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Sex Discrimination and Growth

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Abstract

This paper argues that sex discrimination is an inefficient practice. We model sex discrimination as the complete exclusion of females from the labor market or as the exclusion of females from managerial positions. The former implies a reduction in GDP per capita; the latter distorts the allocation of talent and lowers economic growth. Both imply lower female-to-male schooling ratios. Our model predicts a convex relationship between nondiscrimination and growth. Although discrimination is difficult to measure, it will be reflected in schooling differentials. We present evidence based on cross-country regressions that is consistent with a convex relationship between schooling differentials and growth.

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I. INTRODUCTION

Sex discrimination against women in the market place reduces the available talent in an economy, which has negative economic consequences. Sex discrimination takes many forms. Many social practices seen as **normal** from a religious or cultural point of view (which may have deep historical roots) leave women out of the economic mainstream. These social practices may have profound economic consequences because they do not allow society to take advantage of the talent inherent in women. This paper investigates these economic consequences. Although sex discrimination may have a myriad of other important consequences, including psychological, sociological, and religious, these are not discussed in this paper.

We develop a theoretical model that allows us to explore the economic implications of sex discrimination in the labor market. In the model, individuals are born with a given endowment of entrepreneurial talent and decide how much human capital to acquire, and whether to become managers or workers. Their choices depend on what everyone else is doing, because other people's decisions affect the returns to investment in human capital and the relative returns to becoming a manager or a worker. We study three possible scenarios. First, we analyze the labor market equilibrium without sex discrimination. Second, we model sex discrimination as an exogenous exclusion of females from managerial positions. Our model shows how this discriminatory practice affects the labor market, the equilibrium wage rate, the allocation of talent across working and managerial positions, the investment in human capital by individuals (both males and females), and economic growth. We show that sex discrimination tends to lower equilibrium wages for both female and male workers, and to reduce investment in human capital by all females and by male workers. We also show that the average talent of managers is smaller in the presence of discrimination, which reduces the growth rate of the economy. A general prediction of the model, therefore, is a positive correlation between the ratio of female to male education and economic growth.

Finally, we model sex discrimination as a complete exclusion of females from the labor market. In this case, the equilibrium wage rate—and, hence, the average talent and the rate of growth—are the same as in the nondiscrimination model. Nevertheless, this type of discrimination is inefficient, because per capita GDP is reduced to half its level without discrimination. In this case, females optimally decide not to invest in human capital, so female-to-male schooling ratios are lower than in the case of partial discrimination.

The model therefore predicts a convex relationship between sex nondiscrimination and growth. These implications can be tested with data. Although it is very difficult to measure sex discrimination, our model suggests that sex discrimination is reflected in the relative investment in human capital by males and females. Our theory predicts that females who are discriminated against tend to study less, even though our model assumes that sex discrimination is limited to the labor market level, that is, there is no sex discrimination in education.

Our empirical analysis is based on cross-country data for over 100 countries. To frame the analysis within the empirical growth literature, we use the standard regressors from cross-country growth studies (see Barro and Sala-i-Martin (1995), Barro (1997), and Sala-i-Martin (1997)), augmented to include measures of relative school attainment of males and females. The data confirm a convex relationship between female-to-male schooling ratios and growth. In particular, in countries with relatively high female-to-male schooling ratios an increase in this ratio raises growth, while in countries with very low female-to-male schooling ratios, an increase in the ratio lowers growth. However this does not mean that extreme discrimination is a good practice since it also lowers the level of per capita GDP.

The paper is organized as follows. Section II presents the model. Section III describes the data. Section IV presents the empirical evidence. Section V concludes and discusses some policy implications.

II. MODEL

A. The Division Between Managers and Workers in the Labor Market

Following Rosen (1982), we consider an economy where each firm is run by one manager, who employs workers. Workers, in turn, follow the directions that are given by the manager.

Individuals are born with a given endowment of underlying managerial talent, denoted by T.[1] Each individual can optimally choose whether she wants to become a manager or a worker. Each person is described by a vector of skills *(q,r)*, where q denotes productivity as a worker and r denotes managerial skills. The type of skill she actually utilizes is determined by her decision to be either a manager or a worker, while the other skill remains latent. Individuals can invest in human capital in order to increase their skills. In particular, individuals acquire higher education and/or primary education. We assume that those who want to become workers acquire only primary education, while those who want to be managers can acquire both primary and higher education. An individual cannot acquire higher education without first having completed primary schooling. We assume that skills are given by the following:

$$\begin{aligned} r &= cT\overline{H}_p + (1-c)T^{\beta}H_h^{\,1-\beta} \\ q &= 1 + H_p^{\,\sigma}, \end{aligned} \qquad (1)$$

with $0<\beta<1$ and $0<\sigma<1$, for some constant $0<c<1$. If a worker does not invest in human capital, he has a skill equal to 1. H_j, $j=\{p, h\}$ denotes the level of primary and higher schooling acquired by individuals. Complete primary schooling is denoted by $\overline{H}_p$.

We assume that entrepreneurial talent at birth is distributed uniformly for males and females. The total population is P, one-half of which is female. However, investment in education by women and men may be different because of discrimination.

[1] This concept is similar to the notion of **energy** used in Becker (1985).

The product attributable to a manager with r skills supervising a total quantity of labor skills Q is

$$Y_r = sg(r)f(Q), \tag{2}$$

where $f' \geq 0, f'' < 0$ (diminishing returns), $g' > 0$, and s is the current state of technology, which is a nonrival, nonexcludable good.[2]

The form $g(r)$ can be thought of as the analytical representation of the quality of management decisions, so that greater r implies greater $g(r)$. In other words, higher-quality managers make better management decisions. In particular, the term $g(r)$ gives a representation of the quality of the entrepreneur who is running the firm, so that there are multiplicative productivity interactions.[3] It also captures the idea that the quality of managers is embodied. This formulation implies scale economies since the marginal product of the additional quality of workers is increasing in $g(r)$. However, the diminishing returns to Q imply that this scale economy is so congested that the best manager does not take all the market.

We assume that Y_r exhibits constant returns to scale and that f and $g(\cdot)$ are a Cobb-Douglas function; therefore we can rewrite (2) as

$$Y_r = sr^{\alpha}Q^{1-\alpha}, \tag{3}$$

with $0<\alpha<1$.

The managers' problem

A manager with r skills faces a two-stage decision. First, how much education (primary and higher) does she want to acquire as a manager? Second, how many workers is she going to hire? She takes wages (w) as given. We solve the problem by working backward.

Stage 2: Given skills r, the manager's problem is to choose the size of her company (or the size of her labor force, Q_r) that maximizes gross income:[4]

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[2] $Q = \sum_{i=1}^{N_j} q_i$, where N_j denotes the amount of workers hired by firm j's entrepreneur.

[3] This is related to the production function used in Kremer (1993), where the author considers multiple tasks, and explains how failure of one task can have a knock-on effect on other tasks.

[4] The manager's gross income is profits, while net income corresponds to profits minus total cost of education; net income is ignored here because it plays a role only in stage 1.

$$\max_{Q_r} \quad \pi_r = s r^{\alpha} Q_r^{1-\alpha} - w Q_r ,$$

where the price of output is normalized to one and w is the market efficiency price for Q_r (which we call the wage), so that the amount Q_r of worker skills that maximizes profits is given by the first-order condition

$$Q_r = \left[\frac{s(1-\alpha) r^{\alpha}}{w} \right]^{\frac{1}{\alpha}} . \tag{4}$$

Equation (4) is the demand function for worker skills for the firm, which determines the size of the firm. The greater the manager's skills (r), the larger is her firm; the higher the wage, the lower the hiring; and the better the technology (s), the more workers are hired by r. We can rewrite managers' gross income as

$$\pi_r \equiv \left[s^{\frac{1}{\alpha}} w^{\frac{-(1-\alpha)}{\alpha}} \alpha (1-\alpha)^{\frac{1-\alpha}{\alpha}} \right] r . \tag{5}$$

That is, the profit is a linear function of skills, where the factor of proportionality is a combination of wages and technology.

Stage 1: Given that she knows that she will be rewarded according to (5), the manager chooses a level of human capital that maximizes her net income. We distinguish between primary and higher education, and the manager can only choose her investment in higher education because she needs to acquire $\overline{H}_p$ units of primary education in order to get to higher schooling. Therefore, we can write the manager's problem as

$$\max_{H_{h,r}} \quad \pi_r^{net} \equiv \pi_r - a_p \overline{H}_p - a_h H_{h,r} , \tag{6}$$

where $a_j = \{p,h\}$ denotes the cost of each unit of education of primary and higher schooling, respectively.

It makes sense to think that the opportunity cost of education is given by human time and also other inputs, which are combined in the same proportions as in the production of GDP. In particular, it makes sense that a_j and s grow at the same rate. For this reason, we assume that the cost of education evolves according to changes in GDP. That is, $a_j = \lambda_j s$ for positive constants λ_j. The first-order condition for problem (6) implies

$$H_h = \left[(1-c)^{\frac{1}{\beta}} \hat{\alpha} s^{\frac{1}{\alpha\beta}} w^{\frac{-(1-\alpha)}{\alpha\beta}} a_h^{\frac{-1}{\beta}} \right] T , \tag{7}$$

where $\tilde{\alpha} \equiv \alpha^{\frac{1}{\beta}}(1-\alpha)^{\frac{1-\alpha}{\alpha\beta}}(1-\beta)^{\frac{1}{\beta}}$ is an irrelevant constant.

That is, since $a_p\bar{H}_p$ is a fixed cost to entrepreneurs, it enters their net income function (6) but does not affect their marginal decisions.

Using (1) and (7), we see that a manager's skill is optimally determined as a function of entrepreneurial talent at birth:

$$r = \left[c\bar{H}_p + (1-c)^{\frac{1}{\beta}} s^{\frac{1-\beta}{\alpha\beta}} w^{-\frac{(1-\alpha)(1-\beta)}{\alpha\beta}} a_h^{-\frac{1-\beta}{\beta}} \hat{\alpha} \right] T, \qquad (8)$$

where $\hat{\alpha} \equiv \tilde{\alpha}^{1-\beta}$ is an irrelevant constant.

