Economic Growth and Evolution of Gender Equality*

Tatiana Damjanovic † Geethanjali Selvaretnam‡

Abstract

We put forward a theoretical growth model where the degree of gender equality evolves towards the value maximising social output. It follows that a woman's bargaining power positively depends on her relative productivity. When an economy is less developed, physical strength is quite important for production and therefore the total output is bigger when the man has larger share of the reward. As society develops and accumulates physical and human capital, the woman becomes more productive, which drives social norms towards gender equality. By endogenising gender balance of power we can explain why it differs across societies and how it evolves over the time.

Key Words: gender inequality, economic growth, female bargaining power, human capital, natural resources

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

*Acknowledgements: We thank seminar participants at the University of St Andrews, especially David Ulph, Paola Manzini, Radoslaw Stefanski, Ian Smith and Helmut Rainer for helpful comments and discussions. The usual disclaimer applies.

†Business School, Durham University Stockton Road, Durham, DH1 3LE; Tel: 0044 (0)191 33 45198; email: tatiana.damjanovic@durham.ac.uk

‡Adam Smith Business School, University of Glasgow, G12 8QQ; Tel: 0044 (0)141 330 4496; email: Geethanjali.Selvaretnam@glasgow.ac.uk

1 Introduction

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

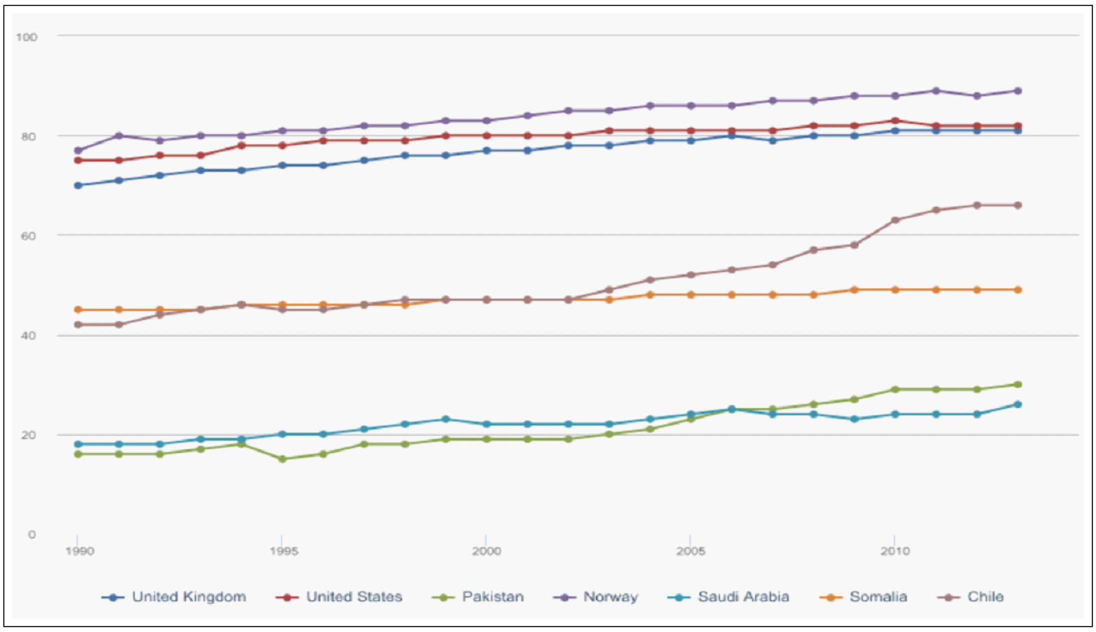
We will use a popular assumption that social institutions evolve towards the largest probability of survival. This idea was formulated by behaviour biologists (Hamilton 1964, Levin and Kimer, 1974) and has been accepted and developed by economists (Frank, 1998; Bergstrom, 1995; Alger and Weibull, 2010, 2012). Ceteris paribus, a society which produces larger economic output can afford a stronger defence and will survive with a larger probability in a hostile environment. 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 the social output. We apply that concept to explain the evolution of gender balance of power.

Women have been subjected to many forms of discrimination within the family, workplace and society throughout history. This discrimination can start even before birth in some regions where boys are preferred to girls for various reasons, resulting in sex selective abortions and deaths of baby girls (Bhaskar and Gupta, 2007; Edlund and Lee, 2013; Almond et al, 2009). Many religions and cultures encourage women to be subservient to men. This is implicitly reflected in the evidence of domestic abuse. Borooah and Mangan (2009) found that women are eight times more likely to be subjected to spousal attacks in Australia and six times more likely in Canada. Kury et al (2004) compare domestic violence across Europe and say that the variation is explained by general tolerance towards domestic violence, economic conditions and cultural outlook on women and their position.

An increasing trend in women's position in society, labour market and family during the last century has been observed and documented in academic literature and it has been shown that gender wage gap has significantly decreased [Blau, 1998; Edin and Richardson, 2002; Goldin, 2006; Mulligan and Rubinstein, 2008; Heathcote et al., 2010. According to Dugan et al (1998) domestic homicide rate has been reduced in the US over the past 25 years. Farmer and Tiefenthaler (2003) empirically show that increase in economic conditions of women and better legal provision for victims have played a role in the reduction of domestic violence over the recent past.

Although female balance of power has increased over time, its level and the rate of increase is different across countries. Figure 1 shows the recent trend in the percentage of female to male labour force participation for a few countries.[1]

Figure 1. Labour force participation Female/Male, percentage



It would be interesting to investigate the reasons behind the improvement of female bargaining power. According to Mulligan and Rubinstein (2008) and Heathcote at al (2010), the decrease in wage gap should be accounted to the higher return to investment in human capital and also to change in technology towards the sector where women have comparative advantages. Farmer and Tiefenthaler (2003) suggested that the main reason behind reduction of the domestic violence is contemporary law enforcement.

We go one step further and provide a model which endogenises the design of legal environment, social norms and institutions and relates their evolution to economic growth causing structural change in production technology. We model social norms as gender bargaining power which affect men's and women's productive effort and investment in human capital. When man is more productive, it is efficient to give him larger share in the division of family product. If social norms are designed to maximise the total output, the relative bargaining power of woman should increase with her relative productivity. This is consistent with the assumption of Iyigun and Walsh (2007) that bargaining power between husband and wife depends on their relative labour income. Our model relates gender balance of power and economic growth by endogenising woman's relative productivity.

The production process in the model comprises of three sectors - natural resources, physical capital and human capital. Our assumption is that man's relative productivity is

[1]Source: www.databank.worldbank.org

very high in resource extraction sector but it declines when physical capital accumulated. Furthermore, we assume that the marginal productivity of a woman with respect to human capital is not less than that of a man. 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, his relative productivity declines and therefore the social institution evolved towards lower gender inequality. That in turn, incentivises female education and labour market participation. Over time, as human capital accumulates, total production keeps increasing and relative productivity of man declines, which increases female bargaining power. So long as human capital productivity is the same for both man and woman, gender balance of power will converge to equality.

