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Are there Gender-Separate Human Capital Effects on Growth? A Review of the Recent Empirical Literature

by

Paula K. Lorgelly

Centre for Research in Economic Development and International Trade, University of Nottingham

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The Author
Paula Lorgelly is lecturer, School of Economics, University of Nottingham.

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Abstract
This paper provides a review of the recent empirical growth literature which includes human capital as a determinant of economic growth; special attention is given to the studies which investigate gender-separate human capital effects. While there is a general consensus regarding the role of (gender-neutral) human capital in the growth process – increasing educational attainment and health status increases labour productivity resulting in greater economic growth – there is a great deal of contradictory evidence regarding the effect of gender-separate human capital on economic growth. For example, in their seminal article, Barro and Lee (1994) find that, while growth is positively related to male education, it is negatively related to female education; Caselli, Esquivel and Lefort (1996), however, find the opposite, while Birdsall, Ross and Sabot (1997) report no significant difference between the genders. This article attempts to appraise and critique this confusing literature, and in the process, resolve many of the existing ambiguities.

Outline

1. INTRODUCTION

The theoretical and empirical literature on economic growth and its determinants is extensive and continues to grow. "'Not another growth regression!' has been more than one seminar participant's cry" (Caselli, Esquivel and Lefort, 1996, p.386, fn.1). The literature ranges from theories of neoclassical growth (Solow, 1956; Swan, 1956) and endogenous growth (e.g. Romer, 1994) to empirical estimations which are becoming more refined, include more variables and use a variety of estimation methods as interest expands. Much of the literature investigates the role of convergence (Mankiw, Romer and Weil, 1992; Barro and Sala-i-Martin, 1992; Caselli, Esquivel and Lefort, 1996) while other researchers seek to determine the relationship between their variable(s) of interest and growth, e.g., inflation and growth (Barro, 1996b) or the role of R&D in the growth process (Nonneman and Vanhoudt, 1996); the list goes on. This article, however, is selective, choosing to focus on empirical growth models that include human capital in gender-separate forms, that is, separate female and male education and health capital.

Before focusing on the gender-separate literature it is first necessary to briefly review the role of aggregate human capital in cross-country growth models. While it is widely accepted that economic growth is the result of capital accumulation (early growth theorists, Solow (1956) and Swan (1956), modelled economic growth using a neoclassical production function, with labour and capital as the determinants of long-run growth), it was not until the late 1980's and early 1990's that economists began to place greater emphasise on the role of human capital as a determinant of productivity and growth. Many empirical studies have since found that human capital accumulation is an important determinant of economic growth. Birdsall, Ross and Sabot (1995) note that "the accumulation of human capital … has consistently emerged as an essential feature of economic growth and development" (Birdsall, Ross and Sabot, 1995, p.180).

In addition to the discussion of the literature that follows, the Appendix provides detailed summary tables of the relevant literature. Table 1 summarizes a large number of growth regressions with gender-neutral human capital, while all the gender-separate human capital growth regressions (known to date) are summarized in Table 2. For each of the studies examined, the tables detail the estimation periods, countries included and explanatory variables, and they also provide details of the estimation methods employed and quote significant findings.

2. AGGREGATE HUMAN CAPITAL GROWTH LITERATURE

2.1 Human Capital in Neoclassical Growth Models

One of the most influential empirical growth studies which includes human capital is Mankiw, Romer and Weil (1992), who test the Solow-Swan theoretical growth model empirically. They assume a Cobb-Douglas production function with two inputs, labour and capital, and model the rates of saving, population growth and technological progress as exogenous. Their empirical results find some support for the Solow-Swan neoclassical model but, because the output elasticity of capital is higher than the expected value of one third (capital's share of income, a, as calculated from national accounts, is approximately one third), they augment the Solow-Swan model to include human capital (in addition to physical capital).[1] Investment in education is proxied by the proportion of the working-age population that is enrolled in secondary school. The augmented model is found to have greater explanatory power than the traditional neoclassical model and it gives a more plausible value for the output elasticity of capital, and more importantly, they find that human capital accumulation positively affects the level of income per worker and, in the transition to the steady state, economic growth.

Mankiw, Romer and Weil estimate their model using cross-sectional data for a sample of 98 countries; the cross-sectional nature of the data means that they are required to assume that each country shares a common production function and that technological progress occurs at a common rate, *g*, for all countries. The assumptions that each country from the poorest to the richest has the same production function, and that technology grows at the same rate in all countries, have been subjected to a great deal of criticism. Temple (1995, 1998) tests Mankiw, Romer and Weil's assumption of a common production function by re-estimating the model but with a different sample of countries. When the OECD countries are excluded from the sample, Temple finds that the coefficient on population growth is no longer significant and that the constant term is higher, suggesting that "either developing countries started with higher initial levels of efficiency – which seems unlikely – or that TFP [total factor productivity] growth was

1 Note that, under the assumption of perfect competition (with no externalities) the output elasticity of capital is equal to capital's share of income.

relatively fast for at least some developing countries" (Temple, 1995, p.9).[2] Temple argues that this evidence suggests that to assume a common production function is incorrect. Brumm (1996) also finds that Mankiw, Romer and Weil's results are sensitive to the sample of countries included. For a sample of "less well-off" countries he finds evidence which rejects the implied restriction that the coefficients on investment and population growth sum to zero; he argues that, for this reason, Mankiw, Romer and Weil's model is not robust. Pugno (1996) also tests the stability of Mankiw, Romer and Weil's results. He finds that the model exhibits structural breaks, such that the coefficient on human capital is insignificant for a sample of labour abundant countries and if influential observations are excluded.

