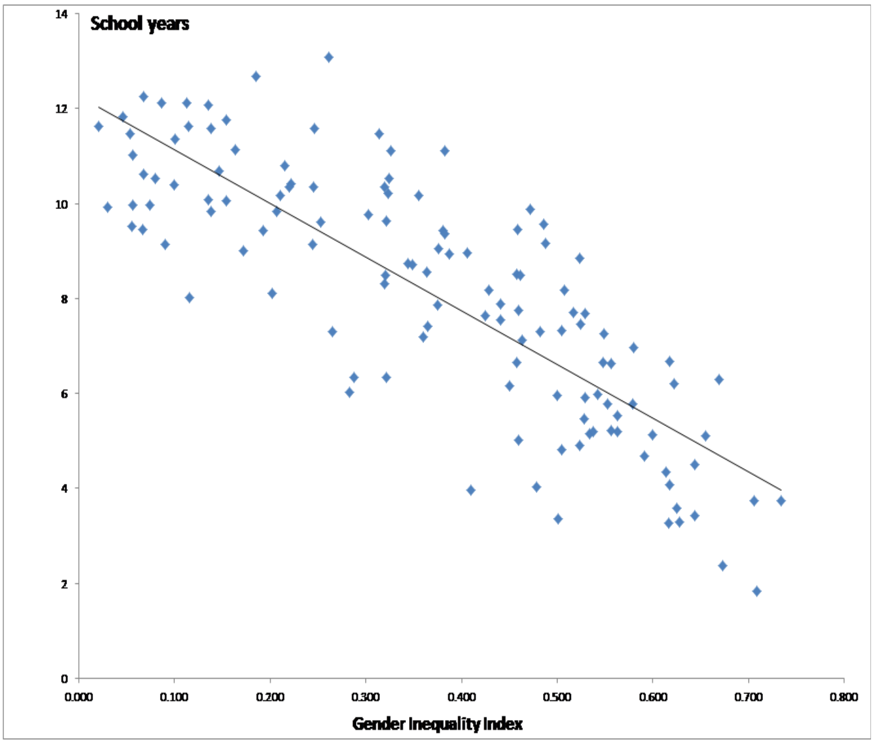
The inclusion of natural resources in the total production is an important facet of our model which allows for an alternative explanation of the "curse of resources", shown by Papyrakis and Gerlagh (2007). Their results are consistent with our model which predicts that an economy with more resources will not only grow at a lower rate but also experience higher gender inequality. The size of the resource sector in our model can be a proxy to the relative male productivity in the pre-industrial time. Indeed, Alesina *et al.* (2013) report strong empirical evidence that a "plough positive" community have norms which are less gender equal. Our model provides a theoretical support to that relation. Higher the share of the natural resources sector within total output, relative productivity of women will be lower, which would not only result in lower bargaining power for women, but also lower investment in human capital by both men and women. On the other hand, higher human capital being used in production will result in higher relative productivity of women, which will give them more bargaining power. According to the UN Development Report[2], Gender Inequality Index (GII) has a positive correlation with the percentage of natural resources per GDP in 2013 across countries (Figure 2) but has a negative correlation with the number of years in school (Figure 3).

Figure 2. GII and Natural resources



[2]http://hdr.undp.org/en/data.

Figure 3. GII and Education



With the accumulation of human capital, the optimum gender balance of power evolves towards equality as would the social norm on gender equality. However, there could be a time lag on a society adopting the gender balance of power which maximises social output. We show that a faster adaptation of the optimum level would lead to higher economic growth. This paper goes further than just showing how social norms evolve towards gender equality over time. We explore the outcome if an economy adopts gender equality prematurely through some intervention. Our simulations provide some interesting and useful insights. In the short run, an economy with gender equality can lag behind an economy where gender balance of power maximises social output. Gender equality is less beneficial in terms of current social output in an economy which is less developed. However, in the long run a gender equal economy can outperform an economy which maximises current output. This is because gender equality will induce higher accumulation of human capital which is beneficial for future generations, thus propelling the economy forward.

The rest of the paper is organised as follows. In Section 2, we present an economic environment with a representative household comprising a man and a woman. For the given level of development, we compute the gender balance of power which would have been the best for that particular generation. In Section 3, we apply a traditional economic growth framework for the accumulation of both physical and human capital. Further, we add an adaptive motion for social norms, assuming that they evolve towards the optimal value for society. In Section 4, we perform an empirical analysis to strengthen the theoretical findings. Section 5 concludes the paper.

2 One Generation Economy

We investigate a representative household composed of a man and a woman contributing to the household's total production. Throughout the model, superscript $j = m, w$ denotes agent j being a man or a woman, respectively. We consider a simple production function

$$Y^j = \left(A^j e^j\right)^\beta, \tag{1}$$

where Y^j is the production output of j, which increases concavely with effort e^j. The term A^j captures some parameters which influence the productivity. where $\beta < 1$ is the effort elasticity of production. The joint family income of the household is given by Y,

$$Y = Y^m + Y^w. \tag{2}$$

Following Chiappori (1988) we assume that the woman and man receive different shares of the family output, which is an outcome of the Nash bargaining process, where f^w and f^m correspond to the bargaining powers of w and m respectively.[3] As a result of Nash bargaining, each agent j receives a proportion $f^j \in [0,1]$ of the total household production for consumption, C^j, where $f^w + f^m = 1$. This proportion is determined by the bargaining power of w and m which is generally accepted as the social norm

$$C^j = f^j Y. \tag{3}$$

The net utility of j is U^j. It increases with consumption, C^j, and decreases with effort, e^j,

$$U^j = u(C^j) - V(e^j), \tag{4}$$

where $u_C > 0$ and $u_{CC} < 0$. The disutility of effort is convex: $V_e > 0$, $V_{ee} > 0$. We assume the following functional forms for the purpose of our analysis and simulations

$$u = \frac{C^\sigma}{\sigma};\ V = \frac{e^{1+v}}{1+v}. \tag{5}$$

where $0 < \sigma \leq 1$ and $v \geq 1$.

2.1 Bargaining Power and Production

The decision problems are the same for both the man and the woman who are similar in everything except for their productivity and bargaining power. Given f^w, the woman maximises her utility by choosing the level of effort as shown in (6).

$$\underset{e^w}{Max}\ u\left[f^w\left(Y^w\left(e^w\right) + Y^m\right)\right] - V(e^w). \tag{6}$$

The first-order condition given by (7) defines the woman's supply of effort

$$f^w u_C\left(f^w Y\right) Y^w_{e^w} - V_{e^w} = 0. \tag{7}$$

Similarly, the man's decision is given by

$$f^m u_C\left(f^m Y\right) Y^m_{e^w} - V_{e^m} = 0. \tag{8}$$

The purpose of our paper is to investigate the evolutionary process which maximises social output and therefore the survival productivity of the community which adopts particular social norms about women's position, f^w. Given the effort supply decisions of m and w, we calculate f^w which would maximise social product Y.

[3] This assumption is common in the literature. See, for example, Basu (2006), Rainer (2008) and Iyigun and Walsh (2007), De la Croix and Vander Donckt (2010).

Applying the implicit function theorem, we can prove that j's effort increases with j's bargaining power. However, we cannot increase the bargaining power of the woman without decreasing that of the man. The social return on extra effort e^j depends on productivity A^j and we expect that output maximising solution would be to give a larger share to a more productive person. We can check this formally.

First, we define socially desirable norms.

Definition 1 *Social norms, f^{w*}, are the most desirable in society $S := (A^m, A^w)$ if they maximise the output Y given in production function (1) and private choice of efforts (7, 8).*

The corresponding first-order conditions imply Proposition 1.

Proposition 1 *The optimal relative bargaining power is equal to the relative output, $\frac{f^{w*}}{f^{m*}} = \frac{Y^w}{Y^m}$.*

Proof. *See Appendix A* ■

Proposition 1 states that the man's share should be larger when his relative output is higher. On the whole, it is optimal to give a higher share to the agent who is more productive, in order to encourage higher social output.

For further reference, it is convenient to define the relative parameters. Let $\hat{e}$, $\widehat{A}, \widehat{Y}$ and $\widehat{f}$ be the woman's relative choice of effort, productivity, production and balance of power respectively

$$\hat{e} = \frac{e^w}{e^m}; \; \widehat{A} = \frac{A^w}{A^m}; \; \widehat{Y} = \frac{Y^w}{Y^m}; \; \widehat{f} = \frac{f^w}{f^m}. \tag{9}$$

Note that Proposition 1 only presents the partial equilibrium result as the production of the man and woman are endogenous to their choice of effort. The effort supply equations (7, 8) imply

$$\frac{f^w u_c\left(f^w Y\right) Y_e^w e^w}{f^m u_c\left(f^m Y\right) Y_e^m e^m} = \frac{V_e^w e^w}{V_e^m e^m}, \tag{10}$$

which for the constant elasticity functional forms (5) gives

$$\left(\hat{f}\right)^{\sigma} \hat{Y} = (\hat{e})^{v+1}. \tag{11}$$

Combining this with production function (1), we get relative effort and relative output as a function of relative productivity and gender inequality given by (12) and (13).

$$\hat{e} = \left(\widehat{A}\right)^{\frac{\beta}{v+1-\beta}} \left(\hat{f}\right)^{\frac{\sigma}{v+1-\beta}}. \tag{12}$$

$$\hat{Y} = \left(\widehat{A}\right)^{\frac{\beta(v+1)}{v+1-\beta}} \left(\hat{f}\right)^{\frac{\beta\sigma}{v+1-\beta}}. \tag{13}$$

As expected, $\frac{d\hat{e}}{d\widehat{f}} > 0$. When the share obtained by the woman increases, it has a positive effect on her effort and a negative effect on the man's effort, $e_f^w > 0, e_f^m < 0$.

