The impact of gender stereotypes on economic growth*

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Abstract

This paper argues that gender-specific educational choices have macroeconomic consequences in terms of economic growth. The presence of a social norm affecting persons choosing gender atypical educations at the university level generates a suboptimal allocation of ability, which lowers technological change and the stock of human capital, and thus hurts growth. The analysis of a cross-section of 88 countries over the period 1970 to 1998 lends empirical support for the importance of the educational gender stereotypes for economic growth.

JEL Classification: O4, I21, J16, Z13

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1 Introduction

Glancing at higher education statistics for the last 30 years, gives a strange impression. While the number of female students has increased to such an extent that in many countries they dominate higher education, there is an impressive lack of convergence in men's and women's choices of field of study.[1] To put it simply, women still tend to choose arts and not science, while men tend to do the exact opposite.[2] Figure 1 indicates that in 1990 this pattern is present in all countries, except for the few where men dominate education in general.[3]

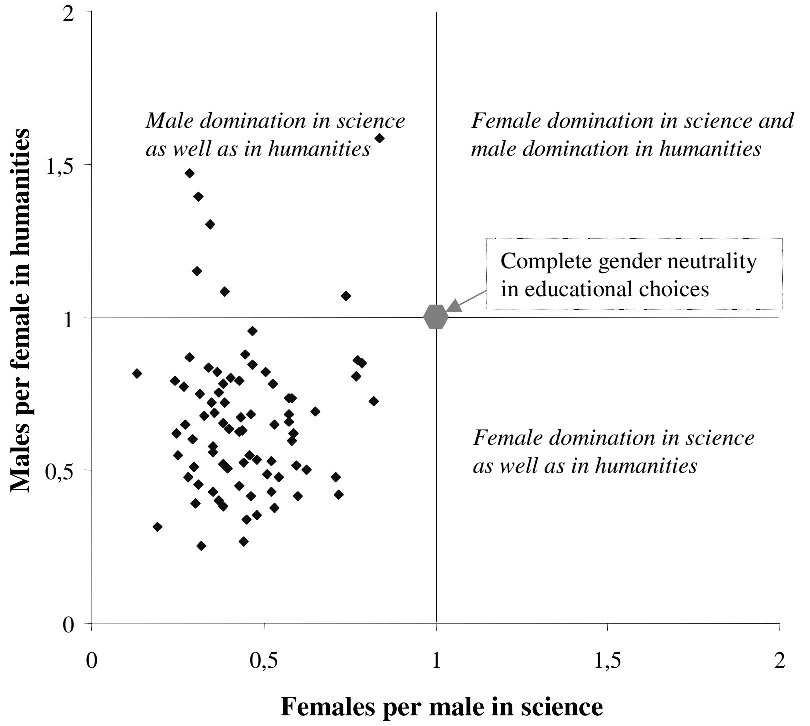

Figure 1. Females dominate humanities and males dominate science, 1990

This paper suggests that gender specific educational choices have macroeconomic consequences in terms of economic development. The key factor to the reasoning will be cognitive ability. If we take biologists seriously when they state that the ability differences between genders are smaller than the ability differences within genders,

[1] Based on Unesco Statistical Yearbooks, humanities and science are the two broad fields of studies with a clear gender-pattern. Social sciences (roughly one third of total students) tend to have equally many men and women.

[2] The traditional argument, following Mincer and Polachek (1974), has been that women prefer educations depreciating less over time, so that they can take parental leave without losing their human capital. According to this logic, women should prefer to study languages and literature to medicine, law and engineering as the latter three all require more active labor market participation. But contrary to expectations, there are, at least, as many female as male students in medical school and law school, while there is a lack of women in science and engineering.

[3] The data employed in Figure 1 is from *Unesco Statistical Yearbook* and regards the 88 countries used in Section 4.

and we take economists seriously in that growth has been ability biased during the last decades, then it should have economic implications that men and women choose so different fields of educations at the university level.[4] That is, there should be an unexploited ability reserve consisting of men that although being better in arts have studied science, and women that although being better in science have studied arts.

Why would people not choose according to their abilities? The answer suggested in this paper is that there is a social norm at work inflicting costs on persons breaking the social expectations of gender acceptable behaviour. In fact, there is plenty of sociological evidence indicating that math and science are considered "male domains".[5] This takes the form of women enrolling in science programs at the university states that they feel they are in the wrong place, and even students believing that math and science are better understood by men than by women.[6] Even though biological research has proven the last claims to be false, that does not mean that they lack economic bite.

On the contrary, if women believe that they are less gifted in math and science, or sense that others believe they are, then that certainly will affect their behavior.[7] Gender-specific behaviour would also be enhanced by men, hearing how good they are in science and math, choosing these subjects to a larger extent than otherwise. On aggregate, that would lead to having less talented science and arts majors than necessary, which in a world where ability influences aggregate growth directly could have pervasive economic consequences.

The paper is closely related to the strand of literature examining the role of human capital for economic growth. Although a vast literature has aimed at uncovering the links between human capital and development, few have dealt with the importance of tertiary education for development.[8] There is only one paper that, to my knowledge, tries to distinguish the importance of different fields of education for growth, namely Murphy, Shleifer and Vishny (1991). They argue that a talented agent might gain the most from rent-seeking activities, such as becoming a lawyer, but that society might profit the most if she became an engineer. By carrying out cross-country growth regressions augmented with college enrolments in engineering, they show that such enrolments are correlated with growth in a positive and significant way. Choices by men and women are, however, not considered nor, of course, their implications for the average productivity of the skilled workers. Klasen (1999), Knowles, Lorgelly and Owen (2000) and Kalaitzidakis et al (2001)

[4] See, for example, Fausto and Sterling (1992) and Correll (2001) for evidence on the ability differences within and between genders. Articles finding evidence for the importance of cognitive ability for technological change range from Nelson and Phelps (1966) to Doms, Dunne and Troske (1997) and Murnane, Willett and Levy (1995).

[5] For evidence on British data, Arnot et al (1998) provide an excellent overview of the findings; Correll (2001) does the same for the United States. For accounts on the situation in the developing world, see Chawanje (1991).

[6] See Eccles et al (1984), Seymour and Hewitt (1997) and Correll (2001) for studies on students' perceptions of gender and science.

[7] For example, an international study with 19 countries, Baker and Jones (1993), shows that gender specific mathematical performance, among other things, varies with occupational education.

[8] For example, Gemmell (1996) and Wolff (2000) show that university enrolment is the most important form of human capital for growth in OECD countries.

have studied the importance of gender inequalities in education for growth. While they generally find that female education is important for economic development, they do not separately address the role of gender inequalities in higher education.

Gender-specific educational choices have hitherto been modelled as the outcome of bargaining within a household in, for example, Becker (1991) and Echevarria and Merlo (1999). I argue that, although most people do live within a household, very few live with the partner with whom they will form a family at the age when choosing a major and, hence, the choice of educational field should not be analysed as the outcome of intrahousehold bargaining.

Section 2 presents a model where the extent of gender specific educational choices is determined by a social norm and educational choices might have consequences for economic growth. Section 3 discusses what are the testable implications derived from the model. Section 4 proceeds to confront the testable hypothesis with data. Section 5 concludes.

2 The model

To study the macroeconomic implications of gender-specific educational choices, consider an overlapping generations model with a constant population, that is normalized to one. A new generation is born every period. Women form one half of the population, men the other half and they live for two periods. In the first period a person can invest in higher education before starting to work. There are, for simplicity, only two fields of education, science and arts. Science here comprises broad category of subjects like physics, engineering, chemistry, science, and related subjects, while arts includes all the other subjects, such as literature, art, economics and so on. The choice of subject degree will depend on the person's comparative talent and on an endogenously determined social norm. In her second period, a person is retired and lives on her savings from her first period. In analysing the macroeconomic consequences of gender-specific educational patterns I make the assumption that only science majors enhance technological progress, while all persons in higher education contributes to aggregate production to the same extent.[9]

The process of technological change is ability-biased, meaning that the demand for skilled individuals with a high ability increases with the rate of technological change. At the same time, a general increase in the level of human capital also enhances technological change. The basic structure of the ability-biased technological process draws upon Galor and Moav (2000). The following subsections spell out the details of the model.