Notice that there is a one-to-one relationship between the person's underlying entrepreneurial talent, T, and her managerial skills, r. Substituting (7) and (8) into (6) and (5) allows us to write managers' net income as a linear function of talent at birth:

$$\pi_T^{net} = \left[c\bar{\alpha}\bar{H}_p s^{\frac{1}{\alpha}} w^{-\frac{1-\alpha}{\alpha}} + (1-c)^{\frac{1}{\beta}} s^{\frac{1}{\alpha\beta}} w^{-\frac{1-\alpha}{\alpha\beta}} a_h^{-\frac{1-\beta}{\beta}} \bar{\alpha}\beta(1-\beta)^{\frac{1-\beta}{\beta}} \right] T - a_p\bar{H}_p, \qquad (9)$$

where $\bar{\alpha} \equiv \alpha(1-\alpha)^{\frac{1-\alpha}{\alpha}}$. That is,

$$\pi_T^{net} = \psi(\underset{(-)}{w}, \underset{(+)}{s}, \underset{(-)}{a_h}) \cdot T - a_p\bar{H}_p.$$

Managers' net income is depicted as in the profit line in Figure 1.

Since s and a_h are proportional, then ψ is homogeneous of degree one in s (because the wage rate will also grow at the same rate as s). That is, since s and a_j grow at the same rate, in the steady state profits, wages and, therefore, GDP all grow at the same rate. However, H_h will remain constant over time.

The workers' problem

Workers earn qw as gross income. They can increase their productivity (q) by studying. Education for workers is primary education, with unit cost equal to a_p. Since the maximum amount of primary schooling is $\bar{H}_p$, more schooling does not benefit workers. Using (1), we can write the problem of workers as

$$\max_{H_p} \quad I_w^{net} = wq - a_pH_p$$
$$s.t. \quad H_p \leq \bar{H}_p$$
$$q = 1 + H_p^{\sigma}.$$

The optimal investment in primary education by workers is given by the first-order condition

$$H_{p,w} = \left[\frac{w\sigma}{a_p}\right]^{\frac{1}{1-\sigma}}. \tag{10}$$

The optimal decision in (10) is smaller than $\overline{H}_p$ as long as the wage rate is relatively low, in particular, as long as

$$w \le \frac{a_p \overline{H}_p^{\,1-\sigma}}{\sigma}. \tag{11}$$

Also, according to (10), the human capital investment for all workers is the same, regardless of underlying entrepreneurial talent. As long as the cost of schooling is the same, we can write

$$I_w^{net} = w + w^{\frac{1}{1-\sigma}} a_p^{-\frac{\sigma}{1-\sigma}} \hat{\sigma},$$

where $\hat{\sigma} \equiv \sigma^{\frac{\sigma}{1-\sigma}}(1-\sigma)$ is an irrelevant constant. That is, the workers' net income is increasing in the wage rate and decreasing in the cost of schooling. The net income schedule for workers as a function of T is drawn in Figure 1. It is an horizontal line in T because the underlying managerial talent is only useful for managers.

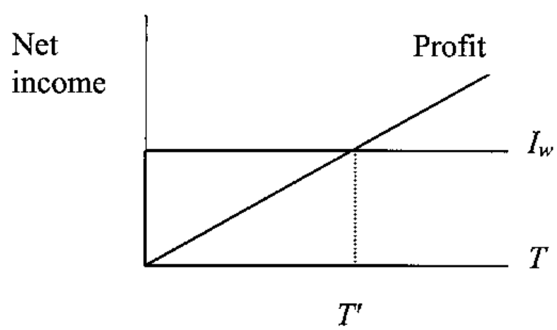

Figure 1. Net Income Schedules for Workers and Managers

The determination of workers and managers

In Figure 1, we see that individuals with underlying entrepreneurial talent less than T' optimally decide to be workers, while those with more underlying entrepreneurial talent than T' optimally decide to be managers. We call T' the cutoff level of talent since this is the level of underlying talent of the least-talented manager in the economy. In particular,

$$T'(w) = \frac{w + w^{\frac{1}{1-\sigma}} a_p^{-\frac{\sigma}{1-\sigma}} \hat{\sigma} + a_p \overline{H}_p}{c\overline{\alpha}\overline{H}_p s^{\frac{1}{\alpha}} w^{-\frac{1-\alpha}{\alpha}} + (1-c)^{\frac{1}{\beta}} s^{\frac{1}{\alpha\beta}} w^{-\frac{1-\alpha}{\alpha\beta}} a_h^{\frac{1-\beta}{\beta}} \overline{\alpha}\beta(1-\beta)^{\frac{1-\beta}{\beta}}} .$$

All the important endogenous variables depend on the wage rate, w. After solving for the equilibrium wage rate, the remaining variables are endogenously determined. As shown in Figure 2, a decline in wages, which entails a decline in workers' net income from I_w to I_w' and hence an increase in profits, from Profit to Profit', unambiguously results in a decline in T', the cutoff level of talent of managers, to T''. That is, $\frac{\partial T'(w)}{\partial w} > 0$. The intuition is that, when wages fall, the incentive to be a manager increases. Since talent is uniformly distributed, some of those who were previously workers now decide to be managers, so that the least-talented manager is less talented than was the case at the higher level of wages.

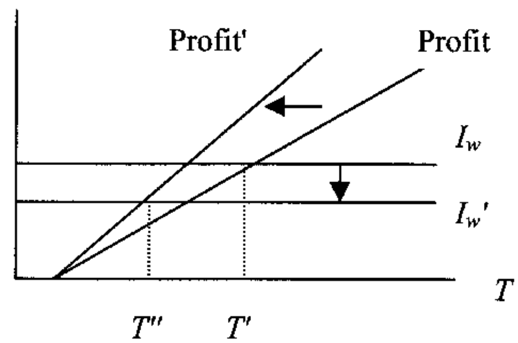

Figure 2. Effects of a Decrease in Wage Rates

B. Labor Market Equilibrium Without Sex Discrimination

In order to solve for the equilibrium wage rate w, we need to compute the aggregate supply and demand for worker skills.

Aggregate supply of workers' skills without sex discrimination

We assume that the distribution of initial talent is uniform between 0 and 1 (Figure 3).

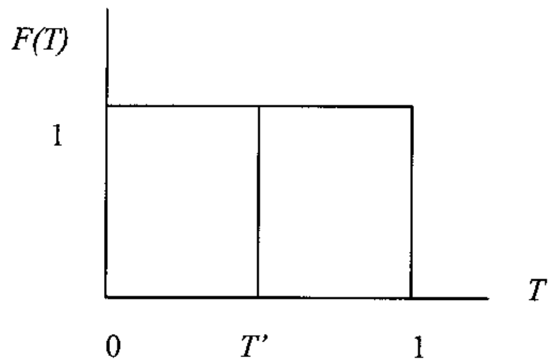

Figure 3. Distribution of Underlying Managerial Talent in Population

The fraction of the entire population that becomes workers is the integral between 0 and T'. From (9) we know that each of them will acquire the same amount of education, so that the skill of each worker is

$$q = 1 + \left[\frac{w\sigma}{a_p}\right]^{\frac{\sigma}{1-\sigma}}.$$

The aggregate supply of worker skills (Q) is, hence, given by

$$Q_s^{ND} = \int_0^{T'(w^{ND})} P\left[1 + \left[\frac{w^{ND}\sigma}{a_p}\right]^{\frac{\sigma}{1-\sigma}}\right] dT = P \cdot T'(w^{ND}) \cdot \left[1 + \left[\frac{w^{ND}\sigma}{a_p}\right]^{\frac{\sigma}{1-\sigma}}\right], \qquad (12)$$

where *ND* stands for nondiscrimination. As we showed above, the cutoff level of talent is an increasing function of the wage rate. Hence, the supply of workers is an increasing function of the wage rate for two reasons. First, higher wages lead to more workers and fewer managers (this is represented by the $T'(w)$ term). Second, higher wages increase the incentive to acquire worker skills. Note than even if we do not allow workers to acquire skills, the labor supply is still upward sloping.

Aggregate demand for worker skills without sex discrimination

Each firm's demand for worker skills is given by (4). There is a one-to-one relationship between managerial skills (r) and underlying entrepreneurial talent (T), given by (8), so that we can write the demand for labor of one firm in terms of T:

$$Q_T = s^{\frac{1}{\alpha}} (1-\alpha)^{\frac{1}{\alpha}} w^{ND^{-\frac{1}{\alpha}}} \left[c\overline{H}_p + (1-c)^{\frac{1}{\beta}} s^{\frac{1-\beta}{\alpha\beta}} w^{ND^{-\frac{(1-\alpha)(1-\beta)}{\alpha\beta}}} a_h^{-\frac{1-\beta}{\beta}} \hat{\alpha} \right] T.$$

Rearranging,

$$Q_T = \left[c\bar{H}_p (1-\alpha)^{\frac{1}{\alpha}} s^{\frac{1}{\alpha}} w^{ND^{-\frac{1}{\alpha}}} + (1-c)^{\frac{1}{\beta}} (1-\alpha)^{\frac{1}{\alpha}} \hat{\alpha} s^{\frac{1}{\alpha\beta}} w^{ND^{-\frac{(1-\alpha+\alpha\beta)}{\alpha\beta}}} a_h^{-\frac{1-\beta}{\beta}} \right] T$$

$$\equiv \mu(\underset{(-)}{w^{ND}}, \underset{(+)}{s}, \underset{(-)}{a_h}) T .$$

The aggregate demand for worker skills is the sum of individual demands across all entrepreneurs; this demand can be represented as the individuals from the cutoff level of talent (T') to talent equal to 1 (Figure 3), multiplied by P, the total population:

$$Q_D^{ND} = \int_{T'(w^{ND})}^{1} \left(\mu(w^{ND}, s, a_h) \cdot T \right) P \cdot dT = P\mu(w^{ND}, s, a_h) \left[\frac{T^2}{2} \right]_{T'(w^{ND})}^{1}$$

$$= P\mu(w^{ND}, s, a_h) \left[\frac{1}{2} - \frac{T'^2(w^{ND})}{2} \right]. \qquad (13)$$

Holding constant T', the aggregate demand for worker skills is decreasing in wages, increasing in technology, and decreasing in the unit cost of higher education. Holding these three constant, aggregate demand for worker skills is decreasing in T'. Since we showed that T' is increasing in wages, it follows that the aggregate demand function depends negatively on wages for two reasons. First, as wages increase, each firm will demand fewer workers. Second, when wages rise, the cutoff level of talent increases, that is, fewer people want to be managers and the number of firms demanding workers declines. Hence, the overall effect of wages on labor demand is negative.

