06-16
Working Paper Series

The Impact of Gender Stereotypes on Economic Growth

by Anne D. Boschini

GEM-IWG
The International Working Group on Gender, Macroeconomics, and International Economics
www.genderandmacro.org

The International Working Group on Gender, Macroeconomics and International Economics (GEM-IWG) is an international network of economists that was formed in 1994 for the purpose of promoting research, teaching, policy making and advocacy on gender-equitable approaches to macroeconomics, international economics and globalization. The Program on Knowledge Networking and Capacity Building on Gender, Macroeconomics and International Economics, which was inaugurated in the summer of 2003, has two objectives: first, to engage with fellow economists in order to enhance capacity building in research, teaching, policy making and advocacy in this area; second, to strengthen the intellectual links among practitioners in networks working on similar issues.

The working paper series is designed to create an international forum for scholarly and policy-oriented work on these issues. The goals of the series include:

- To increase the visibility of and centralize access to work in the area of gender, macroeconomics and international economics.
- To make research immediately available to the community, up to a year or more prior to the conclusion of the lengthy review and publication processes of standard academic journals;
- To increase the international supply of this research by providing a publication venue for interested researchers, including Program graduates.

Criteria for Acceptance. The IWG-GEM working paper series publishes papers of high quality that have the following characteristics:

- Make an important contribution to the field of gender, macroeconomics and international economics;
- Build upon and adequately reference the appropriate literatures;
- Are clearly written and accessible to a broad international audience;
- Present clearly the core arguments and methodology.

Submission. To submit a paper to the working paper series, please go to the GEM-IWG website, *www.genderandmacro.org*.

The Impact of Gender Stereotypes on Economic Growth[1]

Anne D. Boschini

GEM-IWG WP 06-16
November 2006

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 69 countries over the period 1970 to 1998 lends empirical support for the importance of the educational gender stereotypes for economic growth.

Anne D Boschini is Assistant Professor at the Department of Economics at Stockholm University. Her main research interests are economic growth, gender, and political economy. Among her publications are "Is team formation gender neutral? Evidence from coauthorship patterns"(joint with Anna Sjögren) forthcoming in *Journal of Labor Economics*, "Foreign aid: An instrument for fighting Communism?" (joint with Anders Olofsgård), forthcoming in *Journal of Development Studies*, and "The political economy of industrialisation" in *European Journal of Political Economy* 22:4 (2006). She has worked as a consultant for the World Bank, and Swedish governmental committees.

[1]I would like to thank Raquel Fernandez, Torsten Persson, and Jesper Roine for comments and suggestions on various drafts of this paper.

The Impact of Gender Stereotypes on Economic Growth

INTRODUCTION

Glancing at higher education statistics for the last 30 years, gives a mixed 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.[2] To put it simply, women still tend to choose arts and not science, while men tend to do the exact opposite.[3] Figure 1 indicates that in 1990 this pattern is present in most countries, except for the few where men dominate education in general.[4]

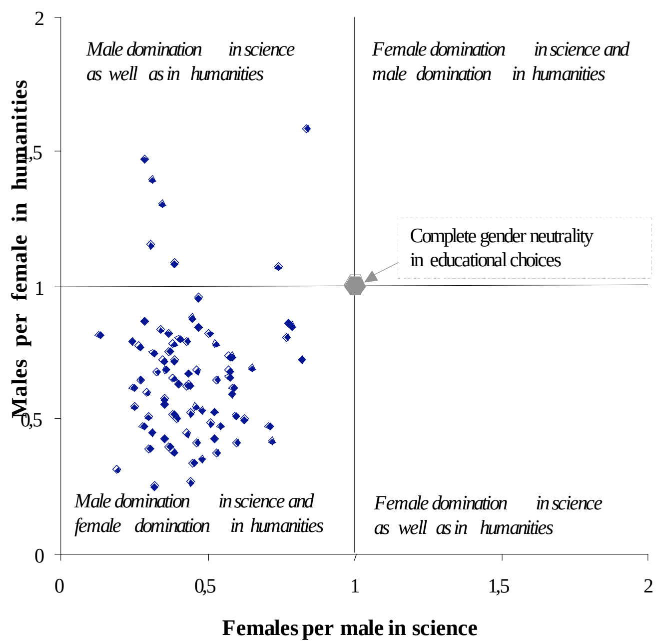

Figure 1. Females dominate humanities and males dominate science, 1990

This paper suggests that gender-specific educational choices have macroeconomic

[2]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.

[3]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 since at least a decade as many female as male students in medical school and law school, while there is a lack of women in science and engineering in many OECD countries.

[4]The data employed in Figure 1 is from *Unesco Statistical Yearbook* and regards the 69 countries used in Section 4.

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, 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.[5] 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 a social norm inflicts 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".[6] For example, interviews with women enrolling in science programs at the university reveal that they feel they are in the wrong place, while interviewed students believe that math and science are better understood by men than by women.[7] 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 behaviour.[8] 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.

What is interesting is that the gender-specific pattern of educational choices remains even when holding the ability of students constant. Take for example the students who are

---

[5]See, for example, Fausto-Sterling (1992), Correll (2001) and Pinker (2002) 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).

[6]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).

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

[8]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.

excellent in math, i.e. those with math SAT scores above 750. Turner and Bowen (1999) show that out of these students, the largest group of females choose to study the humanities, while the largest group of male students choose engineering. Moreover, taking into account that women tend to have a comparative advantage in verbal ability is not sufficient to explain the divergence in educational choices.[9] Also, one could suppose parents' income and education to play a role in the choice of education. Correll (2001) indicates, however, that these variables do not have a different effect on daughters and sons. To sum up, something beyond innate abilities appears to affect women's and men's choices asymmetrically.

