

## Low Schooling for Girls, Slower Growth for All? Cross-Country Evidence on the Effect of Gender Inequality in Education on Economic Development

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Using cross-country and panel regressions, this article investigates how gender inequality in education affects long-term economic growth. Such inequality is found to have an effect on economic growth that is robust to changes in specifications and controls for potential endogeneities. The results suggest that gender inequality in education directly affects economic growth by lowering the average level of human capital. In addition, growth is indirectly affected through the impact of gender inequality on investment and population growth. Some 0.4–0.9 percentage points of differences in annual per capita growth rates between East Asia and Sub-Saharan Africa, South Asia, and the Middle East can be accounted for by differences in gender gaps in education between these regions.

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Many developing countries exhibit considerable gender inequality in health, employment, and education. For example, girls and women in South Asia and China suffer from much higher mortality rates than do men—creating what Amartya Sen calls “missing women” (Klasen and Wink 2002, Sen 1989). Employment opportunities and pay also differ greatly by gender in most developing regions (as well as most industrial regions; see United Nations Development Programme [UNDP] 1995 and World Bank 2001). Finally, there are large gender discrepancies in education, particularly in South Asia, the Middle East and North Africa, and Sub-Saharan Africa.

When assessing the importance of these gender inequalities, one has to distinguish between intrinsic and instrumental concerns. If the concern is aggregate well-being—as measured by, for example, Sen’s notion of “capabilities” (Sen

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1999)—then longevity and education should be seen as crucial constituent elements. Given inequality aversion (or, equivalently, declining marginal social valuation of these achievements), gender inequality in these achievements will reduce aggregate well-being.

In addition, one may be concerned about gender equity as a development goal in its own right (apart from its benefits for other development goals)—as recognized by the Convention on the Elimination of All Forms of Discrimination against Women, which has been signed and ratified by 165 countries (UNDP 2000). If this is the concern, there is no need to do more than demonstrate inequity in a particular country, which would justify corrective action.

Apart from intrinsic problems of gender inequality, one may be concerned about instrumental effects of gender bias. Gender inequality may undermine a number of development goals. First, gender inequality in education and access to resources may prevent reductions in fertility and child mortality and expansions in education of the next generation. A large literature documents these linkages (Klasen 1999, Murthi, Guio, and Drèze 1995, Summers 1994, Thomas 1990, 1997, World Bank 2001). Thus gender bias in education may generate instrumental problems for development policymakers as it compromises progress on these other important development goals.

Second, gender inequality may reduce economic growth. This issue is important to the extent that economic growth advances well-being (as measured by such indicators as longevity, literacy, and poverty), though not all types of growth do so to the same extent (Dollar and Kraay 2000, Drèze and Sen 1989, Pritchett and Summers 1996, Ravallion 2001, UNDP 1996, World Bank 2000). Thus policies that advance economic growth (and do not impede other development goals) should be of great interest to policymakers.

This article focuses on the instrumental effect of gender inequality in education on economic growth.<sup>1</sup> Using cross-country regressions, it shows how gender bias in education reduces economic growth. This effect accounts for a considerable portion of the differences in growth between developing regions. In particular, South Asia, the Middle East, and Africa are held back by high gender inequality in education.

## I. PREVIOUS FINDINGS ON INEQUALITY IN EDUCATION AND ECONOMIC GROWTH

Recent years have seen renewed interest in the theoretical and empirical determinants of economic growth. On the theoretical front, Roemer (1986), Lucas (1988), and Barro and Sala-i-Martin (1995) emphasize the possibility of endogenous economic growth where growth is not constrained by diminishing returns

1. A longer, more detailed working paper (Klasen 1999) also considers the impact on growth of gender inequality in employment and examines the impact of gender inequality in education on fertility and child mortality.

to capital. These models stand in contrast to Solow (1956), which, by using a neoclassical production function (with diminishing returns to each input) and exogenous savings and population growth, suggests convergence of per capita incomes—conditional on exogenous savings and population growth rates. Many growth models also emphasize the importance of human capital accumulation. Human capital can be included in the traditional Solow model and still yield conditional convergence. It can also be incorporated into (and indeed, be a major reason behind) endogenous growth models (Barro and Sala-i-Martin 1995, Mankiw, Roemer, and Weil 1992).

Few growth models explicitly consider the impact of gender inequality in education. Knowles, Lorgelly, and Owen (2002) extend the Solow model by considering male and female human capital as separate, and thus imperfectly substitutable, factors of production. Given diminishing returns to each factor, a more balanced distribution of education among males and females would lead to higher steady-state per capita income.

Lagerlöf (1999) and Galor and Weil (1996) examine the links between gender inequality in education or earnings on fertility and economic growth in an overlapping generations framework. Lagerlöf shows that initial gender inequality in education can result in high fertility, low economic growth, and continued gender inequality in education, thus creating a poverty trap that justifies public intervention.<sup>2</sup> Similarly, Galor and Weil postulate that economic growth narrows the gender gap in earnings, lowering fertility and advancing economic growth. Conversely, low-income countries, who often have high gender gaps in earnings, will suffer from high fertility and low economic growth, which will perpetuate the gender earnings gap and generate a similar poverty trap. In both models gender gaps in education and earnings reduce economic growth mainly through their demographic effects.

On the empirical front, the development of international panel datasets has, for the first time, allowed sophisticated time-series, cross-section, and panel analysis of the determinants of long-run growth (e.g., Asian Development Bank [ADB] 1997, Barro 1991, Barro and Sala-i-Martin 1995, Mankiw, Roemer, and Weil 1992). These empirical studies are usually based on estimating the transitional dynamics to a steady state in a Solow framework and so examine the issue of convergence as well as the importance of savings, population growth, and human capital accumulation. They often add largely ad hoc specifications to proxy for country differences in the technological shift parameter (broadly conceived) of the production function. These shift parameters affect steady-state gross

2. Lagerlöf's model assumes that parents aim to maximize the household incomes of their children. If there are gender gaps in education, it may be optimal for parents to focus education investments on sons because daughters are likely to marry an educated man, whereas sons are likely to marry an uneducated woman. These self-perpetuating gender gaps in education lead to high fertility because the opportunity cost of time is low for uneducated women. High fertility results in low investments in each child, which can mire an economy in a poverty trap. Public action to reduce the gender gap can break this self-perpetuating cycle and help move the economy out of a poverty trap.

domestic product (GDP) levels in conditional convergence models and long-term growth rates in endogenous growth models. Factors examined in this context include the level of corruption, political instability, ethnolinguistic fractionalization, openness to trade, geographic and climatic constraints, the quality of public services and institutions, and the dependency burden (ADB 1997, Barro 1991, Bloom and Williamson 1998, Collier and Gunning 1999, Easterly and Levine 1997, Sachs and Warner 1995).

These empirical analyses differ not only in their inclusion of parameters thought to affect steady-state GDP but also in their approach to treating proximate determinants of economic growth—especially the investment rate. Some studies include the investment rate as an explanatory variable (Barro and Sala-i-Martin 1995, Mankiw, Roemer, and Weil 1992). Others leave it out in the belief that it is determined by other regressors in the equations, such as the level of human capital or the quality of institutions (ADB 1997, Barro 1991, Bloom and Williamson 1998). Thus the second type of analysis has estimated “reduced form” equations in which proximate determinants of economic growth (especially the investment rate) are omitted from regressions to measure the total effect of independent variables.

Taylor (1998) presents results on both types of regressions. He first regresses growth rates on a number of structural factors derived from the Solow growth model (investment rate, population growth rate, initial income, and some shift parameters). Then he regresses each of those factors on a range of other determinants, such as policy distortions and political, social, and demographic variables.<sup>3</sup> Thus he aims to show the direct and indirect effects on growth of some policy variables and to better understand the process that leads to poor economic growth. For example, the population growth rate may affect economic growth directly, but it may also affect it through its impact on the investment rate or human capital accumulation.<sup>4</sup>

Although their results differ, the studies discussed generally show that there is evidence of conditional convergence, that initial and subsequent investments in human capital are associated with higher growth, that population growth dampens economic growth, that openness increases economic growth, and that high government consumption, political instability, and ethnic diversity reduce economic growth (Barro 1991, Bloom and Williamson 1998, Easterly and Levine 1997). Being landlocked or located in the tropics, having a small coastline, and having a large natural resource endowment also appear to dampen growth (ADB 1997, Sachs and Warner 1997).