Mankiw, Romer and Weil's use of cross-sectional data results in any unobservable country-specific effects (like differing technologies) being consigned to the error term. Knight, Loayza and Villanueva (1993) and Islam (1995) use a panel data approach to test this assumption, that technological progress occurs at a common rate for all countries. Panel data estimation, argue Knight, Loayza and Villanueva, "allows for a more general econometric specification of the model by appropriately using panel data to account for important country-specific effects" (Knight, Loayza and Villanueva, 1993, p.515). Knight, Loayza and Villanueva and Islam both find evidence of significant country-specific effects, such that estimation of the Mankiw, Romer and Weil model using cross-sectional data is inappropriate. Most of the other Mankiw, Romer and Weil results are confirmed, although Knight, Loayza and Villanueva find a *negative* and significant relationship between human capital and growth. This is explained by the fact that they are using data with a time-series dimension, so the coefficient shows, not only cross-country differences between education and growth, but also changes in education that have occurred over time in each country; and "[t]his temporal relationship has been negative over the years, especially in developing countries … adjusted secondary-school enrollment ratios rose steadily in most developing countries during 1960-85, sometimes by large amounts, while output growth remained stable or fell" (Knight, Loayza and Villanueva, 1993, p.532). Moreover, they suggest that secondary school enrolments may not be a very good proxy for human capital when the span of the data (in their case five years) is too short. Similarly, Temple (1999b) argues that "the effect of human capital

2 A further alternative is that the constant term is a proxy for variables other than technology.

has to be almost immediate if it is to be detected in a panel" (Temple, 1999b, p.133), which is not possible when using school enrolment rates.

In contrast, Islam finds that his education variable (average years of schooling) is not significant in two out of three samples, and subsequently "that in all three samples, the coefficient on the human capital variable now appears (in the restricted version of the model) with the wrong sign" (Islam, 1995, p.1153). He argues that perhaps this lack of significance suggests that human capital accumulation affects growth indirectly through its impact on technology (and hence economic growth) rather than human capital accumulation raising output levels directly. While these two approaches tackle some faults in the Mankiw, Romer and Weil model they are not without faults of their own. Despite the apparent benefits of using a time-series approach (e.g. country-specific effects can be included) disadvantages also exist. Data quality is often low, with a high proportion of the data being based on projections (extrapolations/interpolations) especially when the time span of the data is short, say five years; there is also the problem that annual time-series data (or data with any short time span) requires growth effects to be distinguished from business-cycle effects. Knight, Loayza and Villanueva note that the length of interval is a disadvantage when proxying for human capital and that "cross-sectional data (data where the observations for each country is an average of its respective time series observations) may be the preferred proxy in estimating the growth effects of human capital investment" (Knight, Loayza and Villanueva, 1993, p.533).

In addition to broadening the definition of "capital" to include human capital, human capital has also been extended to include health capital, as well as educational capital. This extension is tested in the context of the Mankiw, Romer and Weil model by Knowles and Owen (1995, 1997).[3] They augment the Mankiw, Romer and Weil model so that health capital, as well as educational capital, are determinants of growth. Health capital is

3 Nonneman and Vanhoudt (1996) also extend Mankiw, Romer and Weil, in an attempt to explain the poor performance of the OECD countries, by including technological know-how. They find support for including R&D in their model, but in the process discovered that human capital is no longer a significant determinant of income per worker and the growth rate for the sample of OECD countries. Mankiw, Romer and Weil report a significant role for human capital in their income per worker regression for the OECD sample, but find a more marginal relationship between human capital and growth.

proxied by average life expectancy at birth.[4] Their results show a "relatively robust relationship between life expectancy, as a proxy for the health capital stock, and income per capita. By contrast the relationship between income per capita and educational human capital, emphasized in the recent theoretical and empirical literature [namely Mankiw, Romer and Weil (1992) and Barro (1991)], is surprisingly 'fragile'" (Knowles and Owen, 1995, pp.105-106).[5] Because Knowles and Owen follow the estimation method of Mankiw, Romer and Weil (they use cross-sectional data) their model is also subject to the criticisms discussed above, with regard to a common production function and a constant rate of technological progress across countries; however, the possibility of bias due to simultaneity is considered, something that is not examined by Mankiw, Romer and Weil. Using two-stage least squares Knowles and Owen find results similar to the original estimation by OLS, implying that causation runs from health to income (although they argue that because it is difficult to obtain valid instruments to control for endogeneity it is easy to overstate such a significant relationship).

Health capital, is also the subject of research for Pritchett and Summers (1996). They aim to determine the direction of causation between health and income. Using an instrumental variables approach they try to identify the effect that income has on health. They proxy for health (the dependent variable in their regression) using both infant mortality and life expectancy; GDP per capita and years of schooling are the explanatory variables. Not only do they find that increases in income raises health status but they also find strong evidence of a causal relationship running from income to health; that is economic growth results in better health. This is contrary to what Knowles and Owen find and suggests that the casual relationship flows both ways or that either one or both studies use instrumental variables that do not adequately control for simultaneity. Knowles and Owen use lagged values as instruments (admitting that they may not be the most appropriate instruments), whereas Pritchett and Summers use instruments which they believe are exogenous in growth models, such as the terms of trade, the ratio of

4 Others, e.g., Barro and Lee (1994) and Wheeler (1980), also include life expectancy as a proxy for health capital in growth regressions, although not in the context of the Mankiw, Romer and Weil neoclassical growth model.

5 Knowles, Lorgelly and Owen (2000), also find the inclusion of life expectancy in a Mankiw, Romer and Weil style model, renders all the explanatory variables but life expectancy to be insignificant, unless base period technology is included in the regression equation. They argue that this suggests that "life expectancy is partly proxying for unmeasured country-specific effects" (Knowles, Lorgelly and Owen, 2000, p.16).

investment to GDP and the black market premium on foreign exchange.[6] Both studies conduct diagnostic tests on the validity of the instruments and find support for the set they use, so which, if either, is incorrect is unknown.

Despite the many differing opinions there is generally wide support in neoclassical growth models for the inclusion of human capital. Both educational capital and health capital are found to be significant determinants of growth. There is also general acceptance in the endogenous growth literature.

2.2 Human Capital in Endogenous Growth Models

Lucas' (1988) seminal work on endogenous growth theory centred around the importance of human capital accumulation as a source of economic growth. Lucas regarded growth as being primarily driven by the accumulation of human capital, such that differences in growth rates are mainly attributable to differences in the rates at which a country accumulates human capital. The earlier work of Nelson and Phelps (1966) also described growth as being driven by human capital, but by its stock (which alters a country's ability to achieve technological progress), rather than its accumulation.