[9] It is of course a simplification to say that the rate of technological change is determined only by the number of science majors. It is, however, reasonable to assume that people working with developing new inventions and innovations should be more important for progress than those not employed in the sector. According to US data reported by the National Science Foundation, R&D personnel almost entirely consists of scientists and engineers. Moreover, it also shows that a majority of scientists and engineers are employed in R&D. Thus, if we believe that R&D is crucial in generating technological change, it is reasonable to believe that majors in science and engineering are more important for technological change.

2.1 Production and factor prices

Consider a small open economy, which takes the rate of return to capital as given by the world interest rate $r_t^* = \overline{r}$. There are perfect capital markets, and a single good is produced in the world economy. The capital stock, K_t, is equal to aggregate savings less international lending. A large set of competitive and homogenous firms access the same neoclassical production function, that uses capital and labour (in efficiency units), H_t, as inputs. The technological level, A_t, is labour-augmenting and its initial level is exogenously given and set to A_0. The production function can be expressed as a function of the capital-labour ratio adjusted for the technological level, $k_t = \frac{K_t}{A_t H_t}$.

$$Y_t = F\left(K_t, A_t H_t\right) \equiv A_t H_t f\left(k_t\right) \ ,$$

The function f satisfies the Inada conditions and is such that $f_k > 0$ and $f_{kk} < 0$. labour input, H_t, is the weighted sum of the number of efficiency units of skilled, S_t^j, and unskilled labour, U_t^j, of sex j employed in production at time t:

$$H_t = \sum_j H_t^j = \sum_j \left(\beta S_t^j + \left(1 - \delta g_t\right) U_t^j\right) \ , \tag{1}$$

where $\beta > 1$, $\delta \in (0,1)$, and g_t is the rate of technological change, defined as $g_t = \frac{A_t - A_{t-1}}{A_{t-1}}$. Productivity is, thereby, assumed to be the same for all skilled agents independently of their subject degree, that is, a science major produces as much output as an arts major. I assume that $0 < g_t < 1$. In this way, a higher rate of technological change raises the relative demand for skilled agents; i.e., technological change is ability-biased (and the weight on unskilled labour is positive and less than one).

The rate of technological change is determined by the number of scientists and engineers in the economy, X_t,

$$g_{t+1} = X_t \quad . \tag{2}$$

Profit-maximizing firms compete for the factors of production until their rewards correspond to their marginal productivities:

$$\begin{cases} f_k\left(k_t\right) = r_t \\ A_t\left[f\left(k_t\right) - k_t f_k\left(k_t\right)\right] = w_t \end{cases} \quad .$$

Since the interest rate is constant at $\overline{r}$, the wage rate in any given period depends only on the technological level and a constant, $w_t = \overline{w} A_t$. It is now possible to derive the wage rates per efficiency unit of labour for skilled, w_t^S, and unskilled, w_t^U, respectively, consistent with profit maximization:

$$\begin{cases} w_t^S = \beta \overline{w} A_t \\ w_t^U = \overline{w} A_t \left(1 - \delta g_t\right) \end{cases} \quad . \tag{3}$$

Notice that all skilled agents receive the same wage independently of subject degree and gender.[10]

[10] In Boschini (2002), the well-documented gender pay gap is captured by incorporating more

2.2 Expected return to talent

In this model of ability-biased technological change, a person's expected income is determined by her talent. I assume that cognitive ability is distributed in the same way between men and women. So, in period t, an agent i possesses two kinds of broadly defined abilities, science ability, $a_t^{sci_i}$, and ability in arts, $a_t^{art_i}$. Both abilities are uniformly distributed over the unit interval, and assumed to be independent.[11]

All agents have one unit of labour input. Investing in education costs τ units of this labour input with $\tau \in (0,1)$. The efficiency units of human capital provided by an individual are proportional to her cognitive ability. The expected number of efficiency units provided by an arts major, a science major and an unskilled agent are:

$$E\left(s_t^{art_i}\right) = (1-\tau)\, a_t^{art_i} \quad , \qquad E\left(s_t^{sci_i}\right) = (1-\tau)\, a_t^{sci_i}$$

and $E(u_t) = 1$. The expected income of an unskilled agent, $E(I_t^u)$, is simply equal to her efficiency units of unskilled labour times the wage rate for the unskilled, $E(I_t^u) = \overline{w} A_t (1-\delta g_t)$. Analogously, the expected incomes of the skilled can be derived, so as to obtain:

$$\begin{array}{l} E\left(I_t^{art_i}\right) = w_t^S E\left(s_t^{art_i}\right) = A_t \overline{w} R a_t^{art_i} \\ E\left(I_t^{sci_i}\right) = w_t^S E\left(s_t^{sci_i}\right) = A_t \overline{w} R a_t^{sci_i} \end{array} \quad . \tag{4}$$

where $R = \beta(1-\tau)$ is the net premium to education. Thus, the expected income of a skilled agent only depends on that person's ability in her field of education.[12]

2.3 Educational choices

Individuals differ in two regards, namely with respect to their gender and their cognitive ability. When making their educational choices, men and women are influenced by a social norm that affects people's identity. As has been shown by Akerlof and Kranton (2000), the concept of identity is important for many economic decisions. They argue that

> "following the behavioral prescriptions for one's gender affirms one's self-image, or identity, as a 'man' or as a 'woman'. Violating these prescrip-

features of the wage setting process. To notice is that the existence of a gender pay gap would only accentuate the qualitative findings of the model. The fact that arts and science majors earn the same wage can also be questioned. It should be kept in mind, however, is that arts majors in this paper constitute a heterogeneous group including lawyers, economists, high school teachers, philosophers and many other groups with different earning possibilities. Thus, the most neutral assumption is that giving all the skilled agents the same wage rate. Assuming that science majors earn more than arts majors would only strengthen the qualitative results of the model.

[11] If there was a positive correlation between individuals' levels of arts and math ability, then the results of the model would be qualitatively strengthened. This means that independence is the mildest possible assumption.

[12] This way of modelling expected income as a function of individual cognitive ability has empirical support. Cawley, Heckman and Vytlacil (2001) show that there is a positive and significant wage return to ability (at the 1 per cent level).

> tions evokes anxiety and discomfort in oneself and in others. Gender identity, then, changes the 'payoffs' from different actions."[13]

In this model, the social norm is such that it imposes a cost on persons choosing a gender atypical education.[14] What society views as a typical behavior for a person of sex j is correlated with how many j-people behave in this way. Studying science or the arts will, therefore, be associated with different costs in terms of identity for men and women, depending on the number of each sex expected to choose a science and an arts degree, respectively. For example, the fewer men are choosing a certain field of education, the smaller is their perceived utility of majoring in this field due to the identity cost imposed by the social norm. Thus, the norm creates an interior conflict within a person, who is torn between what she is best at and what society considers most suitable for a person of her sex.