3. This procedure can be done using ordinary least squares and yields consistent estimates because the system of equations being estimated is recursive, not simultaneous. Thus one can first consistently estimate the structural equations determining the endogenous variables, then estimate the growth regression using those endogenous variables. But care must be taken in interpreting the results, because direct effects must be distinguished from indirect effects.

4. In addition, some variables may influence economic growth only through their impact on structural parameters. Taylor (1998) finds, for example, that government spending affects GDP growth not directly, but only through its impact on investment.

Few studies have explicitly considered the impact on growth of gender inequality in education. Barro and Lee (1994) and Barro and Sala-i-Martin (1995) report the “puzzling” finding that in growth regressions that include male and female years of schooling the coefficient for female primary and secondary schooling is negative. They suggest that a large gap in male and female schooling may indicate backwardness and so may be associated with lower economic growth.

But there are reasons to question that “puzzling” finding. Dollar and Gatti (1999) show that it disappears once a dummy variable for Latin America is included, suggesting that the finding may be due to the combination of low growth and comparatively high female education in Latin America.<sup>5</sup>

The finding may also be related to multicollinearity. In most countries male and female education levels are closely correlated, making it difficult to identify empirically their individual effects. The correlation coefficient between male and female years of schooling and similar attainment measures (such as the share of adults with secondary education) is consistently above 0.9 for the large sample of countries considered by Barro and colleagues and in this study. Large standard errors for male and female education and the sudden reversal of this finding in different specifications is further evidence of this problem (Forbes, 2000, Knowles, Lorgelly, and Owen 2002, Lorgelly and Owen 1999). To avoid these pitfalls, this article adjusts the specification of education variables (see following discussion) and includes regional dummy variables.

Hill and King (1995) also study the effect on income of gender inequality in education. Instead of trying to account for GDP growth, they relate gender inequality in education to GDP levels. They find that a low female-male enrollment ratio is associated with lower GDP per capita, over and above the impact of female education levels on GDP per capita.

Knowles and others (2002) estimate the impact of gender inequality in education on GDP per capita using an explicit Solow framework, treating male and female education as separate factors of production. They find that gender inequality in education significantly reduces GDP per capita.<sup>6</sup>

This article differs from Hill and King and from Knowles, Lorgelly, and Owen in that it tries to explain differences in long-term growth rates of GDP rather than in levels of GDP per capita. It does so by including other standard regressors from the empirical growth literature. In addition, it differs from Hill and King in that it uses a broader, longer dataset and a more reliable measure of human capital.

5. Moreover, as Knowles, Lorgelly, and Owen (2002) argue, the use of base-period values for human capital in Barro and colleagues’ growth regressions contributes to this effect because high-growth East Asian economies had large initial gender gaps in 1960, so the coefficient on female education might pick up East Asia’s initial gaps as growth-enhancing. Inclusion of regional dummy variables should deal with this problem as well. In addition, Lorgelly and Owen (1999) suggest that this problem may be partly due to the impact of outliers.

6. Knowles, Lorgelly, and Owen (2002) refer to Klasen (1999) and specifically include in their specifications this article’s parametrization of measuring the impact on growth of gender inequality. They find that this article’s parametrization best deals with the problem of collinearity and confirm its main findings.

Dollar and Gatti (1999) also examine the relationship between growth and gender inequality in education. They try to explain five-year growth intervals (between 1975 and 1990) and to control for the possible endogeneity between growth and education using instrumental variable estimation. In contrast to Barro and colleagues, they find that female secondary education (as measured by the share of female adults with some secondary education) is positively associated with growth, whereas male secondary education is negatively associated with growth. In the full sample both effects are insignificant. But in countries with low female education, increasing it has little effect on economic growth—and in countries with high female education, increasing it significantly boosts economic growth.<sup>7</sup>

This study differs from Dollar and Gatti in that it uses a longer growth interval (based on the presumption that human capital pays off only over the long term), a longer time period (beginning in 1960 rather than 1975), and a different measure of human capital. In addition, it addresses the multicollinearity problem. The following discussion reconciles the different findings between Dollar and Gatti and this analysis.

Finally, an extensive literature shows that gender inequality in education contributes to higher fertility and child mortality (e.g., Hill and King 1995, Klasen 1999, Murthi, Guio, and Drèze 1995, Schultz 1994, World Bank 2001). Combined with the negative effects that high fertility and population growth have on economic growth,<sup>8</sup> the effects that gender inequality in education have on fertility and child mortality may point to an indirect link between gender bias in education and economic growth. Thus regressions that include the fertility rate or population growth as a regressor may understate the total effect of gender bias in education, making it important to explicitly model these indirect links.<sup>9</sup>

## II. THEORETICAL LINKS BETWEEN GENDER-BASED EDUCATION INEQUALITY AND ECONOMIC GROWTH

Based on the previous discussion and related theoretical considerations, the following causal links between gender inequality in education and economic growth might exist.

7. Forbes (2000) and Caselli, Esquivel, and Lefort (1996) use GMM estimators, a version of panel data analysis, and also find a positive effect of female education and a negative effect of male education on economic growth. Both analyses are focused on other questions and only use a very small number of covariates and, in the case of Forbes, a nonstandard income variable (non-PPP adjusted income). Their estimates might therefore partly be due to these shortcomings.

8. For example, a study of the Asian Development Bank (ADB) finds that high population growth depressed annual per capita growth in Sub-Saharan Africa by 0.7 percentage point between 1965 and 1990. This factor alone accounted for about 15 percent of the difference in growth performance between Sub-Saharan Africa and Southeast Asia (ADB 1997). Similarly, Bloom and Williamson (1998) find that East Asia's early fertility transition was an important factor in the region's economic success.

9. The same might be true, to a lesser extent, for growth regressions that include child mortality or life expectancy.

### *Lower Average Human Capital*

Assuming that boys and girls have a similar distribution of innate abilities and that children with more abilities are more likely to receive education, gender inequality in education means that less able boys than girls have the chance to be educated. As a result, the average innate ability of educated children is lower than it would be if boys and girls had equal education opportunities. Assuming that the amount of human capital of a person is the outcome of a combination of innate abilities and education, gender inequality in education would therefore lower the average level of human capital in the economy and therefore slow economic growth. For the same reason, such gender inequality would lower the impact of male education on economic growth and raises the impact of female education (Dollar and Gatti 1999, Knowles, Lorgelly, and Owen 2002).

Empirically, this lower human capital should directly reduce economic growth. This effect alone could shrink annual per capita growth by 0.3 percentage point in countries where gender inequality in education is similar to current levels in Africa, compared to a situation with no gender inequality in education.<sup>10</sup> It could also reduce the investment rate and thus indirectly reduce growth, because countries with lower human capital have smaller returns on investments.

A similar lowering of human capital occurs if male and female human capital are considered imperfect substitutes and there are declining marginal returns to education (Knowles, Lorgelly, and Owen 2002). In such cases diminishing returns to higher male education (rather than selection of less able males) lower the average level of human capital and thus economic growth.

All these effects are supported empirically. In many developing economies marginal returns to education are higher for girls than for boys, probably because of the selection effect and declining marginal returns to education (Alderman and others 1995, 1996, Hill and King 1995, World Bank 2001). Similarly, there is considerable evidence for the imperfect substitutability of male and female labor in many settings, and simulation studies have shown that a more equal allocation of male and female labor among industries would boost economic growth (Tzannatos 1999, World Bank 2001).

### *Wage Discrimination and Female Employment*

In most countries women experience wage discrimination in formal employment. This discrimination shows up in earnings regressions as the unexplained portion of the female–male wage gap (Horton 1999, Tzannatos 1999, World Bank 2001). If women have enough education to participate effectively in the

10. The calculations assume that innate abilities are normally distributed and compares two possible distributions of the student population. In one, half of an age cohort gets educated, and half are male and half are female. In the other, half of a cohort gets educated, and 70 percent are male and 30 percent are female. Average human capital would be 12 percentage points lower in the second scenario. Using the regression coefficient on human capital from Mankiw, Roemer, and Weil (1992) would yield a 0.3-percentage-point difference in annual growth.



formal labor market, wage discrimination can boost investment in industries that employ female workers. Reducing gender inequality in education may enable employers to employ cheaper female workers—boosting investment and thus economic growth.

Again, there is some empirical support for this effect. In many countries a considerable portion of high growth has been based on the use of female workers in export-oriented manufacturing industries. In some export-oriented Asian economies, for example, female education improved rapidly while there were large wage gaps between women and men, favoring female employment and the development of female-intensive industries (Seguino 2000b, Standing 1999).<sup>11</sup>

### *Direct Externality Effects*

Lower gender inequality in education means higher female education at each level of male education. Because female education is believed to have positive external effects on the quantity and quality of education for educated women's children (through the support and general environment that educated mothers can provide), lower gender inequality would therefore improve the human capital of the next generation, which should also promote economic growth (World Bank 2001).