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.[10] 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 skilled workers. One of the first articles to incorporate gender in economic growth analysis was Galor and Weil (1996), while later Klasen (1999), Knowles, Lorgelly and Owen (2000) and Kalaitzidakis et al (2001) 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

---

[9]Jonsson (1999) shows that about 10 to 30 per cent of the gender-specific educational choices can be accounted for by men's and women's comparative advantage in different fields of studies at the upper secondary level of education in Sweden.

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

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.

This paper also relates to Knack and Keefer (1997) and Hall and Jones (1999) on the importance of social infrastructure for economic development in that it stresses the importance for growth of gendered social norms in education. As the norm inhibits parts of the population of investing optimally in education it has similar implications as credit constraints on economic growth, that are captured in for example Galor and Zeira (1993), Banerjee and Newman (1993) and Lloyd-Ellis and Bernhardt (2000).

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.

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 in science and arts 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.[11]

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.

Production and Factor Prices

Consider a small open economy, which takes the rate of return to capital as given by the world interest rate $r_t^* = \bar{r}$. 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 have access to 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 in terms only of the capital-labour ratio adjusted for the technological level, $k_t = \frac{K_t}{A_t H_t}$:

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

where the function f satisfies the Inada conditions and is such that $f_k > 0$ and

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) employed in production at time t of sex $j \in \{f, m\}$, where *f* stands for females and *m* for males:

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

In (1) $\beta > 1$ 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. Moreover,

[11] 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.

$g_t \in (0,1)$, so that a higher rate of technological change raises the relative demand for skilled agents, i.e. technological change is ability-biased.

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

$$g_{t+1} = X_t . \qquad (2)$$

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

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

Since the interest rate is constant at $\bar{r}$, the wage rate in any given period depends only on the technological level and a constant, $w_t = \bar{w}A_t$. 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:

$$\begin{cases} w_t^S = \beta\bar{w}A_t \\ w_t^U = \bar{w}A_t(1-g_t) \end{cases} . \qquad (3)$$

Notice that all skilled agents receive the same wage rate independently of subject degree and gender.[12]

Return to Talent

In this model of ability-biased technological change, a person's expected income is determined by her talent in two broad fields (fld), namely science and arts so that $fld = \{sci, art\}$. I assume that cognitive ability is distributed in the same way between men and women in each of the two fields. So, in period t, an agent of sex j possesses two kinds of abilities, science ability, $a_t^{sci_j}$, and ability in arts, $a_t^{art_j}$. For each sex, science and arts abilities are uniformly distributed over the unit interval, and assumed to be

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

independent.[13]

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 number of efficiency units provided by skilled, depending on their specific abilities, and unskilled agents are respectively:

$$s_t^{fld\,j} = (1-\tau) a_t^{fld\,j} \quad \text{and} \qquad u_t = 1.$$

The income of an unskilled agent, I_t^U, is simply equal to her efficiency units of unskilled labour times the wage rate for the unskilled, $I_t^U = \overline{w} A_t (1-\delta g_t)$ and this is the same for men and women. The income of skilled depends on their ability in their chosen field of study, so that the ability in science determines the scientist's income and so on. The gender-specific income of a skilled agent is:

$$I_t^{fld\,j} = w_t^S s_t^{fld\,j} = A_t \overline{w} R a_t^{fld\,j}, \qquad (4)$$

where $R = \beta(1-\tau)$ is the net premium to education. Thus, the income of a skilled man, or woman, only depends on that person's ability in her field of education and her sex.[14]

Educational Choices

When making educational choices, men and women are influenced by a social norm that affects their identity. Akerlof and Kranton (2000) in fact suggest that 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 prescriptions evokes anxiety and discomfort in oneself and in others. Gender identity, then, changes the 'payoffs' from different actions."[15]

[13] 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.

[14] This way of modelling 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).

[15] 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.

In this model, the social norm is such that it imposes a cost on persons choosing a gender atypical education.[16] What society views as a typical behavior for a person of sex j is correlated with how many j -people behave in the same way. Thus, the social 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. Studying science, or the arts, is 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. The norm, $\xi_t^{fld_j}$ depends on the chosen field of study, where $fld \in \{art, sci\}$, and the person's sex.[17]

In formal terms, an agent, that chooses not to invest in education, maximizes her utility so as to respect her budget constraint:

$$\max \quad c_{1t} + \theta c_{2t+1} \qquad \text{s.t.} \;\; c_{1t} + \left(1 + r_{t+1}\right)^{-1} c_{2t+1} = I_t^U ,$$

where c_{1t} 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_{2t+1} is the consumption of that person as retired in $t+1$, and r_{t+1} is the interest rate paid on savings held from t to $t+1$. An agent that does invest in education has the following utility to maximize:[18]

$$\max \quad c_{1t} + \theta c_{2t+1} - \xi_t^{fld_j} \qquad \text{s.t.} \;\; c_{1t} + \left(1 + r_{t+1}\right)^{-1} c_{2t+1} = I_t^{fld_j} ,$$

The social norm in other words directly influences the utility of an agent that invests in education. The resulting indirect utility function for a skilled agent is:

$$v(\cdot) = I_t^{fld_j} - \xi_t^{fld_j} \quad ,$$

while that of an unskilled agent only depends on earned income.

---

[16] 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.

[17] There is in other words a correspondence between the possible fields of study and agents' broad fields of abilities. In the absence of educational norms, the persons that are more talented in science than in arts will major in science and vice versa. A norm can bias the choice of an individual so that it becomes individually rational, but socially inefficient.