The inclusion of natural resources in the household production is an important facet of our model which allows for an alternative explanation of the "curse of resources". The relative productivity of women is negatively related to the share of the natural resources sector within the total output. According to the UN Development Report, 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

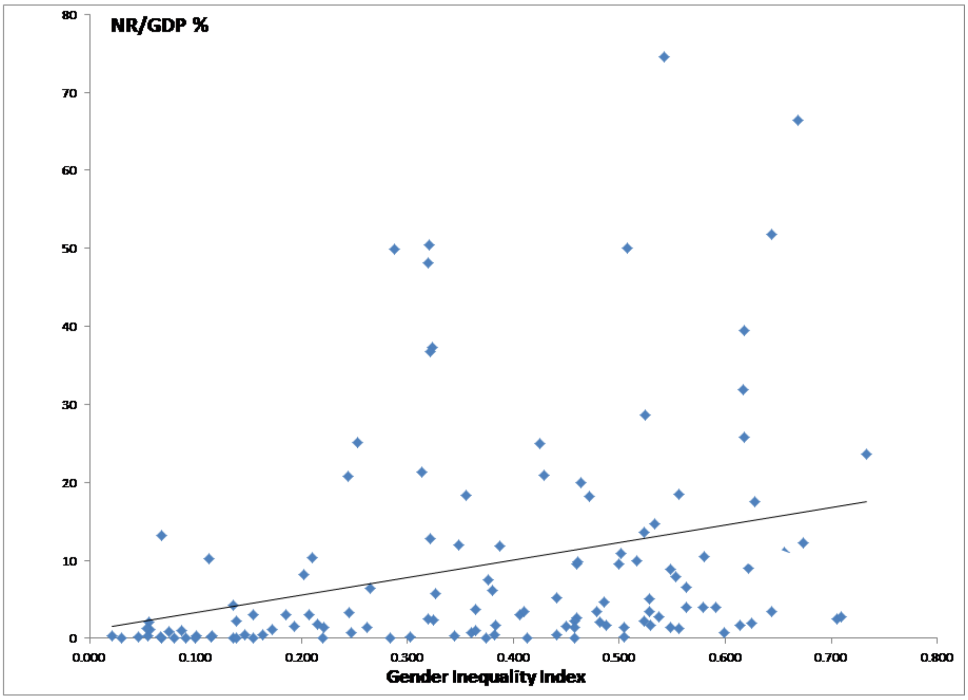
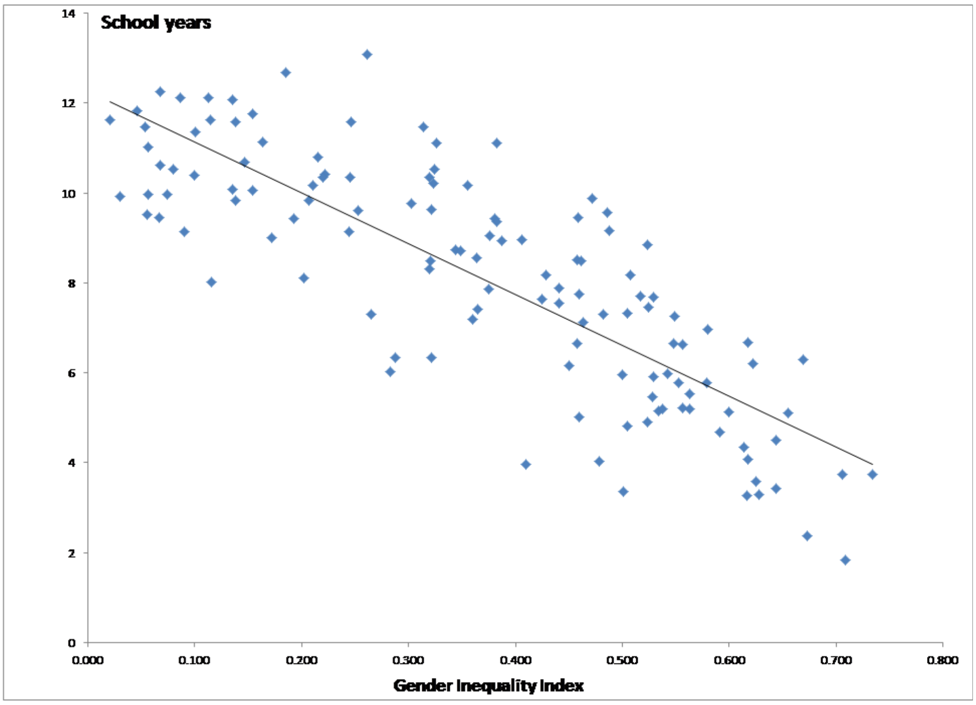


Figure 3. GII and Education



Our model predicts that an economy which is richer in natural resources would not invest much in human capital, which in turn would reduce the consumption share of women. The curse of resources as empirically found by Papyrakis and Gerlagh (2007), is 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 equality. However, if additional resources are discovered at a later stage of development when human capital is already accumulated, the effect can be small as in the case of Norway.

The rest of the paper is organized as follows. The static model is presented in Section 2. In Section 3, the dynamic growth model and the results of the simulations are given. The empirical analysis using regression models is performed to strengthen the theoretical findings which is found in Section 4. Section 5 concludes.

2 Static Model

We investigate a representative household in an economy made up 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 woman respectively. We consider a simple production function (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.

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

where $\beta < 1$ is effort elasticity of production. The joint family income of the household is given by Y,

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

Each agent j receives a proportion $f^j \in [0, 1]$ of the total household production for consumption ($f^w + f^m = 1$). This proportion is determined by the bargaining power of w and m which is generally accepted as the social norm

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

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 $u_{CC} < 0$. Furthermore, we assume that $0 < -\frac{Cu_{CC}}{u_c} < 1$, so that j's relative risk aversion is between zero and one. Disutility of effort is convex: $V_e > 0, V_{ee} > 0, V_{eee} > 0$. 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

Decision problems are the same for both the man and 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).[2]

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

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

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

[2]The second order condition is satisfied because $u^j_{CC}, Y^j_{e^W e^W} < 0$.

$$f^2 u^w_{CC} Y^w_{e^w} Y^w_{e^w} + f u^w_c Y^w_{e^w e^w} - V^w_{e^w e^w} < 0.$$

The man's decision is similar. Applying the implicit function theorem to condition (7) we can prove that the woman's effort increases with her bargaining power. However we cannot increase the bargaining power of woman without decreasing that of the man's. The social return on extra effort e^j depends on the 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 it formally.

Given the effort supply decisions of m and w, we calculate f^w which would maximise social product Y. The first order conditions imply the following proposition.

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. It is optimal on the whole to give a higher share to the agent who is more productive to encourage higher production.

For further reference, it is convenient to define 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.

$$\hat{e} = \frac{e^w}{e^m}; \ \widehat{A} = \frac{A^w}{A^m}; \ \widehat{Y} = \frac{Y^w}{Y^m}; \ \widehat{f} = \frac{f}{1-f}. \tag{8}$$

Notice that Proposition 1 presents only the partial equilibrium result as the production of the man and woman are endogenous to their choice of effort. The effort supply equations imply

$$\frac{f^w u_c\left(f^w Y\right) Y_e^w e^w}{f^m u_c\left(f^m Y\right) Y_e^m e^m} = \frac{V_e^w e^w}{V_e^m e^m}, \tag{9}$$

which for the constant elasticity functional forms (5) gives

$$\left(\hat{f}\right)^{\sigma} \hat{Y} = (\hat{e})^{v+1}. \tag{10}$$

Combining it with production function (1), we get relative effort and relative output as a function of relative productivity and gender inequality.

$$\hat{e} = \left(\widehat{A}\right)^{\frac{\beta}{v+1-\beta}} \left(\hat{f}\right)^{\frac{\sigma}{v+1-\beta}}. \tag{11}$$

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

As expected, $\frac{d\hat{e}}{d\hat{f}} > 0$. 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 (12) optimum balance of power can be written as

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

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 depend 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 higher. We can therefore conclude that when the relative productivity $\widehat{A}$ is lower, $\widehat{f}^{*}$ would be lower, as stated in Proposition 2.

Proposition 2 *An increase in relative productivity results in higher relative effort, relative production and balance of power.*

2.2 Structural Composition

Now we will explain the difference in productivity between man and woman. 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, weaving etc. Here we also include extraction of the 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 this category would not only be those such as the high-tech industry, financial services etc., but also efficient organisation of daily activities, management, creative work, art and entertainment etc.

We will 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 causes an increase in female relative productivity, and consequently on female bargaining power.