Using Proposition 1 and equation (13), the optimum female balance of power can be written as

$$\widehat{f}^* = \left(\widehat{A}\right)^{\frac{\beta(v+1)}{(v+1)-\beta(\sigma+1)}}. \tag{14}$$

The optimum balance of power is what would maximise total production. An important observation from this result is that the relative share received by j positively depends on j's relative productivity, $\frac{d\widehat{f}^*}{d\widehat{A}} > 0$. When the man is given more power (i.e. when $\hat{f}$ is low), it will incentivise him to put in more effort, but it will discourage the woman. So long as the increase in his production is higher than the decrease in the woman's production, the total production will be larger. We summarise these conclusions in Proposition 2.

Proposition 2 *An increase in relative productivity results in higher relative effort, increasing relative production and larger socially-optimal gender balance of power.*

Proposition 2 provides a formal justifications to the wide-spread assumption that the relative bargaining power should be proportional to the relative productivity of the contributer. This assumption is adopted in Iyigun and Walsh (2007) and De la Croix and Vander Donckt (2010), who assume that relative bargaining power is proportional to the relative human capital. In the next section, which outlines some economic factors that explain relative productivity, we clarify this assumption and show that in a dynamic economy the relative productivity of the woman should also depend on the structural composition of the social output. We will also show that female bargaining power increases not only with her own level of education, but also with the share of the human capital intensive sector in the economy.

2.2 Production Technology

Now we will explain the difference in productivity between men and women. Our production process consists of three sectors. The first, *natural resource sector,* uses available natural resources and manual labour. This includes hunting, fishing, gathering fruits and vegetables, building shelter, ploughing, mining etc. In the industrial era it also includes the extraction of natural resources such as oil and minerals. The second, *physical capital sector*, produces with the aid of machinery. Finally, *human capital sector,* produces using creativity and brain power, rather than physical strength. Activities which fall into the later category would not only be the high-tech industry, financial services, research and development, but also the efficient organisation of daily activities, management, creative work, entertainment and other services which require competence and skills. These activities include child rearing, educating children and creative household production which could be contracted out to the service industry. Some papers (Including De la Croix and Vander Donckt, 2010) postulate that child bearing and rearing reduces women's availability for productive work which, is disadvantageous to their bargaining power.[4] However, according to their own estimation the value of this disadvantage can be very small and in some countries (including France, USA and Ireland) they estimate it to be even negative.. We have not considered bearing and rearing children as detrimental to total production, but as something which adds to the household production as part of the human capital sector.

We assume that female relative productivity is highest in the human capital sector. As the economy develops, human capital accumulates and this sector becomes more important in production. That creates an increase in female relative productivity, and consequently, a greater social gain from an increase in female bargaining power.

We consider effort, e^j, to be devoted to the production in each of these sectors, namely natural resource, physical capital and human capital, denoted by r^j, l^j and h^j, respectively.

$$e^j = r^j + l^j + h^j. \tag{15}$$

The total productivity of j in each given sector depends on the existing level of resources in the whole economy as well as j's own productivity in that particular sector. The aggregate level of production factors, such as natural resources, physical capital and human

[4] This argument is presented also in Folbre(2008), Turchi (1975).

capital, are denoted by R, K and H, respectively. They indicate the existing development in corresponding sectors. The productivity of individual j in sector s for given level of resources is denoted by a_s^j, $s = r, l, h$.

The total output is a consolidation of sectorial effective efforts. The total effective effort of j is as given in (16),

$$A^j e^j = \left[\left(a_r^j R r^j\right)^{\frac{\varepsilon}{\varepsilon+1}} + \left(a_l^j K l^j\right)^{\frac{\varepsilon}{\varepsilon+1}} + \left(a_h^j H h^j\right)^{\frac{\varepsilon}{\varepsilon+1}} \right]^{\frac{\varepsilon+1}{\varepsilon}}, \tag{16}$$

where $\varepsilon > 1$ is the elasticity of substitution.[5] The aggregate effective effort increases with the input of each sector at a diminishing rate. Moreover, the sectorial inputs are complementary so that an increase in input in one sector would raise the productivity of input in another.

2.2.1 Sectorial Labour Supply

The objective of j is to maximise own net utility U^j in (4) by choosing r^j, l^j and h^j subject to (15) and (16). As it is proven in Appendix B, the solution implies that the following share of effort would be chosen to be spent on each sector.

$$\frac{r^j}{e^j} = \left(\frac{a_r^j}{A^j} R\right)^{\varepsilon}; \frac{l^j}{e^j} = \left(\frac{a_k^j}{A^j} K\right)^{\varepsilon}; \frac{h^j}{e^j} = \left(\frac{a_h^j}{A^j} H\right)^{\varepsilon}, \tag{17}$$

from which it follows that

$$\frac{r^j}{l^j} = \left(\frac{a_r^j}{a_k^j} \frac{R}{K}\right)^{\varepsilon}; \frac{r^j}{h^j} = \left(\frac{a_r^j}{a_h^j} \frac{R}{H}\right)^{\varepsilon}; \frac{h^j}{l^j} = \left(\frac{a_h^j}{a_k^j} \frac{H}{K}\right)^{\varepsilon}. \tag{18}$$

Therefore, the share of effort in each sector positively depends on the share of productivity. Not surprisingly, we find that both the man and the woman would spend more time in the sector where his or her productivity is higher. Moreover, a higher existing level of sectorial input would positively influence the time allocated to that sector. These findings are presented in Proposition 3.

Proposition 3 *The relative sectorial effort depends positively on the relative productivity of that sector as well as the existing level of relative inputs.*

Proposition 3 implies ceteris paribus, both men and women would spend more time in the human capital sector, h, compared to resource extraction, r, when either human capital, H, is higher or the level of natural resources, R, is lower. In Section 3 we will use this to explain cross country economic development.

2.2.2 Sectorial Productivity and Balance of Power

The total productivity per unit of effort can be computed by combining (16) and (17)[6].

$$A^j = \left(\left(a_r^j R\right)^{\varepsilon} + \left(a_l^j K\right)^{\varepsilon} + \left(a_h^j H\right)^{\varepsilon} \right)^{\frac{1}{\varepsilon}}. \tag{19}$$

[5] Card and DiNardo (2002) use the same type of function for productivity of high-skilled and low-skilled workers to show that human capital and physical capital complement each other, making the other more productive.

[6] Notice that $\frac{\partial A^j}{\partial a_s^j} > 0$, which indicates that any increase in sectorial productivity will increase total productivity.

From Proposition 2, the optimal balance of power increases with the relative productivity defined as

$$\hat{A} = \frac{A^w}{A^m} = \left(\frac{(a_r^w R)^\varepsilon + (a_k^w K)^\varepsilon + (a_h^w H)^\varepsilon}{(a_r^m R)^\varepsilon + (a_k^m K)^\varepsilon + (a_h^m H)^\varepsilon} \right)^{1/\varepsilon}. \tag{20}$$

It is straightforward to notice that $\frac{\partial \hat{A}}{\partial a_s^w} > 0$; $\frac{\partial \hat{A}}{\partial a_s^m} < 0$ and it gives us the following Proposition.

Proposition 4 *Optimal female balance of power $\widehat{f^*}$ increases with her sectorial productivity and reduces with the man's sectorial productivity,* $\frac{\partial \widehat{f^*}}{\partial a_s^w} > 0$; $\frac{\partial \widehat{f^*}}{\partial a_s^m} < 0$.

Proposition 4 implies that given everything else being equal, a country where women are more skilled in using productive resources will have lower gender inequality compared to a country where women are relatively less capable.

2.2.3 Relative Gender Sectorial Productivity

We impose the following assumptions on gender relative sector productivity, denoting $\frac{a_s^m}{a_s^w} = \hat{a}_s$:

$$\hat{a}_h \geq 1 > \hat{a}_k > \hat{a}_r. \tag{21}$$

Our assumptions are based on the following realities. When only natural resources are available ($K = 0$, $H = 0$), the productivity of women is, on average, lower than the productivity of men. This is because resource extraction requires physical strength, which means that $a_r^w < a_r^m$. If people had to survive without capital and education, it would be reasonable to assume that men would be able to produce more than women.

When we add physical capital to natural resources, we can still assume that men can produce relatively more, $a_k^w < a_k^m$. However the relative difference is smaller when capital is available as compared to when it is not. Therefore, an increase in capital will reduce the relative productivity of men.

Finally, we assume that women are at least as productive as men in the human capital sector. When technology requires knowledge and creativity, we assume that the productivity of women can be at least equal to that of men, $a_h^w \geq a_h^m$. That assumption is supported by number of empirical research, for example, Allen (2001) showed that the wage gap narrows in industries that are high-tech and R&D intense and that the gender wage gap becomes lower with education.[7]

2.2.4 Sectorial Size and Gender Balance of Power

Gender balance of power can be affected not only by the relative productivity, but also by the relative size of the sectors, R, K and H. According to (14) and (20),

$$\widehat{f^*} = \left[\frac{(a_r^w R)^\varepsilon + (a_k^w K)^\varepsilon + (a_h^w H)^\varepsilon}{(a_r^m R)^\varepsilon + (a_k^m K)^\varepsilon + (a_h^m H)^\varepsilon} \right]^{\frac{(v+1)\beta}{\varepsilon(v+1-\beta(\sigma+1))}}. \tag{22}$$

By direct differentiation of (22), we prove the next Proposition in Appendix C.