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

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. This might appear as a strong assumption, but, as suggested by Figure 1, this assumption is in line with the empirical evidence. That is science tends to be more male dominated than arts is female dominated. Thus, $\xi_t^{fld_j} = 0$ for all except for female science majors, for whom the norm takes the following form:

$$\xi_t^{sci_f} = (1-\lambda)\xi_{t-1} + \lambda G\left(X_t^f - X_t^m\right), \qquad (5)$$

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 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.[19] 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. I adopt the following simplification, $G\left(X_t^f - X_t^m\right) = a_t^{sci_f^*} - a_t^{sci_m^*}$, which gives that

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

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 income as a science (or arts) major less the value of the social norm. Thus, the following must hold:

$$\max\left\{I_t^{sci_j} - \xi_t^{sci_j}, I_t^{art_j}\right\} \geq I_t^U \quad . \qquad (6)$$

Optimal educational choices are obtained by solving () after substituting for income and the expression for the social norm. The outside option, i.e. the 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

[19] If $\xi_0 = 0$, then in optimum, men and women would choose exactly the same amount and fields of education.

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 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 person to invest in becoming a science major:

$$\begin{cases} I_t^{sci_m} = A_t\overline{w}Ra_t^{sci_m} \geq \overline{w}A_t(1-g_t) = I_t^U \\ I_t^{sci_m} = A_t\overline{w}Ra_t^{sci_m} \geq A_t\overline{w}Ra_t^{art_m} = I_t^{art_m} \end{cases}.$$

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

$$a_t^{sci_m^*} = a_t^{art_m^*} = \frac{1-g_t}{R} \quad . \qquad (7)$$

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

$$\begin{cases} I_t^{sci_f} - \xi_t^{sci_f} \geq I_t^U \\ I_t^{sci_f} - \xi_t^{sci_f} \geq I_t^{art_f} \end{cases}.$$

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

$$a_t^{sci_f^*} = \frac{1-g_t}{R} + \eta_t; \qquad a_t^{art_f^*} = \frac{1-g_t}{R}, \qquad (8)$$

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. $\eta_t < 1-\frac{1-g_t}{R}$. 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.

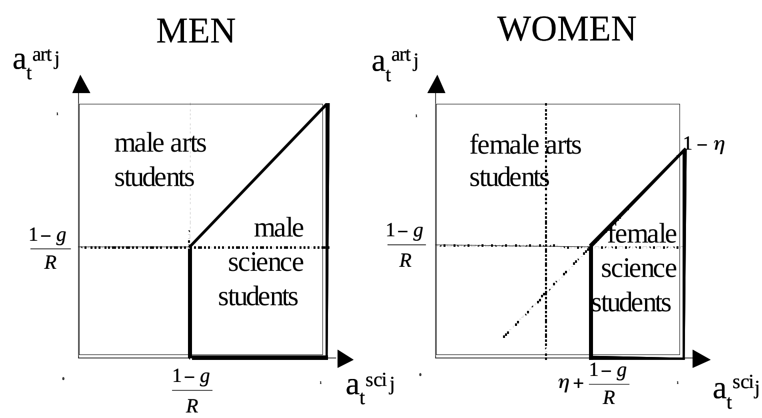

Figure 2. Educational choices in the ability space

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.[20] This is because there are women, who are not talented enough to study arts, but that would have profited from a science major in the absence of 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.

$$X_t^f = \frac{1}{2}\int_{\frac{1-g_t}{R}+\eta_t}^{1}\left(a_t^{sci_f}-\eta_t\right)da_t^{sci_f}; \quad X_t^m = \frac{1}{2}\int_{\frac{1-g_t}{R}}^{1}a_t^{sci_m}da_t^{sci_m} \qquad (9)$$

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, $N_t^f < N_t^m$.

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

It can be shown that the number of students in higher education increases with the rate of technological change and that it decreases with a larger social norm. 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

[20]This outcome of the model might seem to contraddict the recent development in the US and parts of Europe, where there now are at least as many women as men at the universities. It is possible to change this result by minor modifications of the model, but then it would not capture the difficulties of women in accessing education in large parts of the world.

students expands more rapidly than that of male students, due to the diminishing impact of the norm. Proposition 1 formalises these insights.

Proposition *(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 $\frac{(1-\eta_t)^2-\left(\frac{1-g_t}{R}\right)^2}{1+(1-\eta_t)^2-2\left(\frac{1-g_t}{R}\right)^2}$; it is smaller than the share of men in the female dominated arts, $\frac{\frac{1}{2}\left(1-\frac{1-g_t}{R}\right)^2}{\left(1-\frac{1-g_t}{R}\right)^2-\frac{1}{4}\left(1-\eta_t-\frac{1-g_t}{R}\right)^2}$, whenever the assumption made earlier on the maximum size of the norm holds, $\eta_t < 1-\frac{1-g_t}{R}$;
(iii) $\frac{\partial X_t^f}{\partial \eta_t} = \left|-\frac{1}{2}(1-\eta_t)\right| > \left|-\frac{1}{2}\left(\frac{1-g_t}{R}\right)\right| = \frac{\partial N_t^f}{\partial \eta_t}$ since $\eta_t < 1-\frac{1-g_t}{R}$; *(iv)* $\frac{\partial N_t^m}{\partial g_t} = \frac{1-g_t}{R}$, while $\frac{\partial N_t^f}{\partial g_t} = \frac{1-g_t}{R} + \frac{\partial}{\partial g_t}\left(-\frac{1}{2}\left(\frac{1-g_t}{R}\right)\left(\frac{(1-\lambda)\xi_{t-1}}{\bar{w}A_{t-1}(1+g_t)R-\lambda}\right)\right)$, where the last term is positive.