Moreover, to the extent that similar education levels at the household level have positive external effects on the quality of education, reduced gender inequality may be one way to promote such effects. For example, equally educated siblings can strengthen one another's educational success through direct support and play inspired by schooling. Similarly, couples with similar education levels can promote one another's life-long learning.<sup>12</sup>

The higher human capital associated with such processes can increase economic growth directly by boosting worker productivity. But it can also have an indirect effect by increasing returns to physical investment, which raises investment rates and—through the effect of investment on economic growth—increases economic growth.

### *Indirect Externality Effects Operating through Demographic Effects*

As already discussed, there is overwhelming evidence that higher female education, which would obtain as a result of lower gender inequality in education,

11. Seguino (2000b) finds that gender gaps in education reduced economic growth in a sample of export-oriented middle-income economies, whereas gender gaps in pay increased it. Over time this effect will probably erode because the increased demand for female employment will reduce gender gaps in pay, as has been shown in most developing economies—including many fast Asian economies (World Bank 2001, Tzannatos 1999, Horton 1999). But in practice the unexplained portion of the gender gaps has far from disappeared in these countries, so this erosion appears to take a long time. Moreover, in some mature export-oriented economies where the share of manufacturing is declining—for example, Hong Kong (China) and Taiwan (China)—the gender gap appears to have widened recently. For discussions, see Berik (2000) and Seguino (2000a).

12. Even if people prefer to marry people with similar education levels (as appears to be the case), gender inequality in education often forces educated men to marry uneducated women, preventing this spillover. For a discussion of these and related issues, see Baliga, Goyal, and Klasen (1999).



reduces fertility rates. Lower fertility could affect economic growth in four different ways. First, lower fertility reduces population growth and thus facilitates investment's being used for capital deepening (more capital per worker) rather than capital widening (equipping new workers with capital), which would promote economic growth.<sup>13</sup>

Second, reduced fertility lowers the dependency burden, increasing savings rates in an economy, which would increase growth.

Third, lower fertility will, for a limited period of time, increase the share of workers in the population. When a large number of workers enter the labor force as a result of previously high population growth, it increases the demand for investment in capital equipment and social overhead (such as housing). If this higher demand is met by increased domestic savings (as a result of the reduced dependency burden), increased capital inflows, or both, investment will expand—which should boost growth (Bloom and Williamson 1998). This effect operates mainly through the impact of population growth on investment and its impact on economic growth rather than by affecting growth directly.

Fourth, if growth in the labor force is absorbed through increased employment, per capita economic growth will rise even if wages and productivity remain the same. This is because more workers will be sharing their wages with fewer dependents, boosting average per capita income. These last two effects—referred to as a “demographic gift” by Bloom and Williamson (1998)—are temporary because after a few decades growth in the working-age population falls and the number of elderly rises, leading to a higher dependency burden. Still, this temporary effect is thought to have made a considerable contribution to rapid growth in East and Southeast Asia (ADB 1997, Bloom and Williamson 1998, Young 1995; see also following discussion).<sup>14</sup>

### III. DATA, MEASUREMENTS, AND SPECIFICATIONS

A serious measurement problem arises when measuring the impact on economic growth of gender inequality in education. Because many subsistence, household, and reproductive activities are not captured by systems of national accounts, some estimates suggest that two-thirds of female economic activities go unrecorded in developing economies (compared with just one-quarter of male activities; see UNDP 1995, p. 89). Similarly, increases in the quantity and productivity of these

13. In a Solow framework, it would only boost economic growth in the transitional dynamics to a steady state (which can take a long time); in an endogenous growth framework, it could have permanent growth effects.

14. Lagerlöf (1999) describes a fifth demographic effect that suggests an interaction between gender inequality in education, high fertility, and low investment in human capital, and so economic growth. In this case the impact of fertility mainly operates through human capital investments for the next generation. A related demographic effect may operate through the health of the next generation. Educated women have healthier children and so indirectly contribute to economic growth by producing healthier, more productive workers (Klasen 1999, Summers 1994).

activities are often recorded insufficiently or not at all (Waring 1988). Moreover, economic change may lead to lower measured levels of female economic activity (say, through increased informalization of female work or larger burdens on females as a result of smaller social safety nets), depressing measured economic growth (Palmer 1991).

Thus any study of the link between gender-based education inequality and economic growth will suffer from these data weaknesses. Any finding of the impact of gender inequality on economic growth may understate the true relationship—particularly if better female education increases not just female activities included in systems of national accounts but also activities not included.<sup>15</sup>

Bearing in mind that caveat, the following country data were used in this article's analysis:

- Data on incomes and growth are based on per capita incomes between 1960 and 1992 adjusted for purchasing power parity (PPP, expressed in constant 1985 U.S. dollars using the chain index), as reported in the Penn World Tables Mark 5.6 (Heston and Summers 1991, National Bureau for Economic Research [NBER] 1998).<sup>16</sup> An average compound growth rate, calculated for 1960–92, is the dependent variable. Data on investment rates, population growth, and openness (defined as exports and imports as a share of GDP) are also drawn from the Penn World Tables.
- Data on schooling are based on Barro and Lee (1996) and refer to the total years of schooling of the adult population.<sup>17</sup>

15. It is not safe to assume, however, that this is always the case. For example, it is possible to imagine scenarios in which reduced gender inequality increases women's activities included in systems of national accounts and reduces activities not included, resulting in a smaller than observed impact on total economic output. This may happen if, for example, women enter the labor force and hire child care for their children. Both moves increase measured output, but the hired child care is simply replacing previously unrecorded activities.

16. Data are not available for all countries in 1960 or through 1992. Thus the time period considered is shorter for some countries. This fact is taken into account in the calculation of average growth rates for all the variables.

17. In the regressions using data on initial schooling in 1960, adults are defined as people age 15 and older. In the panel regressions adults are defined as people age 25 and older. This difference does not have much effect on the results. The education measure differs from that in Dollar and Gatti (1999), who use the share of the adult population with some secondary education. There are advantages and disadvantages to both types of variables. Using years of schooling captures the average education of the adult population, whereas the other measure does not, for example, differentiate between adults with no education and adults with complete primary education (both are counted as having no secondary education). However, using years of schooling (implicitly) suggests that all adults achieved these average figures and that differences in years of schooling between people do not matter. The other measure, to a limited degree, takes into account such differences. The measure used by Dollar and Gatti—the share of adults who have exactly achieved some secondary education—is a bit peculiar because it excludes people who have achieved more than secondary education. In countries where a growing share of adults have more than secondary education (such as Canada or the United States), this measure will show stagnation and not reflect these further improvements. It would be preferable to use a measure that includes people with some secondary education as well as people with more education. See also the discussion that follows.

- Data on education spending are based on Barro and Lee (1994).
- Data on the working-age population are from version 3.0 of the database on Women's Indicators and Statistics compiled by the United Nations Children's Fund (UNICEF 1996).<sup>18</sup>
- Data on fertility, child mortality, and life expectancy are from World Bank (1993) and UNICEF (1992).

