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Abortion and Human Capital Accumulation: A Contribution to the Understanding of the Gender Gap in Education*

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Abstract

This article analyzes the relationship between abortion and female education. It provides new empirical evidence from sub-Saharan Africa to show that more liberal abortion policies are associated with a higher female secondary school enrollment. It is assumed in the model that easier access to abortion decreases probability of dropping out of school for a female child in the case of an occasional pregnancy. As a consequence, it enhances parental investments in human capital of their female offspring and helps to reduce the gender gap in education, as consistent with the evidence.

Keywords: gender gap, abortion, fertility, human capital, economic growth

JEL classification: I0, J1, O1

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1. Introduction

Gender inequality in education and the importance of female schooling has long been an important issue of public debates. The promotion of female education has been widely argued to be a particularly effective way to achieve females' empowerment, promote various population policy goals and enhance human development and economic growth (see, e.g., a collection of essays in King and Hill, 1993; United Nations, 1995; UNDP, 1995; UNFPA, 1995, 2002; Knowles et al., 2002). One of the eight Millennium Development Goals requires promoting gender equality with a particular target to eliminating disparities in primary and secondary education. This article provides a formal analytical framework to analyze economic incentives behind the particular bias toward male children's human capital observed in many societies (e.g., Rosenzweig and Schultz, 1982; Pitt and Rosenzweig, 1990; Parish and Willis, 1994; Quisumbing, 1994; Kingdon, 2002), and summarizes new evidence from the world's least developed region – sub-Saharan Africa.

An enormous literature points to a diverse set of potential causes of sub-Saharan Africa's poor growth (see Easterly and Levine, 1997; Collier and Gunning, 1999 for references). Low educational attainment is often cited as one of the reasons for this result. By the middle of the first decade of the 21st century, the average secondary school enrollment in sub-Saharan Africa was only 33% for boys and 26% for girls (PRB, 2006). The average figures, however, conceal a strong disparity across African countries. Whereas in several countries the secondary school enrollment ratios are close to 50% and even well above, in some others these figures are below 10%. Moreover, though in some of the countries female educational attainment approaches to and even exceeds that of males, in most of the countries female schooling is much lower (see Table (1) in Appendix). This paper provides an explanation for a particular bias against female education that has been observed in many countries without referring to the popular argument of parental sex preferences and traditional, religious, or cultural reasons for discrimination against females.

As demographers have long observed, in Africa childbearing and education are considered incompatible, so that a pregnant schoolgirl is usually dismissed and not allowed to return (e.g., Caldwell et al., 1992; Goliber, 1997). In most African countries

adolescents also face serious barriers for obtaining contraceptives. Within this context, a notorious example is Gambia, where contraceptive services are not provided to women under age 21 even though 45% of the Gambian population is under age 15 and the median age is about 19 years (United Nations, 1999, v. II, p. 20). Likewise, in Central African Republic women's official access to contraceptives is still subject to their husbands' authorization, which seriously limits the access of teenage school students to means of contraception. In many African countries the provision of any means of contraception to unmarried adolescents is strongly opposed because of the widespread fear that it would promote sexual promiscuity.¹ As a consequence, teenage women are likely to have unintended pregnancies that can destroy their educational opportunities.²

Pregnancies endanger female education in Africa from the very beginning of schooling. Already in primary school there is a certain probability of dropping out of school as a result of pregnancy (e.g., Elaoundou-Engyegue, 2004). Among elder secondary school female students in Africa pregnancies appear as one of the leading cases for leaving school. Figures calculated by Elaoundou-Engyegue (2004) using the 2003 DHS data for 23 sub-Saharan African countries show that pregnancy-related dropouts accounted on average for about 18% of all female dropouts in secondary school.

In the case of an occasional pregnancy it is only abortion that may prevent expulsion from school. Abortion, however, is not easily available in most of the countries in this region of the world. Most African countries still have kept the restrictive abortion laws, which they inherited from the old colonial powers at independence, in force. Not surprisingly, female secondary school attainment comes closest to that of males in the countries where abortion policies are the most liberal, whereas the gap between males and females is highest in the countries where abortion policies are the most restrictive. The analysis also suggests that an increase in the liberality of abortion policy, as captured by a switch from a group of countries with more restrictive abortion policy to a group of

¹ More details with regard to the access to contraceptives for adolescents in Africa can be found in United Nations (1999). Limits to the access of African teenage women to contraceptives have been broadly recognized in the literature (e.g., Goliber, 1997).

² African governments have also expressed deep concern about the growing number of teenage pregnancies in the context of female educational opportunities, although their proposed solutions for this problem are different from the one suggested in this paper. Thus, for example, in a 1984 decree, the President of Togo established that "whosoever makes a girl pregnant if she is a regular member of a school or training college" is subject to imprisonment and a fine (United Nations, 1999, v. III, p. 132).

countries with more liberal abortion policy, is associated with an increase in female secondary school enrollment by 3.5%. Details are in Section 2.

This paper discusses the relationship between abortion and female human capital accumulation in the context of a growth model with endogenous fertility that borrows elements from Galor and Tsiddon (1997), Morand (1999), Azarnert (2008).³ The basic idea may be stated as follows. Consider an economy populated by agents who give birth to male and female children. Suppose that the difference between males and females arises from a possibility that an occasional pregnancy may occur during the school age if a child is female. If abortion is not easily available, this pregnancy may result in dropping out of school in the case of a female child.⁴ The resulting probability to complete education and become an educated adult is thus lower in the case of a female than in the case of a male. This makes it more tempting for parents to invest more in the human capital of their male offspring and leads to the appearance of the gender gap in education.

