The Output Cost of Gender Discrimination: A Model-Based Macroeconomic Estimate*

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Abstract

Gender-based discrimination is a pervasive and costly phenomenon. To a greater or lesser extent, all economies present a gender wage gap, associated with lower female labor force participation rates and higher fertility. This paper presents a growth model where saving, fertility and labor market participation are endogenously determined, and there is wage discrimination. The model is calibrated to mimic the performance of the U.S. economy, including the gender

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wage gap and relative female labor force participation. We then compute the output cost of an increase in discrimination, to find that a 50 percent increase in the gender wage gap leads to a decrease in income per capita of a quarter of the original output. We then compile independent estimates of the female to male earnings ratio for a wide cross-section of countries to construct a new economy, in line with the benchmark U.S. economy, except for the degree of discrimination. We compare the level of output per capita predicted by this model economy with the actual output per capita for each country. Higher discrimination leads to lower output per capita for two reasons: a direct decrease in female labor market participation and an indirect effect through an increase in fertility. We find that for several countries a large fraction of the actual difference in output per capita between the U.S. and the different economies is due to gender inequality. For countries such as Ireland and Saudi Arabia, wage discrimination actually explains all of the output difference with the U.S. Moreover, we find that the increase in fertility due to discrimination is responsible for almost half of the decrease in output per capita, and equivalent to the direct decrease in output due to lower female participation. Our basic model suggests the costs of gender discrimination are indeed quite substantial and should be a central concern in any macroeconomic policy aimed at increasing output per capita in the long-run.

JEL Classification Numbers: E0, J1, O1

Keywords: Economic Development, Gender Inequality, Female Labor Force Participation, Fertility.

1 Introduction

It is widely recognized that gender discrimination is a pervasive phenomenon. It is also a costly phenomenon, though macroeconomic estimates of its cost are rare, and seldom model-based. Everywhere females find it more difficulty than males to access market activities, political power, or health and education inputs. As mentioned in Hausmann, Tyson, and Zahidi (2006), "*no country in the world has yet reached equality between women and men in critical areas such economic participation, education, health, and political empowerment.*" Gender discrimination has many guises, probably interrelated in their causes and consequences, as they are part of a complex system of social, cultural and economic determinants. The economics literature has studied the microeconomics of job and wage discrimination in some detail, thus far focusing on the individual cost of discrimination. We believe it is important to provide a model-based macroeconomic estimate of the cost of wage discrimination and that is the goal of this paper.

Providing an estimate of the cost of discrimination to aggregate output is important for several reasons. First, gender discrimination is largely determined by social and cultural characteristics at the national level that hardly change in the short run.[1] Many of the determinants of discrimination are thus exogenous from the perspective of the economy, suggesting the possibility of ascertaining the aggregate costs of discrimination.[2] Second, the pervasiveness of discrimination across economies implies that aggregate costs are sizable and should be easily captured by aggregate models

[1]This is an important argument in Fernández (2007), which states that, "*if culture is, on the whole, evolving slowly, then this variable should also have explanatory power for individual women's labor supply.*"

[2]Other authors have argued, convincingly, that the tax rates on second earners (usually the woman) are much higher than those on the first earner. This further discourages female labor force participation. Alesina and Ichino (2007) have suggested going further than equalizing tax rates, given the higher tax elasticity of women's labor supply.

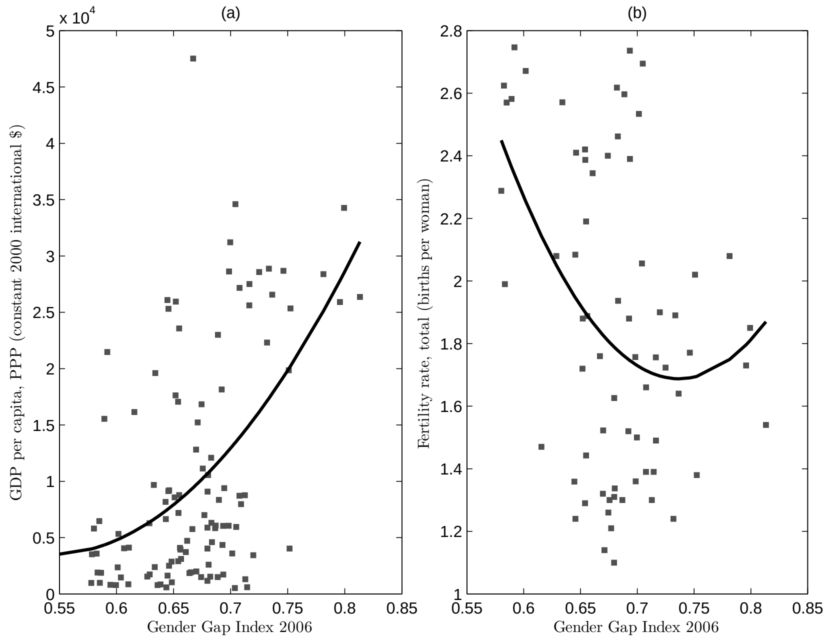
of the economy. Third, an aggregate model will be able to capture costs of gender discrimination related to indirect, but important, effects such as the impact on fertility, and assess the relative importance of the former with the direct cost of the mere lower participation of women.[3] In fact, this is consistent with cross country empirical evidence, as we will discuss below and as is shown in Figure 1. Panel (a) of this figure shows that there is a negative correlation between gender inequality and output per capita and panel (b) reports a positive correlation between gender inequality and fertility. This last correlation will be a key feature of our model economy.

The social sciences literature has uncovered several important relationships between economy, culture, and gender discrimination. Income per capita is associated with lower degrees of discrimination against women, as suggested in Dollar and Gatti (1999) and Guiso, Sapienza, and Zingales (2003). The latter also finds that education is related to lower degrees of discrimination. Fernández (2007) highlight the importance of cultural characteristics as a determinant of female labor force participation, while the empirical results in Algan and Cahuc (2007) point to national family characteristics as a determinant of female participation[4]. In addition, Dollar and Gatti (1999) show that gender inequality is explained to a considerable extent by religiosity, regional factors, and civil freedom. Antecol (2003) focuses on male attitudes toward mothers working outside their home as a determinant of participation, an emphasis that proves productive in the work of Fernández, Fogli, and Olivetti (2004), which show that men whose mothers worked while they were growing up tend to marry

[3]In this paper participation and fertility are substitutes in women's time. The Economist (2007) presents data for some countries where higher male to female wage gaps are associated with *lower* rather than higher fertility. This is due to a third factor that we ignore here, the availability of child care, present in the model developed by Cavalcanti and Tavares (2006), where women "finance" their time in the market by voting for higher taxes and public services.

[4]It is of interest to note thatFernández and Fogli (2005) find that cultural proxies are never significant in explaining male labor force participation.