In formal terms, an agent maximizes her utility so as to respect her budget constraint and to take the gender-specific social norm, ξ_t^j, into account:[15]

$$\max \quad U = c_t + \theta E\left(c_{t+1}\right) - E\left(\xi_t^j\right) \qquad \text{s.t.} \quad c_t + \left(1 + r_{t+1}\right)^{-1} c_{t+1} = I_t^i \qquad ,$$

where c_t is the consumption of a person born in period t during her first period of life, θ is the weight given to consumption in the second period of life, c_{t+1} is the consumption of that person as retired in $t+1$, I_t^i is the income earned in the first period of life, and r_{t+1} is the interest rate paid on savings held from t to $t+1$. The resulting indirect utility function is:

$$v\left(\cdot\right) = E\left(I_t^i\right) - E\left(\xi_t^j\right) \ .$$

So, when will an agent invest in education, and what major will she choose if investing? First, an agent must gain from investing in education at all, which means that her indirect utility as skilled must exceed her indirect utility as unskilled. Second, the agent will choose the major maximizing her indirect utility, i.e. her expected income as a science (or arts) major less the expected value of the social norm. Thus, the following must hold:

$$\max\left\{E\left(I_t^{sci_i}\right) - E\left(\xi_t^{sci_j}\right), E\left(I_t^{art_i}\right) - E\left(\xi_t^{art_j}\right)\right\} \geq E\left(I_t^u\right) \qquad . \tag{5}$$

[13] Akerlof and Kranton (2000) mention four types of identity-related behaviour. In their words "(1) people have identity-based payoffs derived from their own action; (2) people have identity-related payoffs derived from others' action; (3) third parties can generate persistent changes in these payoffs; and (4) some people may choose their identity, but choice may be proscribed for others." Other articles, such as Bénabou and Tirole (1999) and Lindbeck, Nyberg and Weibull (1999), analyse the economic implications of social norms both on the micro and macro level.

[14] It is of course possible to consider the social norm as a tax on educational investments for certain groups of individuals. To have any bearing, the tax would have to be endogenously determined as a result of societal preferences. That is, it would be equivalent to study a social norm, which is enforced by the use of taxes on the share of the population not conforming to the norm. The formulation of the norm as identity related is chosen for its perceived higher degree of realism.

[15] It is possible to generalize the utility function, but it does not add qualitative insights and only makes the problem more complicated.

Solving this condition yields threshold levels of ability for becoming a science major, $a_t^{sci_j^*}$, and an arts major, $a_t^{art_j^*}$, for each sex j. That is, in order to study a subject, the agent must have an ability level in that subject exceeding the threshold level given by the expected income as unskilled.

In order to simplify matters, I assume that the social norm only implies a cost for women who choose to major in science. This corresponds to a normalization of the norm with respect to the male norm negatively affecting men investing in the arts.[16] Thus, $\xi_t = 0$ for all except for female science majors, for whom the norm takes the following form:

$$\xi_t^{sci_f} = (1-\lambda)\,\xi_{t-1} + \lambda G\left(X_t^f - X_t^m\right) \quad , \tag{6}$$

where λ is the weight on the gender-biasedness of educational choices, X_t^j is the number of science majors in period t of sex j, and G is an increasing function. Thus, the social norm is a weighted average of the norm in the previous period and the expected gap in the number of male and female science majors in t. The initial value of the social norm, ξ_0, is given and assumed to be positive in order to capture that there is a social norm affecting women negatively from the beginning. (If $\xi_0 = 0$, then in optimum, men and women would choose exactly the same amount and fields of education.) Since the higher is the number of science majors, the lower is the minimum ability level in science required, $X_t^f - X_t^m$ is increasing in the distance between the thresholds for women and men to become science majors, $D\left(a_t^{sci_f^*} - a_t^{sci_m^*}\right)$. I adopt the following linear simplification, $G\left[D\left(a_t^{sci_f^*} - a_t^{sci_m^*}\right)\right] = a_t^{sci_f^*} - a_t^{sci_m^*}$, which gives that

$$\xi_t^{sci_f} = (1-\lambda)\,\xi_{t-1} + \lambda\left(a_t^{sci_f^*} - a_t^{sci_m^*}\right) \quad .$$

Under the above normalization, condition (5) becomes

$$\max\left\{E\left(I_t^{sci_{ij}}\right) - E\left(\xi_t^{sci_j}\right), E\left(I_t^{art_{ij}}\right)\right\} \geq E\left(I_t^{u_{ij}}\right) \quad . \tag{7}$$

Optimal educational choices are obtained by solving (7) after substituting for expected income and the expression for the social norm. The outside option, i.e. the expected wage obtained when not entering university, is $\overline{w}A_t\,(1-\delta g_t)$. Men will choose to major in science when their ability allows them to earn more than $\overline{w}A_t\,(1-\delta g_t)$ as skilled – after having taking into account the cost of education (τ) – given that their expected wage as science major exceeds that of becoming an arts major. Since the wage rates of science and arts majors are the same, the latter condition translates into requiring science students to have a higher ability in science than arts. Thereby, the following two conditions have to be satisfied in order for a

[16] This might appear as a strong assumption, but, as suggested by Figure 1 and as will be shown in Section 4.1, this assumption is in line with the empirical evidence.

person to invest in becoming a science major:

$$\left\{ \begin{array}{l} E\left(I_t^{sci_{i,m}}\right) = A_t\overline{w}Ra_t^{sci_{i,m}} \geq \overline{w}A_t\left(1-\delta g_t\right) = E\left(u_t\right) \\ E\left(I_t^{sci_{i,m}}\right) = A_t\overline{w}Ra_t^{sci_{i,m}} \geq A_t\overline{w}Ra_t^{art_{i,m}} = E\left(I_t^{art_{i,m}}\right) \end{array} \right. ,$$

Thereby, the threshold levels for investing in higher education are the same in science and arts for men, namely

$$a_t^{sci_m^*} = a_t^{art_m^*} = \frac{1-\delta g_t}{R} \quad . \tag{8}$$

For women, the educational choice is slightly different being distorted by the social norm in the following way:

$$\left\{ \begin{array}{l} E\left(I_t^{sci_{i,f}}\right) - E\left(\xi_t^{sci_f}\right) \geq E\left(u_t\right) \\ E\left(I_t^{sci_{i,f}}\right) - E\left(\xi_t^{sci_f}\right) \geq E\left(I_t^{art_{i,f}}\right) \end{array} \right. ,$$

The social norm affects women's utility from investing in science so that it takes a higher ability in science for women to become science majors. The threshold levels in ability terms for women becoming science and arts majors are respectively

$$a_t^{sci_f^*} = \frac{1-\delta g_t}{R} + \eta_t; \qquad a_t^{art_f^*} = \frac{1-\delta g_t}{R} \quad , \tag{9}$$

where $\eta_t = \frac{(1-\lambda)\xi_{t-1}}{\overline{w}A_{t-1}(1+g_t)R-\lambda}$. It is assumed that η_t is such that it does not completely prevent women from becoming science majors, i.e. $\eta_t < 1 - \frac{1-\delta g_t}{R}$. Thus, men and women face the same ability requirements for becoming arts majors, while for becoming a science major women have to have a relatively higher ability level for gaining by investing in that type of education. Since η_t is the effect of the social norm, $\xi_t^{sci_f}$, on women's educational choices, and thereby what distinguishes women's educational choices from men's, η_t will be used as a measure of the social norm throughout the paper. Figure 2 illustrates the choices of education of men and women in the ability space.

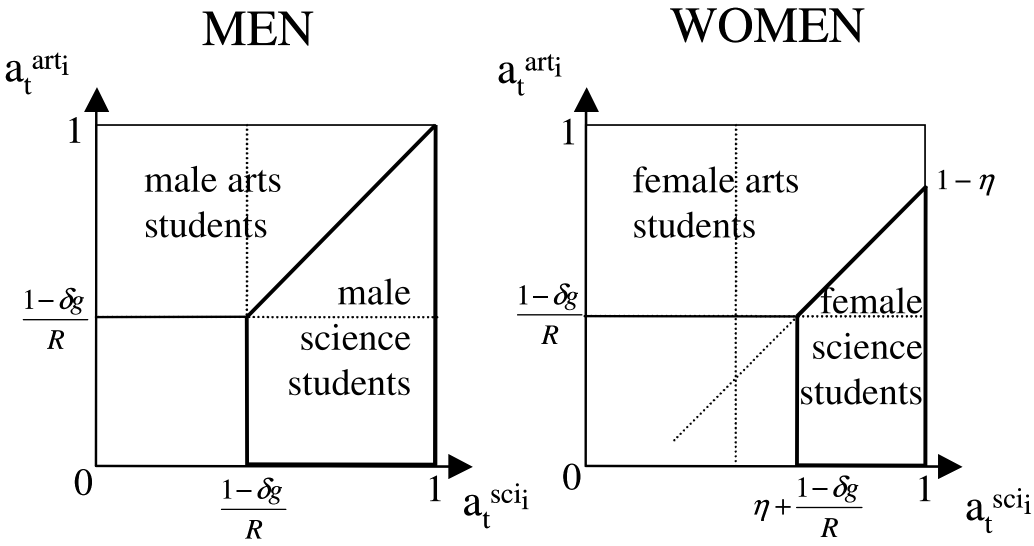

Figure 2. Educational choices in the ability space

The cost imposed by the norm leads to fewer women than men enrolling in science, $X_t^f < X_t^m$. This occurs in two ways. First, fewer women than men invest in education due to the norm. This is because there are women, who are not talented enough to study arts but that would have gained from a science major if there would not have been a social norm. These women become unskilled instead of studying science. Second, there is a group of women who are more talented in science than in arts who, due to the cost imposed by the norm, invests in arts rather than in science.