The equilibrium wage rate is given by the equalization of (12) and (13), as seen in Figure 4.

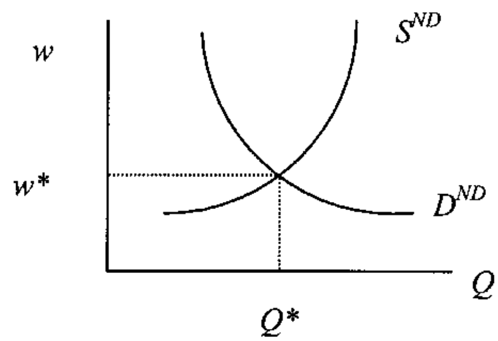

Figure 4. Labor Market Equilibrium Without Discrimination

The number of entrepreneurs

Let the total number of managers be M, which is the sum of male and female entrepreneurs, $M=M^f+M^m$. Since males and females are each one-half of the total population, and both genders are assumed to have the same underlying entrepreneurial talent, the total number of entrepreneurs without discrimination is

$$M^{ND} = M^{m,ND} + M^{f,ND} = \frac{P}{2}\int_{T'(w^{ND})}^{1} 1\,dT + \frac{P}{2}\int_{T'(w^{ND})}^{1} 1\,dT = \left[1 - T'(w^{ND})\right]P. \qquad (14)$$

Economic growth

How does the allocation of talent determine the growth rate of the economy? We assume that the increase in technology is determined by the average quality of ideas in the economy, where the quality of ideas can be represented by the underlying entrepreneurial talent of managers.[5] The reason is that managers are heterogeneous, implying that the average quality of ideas will be a combination of **good** and **bad** ideas. Whether an idea is good or bad is apparent only after it has been tried out. If the idea turns out to be good, then it is adopted and the level of technology increases. If it is bad, time and effort are wasted without any benefit. If more talented people tend to have good ideas and less talented people tend to have bad ideas, then people with smaller-than-average talent will tend to hurt the economy. Hence, what matters is the average talent of managers. In particular,

$$s(t) = s(t-1)\cdot\left[1 + AT(T'(w))\right],$$

where AT denotes average talent. Then it follows that the rate at which technology, costs of education, wages, and profits grow in this economy is AT. Therefore, the growth rate of the economy is

$$AT = \frac{1}{2}\left(1 + T'(w)\right). \qquad (15)$$

C. Labor Market Equilibrium with Sex Discrimination in Managerial Positions

We now consider the implications of sex discrimination. We analyze two cases. First, sex discrimination can occur in managerial positions (that is, the case in which women are not allowed to be entrepreneurs).[6] In the next section, we look at the stronger case of

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[5] This is related to Murphy, Shleifer, and Vishny (1991), where it is assumed that technology is determined by the underlying entrepreneurial talent of the most talented of the entrepreneurs.

[6] This type of discrimination may be rational in the context of religious or traditional beliefs. Several studies report that in some countries it is more difficult for females to have access to

(continued…)

discrimination in which women cannot take part in the labor force either as managers or as workers. We refer to the former as **partial** discrimination (*PD*), and the latter, as **total** discrimination (*TD*).

Aggregate supply of worker skills with partial sex discrimination

Suppose sex discrimination consists of not allowing women to have access to managerial positions. Women, however, may still have access to schooling and worker positions. For every wage, partial discrimination affects the demand and supply of worker skills. The supply of workers will tend to increase because all women are now workers:

$$Q_s^{PD} = \frac{P}{2} \cdot T'(w^{PD}) \cdot \left[1 + \left[\frac{w^{PD}\sigma}{a_p} \right]^{\frac{\sigma}{1-\sigma}} \right] + \frac{P}{2} \cdot q(w^{PD}) = P \left[1 + \left[\frac{w^{PD}\sigma}{a_p} \right]^{\frac{\sigma}{1-\sigma}} \right] \left(\frac{T'(w^{PD})+1}{2} \right). \qquad (16)$$

Since $T'(w)<1$, the rightmost term is larger than $T'(w)$. Hence, for every wage, the supply curve with partial discrimination is to the right of the curve without discrimination.

Aggregate demand for worker skills with partial sex discrimination

Demand for worker skills will tend to fall because there are no female managers:

$$Q_D^{PD} = \int_{T'(w^{PD})}^{1} \left(\mu(w^{PD}, s, a_h) \cdot T \right) \frac{P}{2} dT = \frac{P}{2} \mu(w^{PD}, s, a_h) \left[\frac{1}{2} - \frac{T'^2(w^{PD})}{2} \right].$$

For every wage, demand for worker skills is one-half of what it was without discrimination. In other words, the demand curve with partial discrimination is to the left of the curve without discrimination. Hence, the equilibrium wage unambiguously declines (see Figure 5). The change in the total quantity of worker skills that is hired in equilibrium is ambiguous because, with discrimination, we have higher supply and lower demand.

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human capital, land, and financial or other assets that allow them to be entrepreneurs (see, for instance, Blackden and Bhanu (1999)). Data from the International Labor Office show that even in the 30 most developed countries in the world, the average incidence of females among managers is less than 30 percent. For Africa and Asia (including Pacific countries), the rates are lower than 15 percent (data refer to 1985-95).

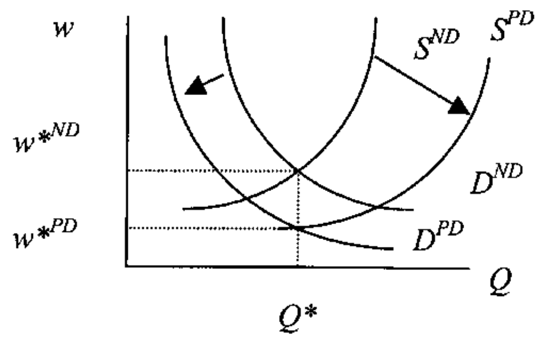

Figure 5. Labor Market Equilibrium with Partial Sex Discrimination

The intuition is that, for a given wage rate, the human capital investment decisions of men and the cutoff level of talent for men remain unchanged. Hence, discrimination against women in managerial positions has two consequences. First, it increases the supply of workers, as all women become workers. Second, it decreases the demand for workers, as all firms that would have been headed by women no longer exist. Both factors work to lower the wages of workers.

The number of managers with partial sex discrimination

In this case, the total number of female managers is zero (by definition); at a given wage, therefore, the total number of entrepreneurs will decline. Since the equilibrium wage is lower, the cutoff level of talent for the remaining male managers is lower, so more males are going to become entrepreneurs. Hence, the total number of managers is

$$M^{PD} = M^{m,PD} + M^{f,PD} = \frac{P}{2}\int_{T'(w^{PD})}^{1} 1\,dT + 0 = \left[1 - T'(w^{PD})\right]\frac{P}{2}.$$

Since $T'(w^{PD})<T'(w^{ND})$ while $P/2 < P$ (that is, the number of male managers is larger because of lower wages while the number of female managers drops to zero), the overall effect of this type of discrimination on the number of entrepreneurs is ambiguous. The change in the number of managers can be written as follows:

$$M^{ND} - M^{PD} = \left[1 - T'(w^{ND})\right]P - \left[1 - T'(w^{PD})\right]\frac{P}{2} = \frac{P}{2}\left[T'(w^{PD}) - T'(w^{ND})\right] + \frac{P}{2}\left[1 + T'(w^{ND})\right].$$

The first term is negative while the second term is always positive. Since the fraction of the population who are managers (1-*T'*) is very small, it is possible that we end up with more managers when there is partial sex discrimination; it depends on the sensitivity to wages of the cutoff level of talent for males and the sensitivity of the wage rate to the requirement that all women work as workers. If there are few women entrepreneurs, the number who become workers under partial sex discrimination represents a small increase in the total supply of worker skills, so that the first negative term is small, in which case the expression is positive. In sum, the change in the number of entrepreneurs is ambiguous, but it is likely that the decrease in the number of managers due to the prohibition of female managers is larger than the increase of male managers due to the lower equilibrium wage.

Economic growth with partial sex discrimination

Since the cutoff level of talent is lower in the partially discriminating economy; that is, $AT^{ND} > AT^{PD}$, the growth rate of the economy is also lower than in the nondiscriminating economy.

The effects of sex discrimination in managerial positions

What are the implications of the lower equilibrium wage for the problem of workers? Recall by (10) that $H_{p,w} \leq \bar{H}_p$, as long as $w \leq \frac{a_p \bar{H}_p^{1-\sigma}}{\sigma}$, because higher wages mean incentives for the worker to invest more in primary education. There are two possibilities:

- In the first case, workers are in the range where $H_{p,w} < \bar{H}_p$. In this case, discrimination lowers the primary human capital of workers. Since some males are entrepreneurs, they will still go through the whole primary schooling process; as a result, the average primary education for males compared to females is

$$AH_p^{males} = \frac{N H_{p,w} + M \bar{H}_p}{P} > H_{p,w} = AH_p^{females},$$

  where *AH* denotes average human capital and *N* denotes the number of workers. In this case, therefore, the ratio of female-to-male primary education decreases with partial discrimination.

- The second possibility is that $H_{p,w} = \bar{H}_p$, which was also true before discrimination because wages were higher. In this case, sex discrimination does not reduce the human capital of workers. Moreover, workers and entrepreneurs, males and females, all go to primary school, so discrimination does not show up in the female-to-male ratio of primary education, but only in the ratio of higher education.