Figure 1: Gender inequality, GDP per capita, and fertility. Source: Gender Gap Index (0 to 1 scale: 0=inequality, 1=equality), see Hausmann, Tyson, and Zahidi (2006); data for GDP per capita and fertility are from World Bank (2007).



working women. This is evidence of "preference transmission".[5] Other researchers have also emphasized how the party system validates or not traditional values (see Sainsbury (1999)). Among the cultural factors that explain female labor force participation, religious affiliation seems to be especially important. Empirical estimates from Psacharopoulos and Tzannatos (1989) suggest that indicators of religious affiliation explains about a third of the variability in female participation rates across ninety countries. Knudsen and Waerness (1999) relate an index of attitudes toward gender roles with mother's employment in three countries and confirm that "*religiously devoted individuals are more negative towards modern gender roles*". [6] Guiso,

[5]Fogli and Veldkamp (2007) propose a subtler mechanism whereby each generation updates beliefs by observing the children of employed women.

[6]Confirming the relationship between male values and female participation, Fernández and Fogli

Sapienza, and Zingales (2003) investigate the role of religion and other factors on both economic attitudes and attitudes toward women. They find that while education and income favor more liberal attitudes toward women, all religions discourage such attitudes.[7] Heineck (2004) also uncovers a relationship between religious affiliation and participation and the adoption of the "*male-breadwinner gender role model*". Siaroff (1994) and Schmidt (1993) suggest a difference between Protestants and Catholics, with the former giving more emphasis to individual autonomy and encouraging female participation. Guiso, Sapienza, and Zingales (2003) suggest that Islam tends to be more discouraging of active female economic roles. Read (2003) re-interprets the correlation between Muslim affiliation and attitudes toward women, suggesting that, in his study, "*Muslim respondents are more gender traditional than their non-Muslim peers, but rather than reflecting the impact of religious affiliation per se, this study finds that differences in ethnicity and religiosity are more significant*".[8] Psacharopoulos and Tzannatos (1989) conclude that Muslims, Hindi, and Roman Catholics are the religious affiliations which are associated with lower female participation rate.[9]

The second motivation to study the aggregate cost of gender discrimination is the

(2005) study the national origins of migrants and conclude that "*women whose parents were born in countries where women participated less in the workforce tend to work less themselves.*"

[7]The authors suggest that this effect is mostly the result of association with the dominant religion in the country. Del Boca and Locatelli (2006) confirm the results on education and attitudes toward women.

[8]Read (2004) confirms these results, namely the importance of religiosity rather than religious affiliation in explaining attitudes toward working women. The population studied is Arab-Americans, comprising both Muslim and Christian, with a substantial variation in religiosity levels. Moreover, religiosity seems to be the determinant of participation only for the case of women with children present in the home.

[9]These authors argue that "*the regression coefficients on the Muslim, Hindu and Catholic religions were negative and highly significant. They implied that religion reduced the female labor force participation rate by more than half in Muslim countries, by 40 percent in Hindu countries, and by 30 percent in Catholic countries.*"

sparsity of model-based macroeconomic estimates. An exception is Dollar and Gatti (1999), who use four gender inequality measures and conclude that there exists a positive empirical relationship between gender equality and per capita income. This is also the case in Hausmann, Tyson, and Zahidi (2006), who report evidence of a negative correlation between gender discrimination in four areas and both output per capita and an index of country competitiveness. Klasen (1999) introduces a very interesting view of gender inequality and growth, considering that inequality is a distortionary tax that leads to a misallocation of education resources, which could affect economic growth through a lower quality of human capital.[10] Blackden and Bhanu (1999) found that gender inequality may have an impact on economic growth through the limit of women's ability to accumulate capital, that is, not only human capital, but also directly productive assets and social capital. Young (1995) found that the rise in female labor force participation accounted for between 0.6 and 1.6 percent of annual per capita growth in the four East Asian tiger economies, giving rise to a controversy on the relative role of productivity and factor inputs as explanations for economic growth.[11] Gümbel (2004) relates three indicators of inequality - in health, in education and in employment - on economic growth and finds that it is differences in gender employment that most explain differences in per capita income growth. Quantitatively, Daly (2007), an economist at Goldman Sachs, argues that reduction in barriers to female labor force participation would increase America's GDP by 9%. He arrives at this figure by rasing women's employment to the same level as men's

[10] The author states that "*artificial barriers to female employment in the formal sector may contribute to higher labor costs and lower international competitiveness, as woman are effectively prevented from offering their labor services at more competitive wages.*" Dollar and Gatti (1999) also suggest that gender inequality in education is particularly harmful for economic growth.

[11] An alternative view is exploited by Seguino (2000), who tries to explain the growth rate of export by a series of variables, including the gender wage gap, and finds that a larger gap has a positive effect on exports. Another main finding of this study was that wage differential boosts investment. Both results, which contradict most of the literature, may be explained by the fact that women have less human capital, though the author partly corrects for this effect.

and assuming that GDP rises in proportion to employment.

As seen above, there is substantial evidence of the influence of “exogenous” factors as determinants of discrimination. The estimates on the macroeconomic cost of discrimination, though generally pointing to a significant cost, are not heretofore based on a macroeconomic model and can thus benefit from an integrated theoretical and empirical approach.[12] Finally, as we pointed above, the lack of a clearer strategy to model the aggregate economy leads to severe problems in assessing the relative impact on output of concurring channels of causation from discrimination to individual behavior. Our paper intends to provide a contribution that is relevant in all three aspects.

2 The Model

In this section we develop a model to study the cost of gender discrimination to output similar to those in Galor and Weil (1996) and Cavalcanti and Tavares (2006). Our strategy is to use a simple growth model with endogenous fertility and female labor market participation to assess the costs of gender discrimination.

Women and Men

Our economy is made up of men and women who live for three periods. In the first period, as children, women and men are indistinguishable, do not make any specific decision, and “consume” a fraction of their parents’ time endowment, our

[12] An exception is Lagerlöf (2003), who focuses on the relationship between gender discrimination and long-run growth. His model is a long-term economy relating gender discrimination with the Industrial Revolution and the Demographic Transition, motivated by the European historical experience. Another possible exception is Esteve-Volart (2004), who focuses on access to the labor market and, in particular, managerial positions, and provides estimates for the cost of discrimination across Indian states.

proxy for parental care. In their second period of life, agents become adult men and women, organized as couples, and differ in their labor endowment such that each man is endowed with one unit of physical labor and one unit of mental labor, and each woman with one unit of mental labor only.[13] Both men and women can use one unit of time, divided between time at work and time raising children. During this second period of life, couples decide how many children to have and allocate their time between the labor market and the task of raising children. In the third period, each couple consumes the life savings.

