Economics Letters 111 (2011) 226–229

Contents lists available at ScienceDirect

Economics Letters

journal homepage: www.elsevier.com/locate/ecolet

The intergenerational transmission of maternal human capital and the gender gap in educational attainment

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ARTICLE INFO

Article history:
Received 27 July 2009
Received in revised form 13 January 2011
Accepted 2 February 2011
Available online 9 April 2011

JEL classification:
D1
E2
I2
J2

Keywords:
Gender education gap
Intergenerational transmission of human capital
Maternal education

ABSTRACT

An intergenerational effect of maternal (and not paternal) human capital on offspring's human capital production is a mechanism that induces males and females to attain different education levels. This mechanism allows for explanations of the reversal in the gender education gap.

Last century's formal education exhibited a tremendous improvement worldwide regarding quality, quantity and coverage. If for someone born in 1900 it was rare to have finished primary school, nowadays even some developing countries have educational systems that guarantee their population universal access to (at least) primary education. The gender education gap has also had its evolution. While at the beginning of the twentieth century in most countries women lagged far behind men in terms of mean educational level attained, today many countries show a negative gender education gap.[1]

The objective of this paper is to examine one possible explanation to the asymmetries observed between male and female education. A wide amount of research on the predictors of education has shown that the education of the mother is a key determinant of the education attained by her offspring. On the other hand, paternal human capital has shown to be less or not at all important. This intergenerational transmission (or *spillover*) effect is a reason for *females* to educate themselves that is absent or minimized in the case of males.[2] Thus, it acts as a differential mechanism that induces males and females to obtain unequal educational levels, even assuming that there is no wage discrimination.

1. Empirical evidence

This section shows some original time series data[3] on the relevant issues that we are willing to explore with this paper.

Fig. 1 exhibits the evolution of overall educational levels and evidences an impressive improvement across Latin-American countries.

Fig. 2 shows a downward trend in the gender education gap for the most recent cohorts. Moreover, it is evident that the gap became negative in most countries, the only exception being Mexico. This phenomenon where females are suddenly getting more education than males is what we call the *reversal* of the gap. Gap reversal is one of the main puzzles we will try to explain throughout this paper.

This phenomenon is not unique to Latin America or to developed economies. Grant and Behrman (2010) document the emergence of a female schooling advantage in several underdeveloped locations that previously experienced large gender gaps favoring boys. In their study of 38 countries in six underdeveloped regions thy document an emerging pattern of education gap reversal that becomes almost

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[1] A *positive* gender education gap is one where males obtain a higher average educational level than females.

[2] The labor market returns from education is another motive, common to males and females.

[3] Built using microdata from the census samples available through the IPUMS-I Project, Minnesota Population Center, 2010.

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doi:10.1016/j.econlet.2011.02.002

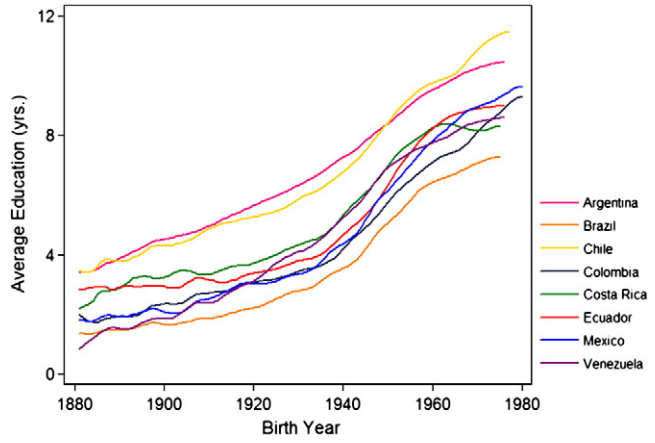

Fig. 1. Latin America: evolution of educational attainment.

universal when they calculate the gap conditional on having ever attended school.

2. The gender education gap

A theoretical explanation for the education gap has not been thoroughly developed in the economic literature. Although some attempts have been made, they do not explore all the possible mechanisms that may explain the phenomenon under study.

Differential decision-making among genders is easily explained through discrimination mechanisms, especially wage discrimination. A paper that includes gender wage discrimination to explain the gender gap is Ríos-Rull and Sá nchez-Marcos (2002).