$$X_t^f = \frac{1}{2} \int_{\frac{1-\delta g_t}{R}+\eta_t}^{1} \left(a_t^{sci_f} - \eta_t\right) da_t^{sci_f}; \quad X_t^m = \frac{1}{2} \int_{\frac{1-\delta g_t}{R}}^{1} a_t^{sci_m} da_t^{sci_m} \tag{10}$$

Besides having less female science majors, this also leads to having fewer women in overall education, N_t^{total}, so that there are less female students than male, $N_t^f < N_t^m$.

$$N_t^f = \frac{1}{2}\left(1 - \int_0^{\frac{1-\delta g_t}{R}+\eta_t} \frac{1-\delta g_t}{R} da_t^{sci_f}\right); \quad N_t^m = \frac{1}{2}\left(1 - \int_0^{\frac{1-\delta g_t}{R}} \frac{1-\delta g_t}{R} da_t^{sci_m}\right)$$

It can be shown that the rate of technological change increases the number of students in higher education and that a larger norm diminishes the number of students. Moreover, it can be shown that there are relatively more males in arts than females in science and that the norm has a bigger impact on the number of female students than on the total number of female students. Lastly, as the rate of technological progress increases, the number of female students increases more rapidly than that of male students, due to the diminishing impact of the norm. Proposition 1 formalises these insights.

Proposition 1 *(i) The total number of students increases with g_t and decreases with ξ_{t-1}; (ii) there are relatively more men in the female-dominated field of the arts* *than women in the male-dominated field of science; (iii) the effect of the social norm is larger on the number of female science students,* $\frac{\partial X_t^f}{\partial \eta_t}$*, than on the number of total female students,* $\frac{\partial N_t^f}{\partial \eta_t}$*, so that* $\frac{\partial X_t^f}{\partial \eta_t} > \frac{\partial N_t^f}{\partial \eta_t}$*, while the numbers of male students and male science students are not affected by the social norm; (iv) the number of female students increases faster than the number of male students with respect to the rate of technological change,* $\frac{\partial N_t^f}{\partial g_t} > \frac{\partial N_t^m}{\partial g_t}$.

Proof. *(i)* Follows directly from taking the first derivative of N_t^{total} with respect to g_t and ξ_{t-1}; *(ii)* the share of women in science is given by $\frac{(1-\eta_t)^2-\left(\frac{1-\delta g_t}{R}\right)^2}{1+(1-\eta_t)^2-2\left(\frac{1-\delta g_t}{R}\right)^2}$; it is smaller than the share of men in the female dominated arts, $\frac{\frac{1}{2}\left(1-\frac{1-\delta g_t}{R}\right)^2}{\left(1-\frac{1-\delta g_t}{R}\right)^2-\frac{1}{4}\left(1-\eta_t-\frac{1-\delta g_t}{R}\right)^2}$, whenever the assumption made earlier on the maximum size of the norm holds, $\eta_t < 1-\frac{1-\delta g_t}{R}$; *(iii)* $\frac{\partial X_t^f}{\partial \eta_t} = \left|-\frac{1}{2}\left(1-\eta_t\right)\right| > \left|-\frac{1}{2}\left(\frac{1-\delta g_t}{R}\right)\right| = \frac{\partial N_t^f}{\partial \eta_t}$ since $\eta_t < 1-\frac{1-\delta g_t}{R}$; *(iv)* $\frac{\partial N_t^m}{\partial g_t} = \delta\left(\frac{1-\delta g_t}{R}\right)$, while $\frac{\partial N_t^f}{\partial g_t} = \delta\left(\frac{1-\delta g_t}{R}\right) + \frac{\partial}{\partial g_t}\left(-\frac{1}{2}\left(\frac{1-\delta g_t}{R}\right)\left(\frac{(1-\lambda)\xi_{t-1}}{\overline{w}A_{t-1}(1+g_t)R-\lambda}\right)\right)$, where the last term is positive. ■

2.4 Macroeconomic implications

The social norm has pervasive consequences for economic growth by affecting the number and average ability of skilled in the economy. In order to study the consequences of the norm on the growth rate of output, let aggregate output be produced by a Cobb-Douglas function in the following way:

$$Y_t = (K_t)^{\gamma}(A_t H_t)^{1-\gamma} \quad ,$$

where $\gamma \in (0,1)$. Thus, the growth rate of output is positively influenced by the capital stock, the level of technological change and the stock of human capital. While the amount of physical capital is not directly influenced by the presence of the social norm, the technological level and the human capital are both affected.

Let me first start by studying the effect of the social norm on technology. The technological level in period t is by definition a function of the technological level in the previous period and the rate of technological change that has occurred, $A_t \equiv A_{t-1}(1+g_t)$. For a given initial technological level, what matters is the evolution of the rate of technological change. As mentioned in Subsection 3.1, g_t depends on the number of science majors in the economy.[17] By substituting the number of female

[17] The rate of technological change could equally well be expressed in terms of efficiency units of skilled labour provided by math majors without altering the results. The discussion about R&D is, however, mostly conducted in terms of the number of scientists and engineers working in the field, and not in terms of their estimated ability.

and male science majors from (10) into (2), the difference equation governing the rate of technological change becomes:

$$g_{t+1} = X_t^f + X_t^m = \frac{1}{2} \int_{\frac{1-\delta g_t}{R}+\eta_t}^{1} \left(a_t^{sci_f} - \eta_t\right) da_t^{sci_f} + \frac{1}{2} \int_{\frac{1-\delta g_t}{R}}^{1} a_t^{sci_m} da_t^{sci_m} \quad . \tag{11}$$

The social norm thus has a negative effect on the rate of technological progress. To understand how the social norm affects the evolution of the rate of technological change, it is helpful to analyse the boundaries of g_{t+1}. First, let the social norm be strong enough to fully impede women from becoming science majors, which happens if $\eta_t > 1 - \frac{1-\delta g_t}{R}$; call the associated pattern of technological change $g_{t+1}^{\min}$. The rate of technological change is thus equal to the number of male science majors in the economy, $g_{t+1}^{\min} = \frac{1}{2} \int_{\frac{1-\delta g_t}{R}}^{1} a_t^{sci_m} da_t^{sci_m}$. Second, take the case when there is no norm, so that $\xi_0 = 0$. Then there are as many female as male science majors; the associated technological path, $g_{t+1}^{\max}$, is such that $g_{t+1}^{\max} = \frac{1}{2} \sum_{j \in \{f,m\}} \int_{\frac{1-\delta g_t}{R}}^{1} a_t^{sci_j} da_t^{sci_j}$.

Proposition 2 shows that g_{t+1} lies in between $g_{t+1}^{\max}$ and $g_{t+1}^{\min}$ for every g_t, and that the rate of technological change in the presence of a social norm converges as t goes to infinity to $g_{ss}^{\max}$, the steady-state of $g_{t+1}^{\max}$, as long as $g_0 \in (0, 1)$. That is, as long as the economy starts out with a positive rate of technological change, then the social norm will eventually fade away and the economy reaches $g_{ss}^{\max}$.