We consider effort e^j to be devoted by j 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.

$$e^j = r^j + l^j + h^j \tag{14}$$

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 inputs natural resources, physical capital and human capital, are denoted by R, K and H respectively, which in other words indicate the existing size of the setors. The productivity of individual j in sector s for a given level of resource is denoted by a_s^j, $s = r, l, h$.

What is produced due to the effort allocated to each sector can be considered a basket of sectorial effective efforts. The total effective productivity of j is as given in (15),

$$A^j e^j = \left[\left(a_r^j R r^j \right)^{\frac{\varepsilon}{\varepsilon+1}} + \left(a_l^j K l^j \right)^{\frac{\varepsilon}{\varepsilon+1}} + \left(a_h^j H h^j \right)^{\frac{\varepsilon}{\varepsilon+1}} \right]^{\frac{\varepsilon+1}{\varepsilon}}, \tag{15}$$

where $\varepsilon > 1$ is the elasticity of substitution.[3] The aggregate effective effort increases with each sector's input at a diminishing rate. Moreover, the sectors' 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 (14) and (15). As proved in Appendix B, the first order conditions imply that the following share of effort would be chosen to be spent on each sector.

$$\frac{r^j}{e^j} = \left(\frac{a_r^j}{A^j} R \right)^{\varepsilon}; \frac{l^j}{e^j} = \left(\frac{a_k^j}{A^j} K \right)^{\varepsilon}; \frac{h^j}{e^j} = \left(\frac{a_h^j}{A^j} H \right)^{\varepsilon}, \tag{16}$$

from which it follows that

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

The share of effort in each sector positively depend on the share of productivity. Not surprisingly, we find that both the man and woman would spend more time in the sector where his or her productivity is higher. Moreover, 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.*

[3] 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.

2.2.2 Sectorial Productivity and Balance of Power

The total productivity per unit of effort can be computed by combining (15) and (16).

$$A^j = \left(\left(a_r^j R\right)^\varepsilon + \left(a_l^j K\right)^\varepsilon + \left(a_h^j H\right)^\varepsilon\right)^{\frac{1}{\varepsilon}}. \tag{18}$$

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 relative productivity defined as

$$\hat{A} = \frac{A^w}{A^m} = \left(\frac{\left(a_r^w R\right)^\varepsilon + \left(a_k^w K\right)^\varepsilon + \left(a_h^w H\right)^\varepsilon}{\left(a_r^m R\right)^\varepsilon + \left(a_k^m K\right)^\varepsilon + \left(a_h^m H\right)^\varepsilon}\right)^{1/\varepsilon}. \tag{19}$$

It is straight forward 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 *Woman's 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 less capable.

2.2.3 Relative Gender Sectorial Productivity

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

$$\hat{a}_h \geq 1 > \hat{a}_k > \hat{a}_r \tag{20}$$

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

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

Finally, we assume that women are at least as productive as men in the human capital sector. When technology requires knowledge, we assume that the productivity of women can be equal to men or can even be larger.$a_h^w \geq a_h^m$. That assumption is supported by number of empirical research. Allen (2001) empirically showed that wage gap narrows in industries that are high-tech and R&D intense and that gender wage gap is lowering with education.[4]

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 (13) and (19),

$$\widehat{f}^* = \left[\frac{(a_r^w R)^\varepsilon + (a_k^w K)^\varepsilon + (a_h^w H)^\varepsilon}{(a_r^m R)^\varepsilon + (a_k^m K)^\varepsilon + (a_h^m H)^\varepsilon} \right]^{\frac{(v+1)\beta}{\varepsilon(v+1-\beta(\sigma+1))}}. \tag{21}$$

which we use in Appendix C to prove the next Proposition.

Proposition 5 *Optimal 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* $\hat{a}_l$ *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 is higher if she lives in a society with higher level of human capital. This is because her relative productivity is highest in the human capital sector.

$$\frac{d\hat{A}}{dH} > 0, \quad \frac{d\hat{f}^*}{dH} > 0. \tag{22}$$

On the other hand, female relative productivity is lowest in the natural resources sector. Therefore, when the share of natural resources is higher, man's total productivity will be higher resulting in lower female bargaining power which would be optimum for the society.

$$\frac{\partial \widehat{f}^*}{\partial R} < 0. \tag{23}$$

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

[4]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).

reduces the relative productivity of men. When human capital to natural resource ratio is low, accumulation of physical capital will empower women. However, in a society with relatively high level of human capital, extra physical capital may reduce female bargaining power.

$$\frac{\partial \widehat{f}^{*}}{\partial K} > 0 \text{ if } \frac{H}{R} < \left[\frac{\left((\hat{a}_l)^{\varepsilon} - (\hat{a}_r)^{\varepsilon}\right)}{\left((\hat{a}_h)^{\varepsilon} - (\hat{a}_l)^{\varepsilon}\right)}\right]^{1/\varepsilon} \frac{a_r^m}{a_h^m}. \tag{24}$$

3 Dynamic Model

Now that we have analysed how a representative man and woman allocate their effort in a static model, we would like 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 physical capital changes over time as in Solow (1956)

$$K_{t+1} = (1-\delta) K_t + \varphi Y_t, \tag{25}$$

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

Human capital accumulates according to Becker et al (1990)

$$H_{t+1} = H_t + \omega \left(h_t^w + h_t^m\right)^{1-\theta} \left(H_t\right)^{\theta} \tag{26}$$

where the investment in human capital, h_t^j, is chosen by j in period t according to the decision problem introduced in the static model. Formula (26) assumes that capital accumulation depends on the time which the current generation spent working in the human capital sector, h_t^j, but also on the current level of technological knowledge in the economy, H_t. Parameter ω represents the productivity of the human capital formation; and $\theta \in (0,1)$ captures the elasticity of human capital accumulation with respect to its current level.

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. Countries which rely a lot on depleting natural resources are those which consider the resource to be plenty. So in a sense, we can consider the depletion rate to be quite small. In this paper, change of natural resources appears as a parameter rather than a choice variable because we want to concentrate on gender balance of power. We ensure that R_t is always positive by setting the evolution of natural resources to be

$$R_{t+1} = \rho R_t, \tag{27}$$

where we assume that $\rho \leq 1$.

3.1 Evolution of Gender Balance of Power

Following the best tradition in the social evolution theory (Frank, 1998; Bergstrom, 1995; Anger and Weibul, 2010, 2012) we assume that social norms $\widehat{f}_t$ evolve towards social optimum. At time t the relative balance of power which maximises Y_t, is $\widehat{f}_t^*$ as defined in (21). Over the time as physical and human capital are accumulated, the sectorial composition of the national output changes. That 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 gender balance of power may be far from its optimum value, it would gradually drift towards that level. The speed of social adaptation of the optimum norm of gender balance of power is captured by the parameter $\phi \in (0, 1)$ as following

$$\hat{f}_t = (1 - \phi)\hat{f}_{t-1} + \phi \hat{f}_t^* . \tag{28}$$

The larger is ϕ, the quicker the society adapts the optimal gender balance power. Notice that $\hat{f}_t^*$ is what maximises Y_t, which means $Y_t(\hat{f}_t) < Y_t(\hat{f}_t^*)$. So the output in each period will be higher if ϕ is higher. Faster adaptation does not necessarily mean more 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 higher $\hat{f}_t$. This helps us to relate the speed of social reforms ϕ to economic growth.

Proposition 6 *If $\hat{f}_{t-1} < \hat{f}_t^*$, then 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 (26) we can compute the growth rate of human capital

$$\frac{H_{t+1} - H_t}{H_t} = \omega \left(\frac{h_t^w + h_t^m}{H_t} \right)^{1-\theta}, \tag{29}$$

which implies that 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 that the growth of H_t. There is a growing literature which empirically and theoretically argue that the more developed a country is, the larger is the share of high-skilled sector (Buera and Kaboski, 2012a, 2012b; Eichengreen and Gupta, 2011; Jorgenson and Timmer, 2011).