Therefore, for countries where wages are high enough, even in the case of partial discrimination (which implies a wage cut), workers still complete primary school. For developing countries, where wage rates tend to be low, the ratio of female-to-male primary education is lower in the case of partial discrimination than in the absence of discrimination. However, for developed countries where wage rates tend to be high, the ratio of female-to-male primary education is the same as without discrimination, that is, equal to one. We derive the following implications of the effects of partial discrimination from the first case, which is empirically the most plausible:

- The optimal investment in human capital by workers is lower than otherwise, as shown in (10).
- Average female education is lower,[7] since potential female entrepreneurs do not acquire higher education, while female workers acquire less primary education because of the decline in wages.
- Average female education is lower than male, for both primary and higher education.
- The effect on average male education is ambiguous because male managers increase their education (see (7)) while male workers reduce it (see (10)).
- The cutoff level of talent for males is lower than otherwise (there is no cutoff talent for females).
- The average talent of entrepreneurs is smaller.
- Even if there is no discrimination in schooling, the education differentials will in general reflect the existence of sex discrimination in the labor market.
- The growth rate is lower.

D. Labor Market Equilibrium with Total Sex Discrimination in the Labor Market

Aggregate supply of worker skills with total sex discrimination

Suppose sex discrimination consists of not allowing women to have access to managerial positions or to become workers. In this case, females' human capital is zero because, in this model, education is only useful to individuals who take part in the labor market. For every wage, this affects the demand and supply of worker skills. Supply in this case is

$$Q_s^{TD} = \frac{P}{2} \cdot T'(w^{TD}) \cdot \left[1 + \left[\frac{w^{TD}\sigma}{a_p} \right]^{\frac{\sigma}{1-\sigma}} \right]. \tag{13'}$$

Hence, for a given wage, the supply of worker skills is one-half of the supply without sex discrimination.

Aggregate demand for worker skills with total sex discrimination

Demand is

$$Q_D^{TD} = \int_{T'(w^{TD})}^{1} \left(\mu(w^{TD}, s, a_h) \cdot T \right) \frac{P}{2} \; dT = \frac{P}{2} \; \mu(w^{TD}, s, a_h) \left[\frac{1}{2} - \frac{T'^2(w^{TD})}{2} \right].$$

[7] This is not ambiguous because females who were managers without discrimination will, with partial discrimination, reduce their investment in primary education as workers because the returns are lower. Women who were workers without discrimination reduce their acquirement of primary studies under partial discrimination.

As in the case of sex discrimination in managerial positions, demand for worker skills is simply one-half of what it was without discrimination. Hence, relative to the situation of discrimination in managerial positions, the equilibrium wage unambiguously increases, while the amount of worker skills hired in equilibrium decreases (see Figure 6).

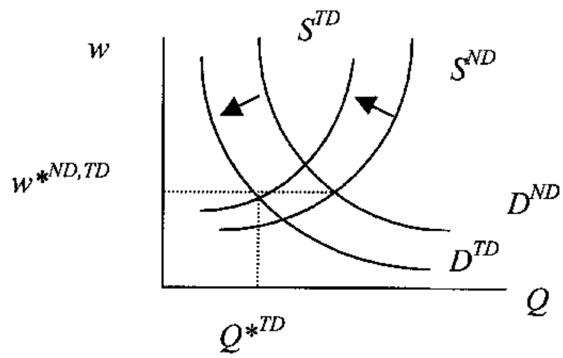

Figure 6. Labor Market Equilibrium with Total Sex Discrimination

Unlike in the nondiscrimination case, since both aggregate supply of, and demand for, worker skills change in the same proportion, the wage rate is the same, although in the total discrimination equilibrium less worker skills are hired.

The number of managers with total sex discrimination

The total number of managers is

$$M^{TD} = M^{m,TD} + M^{f,TD} = \frac{P}{2} \int_{T'(w^{TD})}^{1} 1dT + 0 = \left[1 - T'(w^{TD})\right]\frac{P}{2}. \qquad (14')$$

Since the equilibrium wage rate increases, the number of managers is unambiguously smaller than in the case of discrimination in managerial positions. By (14) and (14'), and given that the cutoff level of talent with total discrimination is the same as without discrimination, the number of managers with total discrimination is one-half of the number without discrimination.

The growth rate with total sex discrimination

We have seen that the cutoff level of talent is higher with total discrimination than with partial discrimination. In particular, $AT^{TD} = AT^{ND} > AT^{PD}$; that is, the growth rate of the economy is higher with total discrimination against women than with discrimination in only managerial positions.

Unlike in the case of no discrimination, the model predicts that females will not acquire any education (primary or higher), so that female-to-male ratios of schooling are going to be very low, because male decisions are exactly the same regardless of total discrimination against women.

GDP per capita

Since the number of managers and workers is one-half of what it is without sex discrimination, and since the population is the same for the two cases, per capita GDP is one-half of what it is without discrimination.

The effects of total sex discrimination (relative to partial sex discrimination) [8]

The effects of total sex discrimination differ from those of partial sex discrimination in the following ways:

- Since the equilibrium wage is higher with total rather than partial discrimination, the optimal investment in human capital by workers is higher.
- Average female education is lower since females do not acquire primary or higher education.
- Average female education with total discrimination is lower than male education, for both primary and higher education.
- Male managers reduce their primary and higher education (compare (7)), and male workers increase their primary education (compare (10)).
- The cutoff level of talent for males is higher than with partial discrimination (there is no cutoff level of talent for females).
- The average talent of entrepreneurs is therefore larger.
- The growth rate is higher than with partial discrimination, but is the same as without discrimination.
- Per capita GDP is one-half of what it is without sex discrimination.

E. Theoretical Conclusions

The previous sections show that sex discrimination is bad for growth in the case where females are not allowed to become entrepreneurs because the equilibrium wage rate and, therefore, the cutoff level of talent of managers, is lower. Surprisingly, sex discrimination is not bad for growth if it affects both skilled and unskilled labor, that is, if women cannot become entrepreneurs or workers.[9] The reason is that the equilibrium wage increases with respect to partial discrimination, so that the cutoff level of talent and the growth rate are higher. The model also predicts that growth rates will be the same for the cases of no

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[8] The equilibrium wage increases with respect to the discrimination in managerial positions. If the analysis is done with respect to nondiscrimination, then the equilibrium wage does not change, and therefore neither does the cutoff level of talent.

[9] Total sex discrimination will affect economic growth only if there are scale effects.

discrimination and total discrimination. In the latter case, however, the female-to-male education differentials will be large.

In other words, when the degree of discrimination against women is low, an increase in discrimination may initially reduce growth, but, after a certain point, more discrimination may lead to an increase in growth. Thus, our model suggests a convex relationship between sex nondiscrimination and growth, as depicted in Figure 7 (*ND*, *PD*, and *TD* denote nondiscrimination, partial discrimination, and total discrimination, respectively).

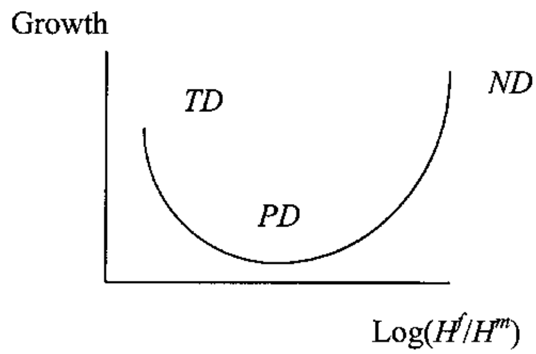


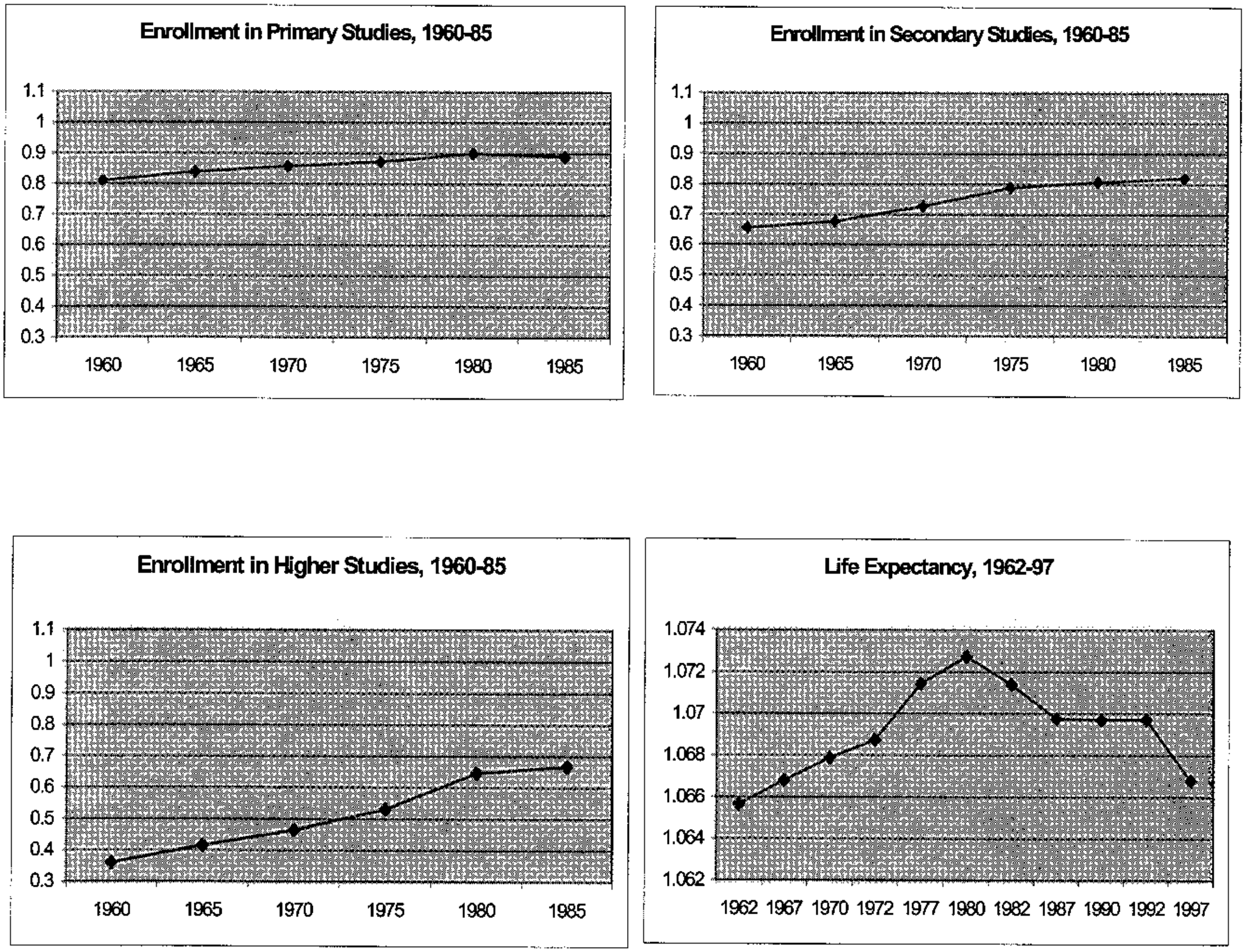
Figure 7. Convex Relationship Between Schooling Inequality and Growth