Proposition 2 *As $t \to \infty$, g_{t+1} approaches the unique stable steady-state, $g_{ss}^{\max}$, as long as $g_0 \in (0, 1)$.*

Proof. Notice that $g_{t+1}^{\min} < g_{t+1} < g_{t+1}^{\max}$ for $\forall g_t \in (0, 1)$. Moreover, $g_{t+1}^{\max}$ and $g_{t+1}^{\min}$ both have unique and stable steady-states, $g_{ss}^{\max}$ and $g_{ss}^{\min}$ respectively, such that $0 < g_{ss}^{\min} < g_{ss}^{\max} < 1$. (Both $g_{t+1}^{\max}$ and $g_{t+1}^{\min}$ are strictly concave functions, with a positive intercept less than 1 and with a value at $g_t = 1$ less than 1. By the intermediate value theorem, there is therefore a unique steady-state for each function.) Since $\frac{\partial g_{t+1}}{\partial g_t} > 0$ for any given levels of technology and social norm, g_{t+1} crosses the 45 degrees-line only once. As g_t increases, A_{t-1} grows and ξ_{t-1} diminishes. As $t \to \infty$, η_t goes to zero and, hence, in the limit, g_{t+1} coincides with $g_{t+1}^{\max}$, which has the unique steady-state $g_{ss}^{\max}$. ■

Does this imply that there are no losses in terms of technological change from the social norm? Of course, in the steady-state there are no losses since there is no social norm. But in every period during the transition to the steady state the rate of technological change is lowered by the presence of the social norm. The cost of the social norm crucially hinges on the initial level of the norm, so that the smaller the initial norm is, the faster will the convergence process to the steady-state be.

Let me now turn to the effect of the social norm on the stock of human capital. Recall that H_t is the weighted sum of the number of efficiency units of skilled, S_t, and unskilled, U_t, so that

$$H_t = \sum_j H_t^j = \sum_j \left(\beta S_t^j + (1-\delta g_t)\, U_t^j\right) \ ,$$

where $j \in \{f, m\}$. Since I have normalised the norm – so that it only affects women – men's choices in the labour market are not altered by the presence of the norm. S_t^m is therefore given by the sum of the number of male science majors times their average ability, $\overline{a}_t^{sci_m}$, and the number of male arts majors times their average ability, $\overline{a}_t^{art_m}$,

$$S_t^m = \frac{\overline{a}_t^{sci_m}}{2} \int_{\frac{1-\delta g_t}{R}}^{1} a_t^{sci_m} da_t^{sci_m} + \frac{\overline{a}_t^{art_m}}{2} \int_{\frac{1-\delta g_t}{R}}^{1} a_t^{art_m} da_t^{art_m} \quad .$$

(The supply of efficiency units of unskilled men is simply equal to the number of unskilled men, U_t^m.) For women, the labour supply reflects the norm in the following way,

$$S_t^f = \frac{\overline{a}_t^{sci_f}}{2} \int_{\frac{1-\delta g_t}{R}+\eta_t}^{1} \left(a_t^{sci_f} - \eta_t\right) da_t^{sci_f} + \frac{\overline{a}_t^{art_f}}{2} \left(1 - \int_0^1 \frac{1-\delta g_t}{R} da_t^{sci_f} + \int_{\frac{1-\delta g_t}{R}+\eta_t}^{1} \eta_t da_t^{sci_f}\right)$$

while the number of female unskilled is U_t^f. The stock of human capital (in efficiency units), H_t, is affected by the norm in three ways. First, it influences the number of women who decide to invest in education – *the female investment effect*. Secondly, it affects the average ability of the skilled by distorting the choice of field of study for a group of women – *the subject effect*. Thirdly, the relatively lower rate of technological change induced by the norm increases the relative number of unskilled in the labour force, thus decreasing the supply of efficiency units of labour – *the allocation effect*.

Proposition 3 *When $g_t < g_{ss}^{\max}$, (i) The female investment effect: $\frac{\partial N_t^f}{\partial \eta_t} < 0$; (ii) the subject effect: $\left.\left(\overline{a}_t^{sci_f} + \overline{a}_t^{art_f}\right)\right|_{g_t, \eta_t > 0} < \left.\left(\overline{a}_t^{sci_f} + \overline{a}_t^{art_f}\right)\right|_{g_t, \eta_t = 0}$; (iii) the allocation effect: $\left.\frac{S_t^m}{U_t^m}\right|_{g_t} < \left.\frac{S_t^m}{U_t^m}\right|_{g_t^{\max}}$ and $\left.\frac{S_t^f}{U_t^f}\right|_{\eta_t, g_t} < \left.\frac{S_t^m}{U_t^m}\right|_{\eta_t, g_t^{\max}}$.*

Proof. *(i)* This follows directly from Proposition 1; *(ii)* This results from the definition of the social norm: the women in the area $\int_{\frac{1-\delta g_t}{R}}^{1} a_t^{sci_f} da_t^{sci_f} - \int_{\frac{1-\delta g_t}{R}+\eta_t}^{1} \left(a_t^{sci_f} - \eta_t\right) da_t^{sci_f} = \int_{\frac{1-\delta g_t}{R}}^{\frac{1-\delta g_t}{R}+\eta_t} a_t^{sci_f} da_t^{sci_f} + \int_{\frac{1-\delta g_t}{R}+\eta_t}^{1} \eta_t da_t^{sci_f}$ are choosing to study arts instead of science although they have a comparative advantage in science. Thereby they lower the total average ability of female skilled; *(iii)* Since $g_t^{\max} > g_t$ and $\frac{\partial S_t^m}{\partial g_t} > 0$, $\frac{\partial U_t^m}{\partial g_t} < 0$, $\left.\frac{\partial S_t^f}{\partial g_t}\right|_{\eta_t} > 0$, $\left.\frac{\partial U_t^f}{\partial g_t}\right|_{\eta_t} < 0$ necessarily $\left.\frac{S_t^m}{U_t^m}\right|_{g_t} < \left.\frac{S_t^m}{U_t^m}\right|_{g_t^{\max}}$ and $\left.\frac{S_t^f}{U_t^f}\right|_{\eta_t,g_t} < \left.\frac{S_t^m}{U_t^m}\right|_{\eta_t,g_t^{\max}}$. ■

It is useful to summarise the findings in this subsection by looking at the effect on the social norm on the growth in aggregate production. The rate of economic growth is simply given by

$$\frac{\Delta Y_t}{Y_{t-1}} = \gamma \frac{\Delta K_t}{K_{t-1}} + (1-\gamma)\frac{\Delta A_t}{A_{t-1}} + (1-\gamma)\frac{\Delta H_t}{H_{t-1}} \quad , \tag{12}$$

where $\frac{\Delta A_t}{A_{t-1}}$ is, by definition, equal to the rate of technological change, g_t. Since g_t equals to the number of science students, the latter will be used as a proxy for the rate of technological change. From the model and the reasoning in this subsection, the following proposition can be stated:

Proposition 4 *Economic growth is, ceteris paribus, positively correlated with the investment in physical capital, the number of science students (as a proxy for the rate of technological change) and by the change in the stock of human capital. Economic growth is indirectly negatively influenced by the social norm through technology and investments in higher education.*

3 Testable implications of the model

The testable implications regard both how the social norm ought to influence men's and women's educational choices differently and how the growth rate of production is affected by the norm. In this paper I focus on those implications that are possible to investigate with aggregate data. The main implications from the model that I set out to confront with data are as follows:

1. *The proportion of female university students out of the total number of students should increase, given that $g_t < g_{ss}^{\max}$* (Proposition 1.iv). Since it is highly problematic to compare total factor productivity rates across countries and over time, I assume that no country has reached the steady-state. Therefore, I will simply study the data on the number of students in higher education.