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 present rate of technological change, $A_t \equiv A_{t-1}(1+g_t)$. For a given initial technological level, what matters is the evolution of the rate of technological change. As mentioned above, g_t depends on the number of science majors in the economy.[21] By substituting the number of female and male science majors from (9) into (2), the difference equation governing the rate of technological change becomes:

$$g_{t+1} = X_t^f + X_t^m = \frac{1}{2}\int_{\frac{1-g_t}{R}+\eta_t}^{1} \left(a_t^{sci_f} - \eta_t\right) da_t^{sci_f} + \frac{1}{2}\int_{\frac{1-g_t}{R}}^{1} a_t^{sci_m} da_t^{sci_m}. \qquad (10)$$

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 $\eta_t > 1 - \frac{1-g_t}{R}$; 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, $g_{t+1}^{\min} = \frac{1}{2}\int_{\frac{1-g_t}{R}}^{1} a_t^{sci_m} da_t^{sci_m}$. 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 $g_{t+1}^{\max} = \frac{1}{2}\sum_{j\in\{f,m\}}\int_{\frac{1-g_t}{R}}^{1} a_t^{sci_j} da_t^{sci_j}$.

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 $g_{ss}^{\max}$.

[21]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.

Proposition *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 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

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

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, $\bar{a}_t^{sci_m}$, and the number of male arts majors times their average ability, $\bar{a}_t^{art_m}$,

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

(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,

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

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

Proof *(i)* This follows directly from Proposition 1; *(ii)* This results from the definition of the social norm: the women in the area

$\int_{\frac{1-g_t}{R}}^{1} a_t^{sci_f} da_t^{sci_f} - \int_{\frac{1-g_t}{R}+\eta_t}^{1} \left(a_t^{sci_f} - \eta_t\right) da_t^{sci_f} = \int_{\frac{1-g_t}{R}}^{\frac{1-g_t}{R}+\eta_t} a_t^{sci_f} da_t^{sci_f} + \int_{\frac{1-g_t}{R}+\eta_t}^{1} \eta_t da_t^{sci_f}$ 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 $\frac{\partial S_t^m}{\partial g_t} > 0$, $\frac{\partial U_t^m}{\partial g_t} < 0$, $\frac{\partial S_t^f}{\partial g_t}\Big|_{\eta_t} > 0$, $\frac{\partial U_t^f}{\partial g_t}\Big|_{\eta_t} < 0$ necessarily $\frac{S_t^m}{U_t^m}\Big|_{g_t} < \frac{S_t^m}{U_t^m}\Big|_{g_t^{\max}}$ and $\frac{S_t^f}{U_t^f}\Big|_{\eta_t,g_t} < \frac{S_t^m}{U_t^m}\Big|_{\eta_t,g_t^{\max}}$.

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

$$\frac{\Delta Y_t}{Y_{t-1}} = \gamma \frac{\Delta K_t}{K_{t-1}} + (1-\gamma)\frac{\Delta A_t}{A_{t-1}} + (1-\gamma)\frac{\Delta H_t}{H_{t-1}} \quad , \qquad (11)$$

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 formulated:

Proposition *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.*

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

$$Norm1_t = \left| \frac{X_t^m - X_t^f}{X_t^{total}} \right| \quad , \qquad (12)$$

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:

$$Norm2_t = \left| \frac{X_t^m - X_t^f}{X_t^{total}} \right| + \left| \frac{Z_t^m - Z_t^f}{Z_t^{total}} \right| \quad , \qquad (13)$$

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.[22] 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.

EMPIRICAL EVIDENCE

The sample consists of 69 countries.[23] 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

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

[23] The countries in the sample are the following, divided by region. *Eastern Europe*: Hungary; Poland. *East Asia & Pacific*: Japan; Korea. Rep.; Malaysia; Philippines; Singapore. *Latin America*: Argentina; Brazil; Chile; Colombia; El Salvador; Equador; Guyana; Honduras; Jamaica; Mexico; Nicaragua; Panama; Paraguay; Trinidad and Tobago; Uruguay. *Middle East & North Africa*: Algeria; Egypt; Iran; Jordan; Syrian Arab Republic; Tunisia. *OECD*: Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Italy; Netherlands; New Zealand; Norway; Portugal; Spain; Sweden; Switzerland; Turkey; United Kingdom. *South Asia*: Bangladesh; India; Indonesia; Nepal; Pakistan; Sri Lanka. *Sub-Saharan Africa*: Benin; Central African Republic; Congo. Rep.; Ghana; Kenya; Lesotho; Malawi; Mozambique; Niger; Rwanda; Senegal; Togo; Uganda; Zimbabwe.

for the number of science majors, while to measure the number of arts majors I employ the number of students in humanities.[24]

	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
	Latin America	0.30	South Asia	0.59
▼ **weak norm**				

Table 1. Regions ranked according to norm strength in 1997

Table 1 reports the strength of the gender stereotypes, defined as *Norm 1* and *Norm 2*, in 1997 and how it has changed in percentage points since 1970 across regions, where *Norm 1* varies between 0 and 1 and *Norm 2* 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 otherwise is performing better than average in terms of women's political, legal and economic rights.[25]

But, it must be remembered that *Norm 1* and *Norm 2* only measure the extent to which there are gender stereotypes in education. It is of course perfectly possible that the

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

[25]In Seager (2003) various measures of gender equality, such as political representation, female labour supply, legal rights, basic education, all indicate that the OECD is in the breach of parity between the sexes. A common measure of gender equality is otherwise the United Nations Development Programme's Gender-related Development Index (GDI), which is "composite index measuring average achievement in the three basic dimensions captured in the human development index---a long and healthy life, knowledge and a decent standard of living---adjusted to account for inequalities between men and women" (UNDP, 2003). This indicator also takes into account women's livings standard, and the OECD is of course by far the highest ranked region.

OECD has stronger gender stereotypes in education while being actively enhancing 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.