For the parameters which we use in our simulation, the human capital sector grows much faster than the others,

$$\lim_{t\to\infty} K_t/H_t = 0. \tag{30}$$

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

$$\begin{aligned}
\lim_{t\to\infty} \widehat{f}_t^* &= \lim_{t\to\infty} \widehat{A}_t^{\frac{\beta(v+1)}{v+1-\beta(\sigma+1)}} && (31)\\
&= \lim_{t\to\infty} \left[\frac{(a_r^w R_t)^\varepsilon + (a_k^w K_t)^\varepsilon + (a_h^w H_t)^\varepsilon}{(a_r^m R_t)^\varepsilon + (a_k^m K_t)^\varepsilon + (a_h^m H_t)^\varepsilon}\right]^{\frac{1}{\varepsilon}\frac{\beta(v+1)}{v+1-\beta(\sigma+1)}} && (32)\\
&= \hat{a}_h^{\frac{\beta(v+1)}{v+1-\beta(\sigma+1)}}. && (33)
\end{aligned}$$

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 women's social position, may converge to a level which is even higher than that of men.

Proposition 7 *The optimum balance of power converges to a level which depends only 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 will simulate economic development within the framework of our model. We will 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 the man and woman.

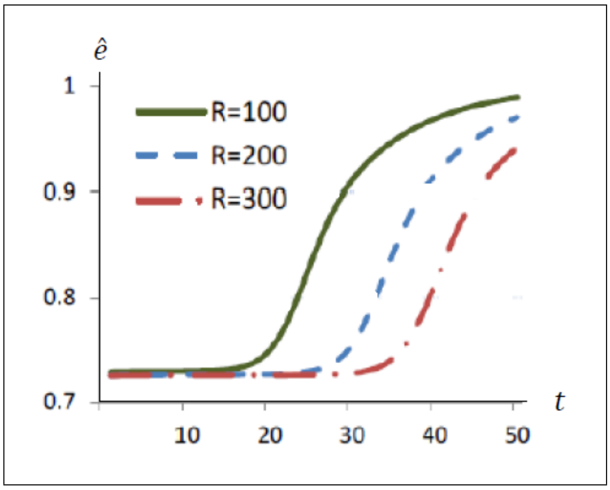
Table 1. Parameter values

parameter	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	ρ
value	2	15	30	4	20	30	0.5	0.9	2	0.3	0.9	1	3	0.2	0.1	1

3.2.1 Relative Effort

As physical capital and human capital increases over time, woman's relative productivity increases, resulting in her willingness to choose higher level of effort. Moreover, the model predicts that relative effort $\hat{e}$ would be lower in countries which starts with larger endowment of natural resources, as shown in Figure 4,. Because the woman's relative productivity in the natural resource sector is lower than that of the man's, her relative effort is lower in countries with higher natural resources. Even without including religious and cultural barriers which exist in some countries, this model explains why labour participation rates of women is lower in countries with high natural resources.

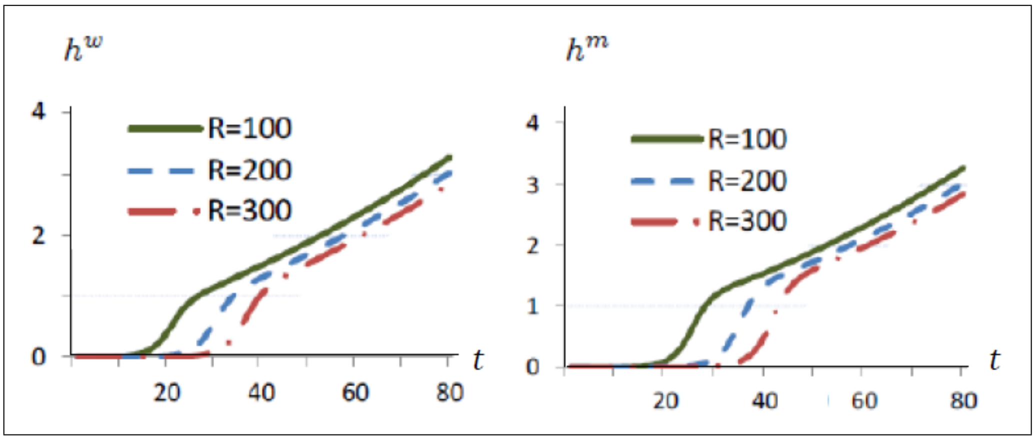
Figure 4. Evolution of Relative Effort



3.2.2 Human Capital

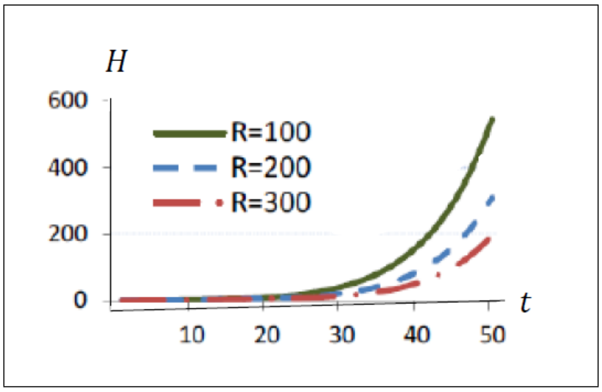
Figure 5 shows that in a country with higher natural resources, human capital is accumulated at a lower speed by both man and woman.This is quite intuitive because the comparative advantage in natural resources extraction demotivates the society from investment in human capital intensive industries.

Figure 5. Evolution of investment in Human Capital



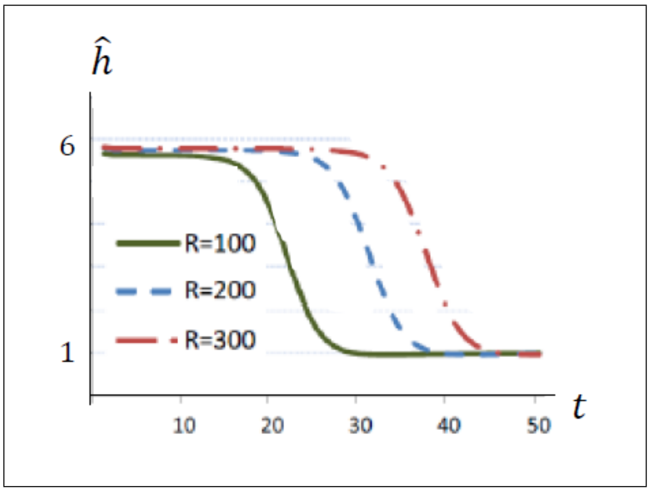
This leads to lower level of human capital as shown in Figure 6.

Figure 6. Evolution of Human Capital.



Although, natural resources reduce the investment into human capital by both men and women, the model predicts, that relative contribution of effort into education by women $\hat{h}$ would be higher in resource abundant countries, as shown in Figure 7.

Figure 7. Relative investment in Human Capital.

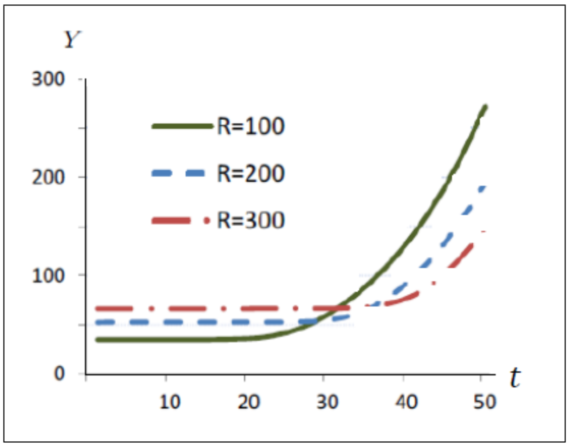


This is because men would choose to divert more effort into the natural resource sector where male productivity is higher. As time goes on, the investment into education by both men and women converge, which is shown by $\hat{h}$ reducing towards equality.