2. *Arts should be less female dominated than science is male dominated at the university level, given that $g_t < g_{ss}^{\max}$* (Proposition 1.ii). That is, on average there should be more men per woman in arts then women per man in science.

3. *The ratio of female to male science students should increase, but at a slower pace than the ratio of female to male university students, given that $g_t < g_{ss}^{\max}$* (Proposition 1.iii). When there is no social norm at work, the model predicts that both the ratio of female to male science students and that of female to

male university students should be equal to one. As long as there is a norm, its impact should be stronger on the share of female science students than on female university enrolment.

4. *Ceteris paribus, GDP per capita growth should be a positive function of investments in physical capital, the number of science majors and the growth in the stock of human capital. Economic growth should also be a negative function of the social norm* (Proposition 4). The exact procedure for investigating this implication is described in subsection 4.2.

Regarding the empirical measure of the norm, it is as close to the formal definition as possible, namely as

$$Norm1_t = \left| \frac{X_t^m - X_t^f}{X_t^{total}} \right| \quad ,$$

where X_t^j is the number of science majors. However, that does not consider the simplifying normalization of the norm. If I instead want to capture the possibility of men facing a corresponding, but weaker, norm when studying the arts, then it is well motivated to consider the following alternative measure of the social norm:

$$Norm2_t = \left| \frac{X_t^m - X_t^f}{X_t^{total}} \right| + \left| \frac{Z_t^m - Z_t^f}{Z_t^{total}} \right| \quad ,$$

where Z_t^m, Z_t^f and Z_t^{total} are the numbers of male/female arts majors and the total number of arts majors.[18] Thus, $Norm1$ indicates how many more men than women are enrolled in science (in per cent), while $Norm2$ measures the full extent of gender-specific choices at the university level, as it is the sum of $Norm1$ and the corresponding indicator for arts students.

4 Empirical evidence

The sample consists of 88 countries – Table A1 in the Appendix lists all the countries. The data captures three intervals: 1970-79, 1980-89 and 1990-98. The students enrolled in science or engineering programs are used as a proxy for the number of science majors, while to measure the number of arts majors I employ the number of students in humanities.[19] Ideally, I would have wanted data on the number of graduates in each subject field, but that is not available for the whole sample period.

[18] Notice that I have weighted both proxies for the number of students in each field to control for differences in enrolment between countries.

[19] Humanities are defined as archaeology, history, languages, letters and other similar subjects in the UNESCO data.

	Norm 1		*Norm 2*	
strong norm ↑	Sub-Saharan Africa	0.70	Sub-Saharan Africa	1.11
	East Asia & Pacific	0.54	East Asia & Pacific	0.83
	Oecd	0.45	Oecd	0.74
	South Asia	0.43	Middle East & North Africa	0.64
	Middle East & North Africa	0.36	Latin America	0.62
↓ **weak norm**	Latin America	0.30	South Asia	0.59

Table 1. Regions ranked according to norm strength in 1997

Table 1 reports the strength of the gender stereotypes, defined as *Norm1* and *Norm2*, in 1997 and how it has changed in percentage points since 1970 across regions, where *Norm1* varies between 0 and 1 and *Norm2* between 0 and 2. The higher the value assumed by the norm the stronger are the gender stereotypes.

Table 1 shows that there are distinctive regional differences in gender stereotypes. Latin America, the Middle East and North Africa and South Asia have the weakest norms. The Oecd is in the middle regarding the strength of the norm. Thus, the educational social norm is capturing something different than the usual gender measures since, by most standards, the Oecd is outstanding in terms of women's political, legal and economic rights. But, one must remember that *Norm1* and *Norm2* only measure the extent to which there are gender stereotypes in education. It thus is perfectly possible that Oecd has stronger gender stereotypes in education while being more protective of gender equality in other areas. Noticeable is that within the Oecd, the education norm is weaker in countries like Spain and Greece than in Sweden – a country that is well-known for its gender equality. So, educational gender stereotypes are not the same as the pervasive level of gender equality in a country.

Moreover, from Table 1 it is also evident that the decrease in *Norm2* over the period mainly is due to the entry of more women in science and not of more men in the arts.

4.1 Educational choices across gender and countries

Table 2 reports the findings regarding the testable Implications 1,2 and 3 from Section 3. Column 1 presents the change between 1970 and 1997 in the share of university students of the total population. All regions have increased their number of university students as percentage of the population. The increase has been highest in the Oecd and the least in the Sub-Saharan region. This confirms the common view that higher education is a matter of economic development.

Column 2 reports the change in the share of female students out of total students since 1970. Latin America has had the largest increase in share of female university students, closely followed by the Oecd and the Middle East and North Africa. So, it has increased in all regions, which is compatible with **Implication 1**.

Finally, columns 3 and 4 report the number of males per female in arts and the number of females per male enrolled in science respectively. **Implication 2** means that there should be relatively more men in arts then females in science, which is confirmed by data. In all regions – despite varying patterns – there are indeed more men in arts than women in science. This is not a matter of economic development. More specifically, it is not the case that the regions with the highest level of economic growth has relatively more females in science. It is not even the case that the regions, which by other accounts can be said to have most gender equality, are those with most women in science and men in arts.

	Change in share of university students (of total population) since 1970	Change in share of female stud. (of total stud.) since 1970	Males per female in arts (average 70–97)	Females per male in science (average 70–97)
East Asia & Pacific	1.11	11.6	1.23	0.19
Latin America	0.61	18.9	0.73	0.43
Middle East & North Africa	1.04	16.7	1.63	0.36
Oecd	2.61	17.6	0.80	0.28
South Asia	0.35	7.4	1.41	0.27
Sub-Saharan Africa	0.19	11.5	4.89	0.17

Table 2. Investigating testable implications (1)-(3)

Figure 3 intends to capture whether it is consistent with data that the ratio of female to male science students increase, but at a slower pace than the ratio of female to male university students - denominated as **Implication 3**.[20] This is done by plotting the regional averages in 1970, 1980, 1990 and 1997. Figure 3 shows that the relative number of females in science indeed is positively related with the share of female university students, but it is – consistent with **Implication 3** – far from a one to one relation. It is, of course, impossible to say that the norm is causing this, but it is the only consistent explanation, to the best of my knowledge, at this point.

[20] In Figure 3 only the observations from countries with more than 10000 university students are used. For smaller university populations the allocation between fields is stochastic and only a few fields are present.

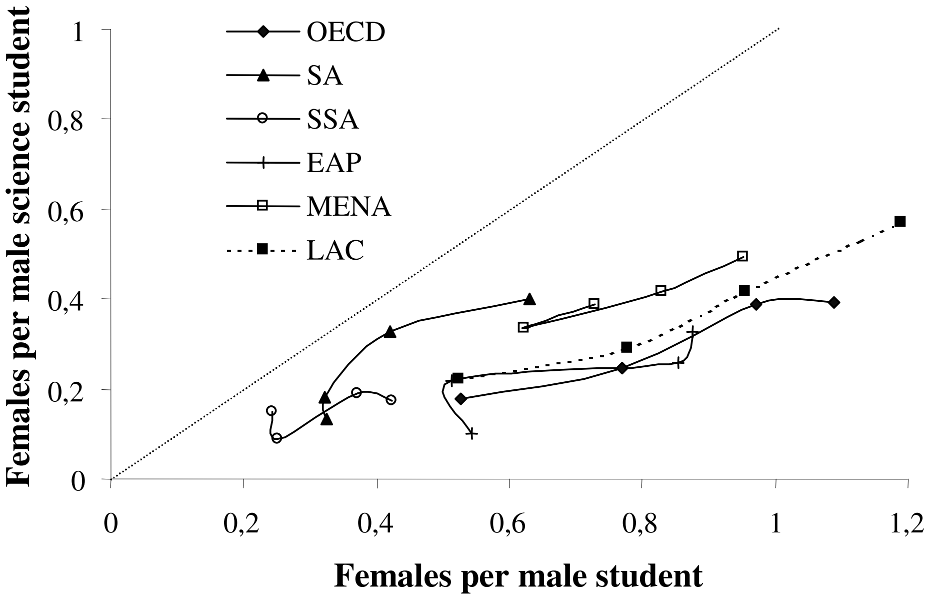

Figure 3. The norm influences females' entry to science more than their entry to university

4.2 Economic growth

This subsection aims at understanding the impact of the social norm on economic development by the use of growth regressions. Putting equation (12) in regression terms gives the following equation to estimate,

$$Growth_t = \beta_0 + \beta_1 Inv_t + \beta_2 TFP_t + \beta_3 \Delta H_t + \beta_4 V_t + \varepsilon_t \quad ,$$

where *Growth* is real GDP per capita growth, Inv is the average level of investment in physical capital, *TFP* is the rate of technological change (i.e. total factor productivity), ΔH measures the rate of change in the stock of human capital and V is a summary term for control variables. (Definitions and sources of all the variables are reported in Table A2 in the Appendix.)