The most notable empirical research in this area is that of Barro (1991). While this research is not strictly an endogenous growth model (few are), some theoretical arguments are used to justify what variables should be included (although no theoretical model is derived to show how these variables should be included). Barro considers unconditional (or absolute) convergence to be unconvincing; poor countries tending to grow faster than rich countries is shown to be inconsistent with the evidence. For this reason Barro models the growth rate to be dependent not only on the initial level of income but also on the initial level of human capital, proxied by enrolments at secondary school level. The regression results support this model; growth rates are found to be positively related to human capital, such that high initial levels of education result in high economic growth. Barro also finds that not only do initial levels of income and human capital matter for income per capita growth rates but they are important in determining physical capital investment and fertility rates too. "Thus poor countries tend to catch up

6 Although, it is possible that they are responding to some other common variable, so are, therefore, not exogenous.

with rich countries if the poor countries have high human capital per person (in relation to their level of per capita GDP), but not otherwise. As a related matter, countries with high human capital have low fertility rates and high ratios of physical investment to GDP" (Barro, 1991, p.437).

Consequently, human capital as a determinant of growth has become widely accepted by most researchers involved in modelling growth. This acceptance, however, did not put an end to research in this area, further debate has arisen regarding whether human capital should enter a growth model in stocks (levels) or in flows (changes).[7]

2.3 Human Capital Measures

Gemmell (1995) provides a good review of the different ways in which human capital enters both the neoclassical and endogenous growth models. In the neoclassical growth model long-run growth in output per worker is a function of the exogenously determined rate of technological progress. By contrast, in endogenous growth models the variables determining the long-run growth rate of output per worker (for example human capital in Lucas, 1988) are endogenously determined. However, Gemmell notes that it is not possible to distinguish between the two models empirically, and he goes on to investigate the role that levels of and changes in human capital have on growth. He uses school enrolment rates to proxy for the human capital stock and accumulation effects. However, school enrolment rates have been criticized as not accurately measuring the stock of human capital, as they reflect only current flows of education (see Barro and Lee, 1993). In a model similar to that of Mankiw, Romer and Weil, Gemmell finds that the level of, and changes in, secondary enrolments have a significant effect on growth in per capita income. Gemmell also finds evidence of an indirect relationship between human capital, investment and growth, such that education has a positive effect on investment which feeds through to growth. Following on from this, Gemmell (1996) constructed a new human capital measure to overcome the interpretation problems of school enrolment rates. The new measure is based on a combination of labour force data and school enrolment rates and is primarily designed to measure educational attainment within the labour force and also allows for the effects of stocks and flows of human capital to be

7 Up to this point most models have been restricted by data availability and have just used the measure that was readily available. However, the 1990's saw the compilation of large educational data sets in this area, for example Barro and Lee (1993, 1996) and Ahuja and Filmer (1995).

distinguished. Using a similar model to that in Gemmell (1995), he again finds support for both initial stocks and subsequent accumulation of human capital in a growth regression.

The measurement of human capital is also foremost in Pritchett's (1996) analysis of growth. Unsatisfied with other measures of human capital, he creates a measure of educational capital from which he determines the growth rate of educational capital (which is a function of the years spent at school and the wage increment of a year's schooling). This measure is used in a growth regression based on the augmented (MRW) Solow-Swan model. The model is estimated using growth rates, because Pritchett regards regressions of growth rates of income on levels of explanatory variables as incorrect in a time series context, "because the stock of education has an obvious upward trend while GDP growth rates do not. Growth rates are stationary (or at least driftless) while the stock of education is non-stationary" (Pritchett, 1996, p.28). Pritchett finds that the impact of growth in educational capital on growth of per worker GDP is small and negative. This result is found to be robust to changes in the sample size, data set and estimation technique. This negative relationship appears again between total factor productivity (TFP) growth and educational capital accumulation. Pritchett uses an argument similar to that of Knight, Loayza and Villanueva to explain this negative correlation. He shows that for various groups of countries, those that experience large rates of economic growth generally have high levels of education (so there is little room for human capital growth), whereas those that greatly increase the level of schooling experience low rates of income growth due to other factors. His main conclusion is that, there is no support for the theory that investment in human capital increases the rate of economic growth, and that it is more likely that economic growth occurs because of a variety of factors working together.

The adoption of human capital as a determinant of growth obviously raises many questions, some of which remain unanswered.[8] However, more recently with the availability of large data sets and the increasing awareness of the role of female education, based on evidence presented in microeconomic studies, the differing roles that female and

8 Some of the non-robustness of these gender-neutral studies may be due to the omission of gender from the models.

male human capital has in the growth process have begun to be analysed. What follows is a detailed discussion of this literature.

3. GENDER-SEPARATE HUMAN CAPITAL GROWTH LITERATURE

There are numerous studies using microeconomic data which highlight the “social” effects of female and male education and health. Greater female education has been found to lower fertility rates (e.g., Blau, 1986; Ketkar, 1978; Cain and Weininger, 1973); while lower fertility rates have been shown to result in lower rates of infant mortality and longer life expectancies (e.g., Blau, 1986; Benefo and Schultz, 1996; Behrman and Deolalikar, 1988). There is also evidence of the inter-generational effects of maternal education and health on children’s education, health and welfare (e.g., Bach *et al*., 1985; Blau, 1986; Schultz, 1988; Behrman and Deolalikar, 1988; Feinstein and Symons, 1999; Behrman *et al*., 1999). Microeconomic rate-of-return analysis also provides evidence of the benefits of female education; Psacharopoulos (1994) finds that the rate of return to female education is positive and marginally higher than that to male education. In contrast, the contribution that female and male education make to growth at a macroeconomic level has only recently been studied, while there is currently only one investigation, to date, on the gender-separate effects of health on growth. Benavot (1989) notes that “models of the impact of education on economic development largely ignore the issue of gender” (Benavot, 1989, p.14). Currently there are around twenty articles (nearly a third of which are by Barro and associates) which investigate the different contributions that female and male human capital make to economic growth and/or productivity levels, see Table 2 in the Appendix. While Benavot was the first to realise this shortcoming in the literature, the most often cited research is that of Barro and Lee (1994).

3.1 Barro and Gender-Separate Human Capital

Barro and Lee extend the earlier work of Barro (1991). Recall that this research finds strong support for conditional convergence, so that the growth rate of a country is not only due to its initial level of income but also due to its initial level of human capital. Barro and Lee further expand this model by widening the measure of human capital to include both education and health capital stock (proxied by life expectancy) and further divide education into separate female and male effects.[9] Barro and Lee's results are obtained using the seemingly unrelated regression equations (SURE) technique applied to cross-country data for two time periods (1965-1975 and 1975-1985), where growth is determined by initial levels of state variables (such as stocks of physical and human capital) and by control or environmental variables (variables which reflect the political environment and actions of private individuals). The resulting regression coefficients have the expected signs (life expectancy is positive and significant), except those on the gender-separate education variables.