The novelty relative to macroeconomic models of fertility and labor market participation is the introduction of gender discrimination. We consider that there are barriers to female labor market participation in the form of wage discrimination.[14] If we take w_t^m to be the mental labor wage rate, women receive the fraction $\phi < 1$ of this wage rate and a lower ϕ represents a more discriminatory society.[15] Our model

[13]This different endowment allows for possible differences in productivity (or, implicitly, preferences) between genders that "explain" part of the different participation in the labor market. As will become clear, we will provide an estimate of the output cost of gender discrimination above and beyond any such gender differences. Its presence in the model simply considers, for the sake of completeness, that discrimination may not be the whole reason for wage inequality. Alternatively we may assume that women are more productive than men in home activities, as presented in Appendix C. In this case, differences in gender inequality still have similar impacts (both qualitatively and quantitatively) on the economy, but the gender pay and the fertility rate are constant over time.

[14]Is there evidence that employers discriminate against women? If the male-female wage differential were due to employer discrimination, then non-discriminatory employers could hire more women and enjoy a higher profit, which is what Kawaguchi (2006) finds using Japanese firm-level panel data. Discrimination in our model also stands for the case where women and men participate more equally in the market in terms of access to jobs, but women are somewhat confined to low-skills, low-paying jobs. Black and Spitz-Oener (2007) document the decline in routine task inputs among women, with little change for men, which they find to explain a substantial fraction of the decrease in the gender wage gap.

[15]A similar approach is used by Jones, Manuelli, and McGrattan (2003), who argue that the narrowing wage gap alone explains a large part of the recent increase in female labor force participation

delivers two facts that are borne out by available evidence: the existence of a gender wage gap and its tendency to decrease over time as income per capita increases.

Technology

The production technology uses capital, K_t, mental labor, L_t^m, and physical labor, L_t^p, to produce output, Y_t, according to a constant returns to scale production function. More specifically,

$$Y_t = K_t^{\alpha}(A_t L_t^m)^{1-\alpha} + B A_t L_t^p, \tag{1}$$

where $A_t = (1+\mu)^t$, $B > 0$, and $\alpha \in (0,1)$. While physical labor is a substitute for physical capital, mental labor is a complement. Thus, physical labor will lose importance as the economy accumulates physical capital and its compensation will deteriorate in relative terms. Parameter $\mu \geq 0$ corresponds to the rate of technical progress. Given the technology and input prices, the representative firm chooses inputs so that profits are maximized.[16] The first order conditions associated with the representative firm's problem are:

$$w_t^p = A_t B, \tag{2}$$

$$w_t^m = (1-\alpha)K_t^{\alpha}(A_t L_t^m)^{-\alpha} A_t, \tag{3}$$

$$r_t^K = \alpha K_t^{\alpha-1}(A_t L_t^m)^{1-\alpha}. \tag{4}$$

The wage of physical labor does not depend on capital accumulation, while the wage of mental labor increases with capital accumulation. Therefore, female labor

in the United States. Lagerlöf (2003), instead, sets up a growth model where gender differences arise endogenously in equilibrium through a coordination process. His idea is that girls may need less education because they are expected to marry a man, who in general may be better educated. The decrease in fertility might improve gender equality as women's human capital becomes more equal to that of men. Related to this article is the model presented by Falcao and Soares (2007) where increases in female labor force participation and reductions in the gender wage gap are the output of reductions in fertility and in mortality rates.

[16] Output is taken as the numeraire.

force participation increases as the relative wage of mental labor increases and, concomitantly, the gender wage gap decreases. As the economy accumulates capital, the opportunity cost of staying at home increases

Preferences

As suggested above, couples draw utility from consumption in their second and third period of life and from the number of children. Let n_t be the number of children born at period t,[17] and c_t and d_{t+1} be the consumption of a couple in their second and third period of life, respectively. Preferences are represented by

$$U_t = \ln c_t + \beta \ln c_{t+1} + \gamma \ln n_t, \ \ \beta, \gamma \in (0,1), \tag{5}$$

where β is the subjective discount factor and γ represents the relative weight of children in the couple's utility function. Let h_t be the time that parents devote to raising children. In the spirit of Greenwood, Seshadri, and Vandenbroucke (2005), we assume that children are costly because they consume time resources according to the equation

$$n_t = D h_t, \ \ D > 0, \tag{6}$$

Solving (6) for h_t gives the time cost for a couple that decides to have n_t children

$$h_t = \frac{n_t}{D}. \tag{7}$$

Budget Constraints

Notice that the opportunity cost of raising children is greater for a man, $(w_t^p + w_t^m)$, than for a woman, ϕw_t^m, $\phi \in (0,1)$. Therefore, if $h_t \leq 1$, only the wife will spend time raising children. In the case where $h_t > 1$ both will raise children, but the husband

[17] Since the household is organized as a couple, we could interpret n_t as the number of couples generated by each household.

will also work some time in the market.[18] The couple's budget constraints for each of the two cases are:

$$c_t + s_t \leq w_t^p + w_t^m + (1 - h_t)\phi w_t^m, \quad \text{if} \quad h_t \leq 1, \tag{8}$$

$$c_t + s_t \leq (w_t^p + w_t^m - (h_t - 1)(w_t^m + w_t^p)), \quad \text{if} \quad h_t \geq 1. \tag{9}$$

where s_t represents savings and the right-hand side shows net income of the couple.

In the last period of life, consumption by the couple satisfies

$$c_{t+1} = (1 + r_{t+1})s_t. \tag{10}$$

Couples choose the level of consumption c_t, the number of children n_t, and savings, s_t, so as to maximize (5) subject to (7) to (10). The fertility decision satisfies

$$h_t = \frac{n_t}{D} = \frac{\gamma}{1+\beta+\gamma}[\frac{1+\phi}{\phi} + \frac{w_t^p}{\phi w_t^m}], \quad \text{if} \quad h_t \leq 1, \tag{11}$$

$$h_t = \frac{n_t}{D} = \frac{2\gamma}{1+\beta+\gamma}, \quad \text{if} \quad h_t > 1. \tag{12}$$

From the expressions above, a necessary condition for women to participate in the labor market is that

Assumption 1: $\frac{2\gamma}{1+\beta+\gamma} \leq 1$.

This assumption is equivalent to $\gamma \leq (1+\beta)$, which is a restriction on the "altruism factor" that "weighs" the benefits of having children against consumption. If the above condition is satisfied, the time spent raising children is given by

$$h_t = \frac{n_t}{D} = \min\{1, \frac{\gamma\theta}{1+\beta+\gamma\theta}[\frac{1+\phi}{\phi} + \frac{w_t^p}{\phi w_t^m}]\}, \tag{13}$$

and private savings are given by

$$s_t = \frac{\beta}{1+\beta+\gamma}((1+\phi)w_t^m + w_t^p) \quad \text{if} \quad h_t \leq 1, \tag{14}$$

$$s_t = \frac{\beta}{1+\beta}(w_t^m + w_t^p) \quad \text{if} \quad h_t = 1. \tag{15}$$

[18] This is consistent with the empirical fact that male labor force participation rates tend to be higher than their female equivalent, and women do by far the greater part of unpaid work.