Not surprisingly, it is very difficult to measure sex discrimination. However, as we have seen, discriminating economies will tend to have larger education differentials between men and women, although this is not necessarily true for countries where wages are relatively high. In general, more discrimination against women will tend to be reflected in larger education differentials between women and men. Hence, the model predicts that for **weakly** discriminating economies there is a positive correlation between the ratio of female to male education and growth, while for **strongly** discriminating economies this correlation is negative. In particular, the model predicts a U-shaped relationship between female-to-male primary education ratios and growth.

III. DATA

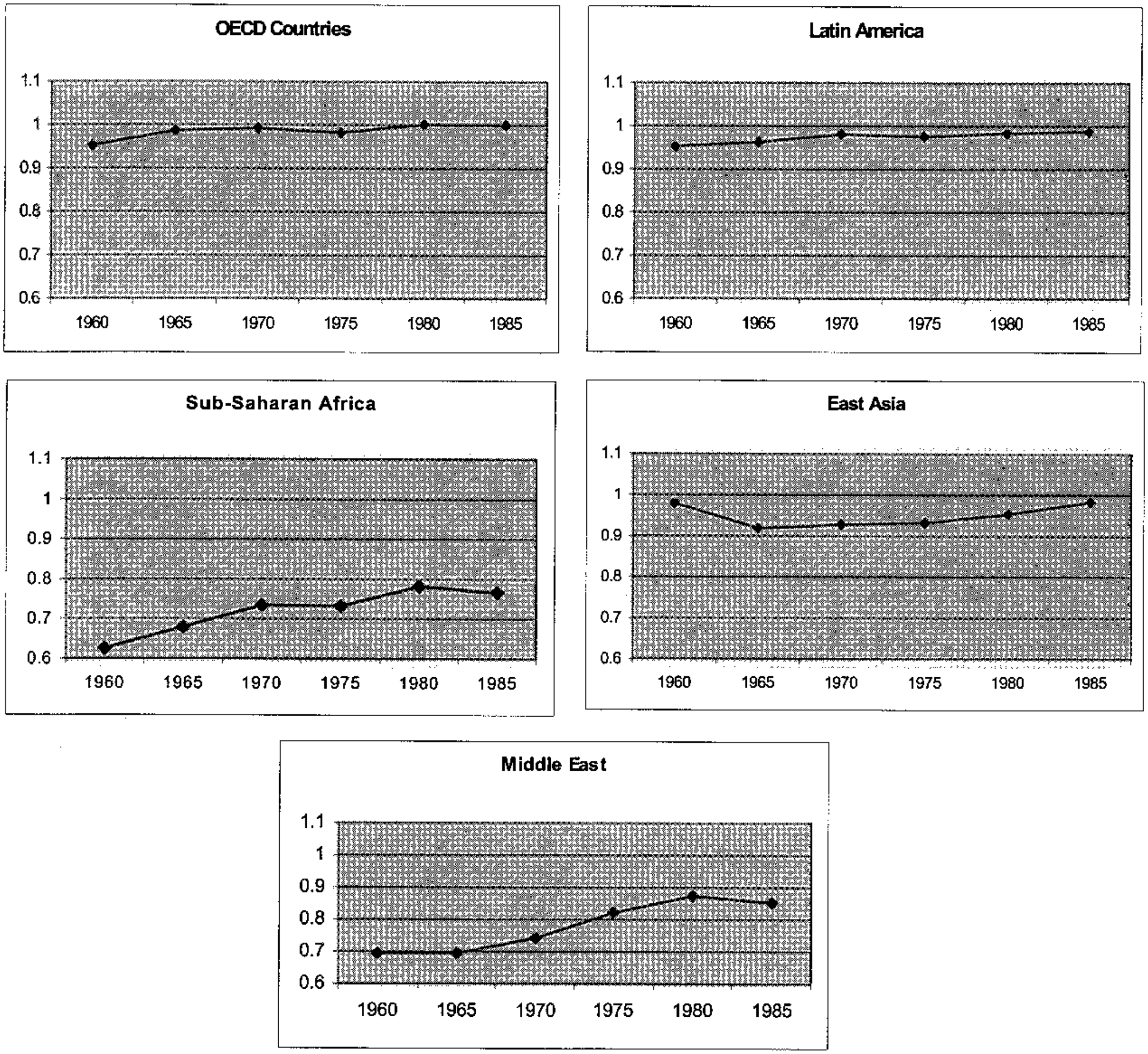
To test the predictions of our theoretical model, we use the Barro and Lee (1994) data set containing cross-country data for over 100 countries over the 1960-89 time period. We measure sex discrimination in education by the average years of primary, secondary, and higher schooling in the female and male population over age 25; the female and male gross enrollment ratios for primary, secondary, and higher education; the percentage of primary,

Figure 8. Gender Inequality in Human Capital: The Ratio of Female-to-Male Enrollment Rates and Life Expectancy



Sources: Barro and Lee (1994); and World Bank, *World Development Indicators*, 1999.

Figure 9. The ratio of Female-to-Male Primary Enrollment Rates by Region, 1960-85



Source: Barro and Lee (1994).

secondary, and higher school completed in the female and male populations; and the percentage of "no schooling" in the female and male populations. In general, the ratio of female-to-male enrollment rates has increased steadily since 1960, except for primary enrollment, where the female-to-male ratio declined after 1980 (Figure 8). The ratio of female-to-male enrollment rates is lowest in sub-Saharan Africa (Figure 9).

IV. EMPIRICAL RESULTS

To test for the convex relationship between education differentials and growth predicted by the model, we regress real per capita GDP growth between 1965 and 1989 on the logarithm of the ratio of the female-to-male primary enrollment rate in 1965: [10]

$$Growth_i = \underset{(0.0015)}{0.0180} + \underset{(0.0112)}{0.0339} \cdot \log\left(\frac{PEF}{PEM}\right)_i + \underset{(0.0138)}{0.0206} \cdot \left[\log\left(\frac{PEF}{PEM}\right)_i\right]^2,$$

with R^2=0.20, observations=94, and p-value for joint hypothesis=0.0000, and where *PEF* (*PEM*) denotes the primary enrollment ratio of females (males), and i denotes countries. A Wald test on the joint significance of the linear and quadratic terms rejects that they are not significantly different than zero at the 1 percent level of significance. The estimated convex relationship is depicted in Figure 10, which shows that growth rates differ substantially among the large number of countries where female and male enrollment ratios are similar. This is consistent with the model since, for countries where wages are relatively high, the decline in wages corresponding to discrimination may not imply lower primary education for female workers.[11] However, as shown before, even if there were no primary schooling differentials between genders, these countries will tend to grow less because the cutoff level of talent is lower.

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[10] The primary enrollment rates are measured as the ratio of students enrolled in primary studies to the population of primary school age. To avoid possible endogeneity problems, proxies for discrimination are always set for the beginning of the period.

[11] See Subsection D of Section II.

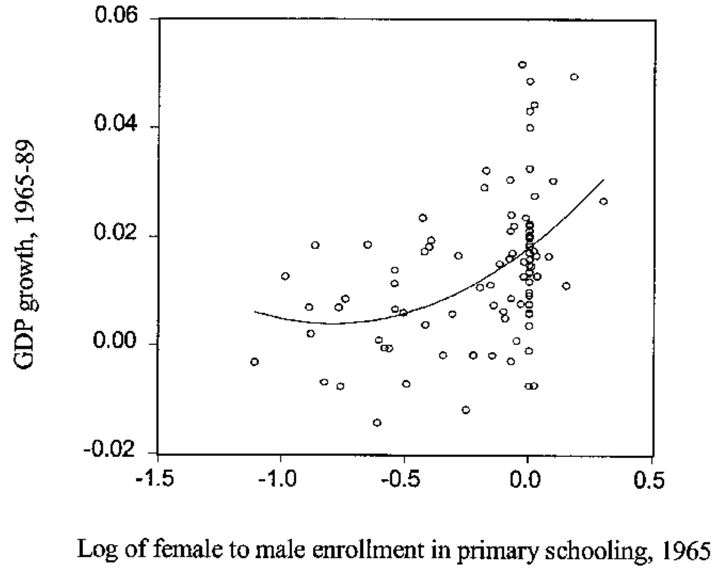

Figure 10. Convex Relationship Between Growth and Sex Inequality in Primary Education.

There are, of course, other variables determining economic growth. To test for these, we regress real per capita GDP growth on other regressors that typically control for differences in the steady state levels of income of different countries, as in Barro and Sala-i-Martin (1995), Barro (1997), and Sala-i-Martin (1997). The basic specification consists of the following variables: the log of 1965 real per capita GDP; the average of the log of life expectancy at age zero between 1960 and 1964; the average of the ratio of real domestic investment (private plus public) to real GDP between 1965 and 1985; the average of the ratio of real government consumption expenditure (net of spending on defense and on education) to real GDP between 1965 and 1985; the average log of black market premium plus one between 1965 and 1985; the average terms of trade shock (growth rate of export prices minus growth rate of import prices) between 1965 and 1985; a war dummy that controls for war conflicts during the period; dummy variables for sub-Saharan African countries and Latin American countries; and some education measures. Finally, following Barro and Sala-i-Martin (1995) we use a variable measuring the interaction between human capital and the log of initial GDP, where these two measures are set in deviations from sample means.