Abortion has long been a subject of intensive research in economics. Since the abortion reform of 1973 in the United States, numerous empirical studies have examined the impact of increased abortion availability in the context of the US economy.⁵ Most notable references include Blank et al. (1994); Kane and Staiger (1996); Angrist and Evans (1999); Gruber et al. (1999); Levine et al. (1999); Donahue and Levitt (2001; 2004); Ananat et al. (2009), among many others. However, the analysis of educational outcomes of abortion liberalization is relatively rare. The study by Angrist and Evans (1999), who examine the influence of reduced teen fertility attributable to abortion legalization on educational outcomes and employment status of women, is perhaps the most closely related to the context of the present work. Their findings decisively demonstrate that after the abortion reform the US black women experienced large reductions in teen fertility that have led to increased schooling and employment rates.

³ For a survey of recent growth literature with endogenous fertility, see Galor (2005); cf. also Azarnert (2004), Moav (2005).

⁴ The observation that teen mothers and especially unwed teen mothers have lower levels of educational attainment has long been well documented in the developed world (e.g., references in Angrist and Evans, 1999). References to more recent literature on the consequences of adolescent fertility for schooling can be found, e.g., in Eloundou-Enyegue (2004) who analyzes pregnancy-related dropouts and gender inequality in education with application to Cameroon.

⁵ Garrow (1994) provides a detailed description of the events leading up to the legalization of abortion in the United States.

The relationship between relative wages of men and women, fertility and economic development has also attracted attention in economic literature. In their seminal study, Galor and Weil (1996) demonstrated the role of economic development in reducing the gender gap in terms of the relative wages. In their model, an increase in women's relative wage reduces fertility by raising the cost of children more than household income, whereas an increase in men's relative wage increases fertility owing to the pure income effect. Economic development decreases the wage differential between men and women thereby reducing fertility as a result of the substitution effect, and triggers the onset of demographic transition. Later on, Zhang et al. (1999) employed a growth model with an explicit gender choice to study interactions between gender bias and economic development. They pointed out that both sex preference and different human capital endowments are possible sources of gender bias and showed the role of growth in reducing gender gaps as measured by the human capital ratio between males and females and the sex ratio of boys to girls at birth.⁶

In contrast to the previous studies, this model shows that, as long as there exists a positive probability that a female student will not be able to complete education as a result of an untermiated occasional pregnancy, economic growth alone can not close the gender gap in education. The present model shows the important role of decreasing probability of dropping out of school for a female in the case of an occasional pregnancy as a result of easier access to abortion in increasing parental investments in the human capital of their female offspring and closing the gender gap in education. By enhancing female human capital accumulation it also contributes to the increase in the general society's average human capital level and economic growth. In addition, although not in this model, easier access to abortion may also indirectly increase male educational attainment by decreasing the likelihood of forced marriage that can disrupt education of boys as well.

The present paper intends to complement the other existing explanations for lower female school enrollment. Thus, at least since Mincer and Polacheck (1974), classic human capital theory rationalizes lower human capital investment by forward looking

⁶ For some references to the voluminous literature on sex selection see Zhang et al. (1999); cf. also a more recent paper by Kim (2005).

women who anticipate having to be out of the labor force to raise and nurture the children. Given African preferences for larger families, this theory captures the major part of the observed male-female enrollment differentials. However, the observed difference in enrollments associated with differences in abortion policies across the countries points to the possibility to enrich this classic explanation in the direction suggested in the present paper.

Another potential explanation is to link human capital investments to life expectancy. According to this theory, because abortion liberalization is likely to induce reductions in maternal mortality, it increases female life expectancy and the relevant time horizon to reap the benefits of additional schooling. In this case, abortion liberalization is responsible for increased education, but the mechanism is quite different from the one proposed in the model.⁷ However, in Africa this mechanism has been to a large extent blocked by the epidemic of AIDS/ HIV, which seriously decreases life expectancy. Moreover, most African countries with high school enrollment rates are, at the same time, most heavily affected by AIDS/ HIV, while female life expectancy in Africa, on average, is by 2 years higher than that of males (PRB, 2006). These observations seriously limit the explanatory power of the hypothesis that points to the effect of life expectancy in the case of Africa.

In addition, if a more educated female population has more access to the political process, it might also be that higher female education may also help cause abortion liberalization, which is an issue of particular concern for women. All these explanations can serve in conjunction with the one I provide below. I believe this explanation is called for since it explains well the evidence documented in Section 2 and contributes to a better understanding of the origin of the gender gap in education.

Finally, although motivated by the present situation in sub-Saharan Africa, this analysis is not particular for one geographic region only. Consider, for example, African Americans. Higher sexual activity among young black relative to the other young in the US has long been widely recognized in the literature (see, e.g., Furstenberg et al., 1987 and references therein). A significant increase in the demand for abortion among young

black females following the legalization of abortion in the US has also been well documented (Donahue and Levitt, 2001). Moreover, it has been decisively demonstrated that after abortion reform black females in the US experienced a large reduction in teen fertility that has led to an increase in their schooling rates (Angrist and Evans, 1999). The present work provides a theoretical framework that is consistent with the evidence above and thereby may also contribute to the analysis of the consequences of the legalization of abortion in the United States under the *Roe v. Wade* decision in 1973.

2. Empirical Evidence from Sub-Saharan Africa

This section summarizes empirical evidence on secondary school enrollment from sub-Saharan Africa – the region where childbearing and education are, generally, considered incompatible, so that a pregnant schoolgirl is usually dismissed and not allowed to return. I start with a graphical presentation of the hypothesis postulated in the paper and then proceed to a more formal examination.