Equilibrium

In equilibrium, demand equals supply in all markets. In the market for mental labor this means that $L_t^m = L_t^p(2 - h_t)$, or $m_t = \frac{L_t^m}{L_t^p} = 2 - h_t$. Let $\hat{k}_t$ be the capital level per unit of efficiency couple, i.e., $\hat{k}_t = \frac{K_t}{A_t L_t^p}$. Then, using the input market equilibrium conditions, equations (2) and (3), into (13), yields

$$h_t = \min\{1, \frac{\gamma}{1+\beta+\gamma}[\frac{1+\phi}{\phi} + \frac{B}{\phi(1-\alpha)\hat{k}_t^{\alpha}(2-h_t)^{-\alpha}}]\}. \tag{16}$$

Proposition 1: *Let assumption 1 be satisfied. Then female hours of work in the market increase with capital accumulation, $\hat{k}_t$, and decrease with labor market discrimination (low ϕ).*

Proof: See Appendix A ∇.

Equation (16) determines h_t as an implicit function of $\hat{k}_t$, $\psi(\hat{k}_t, \phi)$, and a critical value $\hat{k}^*(\phi)$ such that

$$h_t = \begin{cases} 1 & \text{for } \hat{k}_t \leq \hat{k}^*(\phi), \\ \psi(\hat{k}_t, \phi) & \text{for } \hat{k}_t \geq \hat{k}^*(\phi), \end{cases} \tag{17}$$

and $\psi(\hat{k}_t, \phi) \in (0, 1]\ \forall\ \hat{k}_t \geq \hat{k}^*(\phi)$. As a consequence, time devoted to home activities decreases with capital accumulation. Observe that when barriers to female labor force participation are high (ϕ is low), women work fewer hours in the market. Since fertility is an increasing function of hours at home, the number of children decreases with capital accumulation and increases with gender discrimination in the form of barriers to female labor force participation.[19]

[19] Interestingly, Del Boca and Locatelli (2006) find that an increase in female wages increases female labor force participation and finds an association between time spent in childcare currently and the decision to have more children in the future. The force relating discrimination and output in Lagerlöf (2003) is also a decrease in the quantity of children as discrimination decreases.

The condition that equilibrates the capital market is

$$K_{t+1} = L_t^p s_t. \tag{18}$$

Using equations (13),(14), and (15) yields:

$$\hat{k}_{t+1} = \frac{s_t}{(1+\mu)A_t n_t} = \begin{cases} \frac{\beta}{D(1+\beta)(1+\mu)}[(1-\alpha)\hat{k}_t^{\alpha} + B] & \text{for } \hat{k}_t \leq \hat{k}^*, \\ \frac{\beta}{D\gamma(1+\mu)}\phi(1-\alpha)\hat{k}_t^{\alpha}(2-h_t)^{-\alpha} & \text{for } \hat{k}_t \geq \hat{k}^*, \end{cases} \tag{19}$$

Equation (19) defines a non-linear difference equation $\hat{k}_{t+1} = \xi(\hat{k}_t, \phi)$, where

$$\hat{k}^* = [\frac{B\gamma}{(1-\alpha)(\phi(1+\beta)-\gamma)}]^{\frac{1}{\alpha}}. \tag{20}$$

Proposition 2: *Let assumption 1 be satisfied. Then there exists at least one locally stable positive steady-state equilibrium.*

Proof: See Appendix B ∇.

Proposition 2 states that a positive and locally stable steady-state exists. However, here, as in Galor and Weil (1996), one cannot guarantee that the steady-state equilibrium is unique.

3 Measurement: Replicating a Baseline Economy

In this section we provide a first empirical assessment of the cost of gender discrimination by choosing parameter values for our model economy so that it mimics some key statistics of the United States economy. Table 1, part I, provides all parameter values as well as a note on how each one was obtained. Below, we describe our calibration in detail.

The model period in our economy is taken to be 25 years. Therefore, each agent lives about 75 years. The capital share α is set to 0.40, consistent with Gollin (2002). According to Greenwood, Seshadri, and Vandenbroucke (2005), the annual growth rate of total factor productivity (TFP) in the United States was 1.41 percent between 1900 and 1948 and jumped to about 1.68 percent between 1948 and 1974.[20] In our model, we set the parameter μ such that the rate of TFP growth in the sector where labor is complementary to capital (i.e., *mental labor sector*) is equal to 1.5 percent.[21] We set β such that the agents´ subjective discount rate is 4% per year, similar to the risk free yearly real interest rate in the United States in the post war period, as shown in Parente and Prescott (2000). The altruism factor, γ, is calibrated so that the population is constant in the long-run equilibrium. We set the values of the remaining four parameters - $\hat{k}_0$, B, ϕ, and D- so that we approach four empirical observations for the U.S. economy: (i) the ratio of per capita income in 2000 relative to its level in 1900;[22] (ii) the female to male wage earnings in 1900;[23] (iii) the female to male earnings in 2000;[24] and (iv) the ratio of female to male hours of work in 2000.[25] Observe that the calibrated model matches the target values well[26] (see table 1, part II).

Our model, however, suggests that women spend 23 percent less hours in home activities in 2000 than in 1900.[27] Estimates from Ramey and Francis (2006) suggest

[20] After 1974 there was a productivity slowdown as the TFP growth rate decreased by about 0.57 percent. From 1995 to 2000 the TFP growth rate increased to about 1.2 percent per year.

[21] This is the weighted average for the period from 1900 to 1974. Observe that the TFP parameter in the mental labor sector is $Z_t = A_t^{\frac{1}{1-\alpha}}$. This implies that $\mu \simeq (1-\alpha) \times 1.5\% = 0.9\%$. Recall also that a model period corresponds to 25 years. Therefore, $A_t = ((1+\mu)^{25})^t$.

[22] According to Maddison (2006), the 2000 real per capita income in the United States was about 7 times higher than its level in 1900.

[23] Goldin (1990) shows that in 1900 the average employed female earned about 48 percent of the average employed male.

[24] According to Goldin (2006), the female to male earnings ratio in 2000 was about 0.75.

[25] According to Erosa, Fuster, and Restuccia (2005), women worked 40 percent fewer hours than men.

[26] In our calibration $\hat{k}_0 = 0.0042 > 0.0006 = \hat{k}^*$. This implies that only women work at home in our calibrated model and the number of hours in home activities decrease with capital accumulation.