Barro and Lee find that, while growth is positively related to male education (as standard arguments would suggest), it is *negatively* related to female education, implying that an increase in the level of female educational attainment will result in a decrease in the rate of economic growth.[10] In an attempt to explain what they regard as a "puzzling finding" (Barro and Lee, 1994, p.18), Barro and Lee suggest that "a high spread between male and female secondary attainment is a good measure of backwardness; hence, less female attainment signifies more backwardness and accordingly higher growth potential through the convergence mechanism." (Barro and Lee, 1994, p.18). However, this explanation is itself puzzling. Given that base-period income per capita is included in the regression, it is expected that this term should pick up the convergence mechanism. Their argument, therefore, appears unconvincing.

Stokey (1994) suggests an alternative explanation for this puzzling result. She notes "that the female variable becomes insignificant when continental dummies are added (Table 5, column 18). Apparently the female variable acts as a dummy for geographic regions or ethnic groups that educate women differently from men" (Stokey, 1994, p.53). Stokey argues that the four East Asian "Tigers" of Hong Kong, Singapore, Korea and Taiwan are such a group, and that it is because of their influence that Barro and Lee find that low educational attainment of women results in economic growth. Stokey also notes that the female and male education variables are likely to be very highly correlated, so "omitting the former seems likely to substantially reduce the size of the coefficients on the

9 The stock of human capital is measured using average years of school attainment, from the Barro and Lee (1993) data set. Educational attainment is a more reliable measure of the stock of human capital than school enrolment rates as previously used by Barro (1991), see Gemmell (1996).

10 However, Barro and Lee seem reluctant to interpret this coefficient as an output elasticity from an aggregate production function, which implies that increasing female schooling reduces output.

latter, casting doubt on their statistical significance" (Stokey, 1994, p.53). Lorgelly and Owen (1999) examine the empirical validity of Stokey's suggestions. Upon replicating Barro and Lee's results they find that the four East Asian Tigers are influential in obtaining a significant negative coefficient on the female education variable. Other influential countries are also identified and they find that when these influential observations are excluded from the sample, not only is the negative coefficient on female education fragile, but so too is the significance of the male education variable, arguing that "[s]tatistical significance that is dependent on the inclusion of a handful of countries should obviously be treated with a good deal of caution" (Lorgelly and Owen, 1999, p.554).

Greater support for Barro and Lee's results could be given if the growth model had stronger theoretical backing, so that a clearer interpretation of the coefficients and their expected signs could be made (see note 10). Barro and Lee's model is rather *ad hoc*; while they include state and control variables, the choice of these appears arbitrary. Barro and Lee assume that "for given values of schooling and health, a higher level of real per-capita GDP reflects a greater stock of physical capital per person" (Barro and Lee, 1994, p.12); that is, initial income, education and health are, together, proxies for initial physical capital, so together give the initial state from where they will start converging to their steady state. However, convergence can be measured, either by the distance from the steady state by using initial capital stock values (physical, educational and health), *or* by using initial income. To include the combination that Barro and Lee have is a misrepresentation of the neoclassical growth model; if Barro and Lee believe that initial education and initial health affect initial income then their approach to convergence is misspecified. Barro and Lee's convergence modelling also leads to a contradiction of their argument as to why the coefficient on female schooling can be negative. If it is to be believed that initial income, education and health are reflecting the initial state of physical capital, then physical capital would depend positively on income, and negatively on education and health (thus female education, male education and life expectancy should all have the same sign).[11] Since a negative sign is to be expected on initial physical capital

11 If income (y) is a function of physical capital (k), educational capital (e) and health capital (x), then

$$y = f(k, e, x)$$

or imposing a Cobb-Douglas production function in a growth regression (by the theory of convergence), this will give a negative sign on initial income (as was found), but positive signs for education and health, which contradicts Barro and Lee's "backwardness" argument.

Another potential problem with the Barro and Lee model is that they carry out very little diagnostic testing to determine how good the model is and thus how reliable the coefficient estimates are.[12] As noted earlier, Barro and Lee estimate their model using a SURE technique and also impose the restriction that the coefficients for each explanatory variable are equal across the two time periods. The SURE technique assumes that while the country-specific random errors are correlated over time, the disturbances in different countries corresponding to the same or a different time period are uncorrelated; therefore, to gain any efficiency from using SURE, over equation-by-equation OLS, there needs to be some correlation between the country-specific random error terms. Barro and Lee test for such a correlation and report that the correlation is small; however, they do not test the restrictions they placed on the model. These restrictions, if incorrectly imposed, could be a source of model misspecification that could result in incorrect coefficient estimates and signs. Lorgelly and Owen (1999) test these restrictions and find that restricting the parameters on either the revolution or black-market premium variables to be equal over time is invalid; however, imposing the data-acceptable restrictions on the SURE model has little effect on the coefficients of the human capital variables.

No other diagnostic tests are reported by Barro and Lee; thus whether the model satisfies basic assumptions of normality, homoskedasticity or correct specification are unknown.[13] Barro and Lee do, however, attempt to control for any reverse causality by estimating their models using instrumental variables (IV) methods. They use lagged values to account for any endogeneity and the IV results closely resemble those of the SURE

$$y = k^{a} e^{b} x^{j}$$

Linearising the model using logs gives

$$\ln(y) = a \ln(k) + b \ln(e) + j \ln(x)$$

and rearranging such that *k* gives

$$\ln(k) = \frac{1}{a}\left(\ln(y) - b \ln(e) - j \ln(x)\right)$$

12 In all fairness diagnostics are rarely reported in empirical growth studies.

13 Lorgelly and Owen in their replication of Barro and Lee did perform these diagnostic tests and report that the "only concern is possible non-normality of the errors in the equation for 1975-1985" (Lorgelly and Owen, 1999, p.543, fn.14).

results. While Barro and Lee do attempt to take account of the possibility of endogenous explanatory variables, their choice of instrumental variables is somewhat flawed. Lagged values are regularly used in time series analysis; however, in a cross-sectional context it is often thought that lagged values are not ideal instruments (see Mankiw, 1995; Evans, 1998; Sims, 1996). Sims argues that the best instruments to use in a cross-sectional analysis are those that are uncorrelated with the country-specific error term; if a country's error term persists over time then lagged values will still be correlated with the country-specific error term and are, therefore, invalid as instruments. This means that while, say, investment in 1960 is likely to be correlated with average investment from 1965 to 1975, it is also highly likely that it could be strongly correlated with the error term for 1965 to 1975. Even if this is not the case, Barro and Lee give no indication of how good the instruments they use are; tests such as the Sargan test for instrument validity are available, however, it appears that Barro and Lee do not employ them. Barro and Lee's analysis is, therefore, not without its faults, and the "puzzling finding" of more female education leading to lower economic growth, should perhaps be interpreted with caution, although, in a further extension of Barro and Lee, Barro and Sala-i-Martin (1995) and Barro (1996a, 1996b) again find similar results.