Educational Choices across Gender and Countries

Table 2 reports the findings for 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 that higher education is highly correlated with economic development.

	Change in share of university students (in per cent of total population) since 1970	Change in share of female students (in per cent of total students) 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. Inve stigating testable implications (1) -(3)

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 have relatively more females in science. The Middle East and North Africa (MENA) has out of their total students more men studying arts and more women in science than in the OECD. This is in contrast with the MENA region scoring considerable lower than the Oecd for example with regard to the UNDP's Gender-related Development Index, which is a weighted average of key development indicators such as life expectancy, educational attainment, and income.

Figure 3 intends to capture whether it is consistent with data that the ratio of female to male science students increases, but at a slower pace than the ratio of female to male university students - denominated as **Implication 3**.[26] 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.

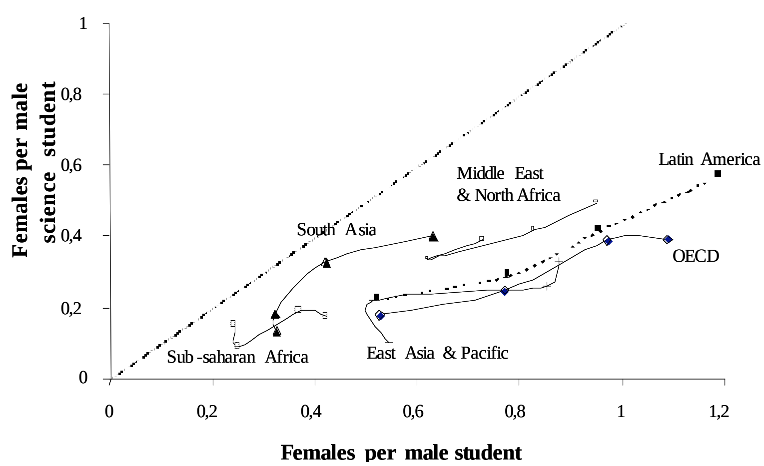

Figure 3. The norm influences females' entry to science more than their entry to university

[26]In Figure 3 only the observations from countries with more than 10000 university students are used. For smaller university populations there is typically too few fields present.

Economic Growth

This subsection aims at understanding the impact of the social norm on economic development by the use of growth regressions. The sample of 69 countries (with an average 2.1 observations each) is pooled so as to obtain in total 145 observations.[27] Putting equation (11) 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), measures the rate of change in the stock of human capital and V is a summary term for control variables.

The model gives a proxy for the rate of technological change, namely the number of science majors - see equation (10).[28] 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, both measured at the beginning of the period, so that $TFP_t = Sci_t + Norm_t$.[29]

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

$$Growth_t = \beta_0 + \beta_1 Inv_t + \beta_2 Sci_t + \beta_3 Norm_t + \beta_4 \Delta School_t + \beta_5 \Delta Norm_t + \beta_6 V_t + \varepsilon_t \quad . \qquad (14)$$

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 stability*, *time dummies* (for decades), *regional dummies* and a proxy to control for overall *gender inequality*. This set of control variables is well motivated by the accumulated findings of the extensive empirical growth literature, reviewed in Temple (1999). Issues of convergence are addressed by including the initial GDP per capita level. The three main potential determinants of long run growth according to Rodrik,

[27]The alternative to pooling the sample is of course not to run a fixed effects model since there are so few observations over time, but rather to run a between estimation or random effects model. As reported in the robustness section 4.2.1 the method of estimation does not alter the qualitative results.
[28]Wolff (2000) also proxied the Solow residual with the number of persons in R&D - a number closely reflecting scientists and engineers.
[29]One could argue that it takes at least a decade before the number of scientists have an impact on the economy. In that case the number of scientist should be lagged by one decade. Testing this empirically however shows that the lagged number (and change) of scientists does not enter significantly.

Subramanian, and Trebbi (2002), namely trade, institutions and geography are roughly incorporated by including *openness*, *political stability* and *regional dummies*.

Following Klasen (1999), it is also crucial to include a proxy for gender inequality, since it otherwise could be the case that what is captured by the social norm is gender inequality. As a proxy I use *fertility,* which is highly negatively correlated with female labor force participation, and thereby the extent to which women are agents in the formal economy, which is the first step towards economic gender equality. (Definitions and sources of all the variables are reported in Table A in the Appendix.) Table 3 shows the descriptive statistics of the major variables in the sample.[30]

	Mean	Std. Dev.	Min	Max
GDP per capita growth **(%)**	1.78	2.25	-3.75	8.20
Investments **(% of GDP)**	18.20	8.32	1.07	47.41
Scientists **(% of students)**	22.02	9.06	2.40	44.52
Norm 1	0.62	0.21	0.04	1
Norm 2	0.93	0.32	0.19	1.81
School **(average years)**	5.36	2.99	0.42	11.42
FM school	0.73	0.27	0	1.18
Fertility	3.81	2.02	1.26	8.26

Table 3. Descriptive statistics

Table 4 reports the results of estimating (14) with ordinary least squares. The first two columns show the outcome when not using any control variables, while the regressions reported in columns (3) and (4) have all control variables included. In the growth regressions in columns (1) - (4), a change in the norm has a significant and expected effect when the norm is measured as *Norm 2*, while *Norm 1* never enters significantly. Also the level of *Norm 2* has a significant negative impact on economic development in two out of three specifications. 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 standard deviation the growth rate increases by approximately 0.73 percentage points, which is a considerable effect. Taking the model seriously, these results are indeed to be expected. Having a non-zero norm only for female scientists is a simplification, so that what ought to be important is not only the net norm for women as

[30]The minimum value of 0 for the ratio of women's and men's average education refers to Nepal 1970, since female average years of education in that year in Nepal approached 0 according to Barro and Lee (2000).

captured by $\xi_t^{sci_f}$, but joint effects of the norms for both female and male skilled agents.