[27] More specifically, $h_{2000}/h_{1900} = 0.77$.

that the number of hours per woman in home production decreased by 40 percent from 1900 to 2000.[28] Our model thus underestimates the reduction in the number of hours spent by women in home activities over the development process. However, we highlight that in our model, as in Galor and Weil (1996), the driving force in the reduction of time spent in home activities is the decrease in the gender wage gap.[29]

Figure 2 shows the evolution of the baseline economy, represented by the solid line. The graph on the left describes the evolution of the capital stock, with $\hat{k}_{t+1}$ on the y axis and $\hat{k}_t$ on the x axis, and the steady state is found where this line is crossed by the 45 degree line. Simulations with the baseline parameter values show that there is a unique steady-state equilibrium for $\hat{k}_t > \hat{k}^*$. The graph on the right shows the mechanics of the increase in women´s hours worked: as capital is accumulated, the gender wage gap narrows; this increases the opportunity cost of staying at home, decreases fertility, and increases female labor market participation. The dotted line in both graphs describes an economy with a female to male earnings ratio in 2000 of 60 percent instead of 75 percent, as in the baseline economy. Observe that, in this case, the capital per unit of efficiency couple is lower and women work fewer hours in the market. In the following section we exploit these "cross-section" changes further.

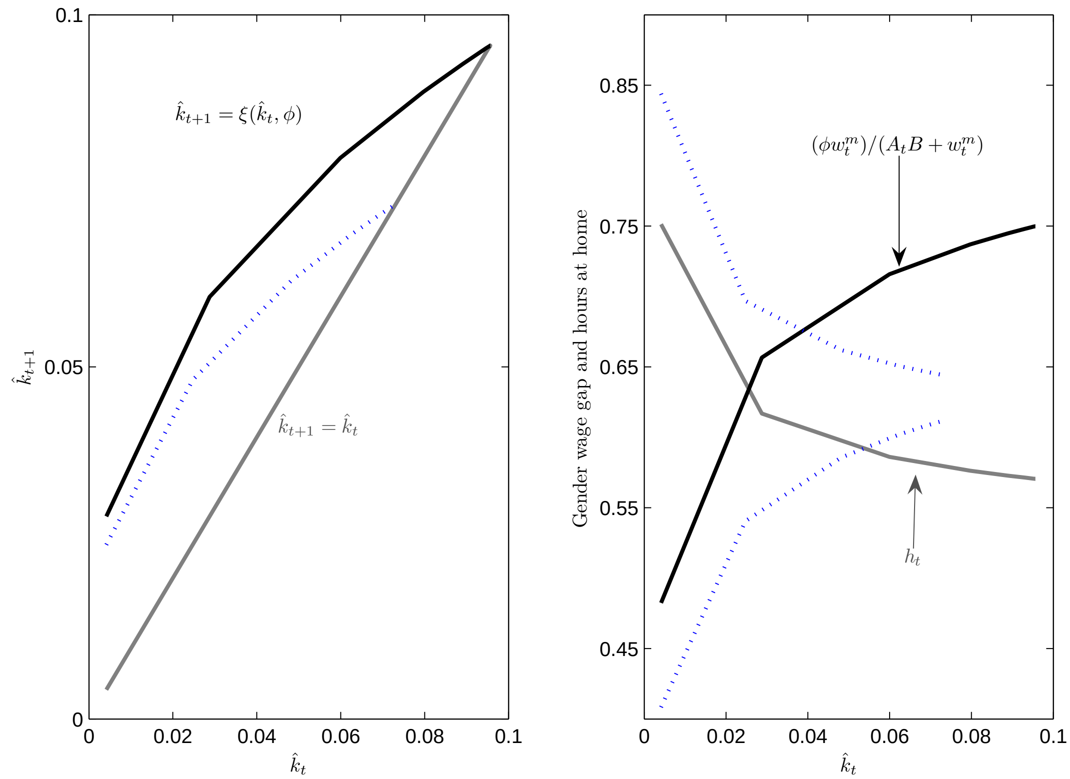
[28]According to Ramey and Francis (2006), women spent on average about 50 hours per week in home activities in 1900, compared with about 30 hours per week in 2000.

[29]As argued by Greenwood, Seshadri, and Yorukoglu (2005), there are other factors, such as technical progress in the home sector, that are important in accounting for the reduction in hours of housework. In fact, Cavalcanti and Tavares (2007) show that a decrease in the relative price of home appliances has a first order effect in female labor force participation. See also Albanesi and Olivetti (2007), who argue that improved medical knowledge and the provision of an effective breast-milk substitute favored women's participation in the market. In the current paper we abstract from technical progress in the home sector, so we underestimate the reduction of hours in home production. Following Greenwood, Seshadri, and Vandenbroucke (2005), we could have increased parameter D in 1950 to mimic the technical progress that occurred in the home sector. This, however, would not have added any new insight to our analysis.

Table 1: Parameter values, basic statistics, baseline economy. Sources: Goldin (1990), Goldin (2006), Maddison (2006), and Erosa, Fuster, and Restuccia (2005).

Part I: Parameter Values		
Parameters	*Values*	*Comment/Observations*
α	0.4	Capital share based on Gollin (2002)
μ	0.009	Rate of TFP growth based on Greenwood, Seshadri, and Vandenbroucke (2005)
β	0.3604	Calibrated to match the U.S. historical post-war return on government bonds (about 4%)
γ	0.445	Population growth rate is constant in the steady-state
D	1.75	Calibrated to match hours worked by women relative to hours worked by men in 2000
B	0.06375	Calibrated to match the U.S. female to male earnings ratio in 1900
ϕ	0.985	Calibrated to match the U.S. female to male earnings ratio in 2000
$\hat{k}_0$	0.00415	Calibrated to match the U.S. per capita output in 2000 relative to its level in 1900 (Maddison (2006))
Part II: Basic Statistics		
	U.S. economy	*Baseline economy*
$\phi w^m_{1900}/(w^p_{1900} + w^m_{1900})$	48%	48.9%
$\phi w^m_{2000}/(w^p_{2000} + w^m_{2000})$	75%	74.8%
y_{2000}/y_{1900}	7.0	7.0
$1 - h^{women}_{2000}/1 - h^{men}_{2000}$	60%	58%

Figure 2: Baseline Economy.



4 Measurement: The Output Cost of Gender Discrimination

We now explore how the equilibrium properties of the model calibrated in the previous section change with gender discrimination, measured by the female to male earnings ratio. We vary parameter ϕ and examine the model's predictions along three dimensions: output per capita as a fraction of U.S. output per capita; female to male earnings ratio; and women's hours worked in the market. All statistics correspond to what would be observed in 2000.