The model gives a proxy for the rate of technological change, namely the number of science majors – see equation (11).[21] Moreover, in order to account for the eventuality of the social norm affecting the quality of science majors, the total factor productivity term consists of two parts, the number of science majors, Sci_t, and the level of the social norm, $Norm_t$, both measured at the beginning of the period, so that $TFP_t = Sci_t + Norm_t$. A similar procedure is applied to the rate of change of the stock of human capital. That is, ΔH_t is supposed to consist of the actual change in the stock of human capital, $\Delta School_t$, corrected for the change in

[21] Wolff (2000) also proxied the Solow residual with the number of persons in R&D - a number closely reflecting scientists and engineers.

the social norm, $\Delta Norm_t$. This gives the following regression equation to estimate:

$$Growth_t = \beta_0 + \beta_1 Inv_t + \beta_2 Sci_t + \beta_3 Norm_t + \beta_4 \Delta School_t + \beta_5 \Delta Norm_t + \beta_6 V_t + \varepsilon_t \quad . \tag{13}$$

As control variables, I use the GDP per capita level at the beginning of each period, the degree of openness of the economy, a measure of political instability, time dummies (for decades), regional dummies and a proxy to control for overall gender inequality, $Gender_t$.

It is crucial to the analysis to include *Gender* since it otherwise could be the case that what is captured by the social norm is gender inequality. As a proxy for gender inequality I use the share of females in the total labour force at the beginning of every decade. This controls for the extent to which women are agents in the formal economy, which is the first step towards economic gender equality.[22]

Now, I am interested not only in the direct effects of the social norm on economic growth, but also in how the norm changes as a function of the dependent variables in the following way

$$\Delta Norm_t = \beta_0 + \beta_1 Inv_t + \beta_2 Sci_t + \beta_3 Norm_t + \beta_4 \Delta School_t + \beta_5 V_t + \varepsilon_t \quad . \tag{14}$$

That is, since the change in the norm is endogenously determined I want know if the effect of the social norm is mainly direct or indirect through investment, human capital and technological change. The total effect of change in the social norm is then given by the direct effect in (13) plus the indirect effect through (14) on the independent variables. (Regarding the level of the norm, the model gives no predictions since the initial level of the social norm is assumed to be exogenously given.)

Table 3 reports the descriptive statistics of the major variables in the sample.

	Mean	Std. Dev.	Min	Max
***GDP per capita growth* (%)**	1.75	2.31	-4.51	8.19
***Investments* (% of GDP)**	16.56	8.75	1.07	47.41
***Scientists* (% of students)**	21.25	9.91	0	53.55
Norm 1	0.64	0.21	0.04	1
Norm 2	0.98	0.34	0.19	1.81
***Schooling* (average years)**	4.87	2.94	0.04	11.42
***Female labour force* (% of total)**	34.91	9.85	5	51

Table 3. Descriptive statistics

[22] Goldin (1994) shows that there is an inverse U-shaped relationship between female labour force participation and GDP per capita levels. In very poor countries the female labour force participation is high. It declines as industrialization or modernization takes off only to increase again. Since I only will be considering countries with at least 10 000 university students this ought not to be a problem if one believes that the extent of higher education is associated with economic development. I have, however, tested to include a quadratic term of the female labour force supply in the regressions, and it never is significant.

Table 4 reports the results of estimating (13) and (14) with ordinary least squares. The first two columns show the results when not using any control variables, while the regressions reported in columns (3) and (4) have all control variables included (although the coefficients for the dummy variables and the constant are not reported.) In the growth regressions in columns (1) – (4), besides all standard variables performing normally, a change in the norm has a significant and theoretically correct effect when the norm is measured as $Norm2$. ($\Delta Norm1$ has the correct sign but is never significant.) That is, when the social norm is measured so as to take into account that both males and females are influenced by gender stereotypes in their choice of education, then as the norm decreases with one unit the growth rate increases by approximately 2 percentage points. This is a huge amount, so let me try and quantify this further.

	(1) **Growth**	(2) **Growth**	(3) **Growth**	(4) **Growth**	(5) **Δ Norm 1**	(6) **Δ Norm 2**
Investments	0.112*** (0.022)	0.109*** (0.022)	0.114*** (0.033)	0.116*** (0.035)	-0.0004 (0.002)	-0.001 (0.003)
Scientists	0.031 (0.020)	0.034* (0.018)	0.012 (0.019)	0.022 (0.017)	-0.002 (0.002)	-0.0003 (0.003)
Norm 1	0.873 (1.005)		0.629 (1.272)		-0.574*** (0.071)	
Norm 2		-0.268 (0.619)		-0.906 (0.813)		-0.604*** (0.080)
Δ Norm 1	-0.313 (1.435)		-0.468 (1.473)			
Δ Norm 2		-2.060** (0.867)		-2.031** (0.930)		
Δ Schooling	0.607** (0.288)	0.569** (0.277)	0.412** (0.270)	0.426** (0.259)	0.029* (0.017)	0.018 (0.028)
Gender	-0.014 (0.022)	-0.006 (0.022)	0.014 (0.035)	-0.002 (0.033)	-0.005** (0.002)	-0.004 (0.003)
Initial GDP per capita			-0.0001*** (0.00004)	-0.0001*** (0.00004)	-0.0000** (0.0000)	-0.000*** (0.0000)
Openness			0.004 (0.005)	-0.0003 (0.005)	0.0002 (0.0004)	0.0001 (0.0004)
Political instability			2.368 (5.330)	1.784 (5.316)	0.006 (0.222)	-0.117 (0.224)
R^2	0.29	0.31	0.43	0.44	0.46	0.46
N. of obs.	145	145	145	145	145	145

*** denotes significance at the 99 per cent level; ** at the 95 per cent level; and * at the 90 per cent level. Robust standard errors in parentheses.

Table 4. Main growth regressions

Let there be 10000 university students in the economy, of which 4000 are women. Assume for simplicity that there is no social norm affecting men's educational choices and that 10 percent of the women and 60 percent of the men study science. Then the initial value of $Norm2$ is equal to one.[23] If the educational gender stereotypes disappear completely so that $Norm2$ in the next period equals zero, then the growth rate of GDP per capita increases with 2 percentage points.

Columns (5) and (6) show how changes in the norm are affected by the other independent variables, and what is interesting is that the changes in the norm are negatively and significantly affected by the initial size of the norm (the higher the initial norm, the slower will a change in the norm be), which is consistent with the theoretical formulation of the norm. As expected, the lower is the initial level of GDP, the more does the educational norm change.

Table 5 highlights that the social norm's influence on economic growth is of a more direct character, and does not stem from its indirect effects on for example technology and investments. One interpretation of the direct effect is that is represents the ability loss in the economy due to the mismatch of people's ability and their educations.