Barro and Sala-i-Martin (1995), Barro (1997), and Dollar and Gatti (1999) include different measures of education for males and females. The first study uses average years of attainment and finds positive, significant coefficients for male secondary education, positive, (marginally) significant coefficients for male higher education, and negative, nonsignificant coefficients for female secondary and higher education; they find nonsignificant coefficients for both male and female primary education. Essentially the same conclusions appear in Barro (1997), while Dollar and Gatti (1999) find nonsignificant positive and negative coefficients for female and male secondary education, respectively. Instead of using this sort of specification, we control for overall education and test for the effect of sex discrimination on growth.[12]

Columns 1 and 2 in Table 1 present our basic specification. The measure of overall education we use is secondary schooling; when using other human capital variables, the results do not change significantly. We present two versions: one testing a linear relationship between the log of female-to-male enrollment ratio in primary studies and growth (column 1), and another one testing the convex relationship predicted by the model (column 2). The regression with only the linear term gives us a positive, significant coefficient. Although the coefficient of the quadratic term is not individually significant at standard levels, a Wald test of the hypothesis of joint nonsignificance of the two terms rejects the null hypothesis at the 1 percent level of significance.

These results indicate that increases in overall education and decreases in discrimination against women are good for growth. This suggests that increases in male education have two effects: they tend to stimulate growth, since more human capital is good; however, to the extent that there is no symmetric increase in female schooling, the rise in inequality tends to reduce growth. The other results are similar to those in the empirical growth literature—for instance, the conditional convergence feature.[13]

The estimated coefficient for female-to-male enrollment rates in primary studies in column 1 implies that a decrease of 1 percent in discrimination against women leads to an increase of 0.0123 points in the growth rate. Alternatively, the convex specification in column 2 implies a minimum threshold level of discrimination at which point both increases and decreases in discrimination raise growth. This minimum level for the ratio of female-to-male enrollment rates in primary studies is 0.37 (the log of the ratio is -1). In only 3 out of the 105 countries in our sample is inequality in primary enrollment so great that an increase in inequality implies an increase in growth.[14]

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[12] Blackden and Bhanu (1999) do perform some basic regressions regarding the effect of the ratio of female education to male education. Our approach differs in that our specification is more comprehensive and that we take the log of this gender measure.

[13] See Barro (1991), Barro and Sala-i-Martin (1992), or Mankiw, Romer, and Weil (1992).

[14] Central African Republic, Afghanistan, and Nepal. Consistent with the model, per capita GDP for these countries is very low (Barro and Lee (1994); and data for 1965-75 from the UN Secretariat).

Table 1. Cross-Sectional Evidence on Growth and Sex Inequality in Education
(ordinary least squares)

	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDP)	-0.0326***	-0.0317***	-0.0303***	-0.0325***	-0.0317***	-0.0421***
	(0.0043)	(0.1532)	(0.0046)	(0.0045)	(0.0044)	(0.0044)
Secondary education	0.0160***	0.0168***	0.0170***	0.0178***	0.0169***	0.0169***
	(0.0052)	(0.0053)	(0.0055)	(0.0055)	(0.0054)	(0.0047)
Log(life expectancy)	0.2859***	0.2942***	0.2999***	0.3043***	0.2949***	0.3252***
	(0.0857)	(0.0858)	(0.0894)	(0.0872)	(0.0869)	(0.0799)
Log(GDP)* human capital	-0.0716**	-0.0768***	-0.0800***	-0.0817***	-0.0772***	-0.0827***
	(0.0276)	(0.0279)	(0.0293)	(0.0288)	(0.0285)	(0.0252)
Investment/GDP	0.011	0.0096	0.0082	0.0109	0.0094	0.0025
	(0.0153)	(0.0153)	(0.0157)	(0.0155)	(0.0156)	(0.0146)
Government consumption/GDP	-0.0569***	-0.0580***	-0.0540***	-0.0594***	-0.0584***	-0.0467***
	(0.0166)	(0.0167)	(0.0180)	(0.0168)	(0.0176)	(0.0145)
Log(1+black market premium)	-0.0122***	-0.0111***	-0.0113***	-0.0111***	-0.0110***	-0.0090***
	(0.0037)	(0.0039)	(0.0039)	(0.0039)	(0.0039)	(0.0033)
Growth rate, terms of trade	0.0426	0.0452	0.0364	0.0530	0.04571	0.1116***
	(0.0343)	(0.0343)	(0.0357)	(0.0361)	(0.0353)	(0.0311)
Log(female-to-male primary schooling ratio)	0.0123***	0.0217**	0.0215**	0.0211**	0.0216**	0.0354***
	(0.0043)	(0.0092)	(0.0094)	(0.0093)	(0.0094)	(0.0110)
Log(female-to-male primary schooling ratio) squared		0.0109	0.0107	0.0104	0.0109	0.0284**
		(0.0094)	(0.0096)	(0.0095)	(0.0095)	(0.0113)
War dummy	-0.0056***	-0.0059***	-0.0063***	-0.0056**	-0.0059***	-0.0011
	(0.0021)	(0.0021)	(0.0022)	(0.0022)	(0.0022)	(0.0021)
Sub-Saharan Africa	-0.0083***	-0.0089***	-0.0094***	-0.0083**	-0.0090**	-0.0080***
	(0.0033)	(0.0033)	(0.0036)	(0.0034)	(0.0035)	(0.0030)
Latin America	-0.0138***	-0.0143***	-0.0149***	-0.0137***	-0.0144***	-0.0119***
	(0.0024)	(0.0025)	(0.0026)	(0.0026)	(0.0027)	(0.0023)
Political instability			0.0025			
			(0.0077)			
Growth rate of population				-0.1078		
				(0.1482)		
Muslim religion					-0.0003	
					(0.0040)	
Rule of law						0.0188***
						(0.0040)
R^2 (number of observations)	0.76	0.76	0.75	0.76	0.76	0.84
	(86)	(86)	(84)	(86)	(86)	(80)
p-values for joint hypothesis		0.0089⊕⊕⊕	0.0119⊕⊕	0.0107⊕⊕	0.0167⊕⊕	0.0030⊕⊕⊕

Notes: The dependent variable is real per capita GDP growth (1985 international prices). Standard errors in parentheses. *=10 percent significance level; **=5 percent significance level; and ***=1 percent significance level. All regressions include an unreported constant term. ⊕=reject joint nonsignificance at 10 percent significance level; ⊕⊕=at 5 percent significance level; and ⊕⊕⊕=at 1 percent significance level. The null hypothesis is that the linear and the quadratic terms are jointly nonsignificant.

This convex relationship can be related to Dollar and Gatti's (1999) result that per capita income explains female secondary attainment in a convex manner. [15] In particular, it seems that increases in income lead to less education inequality, that these reductions in inequality are more important as countries get richer, and that this, in turn, leads to larger increases in income. Therefore, as countries get richer, they reduce sex discrimination (which is reflected in schooling differentials); this leads to higher growth rates (holding other determinants of growth constant), perhaps because sex discrimination is decreasing in a convex manner as well.

In order to see if our measure of discrimination is picking up some effect linked to the political situation, we include as a regressor the average political instability between 1965 and 1985 (see column 3 in Table 1), which is significant in some empirical studies. This estimate is not significant in our case; also, the magnitude and the significance of our two discrimination terms are not affected (actually, we cannot reject that they are the same as in column 2).

It could also be argued that our variables of discrimination might be picking up effects related to changes in the population structure, while the latter variable is related to changes in education. Hence, we include the growth rate of population between 1965 and 1989 in column 4 (Table 1). Population growth has a negative sign (as the Solow model of neoclassical growth predicts), but it neither is significant at standard levels nor implies any change in our estimated coefficients for linear or quadratic discrimination terms.

One of the empirical findings of Dollar and Gatti (1999) is that religion is a fairly good explanatory factor for female education. Do some of these religions have a direct effect on growth?[16] We focus on the Muslim religion since it is likely that it constitutes a rough measure of gender inequality in countries where it is the major religious affiliation. In column 5 (Table 1), we show the results when we include the fraction of individuals who are affiliated to the Muslim religion in each country. It has a negative sign but it is not significant.[17] That is, growth does not seem to be directly explained by religious affiliation.

Our measure of sex inequality could also be picking up some of the effect of the quality of institutions, so that our estimates of the effect of discrimination would be biased. In column 6 we have included the rule of law as a measure of the quality of institutions.[18] We use the

[15] There is also some empirical evidence about the positive relationship between income and gender equality (see Boone (1996) and Easterly (1999)).

[16] Robert J. Barro, who compiled them from the World Christian Encyclopedia, kindly provided data on religious affiliations.

[17] The same happens when we use the Hindu religion or the Muslim and Hindu religions together.

[18] Of the available indicators on the quality of institutions of countries, the rule of law is found by Barro and Sala-i-Martin (1995) to be the most statistically significant.

earliest available measure of the rule of law, beginning in the 1980s. The rule of law seems to be important for growth, but results concerning the significance of inequality in education do not basically change.

In order to check the robustness of these results, we have also estimated our basic specification with two-stage least squares (2SLS). The instruments used in our specification are the log of initial GDP in 1960, and the average values between 1960 and 1964 for investment, government consumption, and the log of the black market premium plus one. For the interaction between human capital and initial GDP, we use its value in 1960. Finally, the terms of trade growth, total secondary education, and our linear and quadratic terms for gender discrimination are all predetermined and, therefore, act as their own instruments. The estimated coefficients for the measures of discrimination in education are still positive but not significant at the same levels as before. The estimated coefficient for the linear relationship is significant at the 10 percent level of significance, while in the quadratic relationship we cannot reject the joint hypothesis of nonsignificance.