Because the focus here is the long-term economic growth rate, the first set of regressions treats 1960–92 as one observation and runs a cross-section regression, which is also the specification preferred by Knowles and others (2002). Like Taylor (1998), the analysis considers both the direct and indirect effects on growth of gender inequality in education. Thus a set of equations is estimated to capture both types of effects. In addition, following Bloom and Williamson (1998) and the earlier discussion, population growth and labor force growth are separated out. Population growth is expected to have a negative effect on growth, and labor force growth a positive effect. In the basic specification, the following equations are estimated.

$$(1) \quad g = \alpha_1 + \beta_1 Inv + \beta_2 Popgro + \beta_3 LFG + \beta_4 ED60 + \beta_5 GED + \beta_6 RED60 + \beta_7 RGED + \beta_8 X + \varepsilon.$$

$$(2) \quad Inv = \alpha_2 + \beta_9 Popgro + \beta_{10} LFG + \beta_{11} ED60 + \beta_{12} GED + \beta_{13} RED60 + \beta_{14} RGED + \beta_{15} X + \phi.$$

$$(3) \quad Popgro = \alpha_3 + \beta_{16} ED60 + \beta_{17} GED + \beta_{18} RED60 + \beta_{19} RGED + \beta_{20} X + \varphi.$$

$$(4) \quad LFG = \alpha_4 + \beta_{21} ED60 + \beta_{22} GED + \beta_{23} RED60 + \beta_{24} RGED + \beta_{25} X + \gamma.$$

$$(5) \quad g = \alpha_5 + \beta_{26} ED60 + \beta_{27} GED + \beta_{28} RED60 + \beta_{29} RGED + \beta_{30} X + \nu.$$

In these equations  $g$  is the average annual compounded rate of per capita income growth in 1960–92,  $Inv$  is the average annual rate of investment (as a percentage of GDP) in 1960–92,  $Popgro$  is the average annual compounded rate of population growth in 1960–92,  $LFG$  is the average annual compounded rate of growth in the labor force (ages 15–64) population in 1960–92,  $ED60$  is total years of schooling in 1960,  $RED60$  is the female–male ratio of total years of schooling of the adult population in 1960,  $GED$  is average annual absolute growth in total years of schooling between 1960 and 1990,  $RGED$  is the female–male ratio of the average annual absolute growth of total years of schooling between 1960 and 1990, and  $X$ 's are other regressors typically included in cross-country growth regressions, including average openness, the log of income per capita in 1960 to test for conditional convergence, and regional dummy variables.<sup>19</sup>

18. Data for the working-age population cover only 1970–94. They were also compared with data from the World Bank, and the regression results did not depend on the data source.

19. In addition, a variety of policy variables were used, such as government consumption and institutional quality. Although some were significant, they added little to the explanatory power of the regressions and were omitted in the final specification used here.

Equation (1) measures the direct effect on economic growth of education and gender bias in education. Because gender bias in education may affect investment, population growth, and (with a delay) labor force growth, equations (2), (3), and (4) measure the effects that education and gender bias in education have on these variables—indicating the indirect effects that education and gender bias in education have on economic growth. Path analysis can then be used to determine the total effect, defined as: Total effect equals direct effect plus indirect effects.<sup>20</sup> For example, the total effect of the initial female-male ratio of schooling (*RED60*) on growth is:

$$\beta_6 + (\beta_{13} * \beta_1) + (\beta_{18} * \beta_2) + (\beta_{18} * \beta_9 * \beta_1) + (\beta_{23} * \beta_3) + (\beta_{23} * \beta_{10} * \beta_1).$$

The first term is the direct effect, the second term is the indirect effect through investment, the third term is the indirect effect through population growth, the fourth term is the indirect effect through population growth and investment, the fifth term is the indirect effect through labor force growth, and the sixth term is the indirect effect through labor force growth and investment.

Equation (5) is a “reduced form” regression that omits investment, population growth, and labor force growth. Thus it should measure the total effect of gender bias in education directly.

It is important to briefly discuss how human capital and gender bias in human capital are modeled here.<sup>21</sup> Instead of including variables for male and female human capital achievement—which have a correlation coefficient of 0.96 between initial levels and 0.69 between growth in education—a different approach was used to avoid the multicollinearity problem. The regressions include a variable that measures overall human capital (*ED60* and *GED*) as well as one that measures the female–male ratio of human capital (*RED60* and *RGED*). The first tries to capture the effect on growth of overall human capital, and the second measures whether a country with smaller gender differences in education would grow faster than a country with identical average human capital but greater inequality in its distribution. This approach generates much smaller correlation coefficients and should make it easier to identify the different effects.<sup>22</sup>

20. An important assumption in interpreting such a path analysis is that one has good reason to believe that the causality in the indirect regressions runs from gender bias in education to investment, population growth, and labor force growth. That seems to be true in these three cases, which is why only these three indirect effects are considered here.

21. An important issue is whether a stock or flow measure of human capital is more appropriate for such an estimation. Because the goal here is to model economic growth, it appears appropriate to focus on flow measures, such as physical and human capital investments, and thus use the change in years of schooling as a proxy for investments in human capital. At the same time, it may be that due to externalities and complementarities between factors of production, the stock of human capital increases economic growth because it makes physical capital more productive. Thus it is useful to include both a stock and a flow measure, as proposed for the regressions.

22. The correlation coefficient between initial levels (i.e., *ED60* and *RED60*) is now reduced to 0.61 or 0.68 and between growth rates of education (*GED* and *RGED*) it is now  $-0.29$  or  $-0.1$ , depending on whether male or average education is used to proxy for average education.

Two assumptions can be made about the relationship between male education and the gender gap in education. The first implicitly assumes that gender inequality in education could be reduced without reducing male education levels. In this case, male years of schooling can be used to proxy for average human capital (*ED60* and *GED*). Given that increases in female education might at least partially come at the expense of male education, this assumption provides an upper bound of the measured effect of gender inequality on growth. In the second assumption any increase in female schooling, other things being equal, would lead to a commensurate decrease in male schooling. In this case the average of male and female years of schooling is used for *ED60* and *GED* and thus provides a lower-level estimate of the measured growth effect of gender inequality in education. The true effect likely falls between these two estimates, probably closer to the first than the second. Both specifications are reported on later in the discussion.<sup>23</sup>

A second issue relates to possible simultaneity problems. Because the estimation relies not only on initial levels of and gender differences in human capital (*ED60* and *RED60*) but also on growth in education attainment and the female–male ratio of that growth (*GED* and *RGED*), it could theoretically be that causality runs from growth to schooling (and reduced gender bias in schooling; see Dollar and Gatti 1999)—not the other way around, as suggested here.

This issue is addressed using three procedures. First, total years of schooling of the adult population is a stock measure of education based on past investments in education. Growth in total years of schooling of the adult population between 1960 and 1990 (*GED*) is largely based on education investments between 1940 and 1975. Thus it is unlikely (but not impossible) that these investments were mainly driven by high economic growth between 1960 and 1992. In addition, some regressions use a stock measure of education among people age 25 and older in 1970—a measure that cannot be heavily influenced by growth after 1960.<sup>24</sup>

Second, instrumental variable techniques are used to address this issue. In particular, education spending (as a share of GDP), initial fertility levels, and changes in fertility rates are used as instruments for changes in education attainment and in the female–male ratio of those changes to explicitly control for possible simultaneity. These instruments pass standard relevance and overidentification tests and so appear to be plausible candidates.<sup>25</sup>

23. Another way to model gender inequality in education would be to have a variable for male education and a second one for the difference between female and male education. The results of that approach are very similar to the results when using ratios.

24. It is not possible for this measure of human capital to have been greatly influenced by economic growth because the investments (especially in primary and secondary education) needed to educate people who were 25 and older in 1970 were completed between 1930 and 1960 and so cannot have been influenced by economic growth since 1960.

25. The instruments are much better at predicting the female–male ratio of growth in education than male growth in education (where they have only a weakly significant impact). To see whether these instruments are appropriate in the sense that they affect the dependent variable only through the variable they instrument and not directly, the overidentification restriction test was run. To do so, the residuals from the second-stage regressions were saved and regressed on the exogenous variables.

Third, the model is reestimated using a panel dataset that divides the dependent and independent variables into three periods (1960–70, 1970–80, and 1980–90). These panel regressions use only initial values of education and gender gaps in initial education as explanatory variables.<sup>26</sup>

These models are estimated for 109 industrial and developing economies. In addition, the same analysis is performed for a sample that includes only developing countries and for a sample that includes only African countries to see whether the relationships differ.<sup>27</sup>

#### IV. DESCRIPTIVE STATISTICS

This section presents regional data on growth and its most important determinants as well as on gender inequality in education and employment. These data form the background for the multivariate analysis in the next section.

Between 1960 and 1992 annual growth in per capita income was slowest in Sub-Saharan Africa, averaging just 0.9 percent (table 1). This was about 40 percent of the world average and 3.3 percentage points less than in East Asia and the Pacific. Latin America also experienced slow growth, followed closely by South Asia. Similarly, average investment rates were low in Sub-Saharan Africa but slightly higher than in South Asia.

Moreover, Sub-Saharan Africa, South Asia, and the Middle East and North Africa suffered from several disadvantages in initial conditions. Between 1960 and 1992 these three regions had the world's highest population growth. Moreover, in 1960 the average woman (age 15 or older) in Sub-Saharan Africa and the Middle East and North Africa had a dismal 1.09 years of schooling; in South Asia female education attainment was even worse. Gender inequality in education was also high in all three regions, with women in Sub-Saharan Africa having barely half the schooling of men and women in South Asia and the Middle East and North Africa having only about a third.