	Δ Norm 1	*Δ Norm 2*
Indirect effects		
Investments	-0.00004	-0.0001
Scientists	-0.00002	-0.00001
Norm 1	-0.361	
Norm 2		0.547
Δ Schooling	0.0120	-0.008
Gender	-0.0001	-0.00001
Direct effect	-0.468	-2.031
Total effect	-0.817	-1.492

Table 5. Direct and indirect effects of the social norm

When studying the robustness of the results reported in Table 4, I will only use $Norm2$ since that is the formulation of the social norm that has the largest empirical potential. A first objection to the growth regression results could be that the social norm is much more important in developed than in developing countries. Column (1) in Table 6 shows that this is not the case. The importance of the norm is not diminished by excluding the Oecd countries, on the contrary the coefficient

[23] The exact numbers are the following in this example. There are initially 400 females and 3600 males in science and 3600 females and 2400 males in arts. Then $Norm2 = \left|\frac{400-3600}{4000}\right| + \left|\frac{2400-3600}{6000}\right| = 1$.

value of $\Delta Norm2$ increases. Column (2) reports the results of using another proxy for $GENDER$, namely the ratio of female to male average years of schooling in the population over 25 years ($Tyrfm25$). Also this gender equality indicator is insignificant. In columns (3) and (4) the sample is restricted to the period 1980 to 1998. The rational for this is to see if the outcome is improves in the period with the most ability biased technological change. The difference between columns (3) and (4) is that in the latter another measure to capture the degree of political stability (*rule of law*) is used. *Rule of law* is highly significant, and would have been used in the other regressions too if it would have been available from 1970. The change in the social norm is still significant in explaining economic growth, while the importance of investments decreases considerably.

	(1 **Growth**	(2) **Growth**	(3) **Growth**	(4) **Growth**	(5) **Growth**
Investments	0.144*** (0.042)	0.129*** (0.033)	0.048*** (0.052)	0.045** (0.067)	0.050 (0.054)
Scientists	0.032 (0.023)	0.025 (0.017)	0.031 (0.023)	0.036 (0.024)	0.015 (0.018)
Norm 2	-1.037 (0.883)	-1.670* (0.904)	-2.106** (0.892)	-2.121** (0.978)	-0.816 (0.765)
Δ Norm 2	-2.682** (1.084)	-2.482** (0.983)	-3.553*** (1.031)	-3.574*** (1.089)	-2.049** (0.946)
Δ Schooling	0.695* (0.383)	0.425* (0.253)	0.387 (0.287)	0.528* (0.303)	0.433 (0.286)
Gender	-0.023 (0.050)	-1.191 (1.115)	0.054 (0.043)	0.033 (0.042)	-0.020 (0.033)
Initial GDP per capita	-0.0003*** (0.0000)	-0.0001*** (0.00004)	-0.0001 (0.0001)	-0.0002** (0.00006)	-0.0001** (0.00004)
Openness	-0.006 (0.007)	0.003 (0.005)	0.0006 (0.008)	0.005 (0.008)	0.006 (0.006)
Political instability	-0.295 (5.043)	1.788 (5.218)	0.272 (6.553)		1.979 (5.443)
Rule of law				0.443** (0.187)	
R^2	0.50	0.47	0.40	0.46	0.42
N. of obs.	90	145	96	96	142

*** denotes significance at the 99 per cent level; ** at the 95 per cent level; and * at the 90 per cent level. Robust standard errors in parentheses. In (1) the sample is restricted to non-Oecd countries. In (2) *Tyrfm25* is used as a proxy for gender. In (3) the sample is restricted to 1980-1998. *Rule of law* is used in (4) as an indicator of political stability. (5) reports a 2SLS where investments are instrumented with lagged values.

Table 6. Robustness check

In the last column I instrument investments (with lagged values) by 2SLS, which, as expected, mainly results in investments being insignificant.[24]

In summary, the educational social norm ($Norm2$) performs better than what could be expected. When including all the most important growth determinants it remains positively significant. This should at least be taken as another indication that there are still much to do in order to obtain good measures of human capital.[25]

5 Concluding remarks

This paper has studied the determinants of gender-specific educational choices and their consequences for economic growth. Preliminary evidence shows that educational gender stereotypes could have large effects on economic growth. It is therefore important to further investigate the determinants of gender-specific educational choices. If educational differences between men and women are motivated by true differences in preferences, losses in terms of foregone development must be accepted to safeguard individual choice. But, if part of the gender-specific educational choices is due to identity-related mechanisms, there is room for policy action. Subsidies to women investing in science majors and to men becoming arts majors would then be beneficial for the economy as a whole.

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[24] Investments are instrumented with lagged values in an attempt to avoid simultaneity bias, which has been argued to be a potential problem in for example Temple (1999) and Barro (2000).

[25] See for example Krueger and Lindahl (2001) for a critical discussion of the standard human capital measures.

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Appendix

Eastern Europe (EE)	Hungary; Poland
East Asia & Pacific (EAP)	Hong Kong; Japan; Korea. Rep.; Malaysia; Philippines
Latin America (LAC)	Argentina; Barbados; Brazil; Chile; Colombia; Dominica; Ecuador; El Salvador; Guyana; Honduras; Jamaica; Mexico; Nicaragua; Panama; Paraguay; Trinidad and Tobago; Uruguay
Middle East & North Africa (MENA)	Algeria; Bahrain; Egypt; Iran; Jordan; Kuwait; Malta; Morocco; Saudi Arabia; Syrian Arab Republic; Tunisia; United Arab Emirates
Oecd	Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Italy; Luxembourg; Netherlands; New Zealand; Norway; Portugal; Spain; Sweden; Switzerland; Turkey; United Kingdom
South Asia (SA)	Bangladesh; India; Indonesia; Nepal; Pakistan; Sri Lanka
Sub-Saharan African (SSA)	Benin; Burkina Faso; Burundi; Central African Republic; Congo. Rep.; Ethiopia; Ghana; Guinea; Kenya; Lesotho; Madagascar; Malawi; Mauritania; Mozambique; Niger; Rwanda; Senegal; Sudan; Swaziland; Tanzania; Togo; Uganda; Zimbabwe

Table A1. Countries in the sample

Variable	Definition and source
Initial GDP per capita	Real GDP per capita in 1996 international dollars measured at the beginning of each decade. *Source*: Penn World Tables 6.1
Growth in GDP per capita	Average annual compounded growth rate of real GDP per capita, averaged over each ten-years period. *Source*: Penn World Tables 6.1
Investments	Average gross domestic investment as a share of GDP. *Source*: Penn World Tables 6.1
Scientists	Students in science and engineering in per cent of total students enrolled in higher education; measured at the beginning of each period. *Source*: UNESCO (various issues)
Norm1	Surplus of men with respect to women enrolled in science in percentage of total science students (in absolute value). *Source*: UNESCO (various issues)
Norm2	*Norm1* plus the surplus of women with respect to men enrolled in the arts in percentage of total arts students (in absolute value). Arts is here intended as students enrolled in the humanities as defined by UNESCO. *Source*: UNESCO (various issues)
Δ Norm1	Absolute change in *Norm1* over a period. For example , $\Delta Norm1_{80} = Norm1_{90} - Norm1_{80}$.
Δ Norm2	Absolute change in *Norm2* over a period
Δ Schooling	Absolute change in the average years of total education in the population aged 25 and above. *Source*: Barro, R. J. and J.-W. Lee (2000)
Gender	Female labour force as a percentage of the total labour force. *Source*: World Bank (2002)
Openness	Total trade (exports plus imports) as a percentage of GDP. *Source*: Penn World Tables 6.1
Political instability	Average number of regime transitions, authority interruptions and authority collapses in POLITY over each period, where POLITY is a single regime score that assumes the value of 0 in full autocracy and 20 in full democracy. Own calculations on data from Polity IV. *Source*: Marshall, M. G. and K. Jaggers (2000)
Population growth	Average population growth over each period. *Source*: World Bank (2002)

Table A2. Definitions and sources of all the variables