For a number of countries in our sample, the changes in inequality have been so large that the initial 1965 value of inequality may not be relevant for the full 1965-89 period. [19] For this reason, we split the sample into two time periods, 1965-75 and 1975-89, and estimate the equations on the resulting panel based on the same specification as above. In Table 2, we present ordinary least squares (OLS), 2SLS, and seemingly unrelated regression (SUR) results from the panel estimation. For both the OLS and SUR estimates (columns 2 and 4), the hypothesis of joint nonsignificance of the convex relationship between inequality and growth is rejected. The OLS estimate determines a minimum growth for a value of the female-to-male enrollment ratio in primary education of 0.5 (the log of the ratio is –0.7), while, for the 2SLS, this value corresponds to 0.55 (the log of the ratio is –0.59). However, the null hypothesis that the linear and nonlinear discrimination variables are jointly significant is rejected (column 6).

[19] Lesotho, Poland, and Papua New Guinea experienced large increases in inequality in primary schooling between 1965 and 1975, while Kenya, Mauritius, Togo, India, Iran, Iraq, Nepal, Syria, and Turkey experienced large decreases over the same period.

Table 2. Panel Evidence on Growth and Sex Inequality in Education, Using Fixed Coefficients
(ordinary least squares (OLS), seemingly unrelated regression (SUR), and two-stage least squares (2SLS))

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	SUR	SUR	2SLS	2SLS
Log(GDP)	-0.0225***	-0.0224***	-0.0226***	-0.0224***	-0.0253***	-0.0261***
	(0.0028)	(0.0028)	(0.0027)	(0.0026)	(0.0031)	(0.0031)
Secondary education	0.0015*	0.0015*	0.0015*	0.0015*	0.0014	0.0014
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Log(life expectancy)	0.0562***	0.0481***	0.0570***	0.0483***	0.0729***	0.0707***
	(0.0147)	(0.0153)	(0.0147)	(0.0145)	(0.0163)	(0.0173)
Log(GDP)* human capital	-0.0054**	-0.0050*	-0.0054**	-0.0051**	-0.0065**	-0.0062**
	(0.0027)	(0.0027)	(0.0025)	(0.0064)	(0.0028)	(0.0028)
Investment/GDP	0.0200**	0.0203**	0.0215***	0.0213***	0.0222**	0.0197*
	(0.0088)	(0.0087)	(0.0083)	(0.0082)	(0.0108)	(0.0107)
Government consumption/GDP	-0.0364***	-0.0037***	-0.0363***	-0.0372***	-0.0413***	-0.0448***
	(0.0112)	(0.0112)	(0.0107)	(0.0105)	(0.0140)	(0.0142)
Log(1+black market premium)	-0.0060***	-0.0051**	-0.0061***	-0.0052***	-0.0029	-0.0047
	(0.0020)	(0.0020)	(0.0019)	(0.0019)	(0.0033)	(0.0033)
Growth rate, terms of trade	0.0245	0.0278*	0.0265*	0.0292**	0.0251	0.0291*
	(0.0158)	(0.0158)	(0.0150)	(0.0150)	(0.0163)	(0.0162)
Log(female-to-male primary schooling ratio)	0.0066**	0.0165***	0.0063**	0.0161***	0.0026	0.0107
	(0.0030)	(0.0065)	(0.0028)	(0.0061)	(0.0032)	(0.0087)
Log(female-to-male primary schooling ratio) squared		0.0118*		0.0113**		0.0091
		(0.0068)		(0.0064)		(0.0085)
War dummy	-0.0026**	-0.0028*	-0.0026**	-0.0028**	-0.0040***	-0.0039***
	(0.0013)	(0.0013)	(0.0012)	(0.0012)	(0.0014)	(0.0015)
Sub-Saharan Africa	-0.0054***	-0.0060***	-0.0053***	-0.0060***	-0.0077***	-0.0074***
	(0.0020)	(0.0021)	(0.0019)	(0.0019)	(0.0022)	(0.0022)
Latin America	-0.0068***	-0.0071***	-0.0065***	-0.0069***	-0.0062***	-0.0064***
	(0.0015)	(0.0015)	(0.0014)	(0.0014)	(0.0016)	(0.0016)
R^2 (number of observations)	0.56 (83)	0.55 (83)	0.57 (83)	0.56 (83)	0.56 (78)	0.56 (78)
	0.53 (86)	0.56 (86)	0.53 (86)	0.55 (86)	0.57 (77)	0.58 (77)
p-values for joint hypothesis		0.0202⊕⊕		0.0132⊕⊕		0.4632

Notes: The dependent variable is real per capita GDP growth (1985 international prices). The time periods are 1965-75 and 1975-89. All coefficients (except for the constant terms) are restricted to be the same for the two time periods. The instruments used for 2SLS are described in Section IV. Standard errors in parentheses. We report the R^2 and number of observations for the two time periods. *=10 percent significance level; **=5 percent significance level; and ***=1 percent significance level. ⊕=reject joint nonsignificance at 10 percent significance level; ⊕⊕=at 5 percent significance level; and ⊕⊕⊕=at 1 percent significance level. The null hypothesis is that the linear and the quadratic terms are jointly nonsignificant for that period.

The change in the distribution of discrimination across countries suggests that the estimated coefficients on discrimination may have also changed. For that reason, we allow for free coefficients on the gender inequality variables, that is, we allow the convex relationship to be different for the 1965-75 and 1975-89 periods (Table 3, columns 1 to 3). For the 1965-75 period, the estimated minima of the convex relationships are at the following values of the female-to-male enrollment ratio in primary education: 0.33 for OLS, 0.32 for SUR, and 0.12 for 2SLS. The Wald test for the null hypothesis of joint nonsignificance is rejected at the 3 percent significance level. For the 1975-89 period, the joint nonsignificance hypothesis is rejected at the 2 percent significance level. The hypothesis of structural stability of the coefficients of the schooling ratios is rejected with a 5 percent significance level (SUR and 2SLS) and a 7 percent significance level (OLS) (the results of these tests are shown at the bottom of each column in Table 3). Thus, it seems that the effect of sex discrimination on growth has changed over time; controlling for the temporal difference, the hypothesis of a convex relationship gains significance.

The results obtained with these last regressions suggest that the correct specification might be a linear relationship between sex inequality and growth during 1965-75 and a convex one for 1975-89. We present the results of this specification in Table 3 (columns 4 to 6). Results do not differ substantially from the ones shown in columns 1-3, but the convex relationship is now significant at the 1 percent level for the OLS and SUR estimations (and still at the 5 percent level for the 2SLS estimation).

In sum, although the cross-sectional analysis may not be good in statistical terms, it provides us with useful economic information since it is a sort of summary of the long-run effect of sex discrimination on growth. In particular, there is some evidence that there is a convex relationship between gender inequality in primary schooling and growth.

We run regressions with other variables, trying to capture sex inequality in education, but none of the estimated coefficients are significant. Although the model predicts that sex discrimination will be reflected not only in primary education differentials but also in higher-education differentials, few data are available on higher schooling.[20] Additionally, sex discrimination in primary education is a determinant of sex discrimination in later stages: if women do not have the possibility of acquiring primary education, they will not be able to have access to higher education, and thus to hold skilled positions. In general, women will not have access to political representation (social capital assets) or to directly productive assets (either land, labor, or financial assets).

[20] We have observations for only 9 out of the 43 sub-Saharan African countries and, therefore, neglect considerable cross-sectional variability from the side of developing countries.

Table 3. Panel Evidence on Growth and Sex Inequality in Education, Using Free Coefficients (ordinary least squares (OLS), seemingly unrelated regression (SUR), and two-stage least squares (2SLS))

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	SUR	2SLS	OLS	SUR	2SLS
Log(GDP)	-0.0218***	-0.0218***	-0.0243***	-0.0219***	-0.0219***	-0.0243***
	(0.0028)	(0.0026)	(0.0031)	(0.0028)	(0.0026)	(0.0031)
Secondary education	0.0018**	0.0018**	0.0014	0.0017**	0.0017**	0.0014
	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)
Log(life expectancy)	0.0528***	0.0534***	0.0630***	0.0548***	0.0554***	0.0638***
	(0.0193)	(0.0182)	(0.0208)	(0.0191)	(0.0181)	(0.0204)
Log(GDP)* human capital	-0.0074*	-0.0075**	-0.0056	-0.0070*	-0.0071*	-0.0054
	(0.0040)	(0.0039)	(0.0044)	(0.0040)	(0.0038)	(0.0036)
Investment/GDP	0.0205**	0.0213***	0.0197*	0.0204**	0.0212***	0.0191*
	(0.0088)	(0.0082)	(0.0108)	(0.0088)	(0.0082)	(0.0107)
Government consumption/GDP	-0.0353***	-0.0352***	-0.0410***	-0.0347***	-0.0346***	-0.0108***
	(0.0111)	(0.0104)	(0.0141)	(0.0111)	(0.0105)	(0.0138)
Log(1+black market premium)	-0.0043**	-0.0044**	-0.0019	-0.0045**	-0.0046**	-0.0023
	(0.0020)	(0.0019)	(0.0034)	(0.0020)	(0.0019)	(0.0034)
Growth rate, terms of trade	0.0321**	0.0331**	0.0305*	0.0314**	0.0323**	0.0305*
	(0.0159)	(0.0150)	(0.0161)	(0.0158)	(0.0150)	(0.0160)
Log(female-to-male primary schooling ratio), 1965	0.0140*	0.0139**	0.0051	0.0087***	0.0086***	0.0040
	(0.0075)	(0.0062)	(0.0103)	(0.0033)	(0.0031)	(0.0036)
Log(female-to-male primary schooling ratio), 1975	0.0295***	0.0291***	0.0350***	0.0288***	0.0285***	0.0342***
	(0.0107)	(0.0103)	(0.0130)	(0.0106)	(0.0103)	(0.0128)
Log(female-to-male primary schooling ratio) squared, 1965	0.0062	0.0062	0.0012			
	(0.0078)	(0.0072)	(0.0098)			
Log(female-to-male primary schooling ratio) squared, 1975	0.0361***	0.0291***	0.0436***	0.0354***	0.0353***	0.0425***
	(0.0129)	(0.0103)	(0.0436)	(0.0129)	(0.0125)	(0.0150)
War dummy	-0.0030**	-0.0030***	-0.0045***	-0.0029**	-0.0029**	-0.0045***
	(0.0013)	(0.0012)	(0.0014)	(0.0013)	(0.0012)	(0.0014)
Sub-Saharan Africa	-0.0059***	-0.0058***	-0.0080***	-0.0057***	-0.0056***	-0.0079***
	(0.0021)	(0.0020)	(0.0023)	(0.0021)	(0.0020)	(0.0023)
Latin America	-0.0074***	-0.0073***	-0.0070***	-0.0074***	-0.0072***	-0.0070***
	(0.0015)	(0.0039)	(0.0016)	(0.0015)	(0.0014)	(0.0015)
R^2 (number of observations)	0.56 (83)	0.56 (83)	0.54 (78)	0.56 (83)	0.56 (83)	0.55 (78)
	0.57 (86)	0.57 (86)	0.62 (77)	0.57 (86)	0.57 (86)	0.62 (77)
p-values for joint hypothesis	0.0253⊕⊕	0.0146⊕⊕	0.5480	0.0194⊕⊕	0.0157⊕⊕	0.0179⊕⊕
	0.0168⊕⊕	0.0135⊕⊕	0.0156⊕⊕	0.0041⊕⊕⊕	0.0022⊕⊕⊕	0.0334⊕⊕
p-values for structural break	0.0616	0.0500	0.0357			