The countries are classified into the following three groups according to the relative restrictiveness of their abortion laws (details are in Appendix):

1. Extremely Restrictive Abortion Policies (*ERA*)
2. Less Restrictive Abortion Policies (*LRA*)
3. Almost Liberal and Liberal Abortion Policies (*LA*)

I present and analyze the following empirical fact:⁸

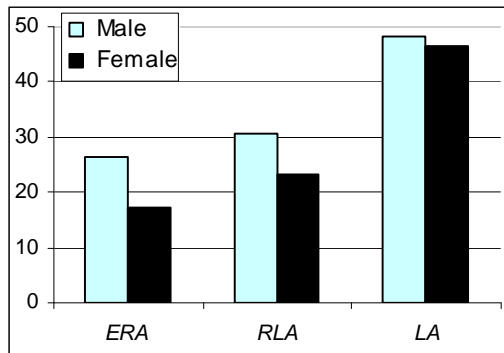
In secondary school, the gender gap in education between males and females is higher in the countries where the legal abortion policies are more restrictive.

2.1. First Look: Primary Evidence

⁷ For a classical model that links mortality reductions to human capital investments, see e.g. Ehrlich and Lui (1991). Among recent empirical papers in this context, Jayachandran and Lleras-Muney (2009) found evidence of the positive effect of maternal mortality reductions on female education in Sri Lanka.

⁸ Although the assumption of the rule of the laws may be less than completely accurate in the case of the countries in the sub Sahara, it has been argued in the literature that the restrictive nature of the abortion legislation is associated with a higher cost of a clandestine abortion that makes abortion less easily accessible under more restrictive abortion laws (Donahue and Levitt, 2001). In addition, some of African

Graph 1: Secondary School Enrollment (2000/2004)



Source: Table 1 in Appendix.

Graph (1) shows the existence of a wide gap in educational attainment in favor of male students among teenagers in the secondary school. On average in the secondary school female enrollment is significantly lower than that on males. More importantly, it demonstrates wide gaps in educational attainments across the groups of countries. The data show that the gender gap in education increases with the restrictiveness of the abortion legislation. Thus in the group of countries, in which abortion policies are relatively liberal (*LA*-group), the average female secondary school enrollment almost coincides with the average secondary school enrollment of males (46% vs. 48%). On the contrary, in the group of countries, in which abortion policy is extremely restrictive, so that abortion is permitted to save the life of the woman only (*ERA*-group), the average female secondary school enrollment amounts only to two thirds of that of males (17% vs. 26%). In the group of countries, in which abortion policies are less restrictive (*LRA*-group), the gender gap is somewhat in the middle, so that the average female enrollment amounts to three fourth of that of males (23% vs. 31%).

The inter-group educational differences also increase with the restrictiveness of the nature of the abortion laws. Comparing educational attainment between the groups, one can see that the average female secondary school enrollment in the *LA*-group is twice as high as the average secondary school enrollment in *LRA*-group and is 2.7 times higher than that in the *ERA*-group. In contrast, the average male enrollment in the *LA*-group is

countries where abortion policies are more liberal also provide a direct support for abortion (United Nations, 1999).

roughly 1.6 times higher than that in the *LRA*-group and roughly 1.8 times higher than that in the *ERA*-group.

Note also that four of six countries where females' enrollment exceeds that of males, Botswana, Cape Verde, Namibia, and South Africa, belong to the *LA*-group. The other two are small South African countries from the *LRA*-group, Lesotho and Swaziland, which are heavily influenced by their giant neighbor South Africa. Moreover, it has been also recognized in the literature that, in addition to services available in their countries, women from Lesotho and Swaziland have access to clandestine abortion in neighboring South Africa (United Nations, 1999).

Further support to the hypothesis postulated in this paper can be found in the experience of the countries that have recently liberalized their abortion legislations. Within this context, a notorious example is Botswana. Thus, by 1980, prior to liberalization of the abortion legislation, female secondary school enrollment in this country did not exceed 70% of that of males. Moreover, in 1986, 56% of female secondary school students in Botswana dropped out of school because they became pregnant (United Nations, 1992 – 1995, v. I, p. 57). By mid-1980s, the Government began drafting a bill to liberalize abortion and sent it to Parliament in 1990. The bill was officially approved by Parliament and signed by the President of Botswana in October 1991. However, in fact, anti-abortion laws were not enforced and abortions were tolerated already from the late 1980s, when the Government started its pro-abortion efforts. At the same time, female secondary school attendance in Botswana increased and in early 1990s it amounted to 112% of that of males (PRB, 2006). Henceforth, female secondary school enrollment remained high and in early 2000s it amounted to 107% of the enrollment of males.

Three other African countries, Cape Verde, Ghana and Burkina Faso, have also recently liberalized their abortion laws: in 1985, 1986 and 1996, respectively. The experience of these countries after liberalization is also consistent with the present hypothesis. Thus, in Cape Verde in early 2000s females' secondary school enrolment amounted to 109% of that of males. The other two countries have also demonstrated an impressive advance toward closing the gender gap. From early 1990s to early 2000s female secondary enrollment as percent of school-age male enrollment increased in

Ghana by 29% and in Burkina Faso by 23%. For comparison, in 33 countries, for which PRB (2006) provides data for early 1990s, as well as for early 2000s, during this period the average increase in female secondary schooling as percent of that of males in the Sub Sahara amounted to 12% only.

Within this context, it also seems interesting to mention that in 34 countries, for which PRB (2006) provides data, among younger children in the primary school female enrollment even slightly exceeds that of males.⁹ More importantly, the educational gap in favor of female students does not differ much across the groups of the countries.