[7] See also Machin and McNally (2005); Charles and Luoh (2003); Dollar and Gatti (1999), Hill and King (1995), Schultz(1995, 2002), Klasen (2002), Klasen and Lamanna (2009), Knowles et al (2002), Barro and Lee (1994), Buchmann and DiPrete (2006), Heckman and Macurdy (1980), Psacharopoulos (1994) and Deolikar (1993).

Proposition 5 *The optimal female balance of power,* $\widehat{f}^*$*, (1) increases with the level of human capital* H*; (2) decreases with natural resources,* R*, (3) increases with physical capital,* K *when* $\hat{a}_k$ *is sufficiently high and* H/R*,* $\hat{a}_r$ *and* $\hat{a}_h$ *are sufficiently low.*

An important finding is that a woman's relative productivity as well as her bargaining power are higher if she lives in a society with a higher level of human capital. This is due to the fact that her relative productivity is the highest in the human capital sector.

$$\frac{d\hat{A}}{dH} > 0, \quad \frac{d\hat{f}^*}{dH} > 0. \tag{23}$$

Similarly, female relative productivity is lowest in the natural resources sector. Therefore, when the share of natural resources is higher, the man's total productivity will be higher, thus resulting in the socially optimal female bargaining power being lower,

$$\frac{\partial \widehat{f}^*}{\partial R} < 0. \tag{24}$$

That result can partly explain Alesina *et al.* (2013) who showed that the communities, with more productive land in the preindustrial period, have developed more unequal gender roles.

The role of physical capital is ambiguous. In developing countries with lower levels of human capital, the use of machinery reduces the importance of physical strength which reduces the relative productivity of men. When the human capital to natural resource ratio is low, the accumulation of physical capital will give women more power. However, in a society with a relatively high level of human capital, extra physical capital may reduce the bargaining power of women.

$$\frac{\partial \widehat{f}^*}{\partial K} > 0, \text{ iff } \frac{H}{R} < \left[\frac{\left((\hat{a}_l)^\varepsilon - (\hat{a}_r)^\varepsilon\right)}{\left((\hat{a}_h)^\varepsilon - (\hat{a}_l)^\varepsilon\right)}\right]^{1/\varepsilon} \frac{a_r^m}{a_h^m}. \tag{25}$$

3 Economic Growth

Now that we have analysed how a representative man and woman allocate their effort in a static model, we move on to investigate how this set up affects the production in successive periods. We use a simple growth model to analyse this issue within a dynamic framework. The similar dynamics can be derived if we consider either a Dynasty Model or Overlapping Generations Model with altruism[8]. However, as the purpose of our paper is to emphasise the role of the structural change in total production on female bargaining power, we use the restricted version of the dynamic equation, purely for tractability and presentation.

The physical capital changes over time as in Solow (1956)

$$K_{t+1} = (1-\delta) K_t + \varphi Y_t, \tag{26}$$

where δ is the rate of depreciation and φ is the proportion of output which is saved and invested in capital.

Human capital accumulates according to Becker *et al* (1990)

$$H_{t+1} = \min(H_t + \omega \left(h_t^w + h_t^m\right)^{1-\theta} \left(H_t\right)^\theta, \overline{H}), \tag{27}$$

[8]Esriche et al (2004), Hauk and Saez- Marti (2002) Echevarria and Merlo.(1999), de la Croix and Vander Donckt (2010), Fernandez (2014).

where the investment in human capital, h_t^j, is chosen by j in period t. Equation (27) assumes that human capital accumulation depends not only on the time that the current generation spent working in the human capital sector, h_t^j, but also on the current level of knowledge and technology in the economy, H_t. Parameter ω represents the productivity of human capital formation; $\theta \in (0,1)$ captures the elasticity of human capital accumulation with respect to its current level; and $\overline{H}$ is the minimum level of knowledge skills which defines human society.

When it comes to natural resources, agricultural and animal husbandry can increase or be replaced. On the other hand, excessive hunting, mining or cultivation will result in depletion. We assume that the depletion rate is small and the amount of natural resources is stable over time and evolves as

$$R_{t+1} = \rho R_t, \tag{28}$$

where $\rho = 1$.

3.1 Evolution of Gender Balance of Power

Following the best tradition in the social evolution theory (Frank, 1998; Bergstrom, 1995; Alger and Weibull, 2010, 2012), we assume that social norms $\widehat{f}_t$ evolve towards the social optimum. At time t, the relative balance of power which maximises Y_t is $\widehat{f}_t^*$ as defined in (22). As both physical and human capital accumulate over time, the sectorial composition of total output changes. This will, in turn, amend the optimal $\widehat{f}_t^*$ towards which the evolutional forces drive the actual social norms, $\widehat{f}_t$.

We assume that although the gender balance of power may be far from its optimum value, it would gradually drift towards that level. Imperfect adjustment of social norms can explain the cultural persistence reported in Alesina *et al.* (2013). Slow adjustment may also be explained by slow social learning as in Fernandez (2013). The speed of social adaptation of the optimum norm of gender balance of power is captured by the parameter $\phi \in (0,1)$ as follows.

$$\hat{f}_t = (1-\phi)\hat{f}_{t-1} + \phi \hat{f}_t^{*}. \tag{29}$$

The larger is ϕ, the quicker does the society adapt the optimal gender balance power. Notice that $\hat{f}_t^{*}$ is what maximises Y_t, which means that $Y_t(\hat{f}_t) < Y_t(\hat{f}_t^{*})$. So output in each period will be higher if ϕ is higher. A faster adaptation does not necessarily mean a larger share for the woman, but the share which maximises total output. However, if $\hat{f}_t^{*} > \hat{f}_{t-1}$, an economy with faster adaptation will experience a higher $\hat{f}_t$. This helps us relate the speed of social reforms ϕ to economic growth.

Proposition 6 *If $\hat{f}_{t-1} < \hat{f}_t^{*}$, then a faster adaptation of the optimal balance of power promotes higher rate of economic growth.*
Proof. *See Appendix D.* ■

Next we work out the level to which some of the important variables converge. From (27), we can compute the growth rate of human capital:

$$\frac{H_{t+1} - H_t}{H_t} = \omega \left(\frac{h_t^w + h_t^m}{H_t} \right)^{1-\theta}, \tag{30}$$

which implies total human capital can be unlimited, $\lim_{t\to\infty} H_t = \infty$;. We can say the same about physical capital K_t; however, the rate of its growth is smaller than the growth of

H_t. There is a growing literature which empirically and theoretically argues that the more developed is a country, the larger is the share of the high-skilled sector (Barany and Siegel 2015, Buera and Kaboski, 2012a, 2012b; Eichengreen and Gupta, 2011; Jorgenson and Timmer, 2011). For the parameters that we use in our simulation, the human capital sector grows much faster than the other sectors,

$$\lim_{t\to\infty} K_t/H_t = 0. \tag{31}$$

In that case, the optimal relative balance of power $\widehat{f}_t^*$ converges to a power function of the relative productivity in the human capital sector:

$$\begin{aligned}
\lim_{t\to\infty} \widehat{f}_t^* &= \lim_{t\to\infty} \widehat{A}_t^{\frac{\beta(v+1)}{v+1-\beta(\sigma+1)}} \\
&= \lim_{t\to\infty} \left[\frac{(a_r^w R_t)^\varepsilon + (a_k^w K_t)^\varepsilon + (a_h^w H_t)^\varepsilon}{(a_r^m R_t)^\varepsilon + (a_k^m K_t)^\varepsilon + (a_h^m H_t)^\varepsilon}\right]^{\frac{1}{\varepsilon}\frac{\beta(v+1)}{v+1-\beta(\sigma+1)}} \\
&= \hat{a}_h^{\frac{\beta(v+1)}{v+1-\beta(\sigma+1)}}.
\end{aligned} \tag{32}$$

If $\hat{a}_h = 1$, then $\lim_{t\to\infty} \widehat{f}_t^* = 1$ which corresponds to total gender equality. However, if $a_h^w > a_h^m$, then $\lim_{t\to\infty} \widehat{f}_t^* > 1$, which means that women's social position may converge to a level which is even higher than that of men.

Proposition 7 *When $\lim_{t\to\infty} K_t/H_t = 0$, the optimum balance of power converges to a level which only depends on the relative productivity of human capital; if $a_h^w \gtreqless a_h^m$, then $\lim_{t\to\infty} \widehat{f}_t^* \gtreqless 1$.*

3.2 Economic Development and Endowment of Resources

In this section, we simulate economic development within the framework of our model. We find that although the limit of $\widehat{f}^*$ does not depend on the original level of natural resources, the transition does. It would be useful to do some simulations to understand the path of the variables. We use the parameter values as in Table 1. Notice that human capital productivity is assumed to be the same for men and women.

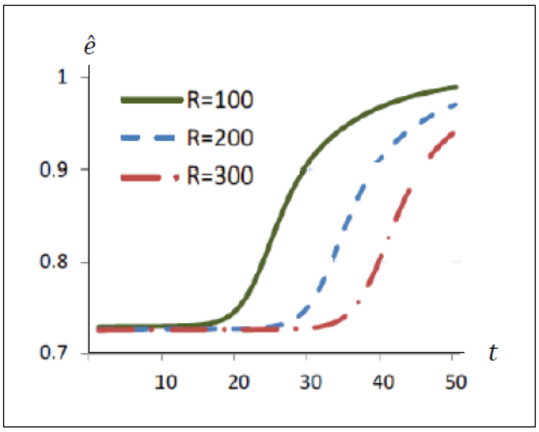
Table 1. Parameter values

	a_r^w	a_k^w	a_h^w	a_r^m	a_k^m	a_h^m	β	σ	v	φ	θ	H^0	ε	ω	ϕ
value	2	15	30	4	20	30	0.5	0.9	2	0.3	0.9	1	3	0.2	0.1

3.2.1 Relative Effort

As physical capital and human capital increase over time, there is an increase in the relative productivity of women resulting in their willingness to choose a higher level of effort. Moreover, the model predicts that relative effort $\hat{e}$ would be lower in countries which start with a larger endowment of natural resources, as shown in Figure 4. Since women's relative productivity in the natural resource sector is lower than that of men, their relative effort is lower in countries with higher natural resources. Even without including religious and cultural barriers which could exist in some countries, this model explains why the labour participation rates of women are lower in countries with high levels of natural resources.