Particularly worrisome is that between 1960 and 1990 education expansion in Sub-Saharan Africa was the lowest of all regions. Moreover, the region's female–male ratio in that growth was 0.89, meaning that females experienced

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the product of  $N$  (number of observations) and the  $R^2$  is distributed as a chi-square, and the null hypothesis is that the exogenous variables have no impact on the residuals. The relevant statistic is 0.49—clearly unable to reject the hypothesis and so confirming that the instruments are appropriate.

26. Specification tests indicate that the best panel regression specification is to use regional and decade dummies but no country-specific fixed effects or random effects. The Breusch-Pagan test for random effects ( $P$ -value of 0.2083) suggests that there is no reason to believe that there are random or fixed effects. Moreover, a fixed regression specification in a panel with only three time-series observations often leads to inconsistent results. The specification with regional and decade dummies has the highest explanatory power and easily passes the Ramsey Reset test for omitted variables. The fixed and random effects specifications yield qualitatively the same results.

27. All standard errors are adjusted for heteroscedasticity, and the Ramsey Reset test is used to investigate the presence of omitted variables.

TABLE 1. Economic and Demographic Indicators by Region, 1960–92

Region	Growth (g)	<i>Inv</i>	<i>OPEN</i>	<i>Popgro</i>	<i>LFG</i>	Initial income	Final income	<i>FED60</i>	<i>MED60</i>	<i>RED60</i>	<i>RED70</i>	<i>MGED</i>	<i>RGED</i>
Average	2.1	18.5	62.5	1.9	2.2	2,422	5,166	3.22	4.01	0.69	0.67	0.07	1.01
East Asia and Pacific	4.2	21.0	98.2	2.2	2.7	1,283	5,859	2.79	4.67	0.59	0.56	0.09	1.44
Eastern Europe and Central Asia	3.2	33.3	54.1	0.4	0.5	2,675	5,308	6.16	7.38	0.83	0.83	0.08	1.26
Latin America and Caribbean	1.3	16.3	57.4	2.1	2.6	2,302	3,471	3.27	3.68	0.89	0.83	0.06	1.11
Middle East and North Africa	2.3	16.0	56.5	2.9	3.1	1,776	3,518	1.09	2.09	0.37	0.34	0.12	0.82
South Asia	1.7	8.9	30.4	2.3	2.7	760	1,306	0.87	1.84	0.33	0.31	0.08	0.77
Sub-Saharan Africa	0.9	10.8	65.1	2.7	2.8	855	1,251	1.09	1.85	0.51	0.49	0.06	0.89
OECD	2.9	27.0	59.8	0.7	0.9	5,583	12,870	6.48	6.86	0.93	0.89	0.07	0.90

*Note:* Data cover 109 countries for which all covariates are available. Regional data are unweighted averages for the countries in each region. For example, female–male ratios for education are calculated as the regional averages of the ratios in each country (not by dividing the regional average for female education by the regional average for male education). Thus dividing *FED60* by *MED60* for a particular region will not equal *RED60* for that region. Variables are defined as follows: *Growth* (g): average annual compounded rate of per capita income growth (percent) in 1960–92; *Inv*: average annual rate of investment as a share of GDP (percent) in 1960–92; *OPEN*: average annual ratio of exports and imports as a share of GDP (percent) in 1960–92; *Popgro*: average annual compounded rate of population growth (percent) in 1960–92; *LFG*: average annual compounded rate of growth in the labor force (ages 15–64) population (percent) in 1970–92; Initial income: average per capita income in 1960 (or first year available), in constant 1985 U.S. dollars using the chain index; Final income: average per capita income in 1992 (or last year available), in constant 1985 U.S. dollars using the chain index; *FED60*: average years of schooling among women age 15 and older in 1960; *MED60*: average years of schooling among men age 15 and older in 1960 (used for average education variable *ED60* in most regressions below); *RED60*: female–male ratio of total years of schooling among people age 15 and older in 1960; *RED70*: female–male ratio of total years of schooling among people age 25 and older in 1970; *MGED*: average annual absolute growth in years of schooling among men age 15 and older in 1960–90 (used for average education variable *GED* in most regressions); and *RGED*: female–male ratio of the average annual absolute growth in total years of schooling among people age 15 and older in 1960–90.

*Source:* See text.



slower expansion in education achievement than males. South Asia and the Middle East and North Africa were equally poor performers. Although male education levels expanded much faster than in Sub-Saharan Africa, females lagged even further behind in education expansion. Again, the contrast with East Asia and the Pacific is striking. There, female years of schooling expanded three times faster than in Sub-Saharan Africa and female education expansion outpaced male expansion by 44 percent.

Thus Sub-Saharan Africa, South Asia, and the Middle East and North Africa suffered from the worst initial conditions for female education and had the worst record of improvements between 1960 and 1990. In contrast, East Asia and the Pacific started out with somewhat better conditions for women's education. But more important, women were able to improve their education levels much faster than men, rapidly closing the initial gaps.<sup>28</sup>

So, if gender inequality in education affects economic growth, Sub-Saharan Africa, South Asia, and the Middle East and North Africa should have suffered the most damage, having experienced the highest gender inequality in initial education and in its expansion. Meanwhile, East Asia and the Pacific and Eastern Europe and Central Asia should have benefited from lower initial and rapidly falling inequality in education.

## V. ECONOMETRIC ANALYSIS

The basic regressions for equations (1–5) are shown in table 2. All the regressions have a high explanatory power and perform well on specification tests. Regression 1 confirms a number of known findings on conditional convergence (*LNINC1960*), the importance for growth of investment and openness (*Inv*, *OPEN*), the importance of initial levels of human capital (*ED60*) and growth in human capital (*GED*), the negative impact of population growth (*Popgro*), and the positive impact of labor force growth (*LFG*; see ADB 1997, Barro 1991, Bloom and Williamson 1998, and Mankiw, Roemer, and Weil 1992). The coefficients for these variables are within the ranges observed in other studies. Some of the dummy variables for different regions are significant—especially for Sub-Saharan Africa and Latin America—suggesting that the growth regression is not picking up all the effects that account for slower growth in these regions (see also Barro 1991).

More interesting for the purposes of this article is the finding that both the initial female–male ratio of schooling (*RED60*) and the female–male ratio of expansion in schooling (*RGED*) have a significant positive impact on economic

28. Eastern Europe is also notable for its small gender gaps in education and employment (see Klasen 1993). In addition, note that Sub-Saharan Africa and South Asia had the world's lowest incomes in 1960, which should have helped boost growth because trade and factor flows should have promoted convergence in income levels. Sub-Saharan economies exhibited average levels of openness, whereas South Asian economies were more closed. But this comparison is slightly deceptive, because one would have expected the many small Sub-Saharan economies to have above-average levels of openness due to their small domestic markets. Relative to East Asia, Sub-Saharan economies were much less open.