Investments and *education* are good for growth; *initial GDP* and *fertility* are negatively correlated with growth; *openness* and *political stability* are never significant but has the expected sign. The *number of science majors* is always positive, but significant in three out of five specifications, while the *change in the number of scientists* never enters significantly. A higher *ratio of female to male schooling* (the proxy for gender inequality) is puzzling enough harmful for growth in the specifications with *Norm 2*.

	(1) Growth	(2) Growth	(3) Growth	(4) Growth	(5) Growth
Investments	0.122***	0.130***	0.106***	0.119***	0.131***
	(0.028)	(0.028)	(0.034)	(0.033)	(0.031)
Scientists	0.037*	0.039**	0.023	0.037*	0.027
	(0.020)	(0.018)	(0.020)	(0.0 19)	(0.020)
ΔScientists			0.069	0.083	0.071
			(0.057)	(0.052)	(0.049)
Norm 1	-0.816		0.760		
	(1.147)		(1.359)		
Norm 2		-2.283***		-1.455	-1.793*
		(0.805)		(0.965)	(0.976)
Δ Norm 1	-1.966		-1.100		
	(1.464)		(1.524)		
Δ Norm 2		-3.253***		-2.810***	-3.007** *
		(0.913)		(1.074)	(1.088)
Δ School	0.597**	0.604**	0.508**	0.520**	0.468**
	(0.291)	(0.264)	(0.255)	(0.235)	(0.230)
FMschool	-1.329	-2.168**	-1.167	-2.131**	-3.902***
	(0.837)	(0.938)	(1.087)	(1.173)	(1.366)
OECD* FMschool					5.722***
					(1.898)
Fertility			-0.466*	-0.411*	-0.507**
			(0.253)	(0.235)	(0.235)
Initial GDP per capita			-0.0001***	-0.0001***	-0.0002***
			(0.00004)	(0.00004)	(0.00004)
Openness			0.007	0.005	0.004
			(0.006)	(0.005)	(0.005)
Political stabi lity			3.947	3.163	3.230
			(4.834)	(4.697)	(4.573)
R^2	0.41	0.45	0.47	0.50	0.52
N. of obs.	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. The c oefficients for regional and decade dummies are not reported in the table.

Table 4. Main growth regressions

A possible explanation could be that this variable becomes a proxy for economic development that captures that women in developing countries generally have less access to education than men. Introducing an interaction term between the *ratio of female to male schooling* and an *OECD dummy* confirms this. They are jointly significant and the net effect for the OECD is positive. An alternative explanation of this finding could of course be that female education is less important in the developing world, but that is not in line with the empirical results in for example Klasen (1999) and World Bank (2001).

Robustness

When studying the robustness of the results reported in Table 4, I will only use
since that is the formulation of the social norm that has the largest empirical potential. The poolability of the sample is the first important issue that is examined. Given the structure of the sample of 69 countries but at most three observations for each country, it is excluded to run fixed effects models to capture the heterogeneity in the sample.[31] A F-test also fails to reject that the coefficients are the same for developed and developing countries. One could otherwise argue that an educational social norm has a different economic impact in the OECD from the rest of the world, but this does not come through in the data and column (1), Table 5, in fact indicates that changes in the social norm has a large impact in the developing world.

Although poolability across countries does not appear to be a problem, it could still be a problem to merge the data over different decades. A F-test cannot reject that the coefficient of the explanatory variables are the same over time. One way of using the panel dimension of the sample is to run an OLS with average country values over time, that is analysing between estimators. Theadvantage would be that each country gets the same weight in the results, the negative is that the mean of a country's observations could be blurring the information contained in each single observations. Column (2) reports the between estimators of the basic specification with all controls, and the qualitative results are unaltered.[32]

[31]First-differencing would in theory be possible. However, since 23 countries just have one observation, some countries lack the middle observation, and one out of three observations is lost, it is not meaningful to run such as specification due to the scarcity of data.
[32]Random effects estimators could be used as well if it presupposed that the sample of countries is random. Even though the results are qualitatively the same with a random effects model (available from the author upon

Another issue of interest is whether the results are sensitive to the formulation of the norms as (12) and (13). Although not exactly in line with the model, a reasonable alternative of the norms could be the following:

$$Diff\ \ Norm\,1 = \left| \frac{female\ science\ students}{all\,female\ students} - \frac{male\ science\ students}{all\ male\ students} \right|$$

$$Diff\ \ Norm\,2 = Diff\ \ \ Norm\,1 + \left| \frac{female\ arts\ students}{all\,female\ students} - \frac{male\ arts\ students}{all\ male\ students} \right|$$

Columns (3) and (4), Table 5, where the results from using these formulations of the social norm are reported, suggests that the outcome is similar to that reported in columns (1) and (2), Table 4.

In columns (5) and (6) the sample is restricted to the period 1980 to 1998. The rational for this is to see if the economic impact of the social norm increases as there is more ability biased technological change, which actually comes through in the data. The difference between columns (5) and (6) 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. In the last column I instrument investments (with lagged values) by 2SLS, which, as expected, mainly results in investments being insignificant.[33] In summary, the educational social norm ($Norm\,2$) 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.

---

request) it does not seem as a reasonable specification. The present sample is certainly biased towards the more developed countries with more gender equality, due to the lack of gender-specific educational data in many less developed countries.

[33]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).