This allows us to speculate that in primary school, where a considerable fraction of students did not yet reach puberty and, as a result, the risk of being expelled from school owing to pregnancy is relatively low and the corresponding chance of completing school for female students is relatively high, parents do not discriminate against their female children. In contrast, in the secondary school, after teenage females start engaging in sexual activity, which increases their chances to discontinue education owing to the untermiated pregnancy, in the countries, where abortion policies are less liberal, parents start to discriminate against their female children.¹⁰

2.2. Second Look: A More Formal Examination

This sub-section provides a more formal examination of the hypothesis postulated in this paper. Such examination is especially needed in view of the fact that in countries with more liberal abortion policies secondary school enrollment is higher for both, males and females, which may suggest that some common unobserved factor might be driving school enrollment of females along with the enrollment of males.

In an attempt to separate the effect of abortion policies, secondary school enrollment of females is regressed on the dummy variable that measures the liberality of the abortion laws, the level of average income, as captured by the country's gross national

⁹ This is consistent with the well known fact that females' school enrollment generally exceeds that of males all over the world.

¹⁰ Of course, this gender gap in education also comes from the more mechanical effect itself: pregnant females being expelled from school. However, it does not seem unlikely to suppose that rationally thinking parents also directly take into consideration different probabilities of completing school for their male and female children, when they decide on the amount of the investment in the education of their offspring in the secondary school.

income (GNI) in PPP per capita, the level of fertility, as captured by total fertility rate (TFR), and the secondary school enrollment of males. The intuition behind choosing these variables is that it is natural to expect that the level of income in the country should increase school enrollment owing to the income effect, while the level of fertility should, on the contrary, decrease school enrollment. In addition, the school enrollment of males should probably control for some of the effect of the unobserved common factor that drives the enrollment of both genders.

The results of estimation are reported in Column (1) in Table (2) in Appendix. In this regression, the estimated coefficient on the liberality of the abortion laws is shown to be positive and highly significant (p -value is 0.05). The magnitude of the estimated coefficient suggests that an increase in the liberality of abortion policy, as captured by the switch from the *ERA*-group to the *RLA*-group, or from the *RLA*-group to *LA*-group, is associated with an increase in females' secondary school enrollment by 3.5%. As to the other control variables, as expected, the estimated effect of the country's GNI per capita is shown to be positive and significant and the effect of TFR is shown to be negative and significant. Likewise, the positive and statistically significant coefficient on the secondary school enrollment of males testifies the existence of some common factor that affects the enrollment of both genders.

To check the robustness of the hypothesis that abortion policies are indeed associated only with females' schooling, rather than capturing some unobserved common factor, the regression model is re-estimated with the secondary school enrollment of males as the dependant variable. The results are reported in Column (2) in Table (2) in Appendix. In contrast to the previous case, in this regression, the estimated coefficient on the abortion policies is not significant at any level, close to zero and is of negative sign. This result probably suggests that, as expected, abortion policies are irrelevant for males' educational enrollment.

As a final experiment, both regressions are re-estimated with GNI per capita in current US\$ instead of GNI per capita in PPP. The results are reported in Columns (3) and (4). Here, as previously, in the case of females' enrollment, the estimated coefficient on the abortion policies is positive and statistically significant (p -value is 0.02), while, in the case of males, the estimated coefficient on the abortion policies is again close to zero and

not significant at all. This result also supports the hypothesis that liberal abortion policies are associated with an increase in females' school enrollment and, at the same time, are irrelevant for males.

3. The Basic Structure of the Model

Consider an overlapping-generations economy, in which activity extends over an infinite discrete time period. In every period the economy produces a single homogenous good using a constant-returns-to-scale technology with human capital as the only input. In each generation, agents live for two periods: childhood and adulthood. During childhood, individuals acquire human capital. During adulthood, they work, become parents and bring up their offspring. As parents, adult individuals must allocate a positive fraction of their time to feeding and raising their children and may also invest in the education of their male and female children.

Parents choose the total number of their offspring, but not the gender of the children. The probability of giving birth to a male child (P^m) or to a female child (P^f) is exogenous and $P^m + P^f = 1$. The only difference between male (m) and female (f) children arises from a possibility of an occasional pregnancy. Suppose that pregnancy can occur in the very end of the first period of a female child's life. If this pregnancy is not terminated, the young female is expelled from school, not allowed to complete her education and becomes an uneducated adult. Suppose this pregnancy becomes birth already in the beginning of the second period of life. As grown adults, male and female individuals may differ only in their acquired human capital.

3.1. Human Capital Production

An adult in period t is characterized by a skill level h_t that is distributed according to the cumulative density function $F_t(\cdot)$ over the strictly positive support $[h_t^{\min}, h_t^{\max}]$. In each period of life, individuals are endowed with one unit of time. In the first period, children devote their entire time for the acquisition of human capital. The acquired human capital increases if their time investment is supplemented with real resources invested in their

education. However, even in the absence of real educational expenditures individuals acquire some basic skills. The human capital level of a child of any gender, who becomes an adult in period $t + 1$, depends on the parental real expenditure on the education of the child of this particular gender (e_t^j , $j = m, f$) and on the average level of human capital of all adult individuals in period t , which is defined as $\bar{h}_t = \int h_t dF_t(h)$, according to the standard human capital production function or learning technology described by

$$h_{t+1} = \Theta(e_t, \bar{h}_t). \quad (1)$$

Such formulation is consistent with the external spillover effect or the so-called global or atmospheric externality of human capital, which implies that an increase in the average level of human capital in the society as a whole increases the rate of return on investment in human capital for the children's generation. First introduced by Tamura (1991), the assumption that the average level of human capital in society is an input in the production of human capital for each individual became common in the growth literature and has been utilized, among many others, by Tamura (1996), Galor and Tsiddon (1997), Morand (1999), Viaene and Zilcha (2002), de la Croix and Doepke (2003), Azarnert (2008).