Barro and Sala-i-Martin (1995) and Barro (1996a, 1996b) employ a variation of the Barro and Lee model, by including a larger number of variables to proxy for the human capital effects. Four education variables are included, female and male secondary and higher education, life expectancy (again as a proxy for health) and an interaction term between initial per capita GDP and the human capital (education and health) variables.[14] The regression results are similar to those of Barro and Lee: the coefficients on male secondary and male higher education are significantly positive, while the coefficients on female secondary and female higher education are significantly negative. Interestingly, in later work, with an updated education data set (Barro and Lee, 1996), Barro (1997, 1998, 1999) finds that "[m]ore surprisingly, female education at various levels is not significantly related to subsequent growth" (Barro, 1997, p.20) so is excluded from subsequent regressions.[15]

14 This interaction term is the mean difference of initial income multiplied by the sum of the mean difference of the five human capital variables (four education variables plus the health variable).

15 The 1996 data set provides estimates of the educational attainment of the population aged 15 and over, as well as for the population aged 25 and over, as in the 1993 data set. Barro and Lee have recently released a

Support for a negative association between female education and economic growth is also given by Perotti (1996). Perotti investigates the relationship between income distribution, democracy and growth in a reduced-form equation *à la* Barro. This equation regresses income distribution, initial per capita GDP, average years of female and male secondary schooling and the PPP (purchasing power parity) value of the investment deflator on the growth rate of GDP per capita, for a group of 67 countries. OLS estimates imply that, like Barro and Lee and Barro and Sala-i-Martin, male education has a positive impact on growth, while female education has a negative impact. Perotti explains this result using the explanation offered by Barro and Sala-i-Martin, that "lower initial female attainment, indicates more backwardness and therefore faster subsequent growth as the economy converges toward its steady state" (Perotti, 1996, p.159).

3.2 Panel Data and Gender-Separate Human Capital

While Barro and his colleagues and Perotti find support for the notion that the education of females will result in lower economic growth others have found the opposite. Caselli, Esquivel and Lefort (1996) argue that much of the existing literature relies on inconsistent estimation methods, so the convergence rate and other coefficients in growth regressions (like those on the male and female education variables) are unreliable. The authors highlight two sources of inconsistency, the incorrect treatment of country-specific effects which results in omitted variable bias and the possibility of simultaneity bias. They argue that almost all existing cross-country empirical growth regressions suffer from one or both of these problems. Caselli, Esquivel and Lefort believe that using panel data and a general methods of moments (GMM) estimator will overcome both these sources of inconsistency.

Their procedure is tested on two growth models, an augmented Solow-Swan model, following the work of Mankiw, Romer and Weil and a more general specification in line with the work of Barro and Lee, which has gender-separate education variables. Using a panel of five-year periods from 1960 to 1985, on a sample of 97 countries, Caselli, Esquivel and Lefort conduct GMM estimation, which involves firstly rewriting the

further updated data set (Barro and Lee, 2000) which also estimates the educational attainment for the population aged over 15 and 25, but is updated to 1995 and provides projections for 2000.

growth regression as a dynamic model in terms of income per capita, then taking differences in order to eliminate the individual country-specific effects and finally instrumenting all the explanatory variables with their lagged values.

The results of the GMM analysis are substantially different from those found by Barro and Lee; life expectancy is no longer significant, but more surprising is the reversal of the signs on the female and male education variable from those reported by Barro and Lee. Caselli, Esquivel and Lefort find growth is positively influenced by female education and negatively influenced by male education. These dramatic changes, they argue, are evidence of the qualitative and quantitative impact that GMM has when used to control for previous inconsistencies. Caselli, Esquivel and Lefort argue that “the female education variable captures both (positive) fertility effects and (negative) human capital effects, and the former outweighs the latter. Male education on the other hand, only represents a human capital effect. Hence its negative coefficient” (Caselli, Esquivel and Lefort, 1996, p.379). However, while they openly admit that “there is no theory that is consistent with different signs for male and female human capital” (Caselli, Esquivel and Lefort, 1996, p.25), is there a theory which suggests that human capital variables should have a *negative* effect on growth, as they have suggested?[16]

Caselli, Esquivel and Lefort make a genuine attempt to overcome some of the problems found in empirical growth research, many of which have been discussed above. By differencing the dynamic model they eliminate individual country effects which, although all researchers accept exist, are generally ignored. They argue that this eliminates any omitted variable bias; however, while this may be the case, differencing the data removes information about the long-run ‘levels’ relationship in the time dimension (Hendry, 1995, p.287). It also introduces measurement error to the model as more noise shows up in changes than in levels of variables (Barro, 1996b; Temple, 1999a).

Caselli, Esquivel and Lefort’s argument, that the changes in their results are due to the impact of GMM, is also supported by Forbes (1998). Forbes also believes that there are

16 There have been a couple of explanations put forward as to why the ‘human capital effect’ should be negative, although they are very much the minority; Barro and Lee (1994) provide the convergence-proxy argument (discussed earlier), while Krueger and Lindahl (1998) suggest that a negative exogenous change in the returns to schooling are consistent with a negative effect.

short-comings in the previous growth literature, namely that of measurement error and omitted variable bias, so employs panel data estimation methods similar to those of Caselli, Esquivel and Lefort. Specifically, Forbes refutes the work of Perotti (1996), that income inequality is detrimental to growth, so estimates a similar equation as Perotti but includes country and period dummies, to control for omitted variable bias and any global shocks, respectively. Using a variety of panel data estimation techniques, namely fixed effects, random effects and a GMM estimator, Forbes finds that, for a sample of 45 countries over the period 1965-1995, the coefficient on income inequality is never negative, but more importantly the coefficient on male education is negative (though not significant) while that on female schooling is positive and significant. Forbes argues that while "this pattern of signs may not support traditional human capital theory, these coefficients … are similar to those found in other growth models estimated using the same technique [namely Caselli, Esquivel and Lefort]" (Forbes, 1998, p.13).