Table 2 shows that as gender discrimination in labor market activities increases, the level of per capita output decreases, and both the gender wage gap and hours spent

Table 2: Gender inequality and development: Quantitative properties of the model

	Output per capita, % baseline	Female to male earnings ratio	Hours at home, % baseline	Output per capita, % baseline (constant fertility)
Baseline	100.00	74.49	100	100
$\phi = \frac{1}{1.5} \times \phi_{\text{base}}$	74.47	47.52	132.48	86.36
$\phi = \frac{1}{2} \times \phi_{\text{base}}$	57.67	34.86	165.17	77.23
$\phi = \frac{1}{3} \times \phi_{\text{base}}$	37.21	23.27	226.13	63.25
$\phi = \frac{1}{4} \times \phi_{\text{base}}$	25.84	18.26	276.55	51.26

by women in home activities increase. The effect of ϕ on output per capita is sizeable: a decrease in ϕ by a factor of two decreases output per capita by approximately 42.3 percent, while hours at home increases by approximately 65 percent.[30]

It is very important to highlight that as barriers to female labor market participation increase (that is, ϕ decreases), there are two channels through which per capita output decreases.[31] First, output per capita decreases because women work fewer hours in the market (h_t decreases), and so output decreases for the same population. Second, output per capita also decreases because discrimination discourages female labor market participation and decreases the couple´s total income, leading couples to choose to have more children, that is, increase n_t.[32] What is the relative quantitative importance of the two effects in the overall impact of discrimination.

[30] $1 - h_t$ can be interpreted as the fraction of the female population that participates in labor market activities in a homogeneous couple setup.

[31] Per capita output in this model is given by: $y_t = \frac{Y_t}{n_t L_t^p + L_t^p + \frac{L_t^p}{n_{t-1}}}$. The first term in the denominator corresponds to the number of existing children, the second term is the number of young couples, and the third term is the number of elderly couples.

[32] In our model, as discrimination limits utility gains through female participation and higher consumption, couples opt for increases in utility through fertility. This effect also accounts, in a larger model, for the lower opportunity cost of time spent at home, which is reflected in the decision to have more children.

In the last column of Table 2 we present results for output per capita in the baseline economy when fertility is kept constant. We have solved a standard overlapping generations economy without fertility in which we feed exogenous values of h_t into the model as observed in each previous experiment. In this case, we are isolating the first channel through which gender discrimination affects output per capita, that is, the effect working solely though number of hours worked by women.[33] When the female to male earnings ratio decreases by a factor of two, output per capita, in the constant fertility case, decreases by 22.77 percentage points, compared to 42.23 percentage points in the first column.[34] The effect of discrimination through women´s hours at work accounts for about 54 percent of the total reduction in output observed in the model with endogenous fertility. It is noticeable how both effects are of similar magnitude.[35]

5 Measurement: Counterfactual Analysis

The exercises in the previous section describe the quantitative properties of the model for systematic variations in gender discrimination through wage discrimination. We now feed the model with independent estimates of the gender wage gap. As Blinder (1973) and Oaxaca (1973) have shown, total wage differential between men and women can be decomposed into an explained part due to differences in characteristics and an unexplained residual ("gender discrimination"). Clearly, for our purpose,

[33]We can infer the role of fertility in the output decrease as the difference between the first and the last column.

[34]Esteve-Volart (2004) estimates, for the case of Indian states, that lower discrimination leading to an increase of 10 percent in the female-to-male ratio of total workers is associated with an increase in per capita output of 8 percent. In our model a decrease in 12 percent in gender discrimination leads to an increase of 10 percent in the female to male ratio of total workers, and consequently to an increase in output of 7 percent.

[35]Note that since ours is a model-based estimate, we take into consideration the change in the productivity of all workers due to changes in the total amount of workers employed.

the correct data is to use cross countries measure of the unexplained residual. However, such data are not readily available for a high number of countries. From our knowledge, the best available source is Weichselbaumer and Winter-Ebmer (2005), that provides a quantitative review of a vast amount of empirical literature on the gender wage gap. Most of the estimates available are from the 1980s and 1990s, and the examined period changes considerably across countries, which is a problem given that, as the authors note, the gender wage gap has decreased across time. In addition, and more importantly, almost all Middle-Eastern economies, some noticeable for high levels of gender discrimination, are absent from the sample. Lastly, the authors unveil a strong positive correlation between the gender wage gap and the unexplained residual, which suggests that the relative discrimination costs across countries we will compute would remain substantially unaltered were we to obtain consistent estimates of the gender wage residual across countries.[36]

We therefore use independent estimates of the female to male earnings ratio for several economies, keeping the other parameters, as in the baseline economy, at the U.S. level.[37] The purpose of this counterfactual exercise is to assess how much the level of U.S. output per capita would decrease if gender discrimination were the same as in, say, Egypt. This will provide us with a first-ever macroeconomic estimate of how much of the existing difference in output per capita between Egypt and the

[36]Figure 2 of Weichselbaumer and Winter-Ebmer (2005) plots the reported gender wage gap versus the reported wage residual. For countries above the 45^0 line (e.g., Cote d'Ivoire, Tanzania, and Korea) women have lower endowments than men. Part of the total wage gap, therefore, can be attributed to differences in human capital. Countries underneath the 45^0 line (e.g., Singapore, Guinea, and Costa Rica) the contrary is true. Women have higher endowments than men, but they are paid less. The majority of countries, however, lies close to the 45^0 line.

[37]Besides the arguments in the last paragraph, we also have that much of the differential endowments of women is also explained by discrimination. Therefore, it makes sense in a long-rum model where education is not explicitly considered, to estimate the cost of discrimination by using the gender wage gap rather that the gender wage residual.

Table 3: Gender inequality and development: Empirical data and model predictions for reference economies. Source: United Nations (2005).

Countries	Data		Model		
	Output per capita, % baseline	Female to male earnings ratio	Output per capita, % baseline	Female to male earnings ratio	Output per capita, % baseline (constant fertility)
Baseline$_{\phi_{US}=0.985}$	100.00	74.49	100	75	100
Ireland$_{\phi_{IRL}=0.5743}$	72.60	41.00	66.47	41.00	82.12
Greece$_{\phi_{GRC}=0.6304}$	40.69	45.45	72.01	45.45	85.07
Argentina$_{\phi_{ARG}=0.5253}$	32.98	37.33	61.31	37.33	79.29
Saudi Arabia$_{\phi_{SAU}=0.2923}$	46.05	21.00	32.28	21.00	58.68
Iran$_{\phi_{IRN}=0.4048}$	17.59	28.49	47.19	28.49	70.74
Egypt$_{\phi_{EGY}=0.3696}$	13.20	26.04	42.68	26.04	67.58
India$_{\phi_{IND}=0.5345}$	7.69	38.02	62.29	38.02	79.84

United States can be accounted for by differences in gender inequality in pay. In effect, we conduct this exercise for a large sample of countries. For each country, we feed in an independent estimate of gender wage inequality and compare the model's predictions with the relevant country data. We keep all parameters at their baseline values, except parameter ϕ, which we adjust until the female to male earnings ratio is similar to what is observed in the data. Table 3 reports the results.