To simplify, assume that females who do not complete their education due to unexpected pregnancy acquire the basic skills only. Assume also that, although it is known in advance what a fraction of female students will be expelled from school, it is unknown who exactly will become pregnant. Suppose also that parents do not discriminate among their offspring of the same gender and invest the same amount of resources in the education of each child of the same gender.

The subsequent two sections describe the basic optimization problem of parents. A particular form of human capital production function is specified below in Section 3.4.

3.2. The Optimization of Parents

Agents derive utility from their own consumption at adulthood and from the future income of their children. The utility function of an individual born at time $t - 1$ is

$$U_t = (1 - \beta) \log C_t + \beta \log(I_{t+1}^N), \quad (2)$$

where C_t is an individual's own consumption and I_{t+1}^N is the future income of the one's offspring.

Adult individuals are endowed with one unit of time, which they allocate between child rearing and labor force participation. As a parent, an adult incurs a total cost of feeding and raising children, measured in terms of work time foregone, at δ per child, regardless of the child's gender. In addition, a parent may invest e_t^j units of the wage per efficiency unit of labor, w , in each child's education: e_t^f units in a female child's education and e_t^m units in a male child's education. The amount of resources invested in the education of male and female children may be different.

In order to maximize their utility function, adult individuals simultaneously choose their current consumption, C_t , the total number of children, N_t^T , for a given probability to give birth to male (P^m) and female (P^f) children, where $P^m + P^f = 1$, and the level of educational investment in each child of each gender, e_t^m and e_t^f , subject to the following budget constraint:¹¹

$$C_t + w(\delta h_t + P^m e_t^m + P^f e_t^f) N_t^T \leq w h_t, \quad (3)$$

and the total future income of the one's offspring is:

$$I_{t+1}^N = w N_t^T (P^m h_{t+1}^m + P^f h_{t+1}^f), \quad (4)$$

where the total future income of the one's male children is

$$I_{t+1}^m = w h_{t+1}^m P^m N_t^T,$$

and the total future income of the one's female children is

$$I_{t+1}^f = w h_{t+1}^f P^f N_t^T,$$

while the total number of children of each gender is

$$N_t^j = P^j N_t^T, \quad j = f, m.$$

The right-hand side of Eq. (3) represents an adult's income, which is allocated between consumption and the total cost of rearing children.¹² Since parents may invest different amount of resources in the education of their male and female children, human capital of

¹¹ The time constraint requires that $0 \leq 1 - (\delta + (P^m e_t^m / h_t) + (P^f e_t^f / h_t)) N_t^T \leq 1$.

grown male and female adults who have been born to the same parent, h_{t+1}^m and h_{t+1}^f in equation (4), may be different as well. The wage per efficiency unit of labor, w , is fixed over time, as follows from, for instance, the assumption of a CRS technology with a single factor of production.

3.3. Quantity - Quality Tradeoff

From optimization, an adult's consumption is

$$C_t = (1 - \beta)wh_t. \quad (5)$$

That is, a fraction $1 - \beta$ of an adult's income is devoted to consumption, and hence a fraction β is devoted to rearing children of both genders.

To allocate resources between child's quantity and quality, an adult makes two simultaneous decisions. First, for a given probability to give birth to male and female children, he decides how much consumption to forego during his adulthood in order to rear a family. Second, he decides what amount of resources to invest in the education of his children of each gender.

In the case of each gender ($j = f$, or $j = m$), the standard condition of setting the marginal rate of substitution between quality and quantity equal to the price ratio (or larger in the case of a corner solution) implies that

$$\frac{h_{t+1}^j}{N_t^j} - \frac{\delta h_t + e_t^j}{N_t^j / [dh_{t+1}^j / de_t^j]} \begin{cases} > 0 & \text{if } e_t^j = 0 \\ = 0 & \text{if } e_t^j > 0, \end{cases} \quad (6)$$

where h_{t+1}^j / N_t^j is the marginal rate of substitution between quality and quantity, $w(\delta h_t + e_t^j)$ is the cost of an additional child for a given level of parental investment in the child's education, and $\frac{wh_t N_t^j}{dh_{t+1}^j / de_t^j}$ is the marginal cost of children's quality (human capital) for a given number of children of each gender.

Optimization with respect to quality of the child of the particular gender (f or m) therefore implies that

¹² The model abstracts from child mortality. For the discussion of child mortality in the context of educational investments see, e.g., Azarnert (2006) and references therein.

$$\frac{dh_{t+1}^j/de_t^j}{h_{t+1}^j} - \frac{1}{\delta h_t + e_t^j} \begin{cases} < 0 & \text{if } e_t^j = 0 \\ = 0 & \text{if } e_t^j > 0. \end{cases} \quad (7)$$

From (7), an optimal non-corner solution must therefore satisfy

$$h_{t+1}^j = (\delta h_t + e_t^j) \frac{dh_{t+1}^j}{de_t^j}. \quad (8)$$

However, if the rate of return on educational investment is below the rate of return on quantity, a corner solution with respect to both genders ($e_t^j = 0$), or one of the genders ($e_t^f = 0$) may exist as well. The next subsection discusses the exact solutions to the parents' optimization problem for a particular form of the learning technology.