3.2.3 Production

Agents in an economy with larger level of natural resources spend a larger proportion of effort on resource extraction and less time on education. Such an economy starts off with higher income because it takes time for human capital accumulation. 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 higher output because it would have accumulated larger amount of human capital. The simulation shows this effect clearly in Figure 8. This result is consistent with Papyrakis and Gerlagh (2007), which empirically documents the curse of natural resources.

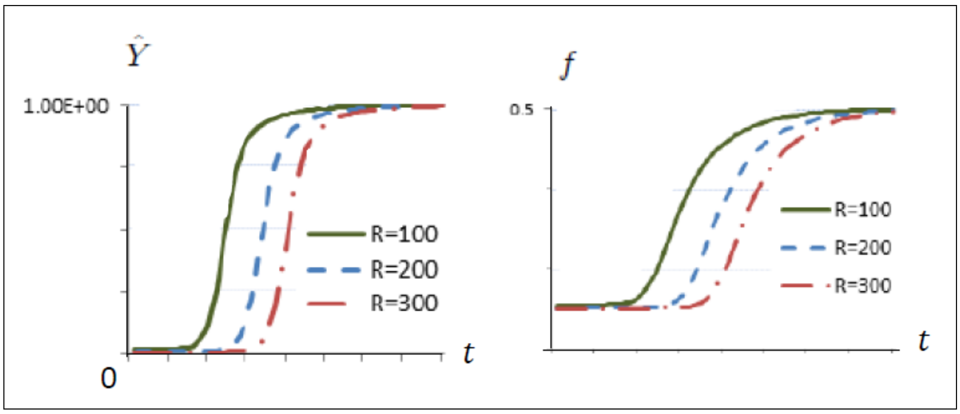
Figure 8. Evolution of Output.



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 in the other two sectors shrink. Moreover, an individual will allocate a larger proportion of labour to the human capital sector as it becomes the most productive.

Figure 9. Evolution of Relative Output and Balance of Power



Since women are as productive as their male counterparts in the human capital sector, higher relative human capital level will lead to an increase in their relative productivity. As the woman's relative productivity rises, so does her bargaining power. Figure 9 demonstrates that relative production and balance of power increases over time and converges to equality. However, higher level of natural resources results in both relative productivity and bargaining power of women to be lower at any point of time.

4 Empirical Analysis

In this section we carry out an empirical analysis to test the predictions of the theoretical model that has been presented above. The empirical model estimates the variables that affect the gender balance of power. First a panel data analysis is performed in order to eliminate the effect of omitted variables and get unbiased results, followed by a cross country ordinary least squares (OLS) analysis with a different independent variable which is available only for one year.

4.1 Model Specification

Panel regression

The regression model described in (34) is used for the panel data analysis where subscripts i and t denote country i year t respectively. We carry out a random-effects panel data analysis, using 69 countries for the 2009 - 2011 period.[5]

$$\begin{aligned} \ln LabourW/M_{it} &= \beta_0 + \beta_1 \ln NRpGDP_{it} + \beta_2 \ln GDPpc_{it} + \beta_3 \ln SchoolYears_{it} \\ &\quad + \beta_4 \ln NRpGDP90_{it} + \beta_5 Hindu_{it} + \beta_6 Christian_{it} \\ &\quad + \beta_7 Islam_{it} + \beta_8 Jewish_{it} + \beta_9 Buddhist_{it} \\ &\quad + \beta_{10} \ln Assault_{it} + \beta_{11} \ln GDPpc90_{it} * \ln NRpGDP90_{it} \\ &\quad + \beta_{12} \ln SchoolYears90_{it} * \ln NRpGDP90_{it} + u_i + \varepsilon_{it}. \end{aligned} \tag{34}$$

The dependent variable, $\ln LabourW/M$, is the natural log of labour participation ratio of women to men. The explanatory variables of particular interest are natural resources, physical capital and human capital. These are given by the natural log of

[5] We decided against a fixed effect model because we wish to check the effect of religion, which does not vary much within each country.

the *rent from total natural resources (coal, forest, mineral, natural gas, oil rent) as a percentage of GDP;* the natural log of *GDP per capita (constant 2005, \$)* and the natural log of the *average years of schooling of those over 15 years old* which are denoted by $\ln NRpGDP$, $\ln GDPpc$ and $\ln SchoolYears$ respectively. The effect of natural resources on female bargaining power in the long term is captured by the natural log of natural resources in 1990 denoted by $\ln NRpGDP90$.[6]

The proxy for social norms of the previous period, $\hat{f}_{t-1}$, can be measured in terms of safety and female-friendly environment. To capture this, we use data on the percentage of the population following different religions in each country in 2010, $Hindu$, $Islam$, $Christian$, $Buddhist$ and $Noreligion$, along with the natural log of assault rate denoted by $\ln Assault$ in 2009, which is the number of attacks per 100,000 people who suffer physical attack against the body of another person resulting in serious bodily injury.[7] The last two variables are interactive terms which show the effect of natural resources in 1990 being further enhanced by the GDP per capita and the level of education in 1990 denoted by $\ln GDPpc90$ and $\ln SchoolYears90$ respectively. The summary statistics of the variables are presented in Appendix E.

Data on labour participation ratio, account holding ratio, GDP per capita, natural resources and school years were obtained from the world bank database. Data on religion for 2010 is from The World Fact Book and International Religious Freedom Report for 2012. Data on assault rate is from the United Nations office on drugs and crime (UNODC)

Ordinary Least Squares Regression Analysis

An ordinary least squares analysis is carried out using the model shown in (35) across 205 countries in the year 2011.

$$\begin{aligned}
\ln AccW/M_i \quad = \quad & \beta_0 + \beta_1 \ln NRpGDP_i + \beta_2 \ln GDPpc_i + \beta_3 \ln SchoolYears_i \\
& +\beta_4 \ln NRpGDP90_i + \beta_5 Hindu_i + \beta_6 Christian_i \\
& +\beta_7 Islam_i + \beta_8 Jewish_i + \beta_9 Buddhist_i + \beta_{10} \ln Assault_i \qquad (35) \\
& +\beta_{11} \ln LabourW/M_i + \beta_{12} \ln SchoolYears90_i * \ln NRpGDP90_i \\
& +\beta_{13} \ln GDPpc90_i * \ln NRpGDP90_i + u_i.
\end{aligned}$$

The independent variable is the natural log of the *ratio of women to men over 15 years*

[6]It is difficult to get formal data about the level of natural resources going back many years, but 1990 will shed some light about the direction in which it affects gender balance of power.

[7]This excludes indecent/sexual assault; threats and slapping/punching. Most of the data is for 2009 but for some countries we had to use 2008 figures because of data availability

old who are account holders in a formal financial institution, denoted by $\ln AccW/M_i$. We include the labour participation ratio $\ln LabourW/M_i$ as an explanatory variable in this model. This is to control for outside jobs playing a role in account holding, as well as a proxy to capture the accessibility of labour opportunities. All the other variables are as described before.

4.2 Results and Discussion

The results of the random effect panel regression is presented in Table 2, which shows the effect each of the explanatory variable has on $\ln LabourW/M_i$. The results of the ordinary least squares regression across the countries is presented in Table 3, which shows the effect of the explanatory variables on $\ln AccW/M_i$. Recall that female balance of power is proxied by female labour participation ratio and the proportion of women holding bank accounts in the panel regression and OLS regression respectively.

To avoid the problem of heteroscedasticity we use robust standard errors to determine the significance of the variables. The robust standard errors which are shown within parenthesis while *, ** and *** indicate the level of significance to be 10%, 5% and 1% respectively. The results of the random effects are unbiased which eliminate u_i so that correlation between the error terms due to omitted variables that are particular to each country is not present.

The results of the panel regression show that while the current level of natural resources has a positive effect on female balance of power (at 5% significance level), in the long term natural resources has a highly significant negative effect (at 1% level). Its effect when combined with human capital is positive as shown by the interactive term (at 10% significance level). We have also checked the effect of GDP per capita in 1990 and found it to be not significant.