	(1) Growth	(2) Growth	(3) Growth	(4) Growth	(5) Growth	(6) Growth	(7) Growth
Investments	0.163***	0.093**	0.125***	0.129***	0.048***	-0.007	0.103***
	(0.039)	(0.036)	(0.030)	(0.031)	(0.052)	(0.054)	(0.032)
Scientists	0.044	0.014	0.041**	0.041**	0.038	0.043	0.026
	(0.027)	(0.030)	(0.020)	(0.020)	(0.024)	(0.027)	(0.019)
ΔScientists	0.103*	-0.019			0.159	0.141	0.073
	(0.060)	(0.103)			(0.109)	(0.106)	(0.052)
Norm2	-2.067*	-0.913			-1.581	-1.409	-1.488
	(1.143)	(1.085)			(1.080)	(1.041)	(0.973)
Δ Norm2	-3.876***	-2.344*			-3.168***	-3.351***	-2.802**
	(1.316)	(1.372)			(1 .129)	(1.128)	(1.086)
Diff Norm1			-1.750				
			(1.358)				
ΔDiff Norm1			-1.426				
			(1.260)				
Diff Norm2				-1.774**			
				(0.955)			
ΔDiff Norm2				-1.232*			
				(0.747)			
Δ School	0.943***	1.019**	0.547*	0.529**	0.275	0.35 9	0.452*
	(0.347)	(0.430)	(0.294)	(0.290)	(0.248)	(0.255)	(0.240)
FMschool	-3.980***	-2.825*	-0.982	-0.997	-1.699	-1.409	-2.340**
	(1.493)	(1.604)	(0.856)	(0.844)	(1.647)	(1.695)	(1.171)
Fertility	-0.521*	-0.513*			-1.113***	-0.972***	-0.424*
	(0. 298)	(0.288)			(0.268)	(0.249)	(0.235)
Initial GDP per capita	-0.0002***	-0.0001			-0.0001	-0.0001*	-0.0001**
	(0.00008)	(0.0001)			(0.0005)	(0.00007)	(0.00004)
Openness	-0.003	0.010*			0.008	0.007	0.006
	(0.007)	(0.006)			(0.007)	(0.007)	(0.005)
Political stability	1.536	5.534*			4.216		3.499
	(4.011)	(3.760)			(5.126)		(4.814)
Rule of law						0.156	
						(0.196)	
R^2	0.58	0.62	0.40	0.40	0.50	0.49	0.49
N. of obs	90	145	145	145	95	95	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, while (2) reports between estimators. In (3) and (4) an alternative proxy for the norm is used. In (5) the sample is restricted to 1980-1998. *Rule of law* is used in (6) as an indicator of political stability. (7) reports a 2SLS where investments are instrumented with lagged values. The coefficients for regional and decade dummies are not reported.

Table 5. Robustness check

CONCLUDING REMARKS

This paper has studied the determinants of gender-specific educational choices and their consequences for economic growth. Preliminary evidence suggests that educational gender stereotypes could have large effects on economic development.

The empirical analysis in this paper is however on reduced form, which does not enable the identification of the mechanism through which a social norm generates gender-specific educational choices. According to the model the social norm is determined by how many men and women previously entered science and arts at the university. The norm could of course be shaped much earlier: sociological research indicates that up to one third of the gender-specific choices of education can be traced already to the choice of high school curriculum. Another hypothesis consistent with the empirical evidence in this paper is that these educational choices are the result of the anticipation of labour market conditions. That is, it is the gender segregated labour market that governs young people's educational choices by setting the norms of which occupations they will have in the future.

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.

REFERENCES

Akerlof, G. A. and R. E. Kranton, 2000, "Economics and Identity", *Quarterly Journal of Economics 115:3*, pp. 715-753.

Arnot, M. et al, 1998, *Recent Research on Gender and Educational Performance*, Office for Standards in Education, London.

Baker, D. P. and D. Perkins Jones, 1993, "Creating Gender Equality: Cross-national Gender Stratification and Mathematical Performance", *Sociology of Education 66:2*, pp. 91-103.

Banerjee, A. and A. Newman, 1993, "Occupational Choice and the Process of Development", *Journal of Political Economy 101*, pp. 274-298.

Barro, R. J., 2000, "Inequality and Growth in a Panel of Countries", *Journal of Economic Growth 5*, pp. 5-32.

Barro, R. J. and J.-W. Lee, 2000, International Data on Educational Attainment: Updates and Implications, Harvard University, *CID working paper 42.*

Becker, G. S., 1991, *A Treatise on the Family*, Harvard University Press, Cambridge.

Bénabou, R. and J. Tirole, 1999, Self-Confidence and Social Interactions, *NBER working paper 7585*.

Boschini, A.D., 2002, "Gender-Specific Educational Choices, Earnings Gaps and Technological Change", Stockholm University, *Dissertations in Economics 2002:3*.

Cawley J., Heckman, J. and E. Vytlacil, 2001, Three Observations on Wages and Measured Cognitive Ability, *Labour Economics 8*, pp. 419-442.

Chawanje, C. C., 1991, "Involving Young and Talented Women in Science and Technology Projects in the Third World" in Faraqui, A. M. et al. (ed), *The Role of Women in the Development of Science and Technology in the Third World*, World Scientific Publishing, London.

Correll, S. J., 2001, "Gender and the Career Choice Process: The Role of Biased Self-Assessments", *American Journal of Sociology 106:6*, pp. 1691-1730.

Doms, M., Dunne, T. and K. R. Troske, 1997, Workers, Wages and Technology, *Quarterly Journal of Economics* 112:1, pp. 254-292.

Eccles, J. S., Adler T. and J. L Meece, 1984, "Sex Differences in Achievement: A Test of Alternate Theories", *Journal of Personality and Social Psychology 46*, pp. 26-43.

Ecchevaria, C. and A. Merlo, 1999, "Gender Differences in Education in a Dynamic Household Bargaining Model", *International Economic Review 40:2*, pp. 265-286.