3.4. Choice of Fertility and Investment in Education

In order to characterize optimal choices of fertility and investment in schooling, when a certain fraction of female children will discontinue their education due to pregnancy, recall that each parent has N_t^f female children. Assume that a fraction P^α of female children avoid or terminate pregnancies and, as a result, complete their schooling and, correspondingly, a fraction $1 - P^\alpha$ of female children drops out of school. In contrast, for a male such a threat does not exist, so that in the case of boys $P^\alpha = 1$.

As has been assumed in Section 3.1, in the event of dropping out of school, individuals acquire the basic skills only. Suppose these basic skills are associated with a constant 1 multiplied by \bar{h}_t in Eq. 9. Therefore, in such a case, parental resources invested in the education of the child will not yield positive return at all.¹³

In order to formalize this idea, the following expected human capital production function is employed:

$$h_{t+1}^j = (1 + P^\alpha e_t^j)^\gamma \bar{h}_t, \quad 0 \leq P^\alpha \leq 1, \quad 0 < \gamma < 1, \quad (9)$$

where P^α corresponds to the fraction of female children who remain in school and complete education.

¹³ This is a simplification assumption only. As long as per any unit of educational investment completed education yields a higher return than uncompleted education, the qualitative nature of this paper's results remains unchanged.

To complete presentation of this technology of human capital production, recall that as has been assumed in Section 3.1, $h_t \in [h_t^{\min}, h_t^{\max}]$ which is a compact interval. The function $h_{t+1}^j = (1 + P^\alpha e_t^j)^\gamma \bar{h}_t$ is thus an unbounded linear relationship. This human capital production function also guarantees that human capital remains positive even if parents do not invest in their offspring's education.

Given this learning technology, the existence of a non-corner choice that is solution to (8) and (9) implies the necessary condition that

$$h_t > \hat{h}^j = \begin{cases} \frac{1}{\gamma\delta} & \text{if } j = m \\ \frac{1}{\gamma\delta P^\alpha} & \text{if } j = f. \end{cases} \quad (10)$$

Obviously, since $0 \leq P^\alpha \leq 1$, $\hat{h}^f = \frac{1}{\gamma\delta P^\alpha} \geq \hat{h}^m = \frac{1}{\gamma\delta}$.

According to (9), there exist three types of parents in the economy.

1. *Parents with human capital levels below the threshold \hat{h}^m* who choose not to invest in the education of their offspring of both genders ($e_t^j = 0$). According to (9), all their children regardless of the gender inherit society's per capita human capital stock that existed in the previous period, when they become adults:

$$h_{t+1}^j = \bar{h}_t. \quad (11)$$

Since no resources are allocated to children's education, the desired total number of offspring is calculated simply by dividing the parent's income after consumption by the quantity cost per child:

$$N_t^T = \frac{\beta}{\delta}, \quad (12)$$

where the fraction P^m of these children are born as males and the fraction P^f of these children are born as females.

2. *Parents with human capital levels above the threshold \hat{h}^f* who choose to invest in the education of all their offspring, male and female. For such parents, the optimal choices of fertility and investment in children's education are as follows:

$$e_t^j = \begin{cases} \frac{\gamma \delta h_t - 1}{1 - \gamma}, & \text{if } j = m \\ \frac{\gamma \delta h_t - (1/P^\alpha)}{1 - \gamma}, & \text{if } j = f, \end{cases} \quad (13)$$

so that, according to (9),

$$h_{t+1}^j = \begin{cases} \left(\frac{\gamma(\delta h_t - 1)}{1 - \gamma} \right)^\gamma \bar{h}_t, & \text{if } j = m \\ \left(\frac{\gamma(\delta h_t P^\alpha - 1)}{1 - \gamma} \right)^\gamma \bar{h}_t, & \text{if } j = f, \end{cases} \quad (14)$$

and

$$N_t^T = \frac{\beta(1 - \gamma)}{\delta - \frac{1}{h_t} \left(P^m + \frac{P^f}{P^\alpha} \right)}, \quad (15)$$

with $N_t^m = P^m N_t^T$ of male children and $N_t^f = P^f N_t^T$ of female children.

3. *Parents with human capital levels above the threshold \hat{h}^m , but below the threshold \hat{h}^f* , for whom the gender of their offspring is crucial in their human capital investment decisions. Such parents invest in the education of their male offspring only. Their optimal choices of fertility and investment in education are

$$e_t^j = \begin{cases} \frac{\gamma \delta h_t - 1}{1 - \gamma}, & \text{if } j = m \\ 0, & \text{if } j = f. \end{cases} \quad (16)$$

As a result, according to (9),

$$h_{t+1}^j = \begin{cases} \left(\frac{\gamma(\delta h_t - 1)}{1 - \gamma} \right)^\gamma \bar{h}_t, & \text{if } j = m \\ \bar{h}_t, & \text{if } j = f. \end{cases} \quad (17)$$

The desired total number of offspring for parents of this type is

$$N_t^T = \frac{\beta(1 - \gamma)}{\delta(1 - \gamma) - P^m(\gamma\delta - (1/h_t))}, \quad (18)$$

with $N_t^m = P^m N_t^T$ of male children and $N_t^f = P^f N_t^T$ of female children.

Although parental human capital does not enter the learning technology function (9) directly, the optimal choice of investment in the offspring's education (Eqs. (13) and

(16)) and, hence, the children's human capital levels (Eqs. (14) and (17)) are positively related to the parent's human capital level. Eq. (15) displays the traditional negative relationship between the parental level of human capital and the choice of fertility.