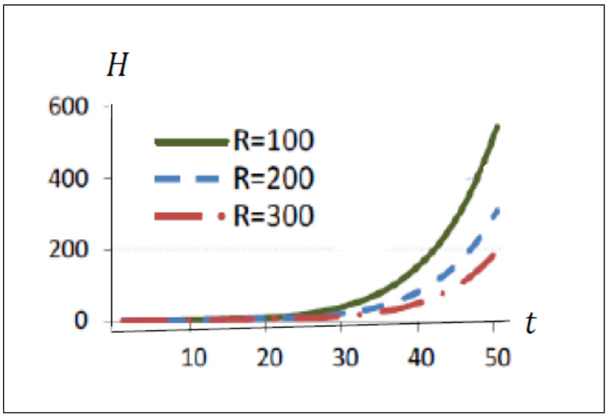
Figure 4. Evolution of Relative Effort



3.2.2 Human Capital

Figure 5 shows that in a country with more natural resources human capital is accumulated at a lower speed. This is quite intuitive because the comparative advantage in natural resource extraction demotivates society from investing in human capital.

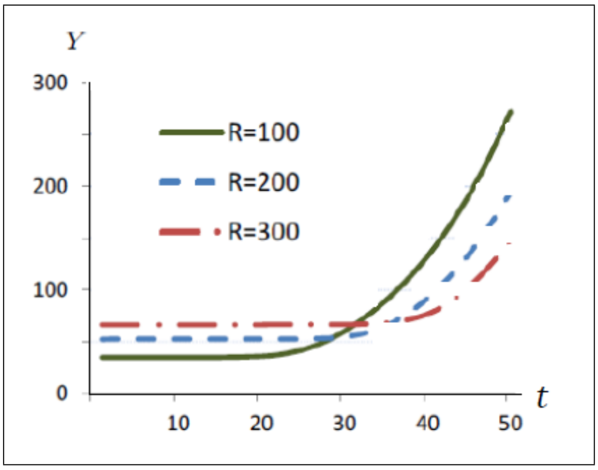
Figure 5. Evolution of Human Capital



3.2.3 Production

Agents in an economy with a larger level of natural resources spend a larger proportion of effort on resource extraction and less time on activities which develop human capital. Such an economy starts off with a higher income because of low return to scarce human capital. Agents, in an economy which is not endowed with much natural resources, would devote more effort to education and accumulate human capital faster. Over time, the country with lower natural resources will have a higher level of output because it would have accumulated a larger amount of human capital. The simulation shows this effect clearly in Figure 6. This result is consistent with Papyrakis and Gerlagh (2007), where the curse of natural resources is empirically documented.

Figure 6. Evolution of Output.

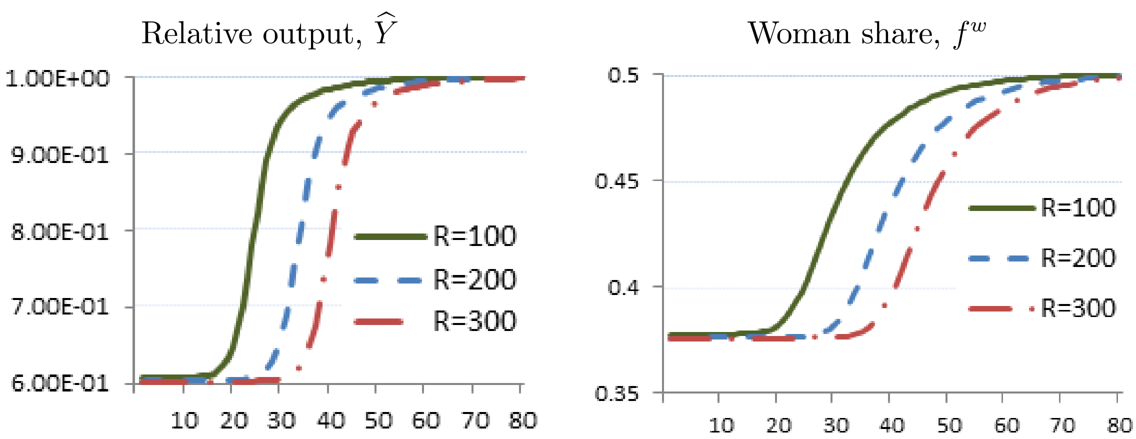


3.2.4 Relative Productivity and Balance of Power

Economic development happens through the accumulation of knowledge. Over time, as human capital increases, the share of production shrinks in the other two sectors. Moreover, an individual will allocate a larger proportion of efforts to the human capital sector as it becomes the most productive. Since women are as productive as their male counterparts in the human capital/service sector, a higher proportion of the service sector in the production structure will lead to an increase in female relative productivity. As women's relative productivity rises, so does their bargaining power. Figure 7 demonstrates that relative production and balance of power increase over time and converge to equality.

Figure 7 also shows that in a country with a higher level of natural resources, women have lower relative productivity as well as bargaining power at any point in time. That observation is consistent with empirical evidence reported in Alesina *et al.* (2014) who found that higher relative productivity of the male in pre-industrial time negatively affects gender equality even today.

Figure 7. Evolution of Relative Output and Balance of Power



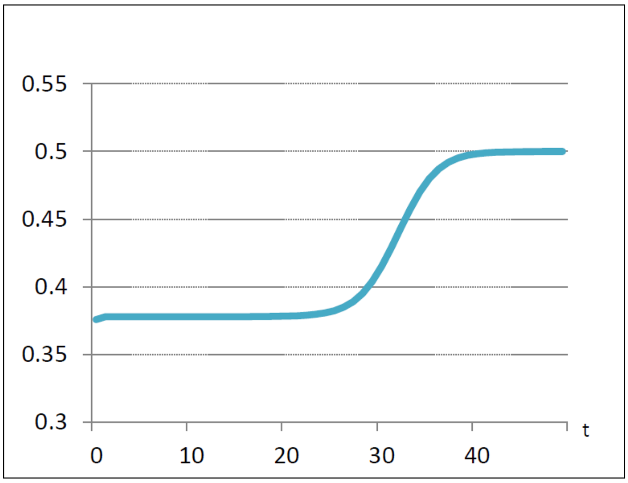
3.3 Premature Gender Equality and Economic Growth

We have seen that gender equality is output maximising when a country is sufficiently developed and that as an economy becomes more developed it also evolves towards being a gender equal society. In less developed economies with relatively low level of human capital, more gender equality results in lower social product. In this section, we analyse what would happen to an economy if and outside force intervened to implement gender equality.

Our simulations show that in the long run, an economy where gender equality is enforced at an early stage of its development can outperform an economy where gender balance is designed to maximise social output. The reason is that in a gender-equal economy, more resources are diverted to the accumulation of human capital and it is accumulated at a higher rate. On the one hand, since women are less productive, incentivising their effort at the expense of men will reduce total output, because it would discourage the higher productive man from producing. On the other hand, women will concentrate their effort in the human capital sector rather than resource extraction and therefore their empowerment will speed up the structural changes in the economy. That will lead to larger investment in human capital which will grow faster. In the long run, this earlier switch to human capital sector will pay off and an economy with gender equality will overtake the one which maximises social output.

To demonstrate what happens when there is premature gender equality through intervention, we run the following simulation. First we generate an economy where gender power is designed to maximise the social output without any postponement in the rigidities in evolution. The graph in Figure 8 represents female bargaining power in such an economy. It is interesting to see that inequality persists for a significant period of time before there is a sudden emancipation (in our simulations it occurs at around period 26).