It appears, therefore, that adding a time dimension to growth empirics has implications for the sign and significance of human capital measures. Caselli, Esquivel and Lefort find that in their short-run estimation life expectancy is no longer significant; while they and Forbes also report a reversal of the signs on the female and male education variables from those reported by Barro and Lee and Barro and Sala-i-Martin. Recall, Knight, Loayza and Villanueva (1993) and Islam (1995) found that (aggregate) human capital and growth are negatively correlated in their panel data estimations. This ambiguity among the previous literature is, however, not just the result of time variability; others who employ simple OLS estimation on cross-country data also report alternate results.

3.3 Other Research on Gender-Separate Human Capital

Benavot (1989) investigates the impact of gender differences in education on development, because he believed that growth research prior to 1989 ignored gender separate issues or explained the role of female education only in terms of its impact on female labour force participation and reproductive behaviour. Benavot sought to rectify this by estimating "panel regression models" (Benavot, 1989, p.20) where the log of per capita GNP for 1985 is regressed on the log of per capita GNP for 1960, female and male primary and secondary enrolment rates, a dummy variable capturing those countries that are major mining and oil exporters, the export commodity concentration (a proxy for economic dependence), the total fertility rate and the rate of female labour force participation, for a sample of 96 countries. Unlike later researchers Benavot does not include female and male education variables in the same regression, "to ensure that the results are not adversely affected by high collinearity" (Benavot, 1989, p.23). This consideration for multicollinearity is one that is often overlooked by other researchers.

Using OLS estimation, Benavot finds that both female and male primary enrolment rates have a positive and significant effect on growth, with secondary enrolments having little effect. He experiments with different sub-samples and finds similar results for less developed countries, classified by region, income and universal primary education. Furthermore, "the parameter associated with females (.0064) is higher than that associated with the primary education of males (.0056)" (Benavot, 1989, p.56) suggesting that the education of females is more important than that of males, so "educational expansion among school-age girls at the primary level has a considerably stronger effect on long-term economic prosperity than does educational expansion among school-age boys" (Benavot, 1989, p.27). However, this interpretation is strictly not correct. Since both female and male education are likely to be highly correlated with the level of total (gender-neutral) education, and both are not included in the same equation, what the results are probably reflecting is the positive relationship between *general* education and economic growth, rather than female and male education *per se*.[17] Given this, one should be cautious when attempting to compare the different contributions of female and male education. Similar caution should be exercised when interpreting Engelbrecht's (1998) results. Engelbrecht investigates the role of human capital in the absorption of R&D spillovers, and the effect of these spillovers on total factor productivity. He finds that the coefficient and "semi-elasticity" on female education is larger than that on male education, thus concludes that female primary schooling is particularly important for growth in developing countries. However, as with Benavot, female and male education are not included in the same estimating equation, so it is more likely that the result is reflecting the general level of education.

Similar problems are encountered when trying to interpret the findings of Birdsall, Ross and Sabot (1997). In their "Barro-style" regression they argue "that increasing primary school enrolments for girls is just as effective in stimulating growth as increasing primary

17 It is also unlikely that the coefficients (0.0064 and 0.0056) are significantly different from each other.

enrolments for boys" (Birdsall, Ross and Sabot, 1997, p.100). However, their estimating equation includes total (aggregate) secondary school enrolments as well as female and male primary enrolments. While they admit that "there is substantial multicollinearity affecting the estimators of the primary school enrolment coefficients" (Birdsall, Ross and Sabot, 1997, p.100, fn.21) which may be influencing the significance of the coefficient estimates, it is also highly likely that the presence of aggregate secondary school enrolments may be taking much of the significance away from the gender-separate primary enrolments.

In addition to these criticisms, the use, by Benavot and Birdsall, Ross and Sabot, of school enrolments as a measure of the human capital stock is misspecified.[18] School enrolment rates do not take into account school repeaters or dropouts, and they also do not accurately measure the stock of human capital; it is for these reasons that Barro and Lee (1993) developed their education data set. They argue that "[s]chool enrollment ratios reflect current flows of education, and the accumulation of these flows will be one element in the stocks of human capital that will be available *later*" (Barro and Lee, 1993, p.365, emphasis added); whereas their measure of educational attainment, average years of schooling, provides a more adequate measure of the quantity of education which is available for *current* production.[19]

Dollar and Gatti (1999) also find evidence to support the argument that gender inequality is harmful for growth, but do so using an alternative measure of education: the percentage of the female or male population for whom primary (secondary) school education is the highest level of education attained. Dollar and Gatti "start with a basic panel growth regression, drawing on a specification that is common in the literature, and then add male secondary achievement and female secondary achievement in order to see whether gender differentials have an impact on growth" (Dollar and Gatti, 1999, p.18). First, however, they estimate equations explaining gender inequality. In this initial estimation a strong convex relationship is found between income and gender inequality, measured as female

18 Admittedly, Benavot would have had a very limited source of education data available to him. Benavot's research predated the Barro and Lee (1993) education data set, as well as many other data sets.

19 Pritchett (1996) is also critical of using enrolment rates, arguing that "initial enrollment rates [are] a worse than terrible proxy for the rate of growth of human capital" (Pritchett, 1996, p.23).

secondary attainment.[20] This relationship is retained even when income is instrumented for and the equation estimated with two stage least squares (2SLS), suggesting that income has a causal effect on female education; therefore, in a growth regression female education is potentially endogenous. The growth regression is also estimated using 2SLS to control for this potential endogeneity, using religion and civil liberties variables as instruments for both female and male education.

Dollar and Gatti estimate this relationship for the whole sample and for “less developed” and “more developed” countries (where development is measured by female secondary attainment). They find that when estimating the growth equation for the full sample “there is a weak negative coefficient on male education and a weak positive coefficient on female education” (Dollar and Gatti, 1999, p.19); Dollar and Gatti argue that this result is primarily due to the presence of regional dummies; that is, Latin America’s poor growth experience is attributed to the female education variable when the regional dummies are not included.[21],[22] More conclusive results are reported for the “more developed” sample which finds “a negative [though not significant] coefficient on male secondary attainment and a significant positive coefficient on female attainment” (Dollar and Gatti, 1999, p.20). This leads them to conclude, “the opposite of what Barro and Lee (1994) found” (Dollar and Gatti, 1999, p.19), that gender inequality is harmful for growth.