Notes: The dependent variable is real per capita GDP growth (1985 international prices). The time periods are 1965-75 and 1975-89. All coefficients (except for the constant terms and the coefficients for sex discrimination) are restricted to be the same for the two time periods. The instruments used for 2SLS are described in Section IV. Standard errors in parentheses. We report the R^2 and number of observations for the two time periods. *=10 percent significance level; **=5 percent significance level; and ***=1 percent significance level. ⊕=reject joint nonsignificance at 10 percent significance level; ⊕⊕=at 5 percent significance level; and ⊕⊕⊕=at 1 percent significance level. We report two Wald tests for each time period: the null hypothesis is that the linear and quadratic terms are jointly nonsignificant for that period.

In Table 4, we directly test the implications of the model regarding female human capital: does sex discrimination imply lower investment in human capital by females? We try to explain the variability in average years of schooling of the female population over 25 years old by using the log of the ratio of the female-to-male enrollment in primary schooling. Sex nondiscrimination in education is positive and significant at the 1 percent level of significance for both OLS and 2SLS estimations performed over the 1965-85 period. Since the model also predicts that discrimination implies a lower acquirement of primary schooling by male workers,[21] in Table 5 we present similar regressions regarding male primary education. Since managers empirically constitute a small fraction of the total, we use investment in primary schooling by all males. Sex nondiscrimination is positive and significant at the 1 percent level of significance. In Appendix Table A1, we present the correlation matrix of average female and male primary, secondary, and higher schooling with indicators of gender inequality in education for the 1965-85 period.[22]

V. CONCLUSION

This paper provides theoretical and empirical support for the view that sex discrimination has harmful economic consequences. If women cannot have access to managerial positions, the equilibrium wage rate declines, and the cutoff level of talent of managers declines as well, so that the average talent of entrepreneurs and economic growth both decline. If females cannot participate in the labor market, the wage rate is the same as without discrimination, so that the cutoff level of talent is the same and, therefore, there are no growth implications. Nevertheless, per capita GDP drops to one-half of what it is without discrimination. In sum, the model predicts a convex relationship between growth and sex nondiscrimination.

The empirical analysis uses cross-sectional and panel data for the 1965-89 period in order to evaluate the effect of sex discrimination. Since our model suggests that gender discrimination will affect both growth rates and schooling differentials in a convex manner,

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[21] This is not true for managers, who acquire $\bar{H}_p$ units of primary education in either case.

[22] Even if the model does predict only that sex discrimination will be reflected in schooling differentials, we have considered possible alternative indicators of discrimination. Concerning sex inequality in nutrition and health, we find that the female-to-male life expectancy ratio has a positive but not significant effect on growth (*t*-statistics over 1-1.5), and that there is a convex relationship between the ratio of boys' malnutrition rates to girls' malnutrition rates and growth (significant at the 5 percent level). A convex relationship between the ratio of female-to-male teachers at universities and growth cannot be rejected at 15-20 percent levels of significance. Gender inequality in representation at senates and equivalent institutions seems to have no effect on growth. All these results are available from the author.

Table 4. Cross-sectional Evidence on Female Human Capital and Sex Inequality in Education
(ordinary least squares (OLS) and two-stage least squares (2SLS))

	OLS	2SLS
Log(GDP), 1965	-10.0622***	-11.0548***
	(3.1838)	(3.2573)
Log(GDP) squared, 1965	1.7541***	1.9218***
	(0.4845)	(0.4955)
Male human capital, 1965	0.8369***	0.8289***
	(0.0524)	(0.0529)
Log(female-to-male primary schooling ratio),	0.9643***	1.0299***
1965	(0.3505)	(0.3527)
Latin America	0.3382*	0.3246
	(0.1963)	(0.1968)
Rule of law	-0.3565	-0.4822
	(0.3146)	(0.3216)
R^2	0.96	0.96
(number of observations)	(84)	(83)

Notes: The dependent variable is average years of schooling of female population over age 25 (1965-85). Standard errors in parentheses. *=10 percent significance level; **=5 percent significance level; and ***=1 percent significance level. The 2SLS estimation uses the log GDP for 1960 and its square as instruments.

Table 5. Cross-section al Evidence on Male Primary Schooling and Sex Inequality in Education
(ordinary least squares (OLS) and two-stage least squares (2SLS))

	OLS	2SLS
Log(GDP), 1965	0.0549	0.8770
	(0.3167)	(0.3421)
Female human capital, 1965	0.5701***	0.5754***
	(0.0501)	(0.0515)
Log(female-to-male primary schooling ratio),	0.9139***	0.8770***
1965	(0.3387)	(0.3421)
Latin America	-0.6528***	-0.6373***
	(0.1898)	(0.1907)
Rule of law	-0.4434	-0.3772
	(0.3102)	(0.3168)
R^2	0.88	0.88
(number of observations)	(84)	(83)

Notes: The dependent variable is average years of primary schooling in the total population over age 25 (1965-85). Standard errors in parentheses. *=10 percent significance level; **=5 percent significance level; and ***=1 percent significance level. The 2SLS estimation uses the log GDP for 1960 as instrument.

we use schooling differentials to test the predictions of the model regarding sex discrimination and growth. We find that sex nondiscrimination and growth are significantly related in a convex manner, as described by the model, and this finding seems to be robust to the various econometric methods and specifications. In particular, in countries with relatively high female-to-male schooling ratios, an increase in this ratio reduces growth, while in countries with very low female-to-male schooling ratios, an increase in the ratio raises growth. Since there is empirical evidence that richer countries tend to reduce sex discrimination,[23] it seems the following process is taking place: as countries get richer, they reduce inequality; this implies higher growth rates, which themselves generate reductions in inequality.

Schooling differentials suggest that discrimination against females is worst in sub-Saharan African and Middle Eastern countries. The evidence in this paper suggests that sex discrimination (or social, cultural, and religious factors that may lead to sex discrimination) can have costly economic consequences in terms of the level and growth rate of per capita GDP. Although the evidence we find concerns inequality in education, efforts should be made to reduce sex discrimination of all types. The reason is that sex discrimination in education is possibly a reflection of discrimination in later stages in life (women will not go to school if they know they will not be given jobs when they graduate). That is, even if women have access to schooling, they will not take advantage of it if they do not benefit from human capital.

[23] See Dollar and Gatti (1999).

Table A1. Correlation Matrix of Female and Male Education Indicators, 1965-85

	AVPYRM	*AVSYRM*	*AVHYRM*	*AVPYRF*	*AVSYRF*	*AVHYRF*	*LRP65*	*LRPYR65*	*LRS65*	*LRSYR65*	*LRH65*	*LHYR65*
AVSYRM	0.63											
AVHYRM	0.70	0.77										
AVPYRF	0.97	0.63	0.71									
AVSYRF	0.66	0.94	0.80	0.71								
AVHYRF	0.62	0.66	0.91	0.65	0.74							
LRP65	0.58	0.40	0.34	0.61	0.44	0.33						
LRPYR65	0.61	0.39	0.41	0.73	0.54	0.42	0.77					
LRS65	0.57	0.35	0.37	0.64	0.45	0.40	0.70	0.78				
LRSYR65	0.50	0.34	0.39	0.63	0.55	0.46	0.52	0.80	0.63			
LRH65	0.56	0.39	0.42	0.58	0.47	0.53	0.43	0.48	0.55	0.38		
LRHYR65	0.36	0.19	0.34	0.40	0.32	0.55	0.13	0.31	0.34	0.52	0.46	
LRHUMAN65	0.62	0.38	0.42	0.74	0.55	0.45	0.74	0.99	0.78	0.85	0.49	0.37

Source: Barro and Lee (1994).

Notes:

AVPYRM	Average years of attainment of primary education among male population, 1965-85
AVSYRM	Average years of attainment of secondary education among male population, 1965-85
AVHYRM	Average years of attainment of higher education among male population, 1965-85
AVPYRF	Average years of attainment of primary education among female population, 1965-85
AVSYRF	Average years of attainment of secondary education among female population, 1965-85
AVHYRF	Average years of attainment of higher education among female population, 1965-85
LRP65	Logarithm of the female-to-male ratio of enrollment in primary studies, 1965
LRPYR65	Logarithm of the female-to-male ratio of average years of attainment of primary education, 1965
LRS65	Logarithm of the female-to-male ratio of enrollment in secondary studies, 1965
LRSYR65	Logarithm of the female-to-male ratio of average years of attainment of secondary education, 1965
LRH65	Logarithm of the female-to-male ratio of enrollment in higher studies, 1965
LRHYR65	Logarithm of the female-to-male ratio of average years of attainment of secondary education, 1965
LRHUMAN65	Logarithm of the female-to-male ratio of average years of education, 1965

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