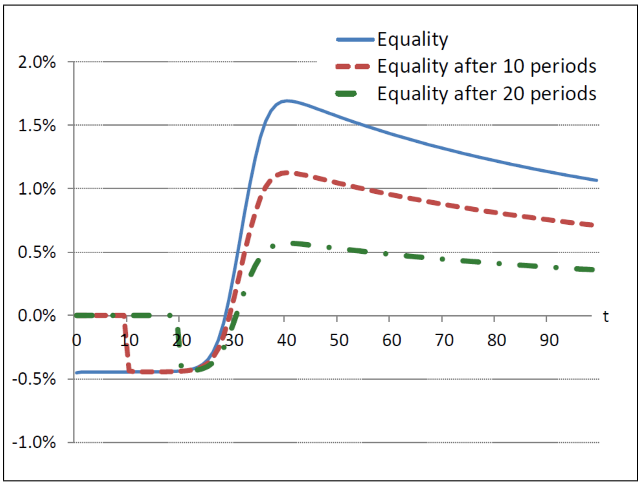
Figure 8. Output Maximising f^w



Next we simulate three economies which start from the same level of endowment and differ only by the period of time when gender equality is introduced. In the first economy, we introduce gender equality from the beginning. We allow the second and the third economy to develop for 10 and 20 periods respectively before introducing gender equality. Figure 9 shows the relative social output in those three economies as compared to an economy which developed at its own pace without any promotion of gender equality - i.e. the lines present the percentage difference in output and human capital between "gender equal policy" and "output maximising policy" in the three economies. The y-axis indicates

$\left(1 - \frac{Y_{\text{output maximising economy}}}{Y_{\text{gender equal economy}}}\right) * 100\%.$

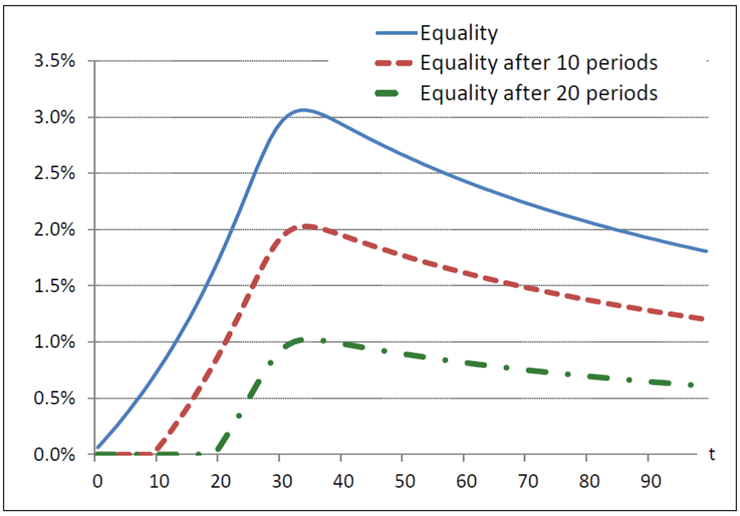
Figure 9. Percentage Difference in Output



We can see that premature introduction of gender equality results in immediate loss of social output compared to an output maximising path. The continuous blue line, which represents the economy which introduced gender equality at the very beginning, shows how it can be at a state of low output for a longer period than those which introduced gender equality later. What is interesting to note is that the economy which introduced gender equality first, grows faster and at a larger scale at the period of emancipation, and stays more advanced for many periods thereafter. This is because gender equality promotes faster accumulation of the human capital.

Figure 10 depicts the relative stock of human capital for the three economies mentioned above. The difference became positive immediately after the introduction of gender equality and stays positive thereafter.

Figure 10. Relative Stock of Human Capital with Gender Equality



We can see that an economy with gender equality may stay behind for a long time in terms of social output. However, it always has a higher level of human capital. Eventually, since the human capital is the most productive, an economy with gender equality will outperform an economy which maintain gender balance of power which maximises social output. The gain may realise in the distant future and whether it is socially desirable depends on the social discount factor. We can say that gender equality is welfare improving if social time discount factor equals one (Ramsey, 1928), which means that the welfare of the current generation is as important as the welfare of the future generations.

4 Empirical Analysis

In this section we carry out a simple empirical analysis to test the predictions of our theoretical model. First, we estimate the variables that affect gender inequality, testing the effect of natural resources, physical capital and human capital. Then, we do a panel data analysis of the effect gender inequality has on the economy. The various data sources and the summary statistics of the variables are presented in Appendix E. There are various proxies that can be used to capture the level of gender equality between women and men, such as labour market participation, years of schooling, life expectancy, bank account holding etc. What we consider as gender equality in our model goes deeper than any one of these factors. This is why we decided to use the *Gender Inequality Index* which encompasses several forms of gender inequalities and seemed the most appropriate variable to represent what is in our theoretical model.[9]

4.1 Factors Affecting Gender Inequality

In order to test the predictions of the theoretical model, we carried out an ordinary least squares regression using 92 countries which are those with the relevant data available in the year 2014. The dependent variable is *Gender Inequality Index, denoted by* GII. The explanatory variables of particular interest are (1) natural resources, captured by rent from natural resources (oil, natural gas, coal, mineral and forest) as a percentage of GDP; (2) physical capital, proxied by energy usage as a percentage of GDP and (3) human capital, represented by the *Human Capital Index*, denoted by $NRpGDP$, $EnergypGDP$, and HCI respectively. The general economic climate of the country is controlled by Unemployment rate, denoted by UN. The natural logs are taken for these explanatory variables. The proxy for social norms is captured by the percentage of the population following different religions in each country. The appropriate functional form for the regression analysis, shown in (33), was chosen by checking for serial correlation, distributions of the variables, and the Ramsey RESET test.

$$\begin{aligned} GII_i &= \beta_0 + \beta_1 \ln NRpGDP_i + \beta_2 (\ln NRpGDP)_i^2 \\ &\quad + \beta_3 (\ln EnergypGDP)_i^2 + \beta_4 (\ln HCI)_i^2 \\ &\quad + \beta_5 (\ln UN)_i^2 + \boldsymbol{\beta}\mathbf{Religion}_i + u_i. \end{aligned} \tag{33}$$

The results of the OLS regression are presented in Table 2. The robust standard errors are shown within parenthesis while *, ** and *** indicate the level of significance to be 10%, 5% and 1%, respectively. Model I includes only the explanatory variables we are interested

[9]According to the UN Human Development Report, "GII measures gender inequalities in three important aspects of human development—reproductive health, measured by maternal mortality ratio and adolescent birth rates; empowerment, measured by proportion of parliamentary seats occupied by females and proportion of adult females and males aged 25 years and older with at least some secondary education; and economic status, expressed as labour market participation and measured by labour force participation rate of female and male populations aged 15 years and older." http://hdr.undp.org/en/content/gender-inequality-index-gii

in. Model II includes all the control variables while Model III checks the robustness of the variables which are significant.

Table 2. OLS regression of factors affecting Gender Inequality Index

	GII		
	I	II	III
$\ln NRpGDP_i$	0.0290^{***} (0.0049)	0.0311^{***} (0.0053)	0.0294^{***} (0.0049)
$(\ln NRpGDP)_i^2$	0.0034^{***} (0.0009)	0.0032^{***} (0.001)	0.0033^{***} (0.0009)
$(\ln EnergypGDP)_i^2$	-0.0039^{***} (0.00122)	-0.0038^{***} (0.0011)	-0.0039^{***} (0.00123)
$(\ln HCI)_i^2$	-0.1888^{***} (0.0312)	-0.1787^{***} (0.0315)	-0.1903^{***} (0.031)
$(\ln UN)_i^2$		-0.0024 (0.0038)	
$Buddhist_i$		0.0143 (0.0926)	
$Christian_i$		0.0628 (0.0981)	
$Hindu_i$		0.1647 (0.1184)	
$Islam_i$		0.0063 (0.1058)	
$Otherreligion_i$		0.1265^{**} (0.0579)	0.0898^{**} (0.0407)
$Noreligion_i$		-0.1061 (0.1514)	
R^2	0.7977	0.8230	0.8020
RESET test $(P > F)$	0.3449	0.0335	0.2450
Number of observations	92	92	92

The independent variables capturing the three sectors of interest, namely the natural resources, physical capital and human capital, show the signs predicted by the theoretical model and are statistically significant. First, the results confirm at the 1% significance level that the level of natural resources increases gender inequality, in other words, has a negative effect on gender equality. Further, the effect is even more at higher levels of $NRpGDP$. The next theoretical prediction is that physical capital (use of machinery etc.) will increase gender equality, as will human capital. Our empirical results confirm this at the 1% significance level by indicating GII will reduce when there is an increase in both the use of energy and the human capital index and moreover, the effect of HCI is higher. Neither the main religions nor unemployment rate play a significant role. As suggested by the theoretical model, the key to the level of gender equality is the production function - how much the economy relies on natural resources, physical capital and human capital.

4.2 Effect of Gender Equality on the Economy

Now that we have tested the predictions of the effect of the various sectors on gender bargaining power, we move to the next segment. If the model is a good description of reality, gender equality should result in economic growth. To test this, a panel data analysis is performed using the model shown in (34), with 129 countries and years 1990-2014 according to the availability of relevant data. The natural log of GDP per capita, $\ln GDPpc.$ is chosen as the dependent variable. The main explanatory variable is the natural log of *Gender Inequality Index,* $\ln GII.$ Then we control for some variables which capture the economic conditions and policies of the country: natural logs of unemployment rate, inflation, government expenditure as a percentage of GDP, exports and imports as a percentage of GDP and life expectancy, denoted by $\ln UN$, $\ln Inflation$, $\ln GovtpGDP$, $\ln Exp\_impGDP$ and $\ln Lifeex$ respectively. The regression included year fixed effects and country fixed effects, while standard errors are clustered by countries.

$$
\begin{aligned}
\ln GDPpc_{it} &= \beta_0 + \beta_1 \ln GII_{it} + \beta_2 (\ln GII)^2_{it} \\
&\quad + \beta_3 \ln UN_{it} + \beta_4 \ln Inflation_{it} \\
&\quad + \beta_5 \ln GovtpGDP_{it} + \beta_6 \ln Exp\_impGDP_{it} \\
&\quad + \beta_7 \ln Lifeex_{it} + u_{it}.
\end{aligned}
\tag{34}
$$

The results are shown in Table 3. It is clear from Model I that increase in the Gender Inequality Index has a negative effect on GDP per capita at 1% significance level, which confirms the prediction that gender equality will increase the total production. Furthermore, the results shown in Model II confirm the prediction that this effect is more so in developed economies at 5% significance level. The influence of gender equality on the output of poorer countries is ambiguous according to Model III where the sign is positive but not significant, which is consistent with our model discussed in section 3.3. The OECD countries were considered as developed, where the dependent variable is denoted by $\ln GDPpcRich$, while less developed countries are those listed by United Nations, denoted by $\ln GDPpcPoor$ [10].