But discrimination is not the only channel that can produce females and males behaving in an asymmetrical way. In the non-discrimination line, a paper worth mentioning is that of Echevarria and Merlo (1999). Their model includes fertility and education decisions and shows that a *positive* gender education gap can be generated by solely taking into account the biological differences between males and females, without having to consider any gender discrimination. Nevertheless, their model cannot predict a negative gender education gap.

One recent paper that looks at gender education gaps is from Goldin et al. (2006). They perform an exhaustive historical analysis of the evolution of the US gender education gap in the twentieth century. They document a reversal of the gap levels that occurred for cohorts born during or after the sixties. They conclude that the reversal of the gap is due to an increase in the relative economic benefits of college for females, together with relatively higher effort costs of college attendance and preparation for males. They notice that female's lower non-pecuniary costs of college preparation and attendance are due to the fact that females display a higher level of non-cognitive skills (for example discipline, behavior and constancy).

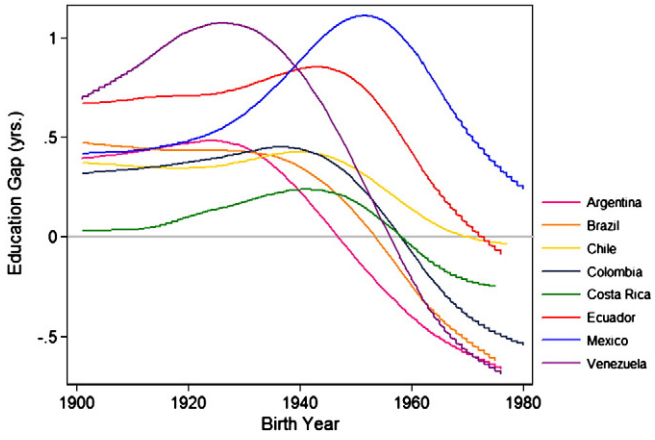

Fig. 2. Latin America: evolution of the education gap.

3. The intergenerational transmission of maternal human capital

Advocates of development and poverty reduction policies that emphasize investments in female schooling suggest that significant returns on women's schooling are to be found in the household sector, where the schooling of women has important effects on the human capital of future cohorts. One particular argument of development strategists is that better educated mothers are superior teachers in the home, so that investments in women's human capital complement those in schools.

Behrman et al. (1999), in their study of the Indian "green revolution," corroborate that for given investments in children, more educated mothers produce children with higher levels of human capital. Hence, female human capital is thought to produce more than private benefits to females due to their labor supply. Female education is thought to affect children human capital acquisition by increasing the children's return to human capital investments. As Butcher and Case (1994) put, "the effect of mother's education is larger than that of father's, which may reflect that mothers have a greater influence on children or that mother's education is in part proxying for the wealth of the household." This is only one of many investigations that conclude with similar findings. A survey of that literature may be found in Schultz (2002) and Haveman and Wolfe (1995), among others.

There is some newer evidence that contends the existence of the maternal human capital spillover (i.e. Behrman and Rosenzweig, 2002; Black et al., 2005) However, the debate is still open. The idea of a maternal human capital spillover is intuitive because mothers, in most cases, are the ones who spend their time with their children. If there is divorce, it is normally mothers who maintain custody of their children and when there is single motherhood, the father does not have any influence on his offspring except through his genes.

4. The model[4]

The economy is populated by a continuum of size one of identical females and a continuum of size one of identical males. Individuals have n children each, one half of them male and the other half female. In this model $n \in (0, \overline{n})$ will be considered as exogenous.

We use the following human capital production function:

Definition 1.

$$h_t^k = A\left(e_t^k\right)^{\chi}\left(h_{t-1}^f\right)^{\tau} \quad \text{for } k = f, m \tag{1}$$

With $\chi, \tau \in (0,1)$. In (1) h_t^k represents human capital, e_t^k educational investment and $A>0$ is a scale parameter and $k=f,m$ represents the gender of the individual (male or female). Note the spillover that comes from maternal human capital h_{t-1}^f.

Definition 2. The value function for males and females is

$$U^k\left(h_{t-1}^f\right) = \ln\left(c_t^k\right) + a(w)n \ln\left(\frac{h_{t+1}^m + h_{t+1}^f}{2}\right) \quad \text{for } k = m, f \tag{2}$$

where $a(w)$ is an altruism function[5] that depends on the net present value of an individual's wages (w), and c_t^k is consumption.