A percentage increase in natural resources per GDP will increase labour participation ratio by 0.01 percent. Natural resources being detrimental to woman's balance of power in the long run is supported with high significance at 1% level -if natural resources per GDP in 1990 is one percentage higher, it will decrease female labour participation by 0.11 percent. However, when number of school years by women in 1990 is higher by a percentage, it negates the effect of natural resources by having a positive effect on female labour participation by 0.04 percent.

Similarly the OLS results confirm at 1% significance level that the level of natural resources has a positive effect on female balance of power in the current period, while having a negative effect in the long term. Its effect when combined with human capital is positive as shown by the interactive term. A percentage increase in natural resources per GDP will increase account holding of women by 0.03 percent. In the long run there will be a significantly negative effect - if natural resources per GDP in 1990 is one percentage higher, it will decrease women holding bank accounts by 0.27 percent. However, when number of school year by women in 1990 is higher by a percentage, it negates the effect of natural resources by having a positive effect on the percentage of women having bank accounts by 0.16 percent. This supports the positive effect of human capital on female balance of power. The negative effect of physical capital is supported by the fact that the negative effect of natural resources in the long term is further exacerbated by GDP per capita by having a negative effect of 0.01 percent.

Table 2. Panel regression of woman/man labour participation ratio

$\ln LabourW/M$	I	II	III
$\ln GDPpc$	0.0124157 (0.0210578)	0.011205 (0.0208247)	
$\ln SchoolYears$	− 0.1745592 (0.1199572)	− 0.1537667 (0.1153718)	
$\ln NRpGDP$	0.0097973** (0.0041603)	0.0098465** (0.0041408)	0.0104309** (0.0042648)
$\ln NRpGDP90$	− 0.2082416*** (0.0640863)	− 0.1765077*** (0.0580234)	− 0.1168586*** (0.0585081)
$Hindu$	− 0.0069531*** (0.0016793)	− 0.0061561*** (0.0008567)	− 0.0056283*** (0.0008081)
$Christian$	− 0.0008393 (0.0012364)		
$Islam$	− 0.0054397*** (0.001599)	− 0.0047138*** (0.0011424)	− 0.0046352*** (0.0011071)
$Jewish$	0.0016488* (0.000952)	0.0021825*** (0.0007878)	0.0016334** (0.0006721)
$Buddhist$	− 0.0016801 (0.0015063)		
$\ln Assault$	− 0.03249* (0.0191578)	− 0.0304572* (0.0179488)	− 0.0297407* (0.0179733)
$\ln SchoolYears90 * \ln NRpGDP90$	0.0708793** (0.0296268)	0.0715351** (0.0260904)	0.0432355* (0.0270586)
$\ln GDPpc90 * \ln NRpGDP90$	0.0039426 (0..0043303)		
ρ	0.9987182	0.99866995	0.99870102

Table 3. Cross country OLS regression of Account-holding ratio

$\ln AccW/M$	I	II	III
$\ln GDPpc$	0.0155119 (0.0125184)	0.0155661 (0.0126082)	
$\ln SchoolYears$	− 0.0031462 (0.0973487)	− 0.0032722 (0.0972527)	
$\ln NRpGDP$	0.0286086*** (0.0098621)	0.028571*** (0.0097749)	0.0267924*** (0.0096213)
$\ln NRpGDP90$	− 0.2196476*** (0.0794928)	− 0.2197045*** (0.0792166)	− 0.2329931*** (0.0482189)
$Hindu$	− 0.0026997* (0.0014781)	− 0.0026853** (0.0014833)	− 0.00330*** (0.000994)
$Islam$	− 0.0042305*** (0.0012879)	− 0.0042163*** (0.0012982)	− 0.0047511*** (0.0010184)
$Christian$	− 0.0031428*** (0.000814)	− 0.0031252** (0.0007646)	− 0.0035226*** (0.0005525)
$Jewish$	− 0.0000611 (0.0004962)		
$Buddhist$	− 0.0021246** (0.0009519)	− 0.0021058** (0.0009206)	− 0.00253*** (0.000601)
$\ln Assault$	− 0.0191813** (0.0092578)	− 0.0192197** (0.0091546)	− 0.0181311** (0.0094082)
$\ln LabourW/M$	0.4205045*** (0.1329131)	0.4204191*** (0.1322736)	0.3893935*** (0.1201541)
$\ln SchoolYears90 * \ln NRpGDP90$	0.1521953*** (0.0406977)	0.152238*** (0.0405315)	0.1600949*** (0.0264151)
$\ln GDPpc90 * \ln NRpGDP90$	− 0.0141623*** (0.002694)	− 0.0141604*** (0.0026882)	− 0.0146861*** (0.002426)
R^2	0.6407	0.6407	0.6377

Cultural and social barriers to women labour participation, productivity and balance of power are captured by proportion of religious communities and level of safety indicated by assault rate. More proportion of people belonging to cultures which do not support gender equality reduce female balance of power. Both regression analyses found that Hindu and Muslim religions have a negative effect on female balance of power at 1% significant level. According to the panel regression, a percentage higher proportion of Hindus and Muslims in a country result in female labour participation ratio being lower by 0.006 and 0.005 percent respectively. A percentage increase in assaults (as described) will decrease female labour participation by 0.03 percent. However, a percentage increase in Jews will increase labour participation ratio by 0.002 percent. Similarly according to the OLS analysis, a percentage higher proportion of Hindus, Muslims, Christians and Buddhists in a country result in the percentage of women holding bank account being lower by 0.003, 0.005, 0.003 and 0.003 percent respectively. A percentage increase in assaults will decrease percentage of women holding bank accounts by 0.02 percent. A percentage increase in women to men labour participation ratio will result in the percentage of women holding financial account by 0.39 percentage which is statistically highly significant at 1% level.

5 Conclusion

This paper explains the difference in 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 woman's relative productivity will increase her bargaining power. The dynamic framework highlights the negative impact of natural resources and positive impact of human capital on the evolution of female balance of power. The empirical analysis with recent data supports this prediction. The dynamic model predicts that the gender balance of power converges to equality only when women are as productive as men in human capital intensive industries.

References

[1] Alfano., W. Arulampalam., and U. Kambhampati (2011). "Maternal Autonomy and the Education of the Subsequent Generation: Evidence from three Contrasting States in India". IZA Discussion Papers 6019.

[2] Alger, I., and J. W. Weibull, (2010). "Kinship, Incentives, and Evolution," American Economic Review, American Economic Association, vol. 100(4), pages 1725-58, September.

[3] Alger, I., and J. W. Weibull (2013). "Homo Moralis—Preference Evolution Under Incomplete Information and Assortative Matching," Econometrica, Vol. 81(6), pp 2269-2302.

[4] Allen, S, G. (2001). "Technology and the Wage structure", Journal of Labour Economics, Vol. 19.2 pp 440 – 482.

[5] Almond., L. Edlund., and K. Milligan (2009). "O Sister, Where Art Thou? The Role of Son Preference and Sex Choice: Evidence from Immigrants to Canada". NBER Working Paper 15391.

[6] Arulampalam, W., A. L. Booth., and M. L. Bryan (2007). "Is there a Glass Ceiling Over Europe? Exploring the Gender Pay Gap Across the Wage Distribution". Industrial and Labour Relations Review Vol. 60 (2) pp 163 - 186.

[7] Barro, R. J. and J. W. Lee (1994). "Sources of Economic Growth". Carnegie-Rochester Conference Series on Public Policy, Volume 40, pp 1–46.

[8] Becker, G. S., K. M. Murphy and R. Tamura (1990). "Human Capital, Fertility, and Economic Growth", Journal of Political Economy, Vol. 98, No. 5, Part 2, The Problem of Development: A Conference of the Institute for the Study of Free Enterprise Systems (Oct., 1990), pp. S12-S37.