Table 3. Panel regression of the effect of GII on GDP per capita

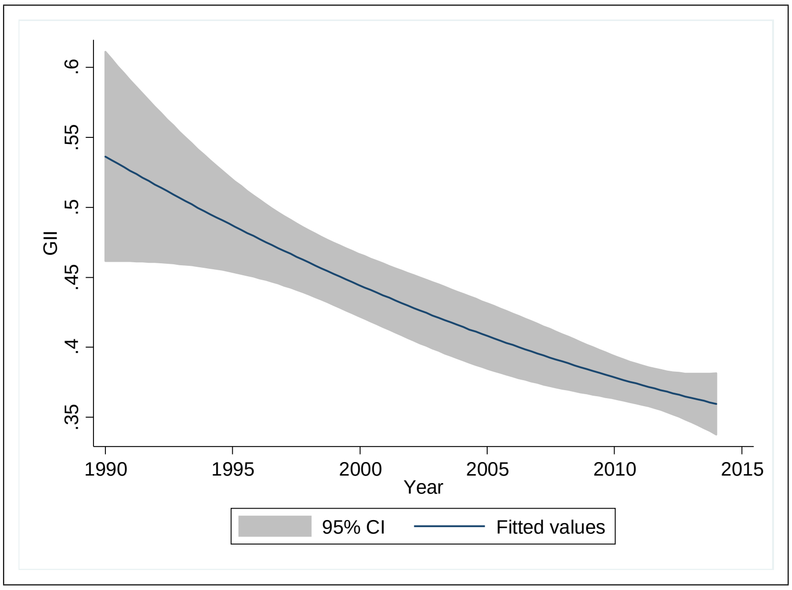
	I	II	III
	$\ln GDPpc$	$\ln GDPpcRich$	$\ln GDPpcPoor$
$\ln GII_{it}$	-0.4466^{*} (0.2469)	-0.523^{**} (0.2597)	1.3011 (1.2271)
$(\ln GII)^2_{it}$	-0.1185^{***} (0.0455)	-0.1046^{**} (0.0422)	1.2733 (1.0019)
$\ln UN_{it}$	-0.0981^{***} (0.0278)	-0.1145^{***} (0.0326)	-0.0656 (0.0414)
$\ln Inflation_{it}$	-0.0174^{**} (0.0085)	-0.0096 (0.0103)	-0.0051 (0.0194)
$\ln GovtpGDP_{it}$	-0.1304^{**} (0.0561)	-0.4054^{*} (0.2242)	-0.0692 (0.057)
$\ln Exp\_impGDP_{it}$	-0.0678 (0.0649)	-0.0321 (0.1191)	0.0141 (0.0892)
$\ln Lifeex_{it}$	0.7823^{***} (0.2835)	4.3385^{**} (1.7152)	0.8244 (0.5329)
Country fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R^2	0.9965	0.9916	0.9703
$Adj\ R^2$	0.9957	0.9894	0.9592
Observations	783	225	148
Countries	129	33	27

Finally, the panel data is used to analyse how GII has evolved over time. Keeping the countries clustered, it was found that GII reduced as years progressed at the 1% significance level, as shown in Figure 11.

[10] http://www.oecd.org/about/membersandpartners/list-oecd-member-countries.htm
UN list of Least Developed Countries: http://unctad.org/en/Pages/ALDC/Least%20Developed%20Countries/UN-list-of-Least-Developed-Countries.aspx

$$\hat{GII}_{it} = 14.8313 - \underset{(0.0006)}{0.0072}\hat{Year}_{it}^{***}. \tag{35}$$

Figure 11. Evolution of Gender Inequality Index



5 Conclusion

This paper explains the difference in the gender balance of power across countries and across time. We based our model on the assumption that social norms evolve towards those maximising economic production. We show that an increase in women's relative productivity will increase their bargaining power. The dynamic framework highlights the negative impact of natural resources and the positive impact of human capital on the evolution of female balance of power. The empirical analysis supports this prediction. The dynamic model predicts that the gender balance of power converges to equality when women are as productive as men in human capital intensive industries.

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Appendix

A. Proof of Proposition 1

The woman's share f is chosen to maximise Y, subject to the two effort supply equations

$$L^Y = (Y^m + Y^w) + s^w \left(f^w u_c^w Y_e^w - V_e^w\right) + s^m \left[(1-f^w) u_c^m Y_e^m - V_e^m\right]. \tag{A1}$$

The first-order conditions are presented below

$$\begin{aligned}
\frac{dL^Y}{df^w} &= s^w \left(u_c^w Y_e^w + f^w Y u_{cc}^w Y_e^w\right) - s^m f^m Y u_{cc}^m Y_e^m - s^m u_c^m Y_e^m = 0 \\
\frac{dL^Y}{de^w} &= Y_e^w + s^w \left[\left(f^w\right)^2 u_{cc}^w Y_e^w Y_e^w + f^w u_c^w Y_{ee}^w - V_{ee}^w\right] + s^m (f^m)^2 u_{cc}^m Y_e^m Y_e^w = 0 \\
\frac{dL^Y}{de^m} &= Y_e^m + s^w \left(\left(f^w\right)^2 u_{cc}^w Y_e^w Y_e^m\right) + s^m \left[(f^m)^2 u_{cc}^m Y_e^m Y_e^m + f^m) u_c^m Y_{ee}^m - V_{ee}^m\right] = 0.
\end{aligned} \tag{A2}$$

We solve the system using the functional forms $u^j = \frac{\left(C^j\right)^\sigma}{\sigma}$, $V^j = \varkappa \frac{\left(e^j\right)^{1+v}}{1+v}$. First, we define elasticity $\eta_{u_c,c}^j = \frac{f^j Y u_{cc}^j}{u_c^j}; \eta_{V_e,e}^j = \frac{V_{ee} e^j}{V_e}; \eta_{Y_e,e}^j = \frac{Y_{ee}^j e^j}{Y_e^j}; \eta_{Y,e}^j = \frac{Y_e^j e^j}{Y^j}$. We use that definition in the above equations to get

$$\begin{aligned}
\frac{dL^Y}{df^w} &= s^w u_c^w Y_{e^w}^w \left(1 + \eta_{u_c,c}^w\right) - s^m u_c^m Y_e^m \left(1 + \eta_{u_c,c}^m\right) = 0 \\
\frac{dL^Y}{de^w} &= Y_e^w + s^m f^m \eta_{u_c,c}^m u_c^m \frac{Y_e^m Y_e^w}{Y} + s^w \left[f^w \eta_{u_c,c}^w \frac{u_c^w}{Y} Y_e^w Y_e^w + f^w u_c^w \frac{Y_e^w}{e^w} \eta_{Y_e,e}^w - \eta_{V_e,e}^w \frac{V_e^w}{e^w}\right] = 0 \\
\frac{dL^Y}{de^m} &= Y_e^m + s^m \left[f^m \eta_{u_c,c}^m u_c^m \frac{Y_e^m Y_e^m}{Y} + f^m u_c^m \frac{Y_e^m}{e^m} \eta_{Y_e,e}^m - \eta_{V_e,e}^m \frac{V_e^m}{e^m}\right] + s^w f^w \eta_{u_c,c}^w u_c^w \frac{Y_e^w Y_e^m}{Y} = 0.
\end{aligned} \tag{A3}$$

We can rewrite this using the effort supply equation (7), $f^j u_c^j Y_e^j = V_e^j$

$$\begin{aligned}
\frac{dL^Y}{df^w} &= s^w u_c^w Y_e^w \left(1 + \eta_{u_c,c}^w\right) - s^m u_c^m Y_e^m \left(1 + \eta_{u_c,c}^m\right) = 0; \\
\frac{dL^Y}{de^w} &= Y_e^w + s^m f^m u_c^m Y_e^m \eta_{u_c,c}^m \frac{Y_e^w}{Y} + s^w u_c^w \frac{Y_e^w}{e^w} f^w \left[\eta_{u_c,c}^w \frac{Y_e^w e^w}{Y} + \eta_{Y_e,e}^w - \eta_{V_e,e}^w\right] = 0; \\
\frac{dL^Y}{de^m} &= Y_e^m + s^m f^m u_c^m \frac{Y_e^m}{e^m} \left[\eta_{u_c,c}^m \frac{Y_e^m}{Y} e^m + \eta_{Y_e,e}^m - \eta_{V_e,e}^m\right] + s^w u_c^w Y_{e^w}^w \left(f^w \eta_{u_c,c}^w \frac{Y_e^m}{Y}\right) 0.
\end{aligned} \tag{A4}$$