[4] The complete analysis or individual proofs of any statement contained in the following pages are available from the author upon request.

[5] The rationale for altruism depending on the net present value of wages is that a parent will assign more value to a child with a determined human capital level when the returns to the child's human capital are higher (and therefore she is able to achieve higher consumption).

For simplicity, we will use $a(w)=\gamma w$ where γ is a scale parameter that represents an (exogenous) parental preference for childbearing. Individuals maximize their utility by choosing their consumption and human capital, given their maternal human capital. They are subject to time and resource constraints (defined below) and to the human capital production function (Eq. (1)).

Individuals have a life endowment of one unit of time, which they can supply to the labor market with a return of w, or they can use for child-rearing. In this model females are the ones responsible of rearing their children, who represent a cost of $\phi\in(0,1\overline{n})$ time units each, where, as defined earlier, $\overline{n}$ is the upper bound of the fertility parameter, n.

Since leisure is not valued, males supply their whole time endowment to the labor market.

Individuals also decide their education level (that will define their human capital through 1), at a cost of $\eta>0$ per education unit. Education is measured in consumption units. The budget constraints are thus

$$c_t^f+\eta e_t^f=wh_t^f(1-n\phi) \qquad \text{for } \textit{females}$$

$$c_t^m+\eta e_t^m=wh_t^m \qquad \text{for } \textit{males}.$$

4.1. Solving the problem

The solution for males indicates that they educate until the cost of the educational investment needed to increase human capital by one unit $\left(\eta\frac{de_t^m}{dh_t^m}\right)$ equals the benefit from that increase (w).This is natural since male's decisions do not influence the their offspring's decisions at all and therefore the altruistic part of males' value function $\gamma wn\ln(g^m(h_t^f)+g^f(h_t^f))$ is treated by males as a given.

The resulting policy function for male human capital is

$$h_t^m=A^{\frac{1}{1-\chi}}\left(\frac{\chi w}{\eta}\right)^{\frac{\chi}{1-\chi}}\left(h_{t-1}^f\right)^{\frac{\tau}{1-\chi}} \tag{3}$$

The solution for females is

$$h_t^f=Mh_t^m \tag{4}$$

where

$$M=\left((1-n\phi)\frac{(\gamma wn\tau+1-\chi)}{(\gamma wn\tau\chi+1-\chi)}\right)^{\frac{\chi}{1-\chi}} \tag{5}$$

So female human capital equals male human capital corrected by two factors: the *labor market correction factor* $(1-n\phi)$ and the *spillover correction factor* $\frac{(\gamma wn\tau+1-\chi)}{(\gamma wn\tau\chi+1-\chi)}$.

This two correction factors illustrate the two distinct mechanisms that lead females to differentiate their human capital choice from males. The *labor market correction factor* reflects the fact that females supply less than one unit of time to the labor market $(1-2\phi)$.On the other hand the *spillover correction factor* takes into account the fact that the female's human capital level will influence the returns on educational investment her children obtain. This *spillover correction factor* disappears $(=1)$ when $\tau\gamma=0$.It is interesting to note that it is the *joint* effect of altruism (represented by parameter γ) and the spillover of maternal human capital (activated when parameter τ is greater than zero , as shown in Eq. (1)) what makes this mechanism work. For this new female incentive to educate to be important we need *both* altruistic females and some spillover of maternal human capital. It is not sufficient to have one or the other.

From its definition, it is clear that the *labor market correction factor* is always smaller than one, so it always acts as a shrinking factor. If this were the only correction factor we would always have females educating less than males. On the other hand, from $\gamma,w,n,\tau>0$ and $\chi\in(0,1)$ it is evident that $\frac{(\gamma wn\tau+1-\chi)}{(\gamma wn\tau\chi+1-\chi)}>1$, meaning that the *spillover correction factor* is an expanding factor.

4.2. Analyzing the gender education gap

We will analyze the gender gap in human capital. The extension of the analysis to the gender gap in education is straightforward using Eq. (1). It is important to note that the human capital gap can be represented by a difference or a ratio. It is sometimes easier to work with the ratio gap and draw the implications on the difference gap from there. Notice that $\frac{h_t^f}{h_t^m}=1$ is equivalent to $h_t^f-h_t^m=0$. This threshold is very important because it represents the stage at which females pass from having a lower level of human capital than males to outperforming them. In order to obtain the sign reversal observed in the data, we need a model that, at least for some parameter values, can produce both $\frac{h_t^f}{h_t^m}<1$ and $\frac{h_t^f}{h_t^m}>1$.