TABLE 2. Gender Inequality in Education and Economic Growth

Dependent variable	(1) Growth	(2) <i>Inv</i>	(3) <i>Popgro</i>	(4) <i>LFG</i>	(5) Growth	(6) Growth	(7) Growth
Constant	6.33*** (3.4)	3.23 (0.5)	3.74*** (4.5)	4.16*** (4.6)	7.50*** (4.7)	6.82*** (3.8)	7.89*** (5.0)
<i>LNINC60</i>	-1.13*** (-5.0)	-0.10 (-0.1)	-0.13 (-1.1)	-0.18* (-1.4)	-1.21*** (-5.3)	-1.16*** (-5.2)	-1.24*** (-5.4)
<i>Popgro</i>	-0.55* (-1.4)	-0.81 (-0.8)	—	—	—	-0.47 (-1.1)	—
<i>LFG</i>	0.62* (1.5)	2.60** (2.2)	—	—	—	0.53 (1.2)	—
<i>OPEN</i>	0.007** (1.9)	0.026** (1.9)	—	—	0.009*** (2.6)	0.007** (2.1)	0.010*** (2.7)
<i>Inv</i>	0.056** (1.7)	—	—	—	—	0.055** (1.7)	—
<i>ED60</i>	0.19** (2.3)	0.64** (1.9)	-0.03 (-0.5)	-0.02 (-0.6)	0.23*** (2.5)	0.18** (2.1)	0.21** (2.3)
<i>GED</i>	12.61*** (3.8)	14.10 (0.9)	-0.86 (-0.6)	0.78 (0.5)	14.38*** (3.7)	14.93*** (4.1)	17.47*** (4.2)
<i>RED60</i>	0.90* (1.3)	7.44*** (2.7)	-0.29 (-1.1)	0.19 (0.8)	1.64** (2.3)	0.78 (1.1)	1.46** (2.0)
<i>RGED</i>	0.69*** (3.0)	1.28 (1.2)	-0.22*** (-2.4)	-0.13* (-1.4)	0.75*** (2.8)	0.51** (2.2)	0.55*** (2.2)
Eastern Europe and Central Asia	-0.77 (-0.9)	14.82*** (5.5)	-1.56*** (-7.1)	-2.12*** (-10.4)	-0.57 (-0.8)	-0.74 (-0.9)	-0.48 (-0.7)
Latin America and Caribbean	-1.31** (-1.8)	-4.12** (-2.1)	-0.01 (-0.1)	-0.12 (-0.5)	-1.58** (-2.2)	-1.30** (-1.9)	-1.56** (-2.3)
Middle East and North Africa	-0.15 (-0.2)	-0.44 (-0.2)	0.50** (2.2)	0.25 (1.1)	-0.25 (-0.4)	-0.10 (0.2)	-0.19 (-0.3)
South Asia	-0.46 (-0.7)	-5.35** (-2.4)	-0.20 (-0.9)	-0.25 (-1.1)	-0.78 (-1.1)	-0.42 (-0.6)	-0.72 (-1.1)
Sub-Saharan Africa	-1.42** (-2.1)	-5.53*** (-2.8)	0.27 (1.1)	-0.10 (-0.5)	-1.95*** (-3.0)	-1.38** (-2.0)	-1.85*** (-3.0)
OECD	0.49 (0.7)	7.89*** (3.6)	-1.23*** (-6.1)	-1.64*** (7.5)	0.46 (0.6)	0.59 (0.9)	0.63 (0.9)
Adjusted $R^2$	0.61	0.74	0.65	0.71	0.57	0.61	0.59
Omitted variables test	Passed	Passed	Passed	Passed	Passed	Passed	Passed
<i>N</i>	109	109	109	109	109	109	109

— Not available.

\*Significance at the 90 percent level (one-tailed test).

\*\*Significance at the 95 percent level (one-tailed test).

\*\*\*Significance at the 99 percent level (one-tailed test).

*Note:* Numbers in parentheses are heteroscedasticity-adjusted *t*-ratios. *LNINC60* refers to the log of income per capita in 1960 adjusted for purchasing power parity. In regressions 1–5 *ED60* refers to average years of schooling among men age 15 and older in 1960, and *GED* refers to average annual absolute growth in years of schooling among men age 15 and older in 1960–90. In regressions 6 and 7 *ED60* and *GED* refer, respectively, to average years of, and average annual absolute growth in schooling for both men and women. Other variables are explained in table 1. The Ramsey Reset test is used to test for omitted variables. In regressions 1 and 6 the Ramsey Reset test is passed only when powers of the right-hand-side variables are considered (not when powers of the fitted values for the dependent variable are considered, as in all the other regressions). East Asia and the Pacific is omitted.

*Source:* Author's calculations.

growth. Because the regressions control for investment as well as population and labor force growth, these results support the claim that gender inequality in education reduces average human capital. They also support the direct externality effect of increased female education. The magnitude of the coefficient is plausible. An increase from 0.5 to 1.0 in the female–male ratio of growth in schooling would raise the annual growth rate by about 0.4 percentage points, similar to the predictions made earlier.<sup>29</sup>

Regression 2 shows the determinants of investments and finds that higher investment rates are related to higher labor force growth, greater openness, and higher human capital. In addition, reduced gender inequality in education appears to lead to higher investment rates, confirming the indirect links between gender inequality in education, investment, and economic growth postulated. In particular, the regression confirms the impact that the quality of human capital has on investment rates. Moreover, it is consistent with the claim that lower gender inequality, combined with wage discrimination boost investment because it makes investing in female-intensive industries especially appealing. The effect through the investment rate seems particularly large for initial gender inequality in education.

Regressions 3 and 4 show that gender inequality in education has the expected impact on population growth and labor force growth, so the indirect link between gender inequality in education and economic growth through these two factors is also present.

Regression 5 shows the “reduced form” estimate of the impact of gender inequality in education. Comparisons between regressions 1 and 5 indicate that the indirect effects of gender inequality in education are large because the size (and significance) of both coefficients—particularly the one related to initial gender inequality—have increased considerably. This finding suggests that initial gender inequality mainly affects growth indirectly, particularly through its effect on investment rates.

In table 3 the results from regressions 1–5 are used to determine the extent to which growth in Sub-Saharan Africa, South Asia, and the Middle East and North Africa has lagged behind growth in East Asia and the Pacific due to initial gender bias in education and gender bias in the growth of education. As this specification used male education to proxy for average human capital, it is implicitly assuming that the female education could have been increased without chang-

29. Empirically, gender inequality in education also appears to be related to the health of the population. When the under-age-5 mortality rate or life expectancy in 1960 are included in the regressions (not shown here), the direct effects on growth of gender inequality in education become smaller (but remain sizable), and the coefficients on child mortality and longevity are in the right direction but not significant. As shown in Klasen (1999), lower gender inequality in education reduces child mortality—suggesting that lower gender inequality also promotes economic growth through its effect on lower child mortality and thus a healthier population. This finding also suggests that the inclusion of initial life expectancy in growth regressions (as in ADB 1997) picks up part of this effect, which is really due to gender inequality in education.

TABLE 3. Gender Inequality in Education and Its Effects on Growth Differences between East Asia and the Pacific and Other Regions (percent)

Indicator	Upper-bound estimate of growth difference between East Asia and the Pacific and:			Lower-bound estimate of growth difference between East Asia and the Pacific and:		
	Sub-Saharan Africa	South Asia	Middle East and North Africa	Sub-Saharan Africa	South Asia	Middle East and North Africa
Total annual growth difference	3.3	2.5	1.9	3.3	2.5	1.9
Accounted for by						
Direct effect of gender inequality in education (1)	0.45 (0.08, 0.37)	0.69 (0.23, 0.46)	0.63 (0.20, 0.43)	0.34 (0.06, 0.28)	0.54 (0.20, 0.34)	0.49 (0.17, 0.31)
Indirect effect through investment (2)	0.07	0.16	0.14	0.07	0.14	0.13
Indirect effect through population growth (2, 3)	0.09	0.13	0.12	0.07	0.11	0.10
Indirect effect through labor force growth (2, 4)	-0.04	-0.03	-0.03	-0.04	-0.02	-0.02
Total direct and indirect effect (sum of above)	0.56 (0.13, 0.43)	0.95 (0.43, 0.53)	0.86 (0.37, 0.49)	0.44 (0.12, 0.32)	0.77 (0.38, 0.39)	0.69 (0.33, 0.36)
Total effect using reduced form regression (5)	0.54 (0.13, 0.41)	0.92 (0.43, 0.50)	0.83 (0.37, 0.46)	0.42 (0.12, 0.30)	0.75 (0.38, 0.37)	0.67 (0.33, 0.34)

*Note:* The numbers in parentheses in the first column refer to the regressions on which the estimates are based. The first number in parentheses in the other columns refers to the difference in growth accounted for by different initial levels of gender inequality in education (based on the variable *RED60*) and the second number refers to the difference accounted for by the gender gap in growth of schooling (based on the variable *RGED*). Barring rounding errors, the two numbers sum to the number reported before the parentheses—the combined effect.

*Source:* Author's calculations.

ing male education levels, the table present upper-bound estimates of the effects (see later discussion for a discussion of lower-bound estimates, which are shown in the right-hand panel of table 3). The data indicate the combined effects (and in parentheses, disaggregated effects) of initial gender gaps in education and gender gaps in the growth of education. Using just the direct effect (regression 1), 0.45 of the 3.3-percentage-point annual difference in growth between Sub-Saharan Africa and East Asia can be accounted for by differences in gender inequality in education, with most due to differences in gender bias in the growth of education.<sup>30</sup>

The comparison between South Asia and East Asia is even more striking. Here 0.69 of the regions' 2.5-percentage-point annual difference in economic growth can be accounted for by differences in gender inequality in education. About two-thirds is explained by differences in gender bias in the growth of education and one-third by differences in gender inequality in 1960. Similarly, gender inequality in education appears to have slowed growth in the Middle East and North Africa by amounts similar to those in South Asia.