We substitute for one of the Lagrange multipliers, $s^m u_c^m Y_{e^m}^m = s^w u_c^w Y_{e^w}^w \frac{\left(1+\eta_{u_c,c}^w\right)}{\left(1+\eta_{u_c,c}^m\right)}$

$$
\begin{aligned}
\frac{dL^Y}{de^w} &= Y^w_{e^w} + s^w u^w_c Y^w_e \frac{1+\eta^w_{u_c,c}}{1+\eta^m_{u_c,c}} f^m \eta^m_{u_c,c} \frac{Y^w_e}{Y} + s^w u^w_c Y^w_{e^w} \frac{1}{e^w} f^w \left[\eta^w_{u_c,c} \frac{Y^w_e e^w}{Y} + \eta^w_{Y_e,e} - \eta^w_{V_e,e} \right] = 0, \quad \text{(A5)} \\
\frac{dL^Y}{de^m} &= Y^m_{e^m} + s^w u^w_c Y^w_e \frac{1+\eta^w_{u_c,c}}{1+\eta^m_{u_c,c}} f^m \frac{1}{e^m} \left[\frac{1}{Y} \eta^m_{u_c,c} Y^m_e e^m + \eta^m_{Y_e,e} - \eta^m_{V_e,e} \right] + s^w u^w_c Y^w_e f^w \eta^w_{u_c,c} \frac{Y^m_e}{Y} = 0.
\end{aligned}
$$

and combine this in one relation as

$$
\frac{Y^w_e e^w}{Y^m_e e^m} = \frac{\left(1+\eta^w_{u_c,c}\right) f^m \eta^m_{u_c,c} \frac{Y^w_e e^w}{Y} + \left(1+\eta^m_{u_c,c}\right) f^w \left[\eta^w_{u_c,c} \frac{Y^w_e e^w}{Y} + \eta^w_{Y_e,e} - \eta^w_{V_e,e} \right]}{\left(1+\eta^w_{u_c,c}\right) f^m \left[\frac{Y^m_e e^m}{Y} \eta^m_{u_c,c} + \eta^m_{Y_e,e} - \eta^m_{V_e,e} \right] + \left(1+\eta^m_{u_c,c}\right) f^w \eta^w_{u_c,c} \frac{Y^m_e e^m}{Y}}. \tag{A6}
$$

We simplify this further using elasticities

$$
\frac{\eta^w_{Y,e} Y^w}{\eta^m_{Y,e} Y^m} = \frac{\left(1+\eta^w_{u_c,c}\right) f^m \eta^m_{u_c,c} \eta^w_{Y,e} Y^w + \left(1+\eta^m_{u_c,c}\right) f^w \left[\eta^w_{u_c,c} \eta^w_{Y,e} Y^w + \left(\eta^w_{Y_e,e} - \eta^w_{V_e,e} \right) Y \right]}{\left(1+\eta^w_{u_c,c}\right) f^m \left[\eta^m_{Y,e} Y^m \eta^m_{u_c,c} + \left(\eta^m_{Y_e,e} - \eta^m_{V_e,e} \right) Y \right] + f^w \eta^w_{u_c,c} \left(1+\eta^m_{u_c,c}\right) Y^m \eta^m_{u_c,c}}. \tag{A7}
$$

In our simple case, when all functions have constant elasticities and the functional forms are the same for men and women, it can be simplified as $\frac{f^w}{f^m} = \frac{Y^w}{Y^m}$.

B. Proof of Proposition 3

The Lagrangian of the decision problem when choosing e^w and its allocation to the three sectors optimally by $j = w$ is solved below.

$$
\begin{aligned}
L &= \frac{\left[f((A^w e^w)^\beta + Y^M) \right]^\sigma}{\sigma} - \frac{(e^w)^{v+1}}{v+1} \\
&\quad -\mu \left[A^w e^w - \left((a^w_r R r^w)^{\frac{\varepsilon}{\varepsilon+1}} + (a^w_l K l^w)^{\frac{\varepsilon}{\varepsilon+1}} + (a^w_h H h^w)^{\frac{\varepsilon}{\varepsilon+1}} \right)^{\frac{\varepsilon+1}{\varepsilon}} \right] \\
&\quad -\lambda \left(-e^w + [r^w + l^w + h^w] \right),
\end{aligned} \tag{B1}
$$

The first-order conditions are

$$
\begin{aligned}
\frac{\partial L}{\partial A^w} A^w &= f\beta \left(A^w e^w \right)^\beta \left[f((A^w e^w)^\beta + Y^M) \right]^{\sigma-1} - \mu e^w A^w = 0; \\
\frac{\partial L}{\partial e^w} e^w &= f\beta \left(A^w e^w \right)^\beta \left[f((A^w e^w)^\beta + Y^M) \right]^{\sigma-1} - \mu A^w e^w - (e^w)^{v+1} + \lambda e^w = 0; \\
\frac{\partial L}{\partial r^w} r^w &= \mu \left(A^w e^w \right)^{\frac{1}{\varepsilon+1}} \left(a^w_r R r^w \right)^{\frac{\varepsilon}{\varepsilon+1}} - \lambda r^w = 0; \\
\frac{\partial L}{\partial l^w} l^w &= \mu \left(A^w e^w \right)^{\frac{1}{\varepsilon+1}} \left(a^w_l K l^w \right)^{\frac{\varepsilon}{\varepsilon+1}} - \lambda l^w = 0; \\
\frac{\partial L}{\partial h^w} h^w &= \mu \left(A^w e^w \right)^{\frac{1}{\varepsilon+1}} \left(a^w_h H h^w \right)^{\frac{\varepsilon}{\varepsilon+1}} - \lambda h^w = 0.
\end{aligned} \tag{B2}
$$

Summation of the last three equations results in

$$
\mu A^w e^w = \lambda e^w; \quad \lambda = \mu A^w. \tag{B3}
$$

Substituting this into the first-order condition, we get the following.

$$\begin{aligned}\frac{\partial L}{\partial r^w}r^w &= \mu\left(A^w e^w\right)^{\frac{1}{\varepsilon+1}}\left(a_r^w R r^w\right)^{\frac{\varepsilon}{\varepsilon+1}} - \mu A^w e^w \frac{r^w}{e^w} = 0; && \text{(B4)}\\ \left(\frac{a_r^w R r^w}{A^w e^w}\right)^{\frac{\varepsilon}{\varepsilon+1}} &= \frac{r^w}{e^w}; && \text{(B5)}\\ \frac{r^w}{e^w} &= \left[\frac{a_r^w R}{A^w}\right]^{\varepsilon}. && \text{(B6)}\end{aligned}$$

Similarly

$$\frac{l^w}{e^w} = \left[\frac{a_l^w K}{A^w}\right]^{\varepsilon}; \quad \frac{h^w}{e^w} = \left[\frac{a_h^w H}{A^w}\right]^{\varepsilon}. \tag{B7}$$

If we do the same exercise for $j = m$, we will get the same outcome.

C. Proof of Proposition 5

According to (14) and (20)

$$\ln \widehat{f}^* = \frac{(v+1)\beta}{\varepsilon\left(v+1-\beta\left(\sigma+1\right)\right)} \ln\left[\frac{\left(a_r^w R\right)^{\varepsilon} + \left(a_l^w K\right)^{\varepsilon} + \left(a_h^w H\right)^{\varepsilon}}{\left(a_r^m R\right)^{\varepsilon} + \left(a_l^m K\right)^{1+\varepsilon} + \left(a_h^m H\right)^{\varepsilon}}\right]. \tag{C1}$$

$$\frac{\partial \ln \widehat{f}^*}{\partial H} = \frac{(v+1)\beta}{\left[v+1-\beta\left(\sigma+1\right)\right]H}\left[\frac{\left(a_h^w H\right)^{\varepsilon}}{\left(a_r^w R\right)^{1+\varepsilon} + \left(a_l^w K\right)^{\varepsilon} + \left(a_h^w H\right)^{\varepsilon}} - \frac{\left(a_h^m H\right)^{\varepsilon}}{\left(a_r^m R\right)^{\varepsilon} + \left(a_l^m K\right)^{\varepsilon} + \left(a_h^m H\right)^{\varepsilon}}\right]. \tag{C2}$$

Therefore $\frac{\partial \widehat{f}^*}{\partial H} > 0$ if

$$\begin{aligned}\frac{\left(a_h^w H\right)^{\varepsilon}}{\left(a_r^w R\right)^{1+\varepsilon} + \left(a_l^w K\right)^{\varepsilon} + \left(a_h^w H\right)^{\varepsilon}} &> \frac{\left(a_h^m H\right)^{\varepsilon}}{\left(a_r^m R\right)^{\varepsilon} + \left(a_l^m K\right)^{\varepsilon} + \left(a_h^m H\right)^{\varepsilon}} && \text{(C3)}\\ \text{i.e. } \left(\left(a_r^m a_h^w\right)^{\varepsilon} - \left(a_r^w a_h^m\right)^{\varepsilon}\right)(R)^{\varepsilon} &> \left(\left(a_l^w a_h^m\right)^{\varepsilon} - \left(a_l^m a_h^w\right)^{\varepsilon}\right)(K)^{\varepsilon}.\end{aligned}$$

This is true due to the assumptions in (21) that $\left(\left(a_r^m a_h^w\right)^{\varepsilon} - \left(a_r^w a_h^m\right)^{\varepsilon}\right) > 0$; and $\left(\left(a_l^w a_h^m\right)^{\varepsilon} - \left(a_k^m a_h^w\right)^{\varepsilon}\right) < 0$. Hence, $\frac{\partial \widehat{f}^*}{\partial H} > 0$.

Similarly, by direct differentiation, we can prove that female bargaining power declines with the existing level of natural resources in the economy.

$$\frac{\partial \ln \widehat{f}^*}{\partial R} = \frac{(v+1)\beta}{\left(v+1-\beta\left(\sigma+1\right)\right)R}\left[\frac{\left(a_r^w R\right)^{\varepsilon}}{\left(a_r^w R\right)^{\varepsilon} + \left(a_l^w K\right)^{\varepsilon} + \left(a_h^w H\right)^{\varepsilon}} - \frac{\left(a_r^m R\right)^{\varepsilon}}{\left(a_r^m R\right)^{\varepsilon} + \left(a_l^m K\right)^{\varepsilon} + \left(a_h^m H\right)^{\varepsilon}}\right]. \tag{C4}$$

Notice that $\left(\left(a_h^m a_r^w\right)^{\varepsilon} - \left(a_h^w a_r^m\right)^{\varepsilon}\right)H^{\varepsilon} < \left(\left(a_l^w a_r^m\right)^{\varepsilon} - \left(a_l^m a_r^w\right)^{\varepsilon}\right)K^{\varepsilon}$, because $\left(\left(a_h^m a_r^w\right)^{\varepsilon} - \left(a_h^w a_r^m\right)^{\varepsilon}\right) < 0$; $\left(\left(a_l^w a_r^m\right)^{\varepsilon} - \left(a_l^m a_r^w\right)^{\varepsilon}\right) > 0$. Therefore, $\frac{\partial \widehat{f}^*}{\partial R} < 0$.