Fausto-Sterling, A., 1992, *Myths of Gender: Biological Theories about Men and Women*, BasicBooks, New York.

Galor, O. and O. Moav, 2000, Ability-Biased Technological Transition, Wage Inequality, and Economic Growth, *Quarterly Journal of Economics 115:2*, pp. 469-497.

Galor, O. and D. N. Weil, 1996, "The Gender Gap, Fertility, and Growth", *American Economic Review 86:3*, pp. 374-387.

Galor, O. and J. Zeira, 1993, "Income Distribution and Macroeconomics", *Review of Economic Studies 60:1*, pp. 35-52.

Gemmell, N., 1996, Evaluating the Impacts of Human Capital Stocks and Accumulation on Economic Growth: Some New Evidence, *Oxford Bulletin of Economics and Statistics 58:1*, pp. 9-28.

Jonsson, J. O., 1999, "Explaining Sex Differences in Eudcational Choice: An Empirical Assessment of a Rational Choice Model", *European Sociological Review 15:4*, pp. 391-404.

Hall R. and C. Jones, 1999, "Why Do Some Countries Produce so Much More Output per Worker than Others?", *Quarterly Journal of Economics 114:1*, pp. 83-116.

Kalaitzidakis, P. et al, 2001, "Measures of Human Capital and Nonlinearities in Economic Growth", *Journal of Economic Growth 6:3*, pp. 229 - 254.

Klasen, S., 1999, Does Gender Inequality Reduce Growth and Development? Evidence from Cross-Country Regressions, *World Bank Gender and Development Working paper 7*.

Keefer, P. and S. Knack, 1997, "Does Social Capital Have an Economic Payoff? A Cross-Country Investigation", *Quarterly Journal of Economics 112:4*, pp. 1251-1288.

Knack S. and P. Keefer, 1995, "Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures", *Economics and Politics 7*, pp. 207-227.

Knowles, S., Lorgelly P. K. and P. D. Owen, 2000, "Are Educational Gender Gaps a Brake on Economic Development? Some Cross-Country Evidence", Department of Economics, University of Otago, mimeo.

Lindbeck, A., Nyberg S. and J. W. Weibull, 1999, Social Norms and Economic Incentives in the Welfare State, *Quarterly Journal of Economics 114:1*, pp. 1-35.

Lloyd-Ellis, H. and D. Bernhardt, 2000, "Enterprise, Inequality and Economic Development", *Review of Economic Studies 67*, pp. 147-168.

Marshall, M. G. and K. Jaggers, 2000, "Polity IV Project. Political Regime Characteristics and Transitions 1800-1999", www.bsos.ukd.edu/cidcm/inscr/polity.

Mincer, J. and S. Polachek, 1974, Family Investments in Human Capital: Earnings of Women, *Journal of Political Economy 82:2*, pp. 76-108.

Murnane, R. J., Willett, J. B. and F. Levy, 1995, The Growing Impact of Cognitive Skills in Wage Determination, *Review of Economics and Statistics 77:2*, pp. 251-266.

Murphy, K. M., Shleifer A. and R. W. Vishny, 1991, "The Allocation of Talent: Implications for Growth", *Quarterly Journal of Economics 106:2*, pp. 503-530.

National Science Foundation, SESTAT database, http://srsstats.sbe.nsf.gov.

Nelson, R. and E. Phelps, 1966, Investments in Humans, Technological Diffusion and Economic Growth, *American Economic Review 61*, pp. 69-75.

Pinker, Steven, 2002, *The Blank Slate. The Modern Denial of Human Nature*, Viking Press, New York.

Rodrik, D., Subramanian, A. and F. Trebbi, 2002, "Institutions Rule: The Primacy of Institutions over Geography and Integration in Economic Development", *CEPR Discussion Paper* 3643.

Seager, J., 2003, *The Atlas of Women. An Economic, Social and Political Survey*, Women's Press Ltd., London.

Seymour, E. and N. M. Hewitt, 1997, *Talking about Leaving: Why Undergraduates Leave the Sciences*, Westview Press, Bolder, Colorado.

Temple, J., 1999, The New Growth Evidence, *Journal of Economic Literature 37*, pp. 112-156.

Turner, S. and W. Bowen, 1999, "Choice of Major: The Changing (Unchanging) Gender Gap", *Industrial and Labor Relations Review 52:2*, pp. 289-313.

UNESCO, various issues, *UNESCO Statistical Yearbook*. Partly available on http://www.uis.unesco.org/en/stats/stats0.htm.

United Nations Development Programme (UNDP), 2003, *Human Development Report 2003. Millennium Development Goals: A compact among nations to end human poverty*, Oxford University Press, Oxford.

World Bank, 2001, *Engendering Development Through Gender Equality in Rights, Resources and Voice*, Oxford University Press, New York.

World Bank, 2002, 2000 World Development Indicators, CD-rom.

Wolff, E. N., 2000, Productivity, Convergence and Education: Evidence from OECD Countries, *OECD Working paper*.

Appendix

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 Norm 1	Absolute change in *Norm1* over a period. For example, $\Delta Norm\,1_{80} = Norm\,1_{90} - Norm\,1_{80}$.
Δ Norm 2	Absolute change in *Norm2* over a period.
Δ School	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).
FMschool	Ratio of female to male average years of education in the population aged 25 and above. Own calculations. *Source*: Barro, R. J. and J.-W. Lee (2000).
Openness	Total trade (exports plus imports) as a percentage of GDP. *Source*: Penn World Tables 6.1.
Political stability	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).
Fertility	Number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with prevailing age-specific fertility rates. *Source*: World Bank (2002).

Table A. Definitions and sources of all the variables