[9] Bergstrom, T. C. (1995), "On the Evolution of Altruistic Ethical Rules for Siblings," American Economic Review, American Economic Association, Vol. 85(1), pp 58-81.

[10] Bhaskar, V., and B. Gupta (2007). "India's Missing Girls: Biology, Customs and Economic Development". Oxford Review of Economic Policy Vol. 2 No. 2, pp 221 - 238.

[11] Blau, F.D. (1998). "Trends in the Well-Being of American Women, 1970-1995". Journal of Economic Literature XXXVI(1), 112-165.

[12] Borooah, V. and Mangan, J. (2009). "Home is where the hurt is: a statistical analysis of injuries caused by spousal assault". Applied Economics, Vol. 41, Issue 21, pp 2779 - 2787.

[13] Buchmann, C., and T. A. DiPrete (2006). "The Growing Female Advantage in College Completion: The Role of Family Background and Academic Achievement" American Sociological Review, Vol. 71, No. 4. pp. 515-541.

[14] Buera, F. J., and J. P. Kaboski. (2012a). "The Rise of the Service Economy". American Economic Review, 102(6), 2540 - 2569.

[15] Buera, F. J., and J. P. Kaboski. (2012b). "Scale and the Organiser Structured Change". Journal of Economic Theory, 142.2, 684 - 712.

[16] Card, D and J. E. DiNardo (2002). "Skill-biased technological change and rising wage inequality: some problems and puzzles" Journal of Labour Economics, Vol. 20, No 4, pp 733 - 783.

[17] Charles, K and M. C. Luoh, (2003). "Gender differences in completed schooling", Review of Economics and Statistics, 85(3), pp 559 - 77.

[18] Deolalikar, A. B. (1993). "Gender differences in the returns to schooling and in school enrollment rates in Indonesia". The Journal of Human Resources, pp 899 - 932.

[19] Dollar, D and R. Gatti (1999). "Gender Inequality, Income, and Growth: Are Good Times Good for Women?". Policy Research Report on Gender and Development, The World Bank Working Paper Series, No. 1.

[20] Dugan, L., Nagin, D. and Rosenfeld, R. (1998). "Explaining the decline in intimate partner homicide: the effect of changing domesticity, women's status and domestic violence resources". Homicide Studies, 3(3).

[21] Edin, Per-Anders and Katarina Richardson, 2002, Swimming with the Tide: Solidary Wage Policy and the Gender Earnings Gap, The Scandinavian Journal of Economics, Vol. 104, No. 1 (Mar., 2002), pp. 49-67

[22] Edlund, L., and C. Lee (2013). "Son Preference, Sex Selection and Economic Development: The Case of South Korea". NBER Working Papers 18679.

[23] Eichengreen, B., and P. Gupta (2011). "The two-waves of service sector growth". Oxford Economic Papers 65(1) 96 - 123.

[24] Farmer, A. and Tiefenthaler, J. (2003). "Explaining the Recent Decline in Domestic Violence". Contemporary Economic Policy, 21(2), 158-172.

[25] Frank, S. A. (1998). Foundations of Social Evolution. Princeton, N. J.: Princeton University Press.

[26] Goldin, Claudia. 2006. "The Quiet Revolution That Transformed Women's Employment, Education, and Family." A.E.R. Papers and Proc. 96 (May): 1–21

[27] Heathcote Jonathan , Kjetil Storesletten and Giovanni L. Violante, The Macroeconomic Implications of Rising Wage Inequality in the United States,Journal of Political Economy, Vol. 118, No. 4 (August 2010), pp. 681-722

[28] Hamilton, W. D. (1964). "Genetical Evolution of Social Behavior I and II" Journal of Theoretical Biology 7: 1-52.

[29] Heckman , J. J. and T. E. Macurdy, (1980). "A Life Cycle Model of Female Labour Supply", The Review of Economic Studies , Vol. 47, No. 1, Econometrics Issue, pp. 47-74.

[30] Hill, M. A and E. King (1995). "Women's education and economic well-being". Feminist Economics Volume 1, Issue 2, pp 21 - 46.

[31] Iyigun, M. F. and R. P. Walsh (2007), "Endogenous gender power, household labour supply and the quantity - quality trade-off". Journal of Development Economics, 138 - 155.

[32] Jorgenson, D. W., and M. O. Timmer. (2011). "Structural change in Advanced Nations: A New Set of Stylised Facts". Scandinavian Journal of Economics 113 (1), 1 - 29.

[33] Klasen, S. (2002). "Low Schooling for Girls, Slower Growth for All? Cross-Country Evidence on the Effect of Gender Inequality in Education on Economic Development". The World Bank Economic Review, Volume 16 Issue 3, pp 345 - 373.

[34] Klasen, S and F. Lamanna (2009). "The Impact of Gender Inequality in Education and Employment on Economic Growth: New Evidence for a Panel of Countries". Feminist Economics, Vol. 15, Issue 3, pp 91 - 132.

[35] Knowles, S., P. K. Lorgelly and P. D. Owen (2002). "Are educational gender gaps a brake on economic development? Some cross-country empirical evidence". Oxford Economic Papers, Vol. 54 Issue 1, pp 118 - 149.

[36] Kury, H., Obergfell-Fuchs, J. and Woessner, G. (2004). "The extent of family violence in Europe, Violence Against Women". 10(7), 749-769.

[37] Levin, B.R., and W. L. Kilmer (1974). "Interdemic selection and the evolution of altruism: a computer simulation study". Evolution 28, pp 527–545.

[38] Lundberg, S and R. A. Pollak (2003). "Efficiency in Marriage". Review of Economics of the Household, pp 153 - 167.

[39] Machin, S and S. McNally, (2005). "Gender and student achievement in English schools". Oxford Review of Economic Policy, Vol. 21. 3, pp 357 - 372.

[40] Max, W., Rice, D.P., Finkelstein, E., Bardwell R. A. and Leadbetter, S. (2004). "The economic toll of intimate partner violence against women in the United States". Violence and Victims, 19(3), 259-72.

[41] Mulligan Casey B. and Yona Rubinstein,(2008), "Selection, Investment, and Women's Relative Wages over Time,", The Quarterly Journal of Economics, Vol. 123, No. 3, pp. 1061-1110

[42] Olivetti, C., Petrongolo, B. (2011). "Gender gaps across countries and skills: supply, demand and the industry structure". Review of Economic Dynamics Vol. 17, Issue 4, pp 842 - 859.

[43] Papyrakis, E., & Gerlagh, R. (2007). "Resource abundance and economic growth in the United States". European Economic Review, 51(4), pp 1011-103

[44] Psacharopoulos, G. (1994) "Returns to investment in education: A global update". World Development, Volume 22, Issue 9, Pages 1325–1343.

[45] Rainer, H. (2008). "Gender discrimination and efficiency in marriage: the bargaining family under scrutiny". Journal of Population Economics 21, pp 305 - 329.

[46] Schultz, T. P. (1995). "Woman's human capital". University of Chicago Press.

[47] Schultz, T. P. (2002). "Why Governments Should Invest More to Educate Girls". World Development, Volume 30, Issue 2, Pages 207–225.

[48] Solow, Robert M. (1956). "A contribution to the theory of economic growth". Quarterly Journal of Economics (Oxford Journals) 70 (1): 65–94.