However, their conclusion is not strictly correct since Barro and Lee’s results are for a full sample of countries, and Dollar and Gatti’s results are a consequence of splitting the sample by high and low levels of female education, given that in their full sample they find both female and male education to be insignificant. The fact that they only find gender inequality to be a significant hindrance on growth for a sample of countries which already experiences high levels of female education is interesting. They state that “[i]t is a fair generalization to say that the relative status of women is poor in the developing world,

20 Gender inequality is also measured using female life expectancy, the differential between female and male educational attainment and life expectancy, indexes of legal and economic equality of women and measures of women’s empowerment. All measures tend to give similar results.

21 Interestingly, when Barro and Lee add regional dummies to their estimating equation (Barro and Lee, 1994, Table 5, column (18), p.17) the results report an insignificant role for female education, one of the few times the female education variable is found to be insignificant, although the coefficient estimate is still negative.

22 Interestingly, when Barro and Lee add regional dummies to their estimating equation (Barro and Lee, 1994, Table 5, column (18), p.17) the results report an insignificant role for female education, one of the few

compared to developed countries" (Dollar and Gatti, 1999, p.20), but in their sample of developing countries (those where less than 10.35% of the female population have some form of secondary attainment) they do not find a significant role for female or male education, and in fact report a negative coefficient (though insignificant) on the female education variable. Dollar and Gatti go on to conclude that their results suggest that lower investment in female human capital is not an efficient economic choice for *developing* countries; however, the evidence they report does not actually support this.

Along side the debate on the varying importance of female and male education in growth equations, investigations into the gap between female and male education and whether this gap hinders economic growth and productivity have emerged. Hill and King (1993, 1995) were the first to investigate the relationship between gender gaps in education and income.

3.4 Research on Gender Gaps in Human Capital

Hill and King's primary focus is on the role that female education and the gender gap in education (measured as the ratio of female to male enrolments) has on indicators of social well-being, mainly fertility, infant mortality and life expectancy. They find support for increases in female education and decreases in the gender gap between female and male education resulting in increases in social well-being.

Hill and King use a recursive model to estimate their social indicator equations. They first estimate an income (GNP) equation, then place this estimate into the social indicator equations. The determinants of the income equation are modelled within, what they regard as, a production function framework. Income is a function of the stock of physical capital, the labour force, the female secondary enrolment rate, the female to male enrolment ratio (primary or secondary enrolment depending on which gives the largest gap for each country) and two interaction terms (the enrolment rate multiplied by the capital stock and labour force). Because female education and the gender gap are included in the income equation and the social indicator equations, it enables Hill and King to investigate both the direct and indirect effects of education.

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times the female education variable is found to be insignificant, although the coefficient estimate is still negative.

A pooled time-series approach is employed by Hill and King, whereby data for five-year periods from 1960 to 1985 are pooled together for a sample of 152 countries. The income regression results find that female enrolment, the labour force and the capital stock are significantly positive, while larger gender gaps in education (that is, smaller female/male ratios) are significant and negative. Hill and King calculate that for a given level of female education, labour force and capital stock, a country with a large gender gap in education is likely to have income that is 25 per cent lower than a country with a smaller gender gap. This leads the authors to conclude that female education and the gender gap are important determinants of both family well-being and economic growth.

This model suffers similar problems to those discussed in the review of Barro and Lee and Barro and Sala-i-Martin. While no diagnostic tests are reported, Hill and King do, however, base their model on a production function, thus appealing to some economic theory; however, their inclusion of a gender gap in that function is misplaced. For the gender gap to be included in the production function it would need to be a factor of production, but, why would the gap between female and male education aid in producing output? Hill and King's use of the term "production function framework" (Hill and King, 1995, p.27) is, therefore, somewhat misleading.

The gender gap is included in the regression in three separate forms. Dummy variables are employed and countries are grouped according to whether their female/male enrolment ratio is less than 0.42, between 0.42 and 0.75 or between 0.75 and 0.95. The use of dummies is surprising since the gender gap variable could be measured continuously. Using dummy variables rather than the actual values results in information being lost from the data. The measurement of the gender gap also introduces a problem. As stated earlier, it is measured as the ratio of female to male enrolment at the primary or secondary school level, depending on which is smaller, where the gap was larger. Since this variable is not being measured consistently across countries, it introduces measurement error to the model; and because the ratio which gives the largest gap is chosen, there will also be upward bias on the gap coefficient, compared to using a consistent measure (primary *or* secondary) across all countries. Despite this, including a gap is one possible approach to reducing the multicollinearity which is likely to exist between male and female education variables.

Finally, the attempt to control for endogeneity in the social indicator equations, by first estimating GNP and then using the predicted value is desirable; however, Hill and King have ignored the possibility of causality in their income equation. GNP is found to be a significant determinant in the authors' life expectancy and mortality equations. It is possible that life expectancy and mortality in turn could influence the size of labour force, a determinant in the income equation, which could result in simultaneity bias.

Despite the problems outlined above, Hill and King's research finds that failure to improve female education to the same (or higher) average level as that of males will act as a brake on development, since improving female education levels not only benefits individuals (greater life expectancy, lower infant mortality and fertility) but also benefits communities (greater income per capita). This result obviously contrasts with that of Barro and Lee and Barro and Sala-i-Martin, further reinforcing that the current empirical evidence on the contribution of female and male human capital is ambiguous.

Klasen (1999) also investigates what effect gender inequality in education has on economic growth. He studies both the direct effects that gender bias in education has on growth, and any indirect effects it may have on investment, population growth and labour force growth. Klasen is weary of previous research which includes female and male human capital variables in the same regression; he believes (like Stokey, 1994) that Barro and Lee's "puzzling finding" is possibly due to the high collinearity between the two education variables. To avoid any multicollinearity in his estimates of growth, Klasen includes proxies for the general level of education and the gender gap in education, whereby "the first variable tries to capture the effect of the overall level of education on growth, and the second one measures whether a country with smaller gender differences in education would grow faster than a country with identical average human capital but greater inequality in its distribution" (Klasen, 1999, p.13). Recall, Hill and King (1993, 1995) also include a measure of the level of education and measure of the female-male ratio in their estimating equation, however Klasen notes that his "study differs from Hill and King in trying to explain long-term *growth* of GDP/capita rather than *levels* of GDP per capita, in using a broader and longer data set, in using a more reliable measure of human capital and in including other standard regressors of the empirical growth literature" (Klasen, 1999, p.5). Unfortunately, while he does include more explanatory variables, he does so (as do Hill and King) in an *ad hoc* fashion, such that his results, like much of the previous literature, are difficult to interpret on a theoretical level.