Indirect effects also account for some of the differences in economic growth between South Asia (and Sub-Saharan Africa) and East Asia. Through its effect on investment, gender inequality in education accounts for another 0.16 percentage point of the growth difference between South Asia and East Asia (and for 0.07 percentage point of the difference between Sub-Saharan Africa and East Asia). Gender inequality in education also accounts for 0.13 percentage point of the growth difference between South Asia and East Asia through its effect on population growth (0.09 percentage point of the difference Africa-East Asia). These indirect effects—especially those operating through population and labor force growth rates—are somewhat smaller than expected and considerably smaller than the direct effect of gender inequality.

The total direct and indirect effects of gender inequality in education account for 0.95 percentage point of the difference in economic growth between South Asia and East Asia, 0.56 percentage point of the difference between Sub-Saharan Africa and East Asia, and 0.85 percentage point of the difference between the Middle East and North Africa and East Asia. Using the reduced form regression (regression 5) yields nearly identical estimates of the total size of the effects as well as their impact on the growth differences between regions (see table 3).

Thus gender inequality in education appears to have a sizable effect on economic growth. It is worth emphasizing that the results in table 3 do not take into account differences in average human capital between regions, just gender inequality in education. The regressions show that differences in average human

30. Through the process of conditional convergence, Sub-Saharan Africa could have been expected to grow faster than East Asia. If this factor is taken into account, the growth difference to be explained increases to 3.9 percentage points.

capital also matter a lot and can account for an additional share of the growth differences between regions.

As noted, it is important to determine the robustness of the results presented. First, as already mentioned, the estimates on gender inequality in education present an upper-bound estimate because they assume that increases in female education could have been achieved without any reduction in male education. Columns 6 and 7 in table 2 present the direct effect and reduced form regressions for the lower-bound estimate,<sup>31</sup> using the average level of human capital rather than the male level of human capital used previously.

As expected, the coefficients for the gender gap in schooling are smaller. But they are still sizable and, in most cases, significant. Calculations of the growth differences accounted for by this measure of gender inequality in education show only small differences from the previous ones (see table 3). Here the total effect of gender inequality in education accounts for 0.77 percentage point of the growth difference between South Asia and East Asia, 0.44 percentage point of the difference between Sub-Saharan Africa and East Asia, and 0.69 percentage point of the difference between the Middle East and North Africa and East Asia.

Second, there is a need to consider possible simultaneity issues. In particular, is it possible that growth led to increases in the female–male ratio of schooling rather than the other way around? This issue is first addressed by replacing the two education gap variables with just one that measures the female–male ratio of schooling of adults above 25 in 1970 (as noted, this statistic could hardly have been affected by economic growth after 1960). In regressions not shown here, this measure has a significant effect on economic growth—supporting the notion that causality runs from gender bias in education to growth, not vice versa.

Simultaneity is also addressed in regressions 8 and 9 in table 4, which are based on a panel analysis in which the dependent and independent variables are divided into three periods. Because only initial levels of schooling and initial female–male ratios of schooling are included in the regression, it avoids the simultaneity issue inherent in the education growth variables. The results are very similar to the cross-section results, which is reassuring because findings from cross-country regressions often change in a panel setting. In fact, even the magnitude of the effects is roughly similar to that in the cross-section regression.

Table 5 estimates the impact of gender inequality in education on differences in growth between regions using the panel regressions. In the 1980s initial gender inequality in education accounted for about 0.3–0.5 percentage point of the growth differences between East Asia and Sub-Saharan Africa, South Asia, and the Middle East and North Africa. These differences are smaller than in the cross-section regression, which is to be expected because the analysis no longer considers the impact of further improvements in the gender gap in education that may have occurred after 1980.

31. Here and in the following, the intervening regressions of the indirect effects are available on request.

TABLE 4. Gender Inequality in Education and Economic Growth:  
Further Specifications

Dependent variable	(8) Growth	(9) Growth	(10) Growth	(11) Growth	(12) Growth	(13) Growth	(14) Growth
Constant	6.33***	3.23	3.74***	4.16***	7.50***	6.82***	7.89***
Constant	7.92*** (3.5)	7.68*** (3.5)	4.34 (1.1)	4.42** (2.2)	5.90*** (3.6)	1.29 (0.3)	3.91* (1.6)
<i>LNINC60</i>	-1.15*** (-3.5)	-1.12*** (-3.5)	-1.30* (-1.6)	-0.96*** (-3.85)	-1.04*** (-4.2)	-0.80** (-1.9)	-1.03** (2.5)
<i>Popgro</i>	-1.02*** (-3.1)	—	—	-0.45 (-1.1)	-1.19 (-1.2)	—	—
<i>LFG</i>	0.61*** (2.4)	—	—	0.70* (1.5)	—	1.66* (1.3)	—
<i>OPEN</i>	0.007** (2.1)	0.012*** (3.7)	0.001 (0.1)	0.008** (2.2)	0.010*** (2.6)	0.015** (2.0)	0.012** (1.8)
<i>Inv</i>	0.111*** (4.7)	—	—	0.035 (0.4)	—	0.019 (-0.4)	—
<i>ED60</i>	0.08 (1.0)	0.19** (1.9)	0.29 (0.8)	0.31*** (3.0)	0.33*** (3.2)	0.06 (0.2)	0.19 (0.7)
<i>GED</i>	—	—	33.96 (1.2)	14.1*** (3.9)	15.39*** (3.2)	11.18** (2.2)	11.78** (2.4)
<i>RED60</i>	1.33** (1.65)	2.12*** (2.6)	1.24 (0.8)	1.14* (1.5)	1.71** (2.2)	2.59** (2.1)	3.29*** (3.0)
<i>RGED</i>	—	—	2.64** (1.7)	0.53** (2.2)	0.52** (2.0)	0.62* (1.5)	0.36 (1.1)
Eastern Europe and Central Asia	-1.83** (-2.3)	-0.70 (-0.9)	0.26 (0.3)	-0.58 (-0.6)	-0.98* (-1.3)	—	—
Latin America and Caribbean	-1.87*** (-3.0)	-2.29*** (-3.5)	-0.50 (-0.4)	-1.39** (-1.8)	-1.62** (2.2)	—	—
Middle East and North Africa	0.22 (0.3)	0.08 (0.1)	0.14 (0.2)	-0.12 (-0.2)	-0.16 (-0.2)	—	—
South Asia	-1.01* (-1.4)	-1.78** (-2.3)	0.40 (0.4)	-0.24 (-0.35)	-0.48 (-0.7)	—	—
Sub-Saharan Africa	1.74*** (-2.9)	-2.76*** (-4.5)	-0.35 (-0.3)	-1.26** (-1.7)	-1.64*** (2.6)	—	—
OECD	-1.01* (-1.6)	-0.34 (-0.5)	1.73** (1.9)	—	—	—	—
1960s	2.60*** (7.9)	2.58*** (7.9)	—	—	—	—	—
1970s	1.74*** (5.9)	2.10*** (6.9)	—	—	—	—	—
Adjusted $R^2$	0.47	0.40	0.19	0.60	0.58	0.55	0.56
Omitted variables test	Passed	Passed	Not applicable	Passed	Passed	Passed	Passed
<i>N</i>	295	295	96	86	86	27	27

— Not available.

\*Significance at the 90 percent level (one-tailed test).

\*\*Significance at the 95 percent level(one-tailed test).

\*\*\*Significance at the 99 percent level (one-tailed test).

*Note:* Numbers in parentheses are heteroscedasticity-adjusted  $t$ -ratios. *LNINC60* refers to the log of income per capita in 1960 adjusted for purchasing power parity. Other variables are explained in table 1. This table shows only the direct effect and reduced form regressions. The intervening regressions of investment, population growth, and labor force growth are available on request. Regressions 8 and 9 are based on a panel regression with three observations per country (1960s, 1970s, and 1980s). In these regressions *ED60* and *RED60* refer to the level and female-male ratio of years of schooling of people age 25 and older at the start of each decade. Regression 10 is the second stage of a two-stage least squares regression. The instruments used for *GED* and *RGED* are government spending on education (as a share of GDP), the fertility rate in 1960, and the change in the fertility rate between 1960 and 1990. Regressions 11 and 12 restrict the sample to developing economies, and regressions 13 and 14 to countries in Sub-Saharan Africa. The Ramsey Reset test is used to test for omitted variables. East Asia and the Pacific is omitted.

*Source:* Author's calculations.