Finally, we can analyse the effect of physical capital accumulation on female bargaining power.

$$\frac{\partial \ln \widehat{f}^*}{\partial K} = \frac{\widehat{f}^*(v+1)\beta\varepsilon}{\varepsilon\left(v+1-\beta\left(\sigma+1\right)\right)R}\left[\frac{\left(\left(a_r^m a_l^w\right)^{\varepsilon} - \left(a_r^w a_l^m\right)^{\varepsilon}\right)(RK)^{\varepsilon} - \left(\left(a_h^w a_l^m\right)^{\varepsilon} - \left(a_h^m a_l^w\right)^{\varepsilon}\right)(HK)^{\varepsilon}}{\left(\left(a_r^w R\right)^{\varepsilon} + \left(a_l^w K\right)^{\varepsilon} + \left(a_h^w H\right)^{\varepsilon}\right)\left(\left(a_r^m R\right)^{\varepsilon} + \left(a_l^m K\right)^{\varepsilon} + \left(a_h^m H\right)^{\varepsilon}\right)}\right], \tag{C5}$$

which is positive if and only if the human capital to resource ratio is sufficiently small

$$\frac{H}{R} < \left[\frac{\hat{a}_l^\varepsilon - \hat{a}_r^\varepsilon}{\hat{a}_h^\varepsilon - \hat{a}_l^\varepsilon}\right]^{1/\varepsilon} \frac{a_r^m}{a_h^m}. \tag{C6}$$

D. Proof of Proposition 6

First, we will show that $\frac{dY_t}{d\phi} > 0$. Indeed $\frac{dY_t}{d\phi} = \frac{dY_t}{d\hat{f}_t}\left(\hat{f}_t^* - \hat{f}_t\right)$. As $\hat{f}_t - \hat{f}_t^* = (1-\phi)\left(\hat{f}_{t-1} - \hat{f}_t^*\right) < 0$, and $\hat{f}_t < \hat{f}_t^*$, therefore $\frac{dY_t}{d\hat{f}_t} > 0$.

Second, from equation (26) we conclude that a physical capital investment is larger for a bigger ϕ. Finally, we can also show that investment in human capital increases with ϕ.

$$\frac{h_t^w + h_t^m}{H^\varepsilon} = \left(\frac{a_h^w}{A^w}\right)^\varepsilon e^w + \left(\frac{a_h^m}{A^m}\right)^\varepsilon e^m. \tag{D1}$$

The effort decision function (7) implies that

$$e^w = \left(\frac{\beta}{\chi}\left(f^w\right)^{\sigma+1} Y^\sigma \left(A^w\right)^\beta\right)^{\frac{1}{v+1-\beta}}. \tag{D2}$$

Furthermore,

$$\frac{h_t^w + h_t^m}{H^\varepsilon} = \left(\frac{\beta}{\chi}Y^\sigma\right)^{\frac{1}{v+1-\beta}}\left[\left(\frac{a_h^w}{A^w}\right)^\varepsilon\left(\left(f^w\right)^{\sigma+1}\left(A^w\right)^\beta\right)^{\frac{1}{v+1-\beta}} + \left(\frac{a_h^m}{A^m}\right)^\varepsilon\left(\left(f^m\right)^{\sigma+1}\left(A^m\right)^\beta\right)^{\frac{1}{v+1-\beta}}\right], \tag{D3}$$

where $f^w = \frac{\hat{f}_t}{\hat{f}_t + 1}$ $f^m = \frac{1}{\hat{f}_t + 1}$ and $a_h^w = a_h^m$

$$\frac{h_t^w + h_t^m}{H^\varepsilon} = \left(\frac{\beta}{\chi}Y^\sigma\right)^{\frac{1}{v+1-\beta}}\left(a_h^w\right)^\varepsilon\left(A^m\right)^{\frac{\beta}{v+1-\beta}-\varepsilon}\left[\hat{f}_t + 1\right]^{-\frac{\sigma+1}{v+1-\beta}}\left[\widehat{A}^{\frac{\beta}{v+1-\beta}-\varepsilon}\hat{f}^{\frac{\sigma+1}{v+1-\beta}} + 1\right]. \tag{D4}$$

Consider the function

$$g(\hat{f}_t) = \left[\hat{f}_t + 1\right]^{-\frac{\sigma+1}{v+1-\beta}}\left[\widehat{A}^{\frac{\beta}{v+1-\beta}-\varepsilon}\hat{f}^{\frac{\sigma+1}{v+1-\beta}} + 1\right]. \tag{D5}$$

If $g(\hat{f}_t)$ is increasing, then human capital investment increases with $\hat{f}_t$

$$\begin{aligned}\hat{f}_t g' &= \left[\hat{f}_t + 1\right]^{-\frac{\sigma+1}{v+1-\beta}-1}\frac{\sigma+1}{v+1-\beta}\left[\left[\hat{f}_t + 1\right]\widehat{A}^{\frac{\beta}{v+1-\beta}-\varepsilon}\hat{f}^{\frac{\sigma+1}{v+1-\beta}} - \hat{f}_t\left[\widehat{A}^{\frac{\beta}{v+1-\beta}-\varepsilon}\hat{f}^{\frac{\sigma+1}{v+1-\beta}} + 1\right]\right] \\ &= \left[\hat{f}_t + 1\right]^{-\frac{\sigma+1}{v+1-\beta}-1}\frac{(\sigma+1)\hat{f}_t}{v+1-\beta}\left[\widehat{A}^{\frac{\beta}{v+1-\beta}-\varepsilon}\hat{f}^{\frac{\sigma+1}{v+1-\beta}-1} - 1\right].\end{aligned} \tag{D6}$$

As $\hat{f} < \hat{f}_t^* = \left[\hat{A}\right]^{\frac{\beta(v+1)}{(v+1-\beta(\sigma+1))}}$ and $\frac{\sigma+1}{v+1-\beta} < 1$

$$\widehat{A}^{\frac{\beta}{v+1-\beta}-\varepsilon}\hat{f}^{\frac{\sigma+1}{v+1-\beta}-1} > \hat{A}^{\frac{\beta(v+1)}{(v+1-\beta(\sigma+1))}\frac{\sigma-v+\beta}{v+1-\beta}+\frac{\beta}{v+1-\beta}-\varepsilon}. \tag{D7}$$

For $\widehat{A} < 1$, we need to show that $\frac{\beta(v+1)}{(v+1-\beta(\sigma+1))}\frac{\sigma-v+\beta}{v+1-\beta} + \frac{\beta}{v+1-\beta} - \varepsilon$ is negative, which is definitely true if $\varepsilon > \frac{\beta}{v+1-\beta}$.

E. Summary statistics

Data on GII is from http://hdr.undp.org/en/data; HCI is from https://www.rug.nl/ggdc/productivity and religious representation is from http://www.pewforum.org/2015/04/02/religious-projection-table/2010/number/all/. The rest of the data are from the world bank (https://data.worldbank.org/).

Table 4. Description of the variables

Variable	Description
GII	Gender Inequality Index[11]
$NRpGDP$	Rent from natural resources as a percentage of GDP (oil, natural gas, coal, mineral and forest)
$EnergypGDP$	Energy usage as a percentage of GDP
HCI	Index using years of schooling and returns to education
UN	Percentage of total labour force who are unemployed
$Religion$	Percentage of population practising major religions
$GDPpc$	GDP per capita (measured in constant 2010 US $)
$Inflation$	Annual growth rate of the GDP implicit deflator
$GovtpGDP$	All government current expenditures for purchases of goods and services as a percentatge of GDP
Exp_impGDP	Tatal exports and imports as a percentatge of GDP
$Lifeex$	Life expectancy at birth

Table 5. Summary statistics of the variables used for the OLS analysis

Variable	Observations	Mean	Std. Dev.	Min	Max
GII	127	0.3509	0.1883	0.043	0.757
$NRpGDP$	153	8.2951	11.1681	0.0004	54.1589
$EnergypGDP$	128	2634.609	3081.16	150.7341	18562.67
HCI	137	2.6308	0.6698	1.1926	3.7343
UN	155	8.0334	5.9322	0.198	28.03
$Buddhist$	159	0.443	0.1618	0	0.9669
$Christian$	159	0.5209	0.3714	0	0.98
$Hindu$	159	0.0245	0.1065	0	0.8134
$Islam$	159	0.2732	0.3745	0	0.9956
$Otherreligion$	159	0.0652	0.12180	0	0.8508
$Noreligion$	159	0.0794	0.1237	0	0.7575

Table 6. Summary statistics of the variables used for the Panel data analysis

Variable	Observations	Mean	Std. Dev.	Min	Max
$GDPpc$	4289	11928.47	17253.96	115.794	111968
GII	979	0.3948	0.1975	0.043	1.07547
UN	4399	8.5664	6.2622	0.16	44.157
$Inflation$	4285	41.7233	530.1547	-31.5659	26762
$Govt$	4090	16.1772	8.1498	2.0471	163.579
Exp_impGDP	3458	4.70e+17	4.78e+18	7.90e+11	8.90e+19
$Lifeex$	4534	67.9339	9.7183	27.61	84.278

[11] An index using factors related to education, health, labour market particpation and empowerment etc.