6 Appendix

A. Proof of Proposition 1

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

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

The first order conditions are presented below

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

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 $\eta^j_{u_c,c} = \frac{f^j Y u^j_{cc}}{u^j_c}$; $\eta^j_{V_e,e} = \frac{V_{ee} e^j}{V_e}$; $\eta^j_{Y_e,e} = \frac{Y^j_{ee} e^j}{Y^j_e}$; $\eta^j_{Y,e} = \frac{Y^j_e e^j}{Y^j}$. We use that definition in the above equations to get

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

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

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

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

$$\frac{dL^Y}{de^w} = Y_{e^w}^w + s^w u_c^w Y_e^w \frac{1+\eta_{u_c,c}^w}{1+\eta_{u_c,c}^m} f^m \eta_{u_c,c}^m \frac{Y_e^w}{Y} + s^w u_c^w Y_{e^w}^w \frac{1}{e^w} f^w \left[\eta_{u_c,c}^w \frac{Y_e^w e^w}{Y} + \eta_{Y_e,e}^w - \eta_{V_e,e}^w\right] = 0 \tag{A5}$$

$$\frac{dL^Y}{de^m} = Y_{e^m}^m + s^w u_c^w Y_e^w \frac{1+\eta_{u_c,c}^w}{1+\eta_{u_c,c}^m} f^m \frac{1}{e^m}\left[\frac{1}{Y}\eta_{u_c,c}^m Y_e^m e^m + \eta_{Y_e,e}^m - \eta_{V_e,e}^m\right] + s^w u_c^w Y_e^w f^w \eta_{u_c,c}^w \frac{Y_e^m}{Y} = 0. \tag{A6}$$

and combine that in one relation as

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

we simplify it further using elasticities

$$\frac{\eta_{Y,e}^w Y^w}{\eta_{Y,e}^m Y^m} = \frac{\left(1+\eta_{u_c,c}^w\right) f^m \eta_{u_c,c}^m \eta_{Y,e}^w Y^w + \left(1+\eta_{u_c,c}^m\right) f^w \left[\eta_{u_c,c}^w \eta_{Y,e}^w Y^w + \left(\eta_{Y_e,e}^w - \eta_{V_e,e}^w\right) Y\right]}{\left(1+\eta_{u_c,c}^w\right) f^m \left[\eta_{Y,e}^m Y^m \eta_{u_c,c}^m + \left(\eta_{Y_e,e}^m - \eta_{V_e,e}^m\right) Y\right] + f^w \eta_{u_c,c}^w \left(1+\eta_{u_c,c}^m\right) Y^m \eta_{u_c,c}^m}. \tag{A8}$$

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

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.

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

The first order conditions are

$$\begin{aligned} \frac{\partial L}{\partial A^w} A^w &= f\beta\left(A^w e^w\right)^\beta \left[f((A^w e^w)^\beta + Y^M)\right]^{\sigma-1} - \mu e^w A^w = 0; \\ \frac{\partial L}{\partial e^w} e^w &= f\beta\left(A^w e^w\right)^\beta \left[f((A^w e^w)^\beta + Y^M)\right]^{\sigma-1} - \mu A^w e^w - (e^w)^{v+1} + \lambda e^w = 0; \\ \frac{\partial L}{\partial r^w} r^w &= \mu\left(A^w e^w\right)^{\frac{1}{\varepsilon+1}} \left(a_r^w R r^w\right)^{\frac{\varepsilon}{\varepsilon+1}} - \lambda r^w = 0; \\ \frac{\partial L}{\partial l^w} l^w &= \mu\left(A^w e^w\right)^{\frac{1}{\varepsilon+1}} \left(a_l^w K l^w\right)^{\frac{\varepsilon}{\varepsilon+1}} - \lambda l^w = 0; \\ \frac{\partial L}{\partial h^w} h^w &= \mu\left(A^w e^w\right)^{\frac{1}{\varepsilon+1}} \left(a_h^w H h^w\right)^{\frac{\varepsilon}{\varepsilon+1}} - \lambda h^w = 0. \end{aligned} \tag{B3}$$

Summation of the last three equations results in

$$\mu A^w e^w = \lambda e^w; \quad \lambda = \mu A^w. \tag{B4}$$

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

$$\frac{\partial L}{\partial r^w} r^w = \mu \left(A^w e^w\right)^{\frac{1}{\varepsilon+1}} \left(a_r^w R r^w\right)^{\frac{\varepsilon}{\varepsilon+1}} - \mu A^w e^w \frac{r^w}{e^w} = 0; \tag{B5}$$

$$\left(\frac{a_r^w R r^w}{A^w e^w}\right)^{\frac{\varepsilon}{\varepsilon+1}} = \frac{r^w}{e^w}; \tag{B6}$$

$$\frac{r^w}{e^w} = \left[\frac{a_r^w R}{A^w}\right]^{\varepsilon}. \tag{B7}$$

Similarly

$$\frac{l^w}{e^w} = \left[\frac{a_l^w K}{A^w}\right]^{\varepsilon}; \quad \frac{h^w}{e^w} = \left[\frac{a_h^w H}{A^w}\right]^{\varepsilon}. \tag{B8}$$

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

C. Proof of Proposition 5

According to (13) and (19)

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

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

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

$$\frac{\left(a_h^w H\right)^{\varepsilon}}{\left(a_r^w R\right)^{1+\varepsilon} + \left(a_l^w K\right)^{\varepsilon} + \left(a_h^w H\right)^{\varepsilon}} > \frac{\left(a_h^m H\right)^{\varepsilon}}{\left(a_r^m R\right)^{\varepsilon} + \left(a_l^m K\right)^{\varepsilon} + \left(a_h^m H\right)^{\varepsilon}} \tag{C3}$$

(36)

$$\text{i.e.}\ \left(\left(a_r^m a_h^w\right)^{\varepsilon} - \left(a_r^w a_h^m\right)^{\varepsilon}\right)\left(R\right)^{\varepsilon} > \left(\left(a_l^w a_h^m\right)^{\varepsilon} - \left(a_l^m a_h^w\right)^{\varepsilon}\right)\left(K\right)^{\varepsilon}.$$

This is true because of the assumptions in (20) 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 $\left((a_h^m a_r^w)^\varepsilon - (a_h^w a_r^m)^\varepsilon\right) H^\varepsilon < \left((a_l^w a_r^m)^\varepsilon - (a_l^m a_r^w)^\varepsilon\right) K^\varepsilon$

because $\left((a_h^m a_r^w)^\varepsilon - (a_h^w a_r^m)^\varepsilon\right) < 0$; $\left((a_l^w a_r^m)^\varepsilon - (a_l^m a_r^w)^\varepsilon\right) > 0$.

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

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

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

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 $\frac{dY_t}{d\phi} = \frac{dY_t}{d\hat{f}_t}\left(\overset{\wedge}{f_t}^* - \hat{f}_t\right)$.

As $\hat{f}_t - \overset{\wedge}{f_t}^* = (1-\phi)\left(\hat{f}_{t-1} - \overset{\wedge}{f_t}^*\right) < 0$, $\hat{f}_t < \overset{\wedge}{f_t}^*$, $\frac{dY_t}{d\hat{f}_t} > 0$.

Secondly, from equation (25) we conclude that physical capital investment is larger for a bigger ϕ.

Finally, we can also show that investment in human capital is also increases with ϕ.

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

Effort decision function (7) implies

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

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 $a_h^w = a_h^m$

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

Consider 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

Table 4. Summary statistics of the variables used for the empirical analysis

Variable	Observations	Mean	Std. Dev.	Min	Max
$AccW/M$	360	0.84	0.22	0.17	1.77
$GDPpc$	360	10815.50	14919.49	145.60	81385.30
$NRpGDP$	357	9.29	14.04	0	78.51
$SchoolYears$	360	8.11	2.63	1.81	13.09
$LabourW/M$	360	40.24	10.67	0	53.51
assault~2009	237	148.53	191.20	0	926.65
Christian	360	54.54	37.88	0.06	99.50
Muslim	360	26.14	37.70	0	99.90
Hindu	360	2.73	11.70	0	80.70
Buddhist	360	4.03	15.52	0	96.90
Jewish	360	0.71	6.88	0	75.60
$GDPpc$1990	350	7195.24	10901.95	0	50608.47
$NRpGDP$1990	353	7.96	10.00	0	46.04
$SchoolYears$1990	359	6.32	2.74	0	12.23