The following proposition summarizes the main result of this section with regard to the gender gap in education.

Proposition 1: *An easier access to the means of pregnancy termination (as captured by an increase in a given parameter P^α) positively affects educational investments in female children and thus closes the gender gap in education.*

In detail, Proposition 1 implies that an increase in P^α :

(i) *Decreases the threshold \hat{h}^f , below which parents do not invest in the education of their female offspring.*

Proof. Equation (10).

(ii) *Increases educational investment in their female offspring for parents with human capital levels above \hat{h}^f .*

Proof. Equation (13)

In addition, as follows from an increase in the optimal quality investment in the female children (Eq. 14; $j = f$), an increase in P^α also decreases the desired fertility for parents who invest in the education of their offspring of both genders (Eq. 15).

3.5. *The Dynamical System*

This section analyzes the dynamic path of individual and average human capital levels in the economy.

Consider an economy, in which the society's average human capital level is below the threshold level \hat{h}^f , although there are some parents with human capital above that threshold, who educate their offspring of both genders. In period $t + 1$, the average human capital level is given by Eq. (A3) in Appendix. Stemming from the global externality in the production of human capital, as captured by the properties of (9) with respect to \bar{h}_t ,

basing on the relative number and skill levels of parents with human capital above \hat{h}^f , this economy evolves along one of the following two cases.

Case 1: If the initial fraction of skilled parents with human capital above the threshold and their skill levels are high enough, the economy evolves along a path of strictly increasing human capital levels, so that for all $j > 0$, $\bar{h}_{t+j} > \bar{h}_t$. In this case, the society's average human capital level ultimately becomes high enough to overtake the threshold \hat{h}^f . From this point onward the economy evolves along a growth path where all agents make strictly positive investments in the human capital of their offspring's of both genders at the expense of reduction in quantity. However, even in such growing economy where human capital levels increase over time, the gender gap in education will not disappear. As long as there exists a positive probability that a female student will not be able to complete education in the case of an occasional pregnancy, it will reduce the ex ante returns to human capital investments in the female children. Pure economic incentives thus will continue entice parents to discriminate among their children and invest more in the education of males. Without easily available abortion – that is with unequal probability of completing school for males and females – the economy has no chance to close the gender gap in education.

Case 2: If the initial fraction of the skilled and their human capital levels are not high enough, the positive contribution of the skilled parents who educate their children to the society's average human capital may be diluted by the growing number of the unskilled. In this case, stemming from the global externality in the human capital production function, skill levels within skilled dynasties start to decline. All parents in the society ultimately converge towards the identical agents with human capital below \hat{h}^m , who do not invest in the education of their offspring of both genders, and the society's average human capital ceases to grow. In this instance, the economy is locked in a low-equilibrium poverty trap with an unchanging per capita human capital $\bar{h} < \hat{h}^m$, that is equally low for both genders.

If the economy is in Case 2, in addition to closing the gender gap in education by decreasing probability to discontinue schooling for a female and, hence, enticing parents to invest more in the education of their daughters, an easier access to abortion will

enhance human capital accumulation among females thereby contributing to the increase in the general society's average human capital level. As a consequence, it may help the economy as a whole to leave Case 2 and switch toward Case 1.

4. Conclusion

This article is motivated by empirical observations, which indicates that in sub-Saharan Africa the gender gap in education is higher in the countries where the legal abortion policies are more restrictive. I have used a growth model with endogenous fertility to show the important role of easier access to abortion in reducing the gender gap in education. If the difference between male and female children arises from a possibility that an occasional pregnancy may occur during female child's school age and if abortion is not easily available, this pregnancy may result in dropping out of school. The resulting probability of completing education and becoming an educated adult is thus lower in the case of a female than in the case of a male. This makes it more tempting for parents to invest more in the human capital of their male offspring, and leads to the appearance of the gender gap in education. The analysis shows that, as long as there exists a positive probability for a female child not be able to complete school as a result of an untermiated occasional pregnancy, economic growth alone can not close the gender gap in education. This is an easier access to abortion that equalizes probabilities of completing school between males and females, and hence enhances female human capital accumulation.

Although this analysis is especially appropriate for sub-Saharan Africa – the region where childbearing and education are, generally, considered incompatible, so that a pregnant schoolgirl is usually dismissed and not allowed to return, it is not particular to one geographic region only. Thus, for example, the present theoretical framework may also contribute to the analysis of the consequences of abortion legalization in the US that has led to reductions in teen fertility along with increases in schooling rates among the US black females.

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Appendix

Consider an economy, in which the society's average human capital level is below the threshold level \hat{h}^f , although there are some parents with human capital above that threshold, who educate their offspring of both genders.

The average human capital level in period $t + 1$ is defined as

$$\bar{h}_{t+1} \equiv \int h_{t+1} dF_{t+1}(h) = \int N_t h_{t+1} dF_t(h) / \int N_t dF_t(h). \quad (\text{A1})$$

Distinguishing period t parents with respect to their human capital levels,

$$\bar{h}_{t+1} = \frac{\int_{h_t > \hat{h}^f} N_t h_{t+1}^j dF_t(h) + \int_{\hat{h}^m < h_t \leq \hat{h}^f} N_t h_{t+1}^j dF_t(h) + \int_{h_t \leq \hat{h}^m} N_t h_{t+1}^j dF_t(h)}{\int_{h_t > \hat{h}^f} N_t dF_t(h) + \int_{\hat{h}^m < h_t \leq \hat{h}^f} N_t dF_t(h) + \int_{h_t \leq \hat{h}^m} N_t dF_t(h)}. \quad (\text{A2})$$