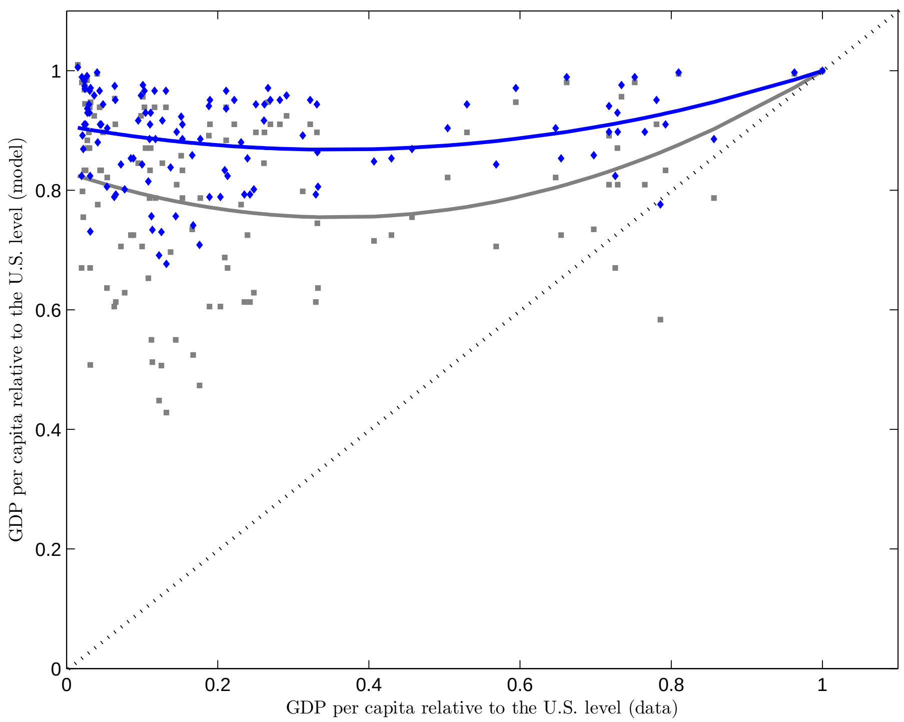
We find that when fertility is endogenous, gender wage discrimination explains a large fraction of the difference in output per capita between any of these countries and the United States. For some countries, such as Saudi Arabia and Ireland, barriers to female labor force participation explain the entire gap in relative output per capita. Notice that, were the United States to have the level of gender pay inequality observed in Egypt, output per capita would be 42.68 percent below its actual level. Since output per capita in Egypt is about 13.20 percent that of the United States, gender discrimination explains about 65.28 percent of the difference in output per capita between the two countries. When fertility is constant the model explains about 36.92 of the difference, still a sizeable fraction.[38]

Figure 3 summarizes the performance of our model for 118 countries, for the baseline model and for the model with constant fertility. The figure plots, on the y axis, the value of country output per capita relative to the U.S. level, as predicted by the model. On the x axis, we plot the value of the exact same variable, as observed in the data. If gender discrimination explained all of the difference in per capita output between a country and the U.S., the corresponding point would lie on the 45 degree line. The graphs reveal three extremely important features. First, the model tends to predict values of per capita output that are higher than those observed in the data. This is expected given that we focus only on barriers to female labor force participation and abstract from all other differences among countries, such as TFP differences, labor market institutions, and government policies, etc.[39] We also abstract from the effects of gender discrimination on human capital, working through a decrease in young girls'access to education, which is also expected to be considerable. Second, for some countries, gender discrimination explains all of the difference in relative output levels, as shown by the cases where the point lies very close to the 45 degree line. Third, the model with endogenous fertility shows a stronger positive correlation between predicted and actual values, when compared to the exogenous fertility model.

[38] Hausmann, Tyson, and Zahidi (2006) present a graph relating gender discrimination and output per capita where the two variables are clearly negatively related. The gender discrimination index is the synthesis of gender discrimination indices in health, education, political and economic empowerment. The Economist (2007) quotes an estimate by Kevin Daly (2007): suppose "*women's employment rates were raised to the same level as men's; and suppose that GDP rose in proportion with employment. Then America's GDP would be 9% higher, the euro zone's would be 13% more, and Japan's would be boosted by 16%.*"

[39] These, as shown by Hall and Jones (1999) for TFP and by Acemoglu, Johnson, and Robinson (2001) for institutions, can be quite sizeable.

Figure 3: Empirical Data and Model Predictions for Selected Economies. Gray squares represent model predictions with endogenous fertility and the corresponding solid line is the best second order polynomial fit. Blue diamonds and the accompanying blue line correspond to the constant fertility model. Dashed line: 45 degree line.



6 Conclusions

The purpose of this paper is straightforward. We present a simple model of growth with endogenous fertility and endogenous labor market participation that allows us to provide a macroeconomic estimate of the output costs of gender discrimination. By choosing parameter values that bring our baseline economy close to the actual U.S. economy we find that the output cost of gender discrimination is sizeable. This decrease in output per capita can reach 43 percent of the current U.S. level, were the U.S. to approach the level of gender wage inequality present in, say, Egypt. This estimate is reached changing *only* the level of gender wage inequality in the U.S. and maintaining all other parameters, including productivity. This decrease in output per capita due to wage discrimination stems from both a decrease in female labor market participation and an increase in fertility, with the first channel slightly more important quantitatively. A counterfactual exercise using 118 developing and developed countries shows that, as expected, our simple model underestimates the difference in output per capita with the U.S. economy. However, as is clearly demonstrated, our parsimonious model shows that a large fraction of country differences in output per capita can be attributed to gender inequality, and for countries such as Ireland and Saudi Arabia, wage discrimination may explain *all* of the output difference. Therefore, many countries may substantial better use of their workforce and increase output per capita by discouraging gender discrimination in the labor market.

We consider the relationship between gender discrimination and output to be of utmost importance and think that further research should concentrate on two different issues. The first is how distinct mechanisms of gender discrimination - say, bias against participation versus wage discrimination - affect output. The second is the relationship between gender discrimination and human capital, in particular how curtailment of girls' education affects overall human capital and output in a dynamic setting.[40]

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A Proof of Proposition 1

Equation (16) defines $h_t = \psi(\hat{k}_t, \phi)$. When $h_t = 1$, we have that $\psi_i(\hat{k}_t, \phi) = 0$. For $h_t < 1$, and using the implicit function theorem, yields:

$$\frac{\partial h_t}{\partial \hat{k}_t} = \psi_1(\hat{k}_t, \phi) = \frac{-B\gamma\alpha\hat{k}_t^{-1}(2-h_t)}{(1+\beta+\gamma\theta)\phi(1-\alpha)k_t^{\alpha}(2-h_t)^{1-\alpha}+B\gamma\alpha} < 0. \tag{21}$$

Clearly, $\psi_2(\hat{k}_t, \phi) < 0$.