TABLE 5. Gender Inequality in Education and Its Effects on Growth Differences between East Asia and the Pacific and Other Regions: Panel-Based Estimates (percent)

Indicator	Estimate of growth difference between East Asia and the Pacific and:		
	Sub-Saharan Africa	South Asia	Middle East and North Africa
Growth difference, 1960s	2.13	2.49	1.26
Growth difference, 1970s	3.82	3.77	0.90
Growth difference, 1980s	3.04	1.54	2.97
Difference in female–male ratio of years of schooling, 1960	0.06	0.18	0.11
Difference in female–male ratio of years of schooling, 1970	0.08	0.23	0.16
Difference in female–male ratio of years of schooling, 1980	0.17	0.21	0.16
Difference accounted for by gender inequality in education			
Direct effect (10)			
1960s	0.09	0.24	0.15
1970s	0.11	0.30	0.22
1980s	0.23	0.28	0.21
Total effect using reduced form regression (11)			
1960s	0.14	0.38	0.25
1970s	0.17	0.49	0.34
1980s	0.36	0.45	0.34

*Note:* Estimates are based on regressions 10 (direct effect) and 11 (total effect using reduced form regression), which are panel regressions with one observation per decade. These regressions measure only the impact of the female–male ratio of years of schooling among people age 25 and older at the beginning of each decade (and thus not the impact of the change in education achievements throughout a decade).

*Source:* Author's calculations.

The panel regressions also show an interesting temporal pattern in the impact that gender inequality in education has on economic growth. In 1960 East Asia did not exhibit much lower gender bias in education than did other regions, and growth differences between it and other regions were comparatively small. By 1970 and especially by 1980, the gender gap in East Asia was much lower than in other regions—and it was precisely during that period when growth differences soared between East Asia and South Asia, Sub-Saharan Africa, and the Middle East and North Africa. These findings suggest that smaller gender gaps in education played a significant role in higher growth.

To approach the simultaneity issue in another way, regression 10 presents a two-stage least squares regression in which growth in average education and in the female–male ratio of education are replaced by their predicted values, using as instruments government spending on education (as a share of GDP), the fertility rate in 1960, and the change in the fertility rate between 1960 and 1990 (see

table 4). The female–male ratio of growth of education still has a significant impact and is much larger in magnitude. This finding lends further support to the contention that causality runs from gender bias in education to economic growth, not the reverse.

Further analyses investigate whether the relationship between gender inequality and growth differs depending on which countries are included in the regression. Although limiting the sample to more homogeneous groups of countries makes it possible to see whether effects differ by region, it eliminates some of the important cross-sectional variation needed to estimate those effects, which may lead to less precise results. Limiting the sample to 85 developing economies (regressions 11 and 12 in table 4) has little effect on the results. Initial gender inequality has a slightly larger effect than in the full sample, and gender bias in the growth of education has a smaller effect. Using these regressions to account for growth differences suggests that gender inequality in education accounts for 0.44 percentage point of the growth difference between Sub-Saharan Africa and East Asia and 0.81 percentage point of the difference between South Asia and East Asia.

Thus gender inequality in education has as much effect on growth in developing economies as in industrial economies. This finding differs from that in Dollar and Gatti (1999), who find that gender inequality in education significantly affects growth only in countries with high female education (see later discussion).

Limiting the sample to Sub-Saharan Africa (27 observations) produces some interesting results, as shown in regressions 13 and 14 in table 4. Initial gender inequality in education has a much larger effect than in the full sample, whereas gender bias in the growth of education has a similar effect. In sum, gender inequality in education appears to matter more in Sub-Saharan Africa than elsewhere, despite the agrarian nature of most African economies. This finding suggests that, given women's important role in agriculture in Sub-Saharan Africa (and elsewhere), their poor human capital appears to be a particularly significant constraint to economic growth. For example, about 30 percent of the large growth differences between Botswana (which had low initial education gaps and closed them rapidly) and Ghana and Niger (which still have gender inequality in education) can be accounted for by differences in gender inequality in education.

## VI. RECONCILING THESE RESULTS WITH THOSE OF OTHER STUDIES

This article has found that gender inequality in initial education levels and in the expansion of education significantly reduces economic growth. These effects are visible in a large sample of industrial and developing economies but are just as evident in a sample only of developing economies—and are especially apparent in Sub-Saharan Africa. The results are robust to different specifications of education variables and controls for possible simultaneity. How do these results compare with those of previous studies?

The results are qualitatively consistent with those of Hill and King (1995) and Knowles, Lorgelly, and Owen (2002), who achieve similar results based on regres-

sions estimating GDP levels. The size of the coefficients are not directly comparable because level regressions (which measure differences in steady states) have different coefficients than growth regressions (which measure transitions to steady states).<sup>32</sup>

The results here are the opposite of Barro and colleagues, who find that female education has a negative effect on growth. I can reproduce Barro's results when I use a specification similar to his, but those results disappear—and indeed, become reversed—once the multicollinearity problem is addressed and regional dummy variables are added. Clearly, his results are largely driven by these two problems.

The findings in this article also contrast somewhat with those of Dollar and Gatti (1999).<sup>33</sup> Although both sets of findings emphasize the negative effect on growth of gender inequality, Dollar and Gatti find that this effect is concentrated among industrial countries. But their study differs from this one in two important ways. First, they use a much shorter period (1975–90) and a three-part panel in that period. Second, they use a different education variable—one that measures the share of adults who have *exactly* achieved some secondary education. This variable appears problematic because it ignores people who have completed secondary education or even have some tertiary education.

If I use their specification and time period but replace their variable with a more plausible one—namely, the share of adults that have achieved *at least* some secondary education—the finding that the gender gap in education hurts growth only in industrial countries disappears. In fact, although the coefficients on gender inequality in this specification are generally not significant, gender inequality in education has a stronger negative effect on growth in developing countries, which is closer to the findings presented here.

If I replace their variable with one more like the one I used—namely, average years of primary and secondary schooling among adults—the results are much closer to my findings. In particular, female education has a strong and significant positive effect on growth in developing economies, and the effect is weaker or even nonexistent in industrial countries. Thus the choice of education variable appears to matter. As argued, it is more plausible to use a variable that measures the average total years of schooling or the share of the population with at least some secondary education.

The choice of time period also appears to matter. When the panel dataset and specification used here are restricted to 1970–90, the direct effect on growth of gender bias in education becomes smaller and falls just below conventional levels of significance in industrial and developing economies separately and when com-

32. Knowles, Lorgelly, and Owen (2002) also present a growth regression, and in a similar specification their coefficient is quite similar to the result found here.

33. I am grateful to Roberta Gatti for providing the database underlying their results. Although I was not able to reproduce their results exactly—because of differences in the number of observations and questions about the use of constant and regional dummy variables—I was able to do so qualitatively and so reconcile them with mine.

bined. But when the reduced regressions are run, the effects remain strong and significant and larger in developing economies. If the time period is further restricted to 1980–90, the effects are even weaker and less significant, although the qualitative story remains the same.

The years of 1975–90 and, more extremely, 1980–90, were exceptional periods for most developing economies. Most suffered negative external shocks, with serious balance of payments and debt crises, forcing them to adopt structural adjustment programs. In such unusual times it is no surprise that human capital variables that pay off only in the long term do not show significant effects.

Thus, the findings here are consistent with earlier studies or exhibit variations that can be traced to different time periods, education variables, specifications, and underlying data. At the same time, the results use the most comprehensive time period, the most plausible education variable, and the most comprehensive robustness checks and show that the effects are found in different subsamples.

## VII. CONCLUSION

This article has examined the extent to which gender inequality in education reduces economic growth. Several findings are especially important. First, gender inequality in education undermines economic growth directly by lowering average human capital and indirectly through its impact on investment and population growth. The effects are sizable. If Sub-Saharan Africa, South Asia, and the Middle East and North Africa had started with more balanced education achievements in 1960 and done more to promote gender-balanced education growth, their annual economic growth rates could have been up to 0.9 percentage point faster.

Second, these effects do not appear to be related to simultaneity issues. Several specifications and the use of instrumental variable estimation show that gender inequality in education has a persistent effect on economic growth. Third, these effects appear to be stronger in Sub-Saharan Africa—suggesting that efforts to promote female education have a higher payoff there than elsewhere.

Thus promoting gender equity in education may be among the few “win–win” development strategies. It advances economic prosperity and efficiency, promotes other essential human development goals (such as lower mortality and fertility), and is intrinsically valuable as well.

Although these results appear to be robust, plausible, and in line with expected theoretical effects, the findings presented here, as with all empirical growth regressions, show associations but cannot prove causality. It is possible that the findings are partly due to the omission of some variable not considered, that measurement error affects the results, or that the model is misspecified in other ways. Further investigations of this nature—as well as complementary analyses using micro-data—are needed to corroborate the findings and the mechanisms underlying them.

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