Remember that the empirical facts show that as the human capital *level* increases, the (difference) gap decreases. This leads us to next proposition:

Proposition 3. A decreasing difference gap with increasing human capital levels *necessarily* implies a decreasing ratio gap.

Proof. We will demonstrate this by contradiction: imagine a constant ratio gap $\frac{h_t^f}{h_t^m}=K$. Then the difference gap $h_t^f-h_t^m=(K-1)h_t^m$ *increases* as h_t^m increases, leading us to a contradiction. The contradiction is even more evident if we suppose that the ratio gap increases. □

The *difference gap* is given by $h_t^m-h_t^f=(1-M)h_t^m$. It is important to note that any effect on that gap that goes only by way of h_t^m is not useful for our purposes. Such a change will not help us explain the stylized facts because the ratio gap $\frac{h_t^f}{h_t^m}=M$ would remain constant (see Proposition 3).

From Eq. (4) we learned that the ratio gap was given by

$$\frac{h_t^f}{h_t^m}=M \tag{6}$$

The females will have a higher human capital level than males when

$$(1-n\phi)\frac{(\gamma wn\tau+1-\chi)}{(\gamma wn\tau\chi+1-\chi)}>1. \tag{7}$$

From Eq. (7) we see that, to guarantee a negative difference gap, it is not sufficient for the *spillover correction factor* to be an expanding factor. To have a negative gap we need the *product* of both correction factors to be greater than one.

4.3. The reversal of the gap

From Eq. (6) we can study the movements of the human capital *ratio gap M*. There are several parameter changes[6] that may have

[6] We assume a human capital production function remains constant all the way, so we will not include in our analysis the effects of eventual changes on the parameters τ or χ.

produced the reversal of the gap. Such a reversal may have occurred due to a decrease in the time devoted to childrearing (ϕn) which may be due to a decrease in fertility[7] or a reduction in the time requirements of each child. Both explanations also have a reasonable theoretical (and empirical) background. The time requirements of children have decreased due to technological change (disposable diapers, microwave, canned food, etc); the fertility transition leading to a sharp decrease in the number of children born is one of the main stylized facts describing last century's demographic evolution.

Another explanation of the reversal of the gap could be an increase in parental altruism (represented in the model by $a(w)=\gamma w$). As before, this increase in overall altruism may be due to an increase in the exogenous child preference parameter γ or to an increase in the net present value of wages. Since child mortality decreased importantly over the last century, a longer time frame over which to estimate the net present value of wages naturally leads to an increase in parameter w. On the other hand, the abolition of child labor and the institution of old age security have diminished the monetary contributions from children to their parental households. This, together with a social environment that favors a greater focus of women on market outcomes, makes us conclude that, if anything, the exogenous child preference parameter decreased. Therefore, in order for our model to explain the reversal of the gap, we would require an increase in w that is more substantial than this possible decrease in the child preference parameter γ.

5. Conclusion

The intergenerational transmission model presented herein is a new tool to study the education dynamics observed in the last decades. It has the particularity of being able to produce a positive gender education gap, even considering that females work less and therefore have smaller market returns to their human capital investments. Several explanations for the reversal of the gap were proposed, among them an increase in overall altruism or a decrease in the time females devote to child rearing. It is very important to keep in mind that those explanations only operate when the intergenerational transmission of human capital mechanism is active in the model. A simpler model without intergenerational transmission (i.e. one where our parameter $\tau=0$) will always produce negative gender education gaps, regardless of the values assigned to the rest of the parameters.

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[7] Strictly speaking, we see from Eq. (7) that when n falls the *market correction factor* increases but the *spillover correction factor* decreases, leading to an uncertain overall result. Nevertheless, for most reasonable parameter values, the effect of n on the former is greater (in absolute terms) than on the latter. It can be shown that a sufficient condition that guarantees that a decrease in fertility will produce a decrease (and eventual reversal) of the gender education gap is $w > \frac{1}{n\gamma\tau}\left(\frac{1-n\phi}{n\phi}\right)\left(\frac{1-\chi}{\chi}\right)^2$ (proof available from the author).