Given the number of children of both genders and the levels of human capital investment of the three types of agents, as determined in Section 3.4, the average human capital level in period $t + 1$ is

$$\begin{aligned}
\bar{h}_{t+1} = \bar{h}_t & \left[\int_{h_t > \hat{h}^f} \left[\frac{(1-\gamma)^{1-\gamma} (P^m (\gamma \delta h_t - 1)^\gamma + P^f (\gamma \delta h_t P^\alpha - 1)^\gamma)}{\delta - \frac{1}{h_t} \left(P^m + \frac{P^f}{P^\alpha} \right)} \right] dF_t \right. \\
& + \int_{\hat{h}^m < h_t \leq \hat{h}^f} \left[\left(\delta - \frac{P^m (\gamma \delta - (1/h_t))}{1-\gamma} \right)^{-1} \left(P^m \left(\frac{\gamma \delta h_t - 1}{1-\gamma} \right)^\gamma + P^f \right) \right] dF_t \\
& + \int_{h_t \leq \hat{h}^m} \left[\delta \left(1 - \frac{\hat{h}^m}{h_t} \right) + \frac{1}{\gamma h_t} \right]^{-1} dF_t \Bigg] / \\
& \left[\int_{h_t > \hat{h}^f} \delta - \left(\frac{1}{h_t} \left(P^m + \frac{P^f}{P^\alpha} \right) \right) / (1-\gamma) \right]^{-1} dF_t + \int_{\hat{h}^m < h_t \leq \hat{h}^f} \left[\delta - \frac{P^m (\gamma \delta - (1/h_t))}{1-\gamma} \right]^{-1} dF_t \\
& + \int_{h_t \leq \hat{h}^m} \left[\delta \left(1 - \frac{\hat{h}^m}{h_t} \right) + \frac{1}{\gamma h_t} \right]^{-1} dF_t \Bigg].
\end{aligned} \tag{A3}$$

Equation (A3), by construction of this model, implies non-decreasing per capita human capital levels over time, because children whose parents do not invest in their education inherit the society's per-capita human capital of the previous period when they become adults. The economy's average human capital may not, however, be strictly increasing.

Table 1: Secondary School Enrollment, 2000/2004 (as % of age group enrolled in secondary school)

Country	Female	Male	Country	Female	Male
<i>Extremely Restrictive Abortion Policy</i>			<i>Less Restrictive Abortion Policy</i>		
Benin	17	38	Angola	17	21
Centr. Afr. R.	6	15	Burundi	9	13
Chad	6	17	Cameroon	28	34
Cote d'Ivoire	18	33	Congo, R.	27	37
Gabon	42	49	Congo, D.R.	13	24
Madagascar	14	15	Equat. Guinea	22	38
Malawi	29	37	Eritrea	22	34
Mali	14	25	Ethiopia	16	28
Mauritania	20	25	Gambia	28	41

Niger	6	8	Guinea	15	33
Senegal	16	23	Kenia	32	34
			Lesotho	39	30
<i>Liberal and Almost Liberal Abortion Policy</i>			Mozambique	13	19
Botswana	75	70	Nigeria	32	40
Burkina Faso	9	14	Rwanda	15	18
Cape Verde	73	67	Sierra Leone	22	31
Ghana	38	47	Sudan	32	38
Guinea-Bissau	13	23	Swaziland	46	45
Liberia	28	39	Tanzania	5	6
Namibia	66	59	Togo	22	51
South Africa	91	84	Uganda	18	22
Zambia	25	30	Zimbabwe	35	38

Notes: Years earlier than specified are in Italics. For Somalia, recent data are not available.

The grounds on which abortion is permitted include: (1) to save the life of the woman; (2) to preserve her physical health; (3) to preserve her mental health; (4) rape or incest; (5) foetal impairment; (6) economic or social reasons; (7) available on request.

The countries are grouped according to the following principle:

(a) Extremely Restrictive Abortion Policy (*ERA*): Abortion is permitted to save the life the woman only.

(b) Less Restrictive Abortion Policy (*LRA*): In addition to (1), abortion is permitted or, generally, tolerated, on some grounds from (2) to (5).

(c) Almost Liberal and Liberal Abortion Policy (*LA*): Abortion is permitted on five grounds at least.

Sources: For abortion policies, United Nations (1999). For secondary school enrollment, PRB (2006).

Table 2: Secondary School Enrollment, Estimation

Dependant Variable	Secondary School Enrollment (2000/04)			
	Female	Male	Female	Male
	(1)	(2)	(3)	(4)
Abortion Policies	3.45 (0.05)	-0.04 (0.99)	4.38 (0.01)	0.03 (0.99)
GNI per capita	2.66E-03 (0.01)	5.16E-04 (0.65)	6.75E-03 (0.00)	-6.01E-04 (0.83)
TFR	-3.25 (0.03)	-0.43 (0.80)	-3.09 (0.03)	-0.32 (0.85)
Other Gender's School Enrollment	0.57 (0.00)	0.70 (0.00)	0.60 (0.00)	0.77 (0.00)
Observations	41	41	42	42
Adj. R ²	0.89	0.81	0.89	0.81

Notes: *p*-values are in parentheses. In Columns (1) and (2) GNI per capita in PPP in 2000; in Columns (3) and (4) GNI per capita in current US\$ in 2000.

Sources: For abortion policies, United Nations (1999). For secondary school enrollment and total fertility rate (TFR), PRB (2006). For GNI in PPP and in current US\$ per capita in 2000, World Bank (2001). For Somalia, data on GNI per capita in PPP are not available.

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