B Proof of Proposition 2

Equation (19) defines a non-linear difference equation $\hat{k}_{t+1} = \xi(\hat{k}_t, \phi)$. As in Galor and Weil (1996), it is clear that $\xi(\cdot, \phi)$ is continuous, and when $\hat{k}_t < \hat{k}^*$, we have that

$$\hat{k}_{t+1} = \xi(\hat{k}_t, \phi) = \frac{\beta}{D(1+\beta)(1+\mu)}[(1-\alpha)\hat{k}_t^{\alpha} + B].$$

Therefore,

$$\xi_1(\hat{k}_t, \phi) = \frac{\beta}{D(1+\beta)(1+\mu)}[(1-\alpha)\alpha\hat{k}_t^{\alpha-1} + B],$$

and

$$\xi_{11}(\hat{k}_t, \phi) = \frac{\beta}{D(1+\beta)(1+\mu)}[-(1-\alpha)^2\alpha\hat{k}_t^{\alpha-1} + B] < 0.$$

Moreover, clearly $\lim_{k_t \to 0} \xi_1(k_t, \phi) = \infty$.

When $k_t > k^*$, then

$$\hat{k}_{t+1} = \xi(\hat{k}_t, \phi) = \frac{\beta}{D\gamma(1+\mu)}\phi(1-\alpha)\hat{k}_t^{\alpha}(2-h_t)^{-\alpha}.$$

Therefore,

$$\xi_1(\hat{k}_t, \phi) = \frac{\beta}{D\gamma(1+\mu)}\phi(1-\alpha)\alpha\hat{k}_t^{\alpha-1}(2-h_t)^{-\alpha-1}[(2-h_t) + \hat{k}_t\frac{\partial h_t}{\partial \hat{k}_t}].$$

From (21), we have that $|\hat{k}_t\frac{\partial h_t}{\partial \hat{k}_t}| < (2-h_t)$, which implies that $\xi_1(k_t, \phi) > 0$ for $k_t > k^*$. In addition, $\lim_{\hat{k}_t \to \infty} \xi_1(\hat{k}_t, \phi) = 0$. Therefore, a positive and locally stable steady-state $\bar{\hat{k}} = \xi(\bar{\hat{k}}, \phi)$ exists.

C Model with gender productivity difference in child raising activities

The model presented in Section 2 relies on the assumption that men are more productive than women in physical labor, but they have an equal productivity in mental labor. Here we present an alternative framework in which there is only one type of labor, which is complementary to capital, but women are more productive than men in raising children. The preferences of the couple are still represented by the same utility function, but both the child raising and the production functions are changed.

In particular, we assume that each man and each woman have one unit of time that can be used to raise children or in market production. Let h_t^w and h_t^h denote the time of the wife and the husband spent in raising children. The child raising production function is given by

$$n_t = D(h_t^w + \theta h_t^h),\ D > 0, \tag{22}$$

We assume that $\theta \in (0,1)$, which implies that men are more productive than women in household chores. The couple's budget constraints are:

$$c_t + s_t \leq w_t(1 - h_t^h) + \phi w_t(1 - h_t^w), \tag{23}$$

$$d_{t+1} \leq (1 + r_{t+1})s_t. \tag{24}$$

It can be shown that only the woman spends time raising children,[41] i.e., $h_t^h = 0$, and

$$h_t^w = \frac{\gamma}{D(1+\beta+\gamma)}\frac{\phi}{1+\phi}, \tag{25}$$

which is increasing in gender inequality (lower ϕ). The time endowment of women requires that $h_t^w \leq 1$. Therefore, for given (γ, D, β), there is a limit on gender wage inequality.

[41] Observe that $h_t^h > 0$ requires $\theta \geq 1/\phi$. But this cannot be the case, since $\phi < 1$ and $\theta < 1$.

The market production function is represented by a standard Cobb-Douglas function

$$Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha}, \tag{26}$$

where L_t represents the labor input in production, $A_t = (1+\mu)^t$, and $\alpha \in (0,1)$.

In equilibrium, we have that capital evolves according to:

$$\hat{k}_{t+1} = \frac{\beta\phi}{D\gamma(1+\mu)}(1-\alpha)\hat{k}_t^{\alpha}(2-h_t^w)^{-\alpha}. \tag{27}$$

In this case there exists a unique and globally stable steady-state level of capital per unit of efficient couple. Again cross-country differences in gender inequality will have two effects on long-run output: (i) one through its direct effect on labor participation; and (ii) another through its impact on fertility. Observe, however, that contrary to the model of Section 2, the present model generates gender wage inequality and fertility rates that are constant over time.

Table 4, part I, provides all parameter values as well as a note on how each one was obtained. The calibration exercises use the same statistics that were used in the previous model. Now, we do not have to calibrate parameter B, but we have to calibrate parameter θ, which is the relative productivity of men in child raising activities. Observe, however, that for any $\theta \in (0,1)$, only women will spend some time at home. Therefore θ can take any value in the $(0,1)$ interval.

We again explore how the equilibrium properties of the model change with gender discrimination, measured by the female to male earnings ratio. Table 5 shows that results are qualitatively and quantitatively similar to those presented in Table 2. A decrease in ϕ by a factor of two decreases output per capita by approximately 39 when fertility is endogenous, and by roughly 20 percent when fertility is exogenous. Recall that this same exercise using the model of Section 2 yielded the following reductions in output per capita (see Table 2): 42.3 and 22.77 percent for the case of endogenous and exogenous fertility, respectively.

Table 4: Parameter values, basic statistics, baseline economy. Sources: Goldin (1990), Goldin (2006), Maddison (2006), and Erosa, Fuster, and Restuccia (2005).

Part I: Parameter Values		
Parameters	*Values*	*Comment/Observations*
α	0.4	Capital share based on Gollin (2002)
μ	0.009	Rate of TFP growth based on Greenwood, Seshadri, and Vandenbroucke (2005)
β	0.3604	Calibrated to match the U.S. historical post-war return on government bonds (about 4%)
γ	0.445	Population growth rate is constant in the steady-state
D	2.5	Calibrated to match hours worked by women relative to hours worked by men in 2000
θ	$\theta \in (0,1)$	Any number in the interval $(0,1)$
ϕ	0.75	Calibrated to match the U.S. female to male earnings ratio in 2000
$\hat{k}_0$	0.0085	Calibrated to match U.S. per capita output in 2000 relative to its level in 1900 (Maddison (2006))
Part II: Basic Statistics		
	U.S. economy	*Baseline economy*
$\phi w_{1900}/w_{1900}$	48%	75%
$\phi w_{2000}/w_{2000}$	75%	75%
y_{2000}/y_{1900}	7.0	7.0
$1-h_{2000}^{women}/1-h_{2000}^{men}$	60%	60%

Table 5: Gender inequality and development: Quantitative properties of the model

	Output per capita, % baseline	Female to male earnings ratio	Hours at home, % baseline	Output per capita, % baseline (constant fertility)
Baseline	100.00	75	100	100
$\phi = \frac{1}{1.5} \times \phi_{\text{base}}$	75.55	50	128.57	87.66
$\phi = \frac{1}{2} \times \phi_{\text{base}}$	60.90	37.50	157.14	80.26
$\phi = \frac{1}{3} \times \phi_{\text{base}}$	47.52	25.00	214.28	70.51