Klasen's estimation of growth also differs from Hill and King's because, as well as including the base period values for the general level of education and the gender gap in education, he also includes the growth rates of these variables, thereby including stock and flow measures of human capital. Recall, Gemmell (1995, 1996) and Pritchett (1995) investigate the varying roles for levels of and changes in (aggregate) human capital; using a similar argument Klasen notes that since he is modelling economic *growth* "it appears appropriate to focus on flow measures such as physical and human capital investment and thus use the change in years of schooling as a proxy for investments in human capital. At the same time it may be the case that … the stock of human capital increases the growth of the economy as it makes physical capital more productive" (Klasen, 1999, p.26, fn.29).[23]

Regressing total years of (male) schooling and the female-male ratio of total years of schooling for 1960, the growth rate from 1960 to 1990 for these two education variables and a variety of other explanatory variables on per capita GDP growth from 1960 to 1990, Klasen finds that both the initial gender gap and the expansion of the female-male ratio (that is, increasing female education and decreasing or constant male education over time) both have a significantly positive impact on economic growth. He also addresses the possibility of simultaneity bias estimating 2SLS regressions, and again, he finds that the coefficient on the educational gender gap variable is significant, which, he argues "lends further support to the contention that causality runs from gender bias in education to economic growth and not the reverse" (Klasen, 1999, p.19). Klasen also finds a significant role for gender gaps in education indirectly hindering economic growth through its impact on investment and population growth.

Sadeghi (1995), using a simple model to investigate the role that gender gaps in literacy levels and enrolment rates have on GNP growth, also finds that narrowing the gender gap in education will result in greater income growth. In a model where growth depends *only*

23 It is important to note that such a debate with regard to stocks and flows would be obsolete if Klasen employed a theoretical model.

on educational gender gaps and country dummies, he finds that reducing the gap between male and female literacy levels or between male and female primary or secondary enrolment rates will have a positive and significant effect on growth. However, the model lacks complexity and it would be desirable to include more variables like a country's initial endowment of resources or variables which reflect a country's growth environment (like investment rates, health, population growth).

One final study which attempts to rectify many of the shortcomings of the literature is Knowles, Lorgelly and Owen (2000). They include gender-separate education in a Mankiw, Romer and Weil style neoclassical growth model; this allows for the coefficients to be interpreted explicitly, and it also allows for them to reparameterize the model to include a gender gap, in a similar fashion to Hill and King (1993, 1995). Knowles, Lorgelly and Owen express similar concerns as Caselli, Esquivel and Lefort (1996) and Forbes (1998) regarding the possibility that much of the growth literature yields biased estimates because the country-specific error terms are likely to be correlated with the explanatory variables. Given that their interest is the long-run steady-state relationship between gender-separate education and output per worker, and differencing the data (as required for GMM estimation) removes information about the long-run and eliminates the between-country variation, they use "cross-section regressions with time averaged data to estimate the parameters in the long-run steady state relationship" (Knowles, Lorgelly and Owen, 2000, p.13).[24] They also attempt to correct for any potential bias in the model, due to unmeasured country-specific effects, by including a measure of base-period technology.

In numerous versions of their model (they add additional control variables, take account of outliers and influential observations, and estimate the model using 2SLS) Knowles, Lorgelly and Owen find the coefficient on female education and its implied elasticity is significantly positive, while the coefficient for male education is not significantly different from zero (although it is negative and significantly so in some of the 2SLS estimations). In the reparameterized version of the model, which allows them to estimate the effect of the gender gap in education and interpret this result explicitly using the theoretical

24 Persaran and Smith (1995) and Phillips and Moon (1999a, 1999b) show that cross-section regressions based on long-time averages can produce consistent estimates of average long-run coefficients.

framework, they report that the "interpretation of the coefficient on the gender gap variable depends crucially on what other education variables (male or female) are included in the equation" (Knowles, Lorgelly and Owen, 2000, p.25), but generally find that there is "a significant long-run effect of the education gender gap on output per work, but no additional effects from either of the separate levels of schooling" (Knowles, Lorgelly and Owen, 2000, p.26). While this finding is similar in nature to Hill and King and Klasen (so again is the opposite to Barro and Lee) it does call into question whether they correctly interpreted the coefficients on their education and gender gap variables given the *ad hoc* nature of the estimation equations.

In an attempt to reconcile their results with the opposing literature, namely Barro and Lee, Knowles, Lorgelly and Owen re-estimate their model using data for one point in time for the human capital variables, rather than with long-run averages. Estimating the model with 1990 values (as the original Mankiw, Romer, Weil model implies) is found to have little effect on the results, however, using base-period values (*à la* Barro) results in a significant positive coefficient for the male education variable, while the coefficient on the female education variable is found to be insignificant. This suggests "that a major contributing factor in explaining the difference between our results and Barro's [and much of the other literature reviewed above] is [the] use of base-period values for the human capital stocks in his growth equation" (Knowles, Lorgelly and Owen, 2000, p.20).

3.5 Gender-Separate Health Capital

Currently, there is just the one investigation on the varying roles that female and male health capital may have on economic growth. This may partly be due to the fact that there have been few studies which consider the role of aggregate health in promoting economic growth; in addition, it may also be due to the limited availability of data on separate measures of female and male health status. Data that are available to measure gender-separate health status include infant mortality, adult mortality and life expectancy.[25] Lorgelly (1999), following Knowles and Owen (1995, 1997), proxies for the stock of female and male health capital using the shortfall of average female and male

25 These are all measures of mortality, rather than morbidity. Ideally when examining the relationship between health and labour productivity, data on morbidity would be preferable, unfortunately this information is not available at an aggregate level for a large cross section of countries, let alone separately for females and males.

life expectancy at birth from 85 years, respectively. In a Solow-Swan type model, which includes gender-separate life expectancy as the sole measure of the stock of human capital, and in a model which includes both gender-separate education and life expectancy, Lorgelly finds, using average long-run data similar to Knowles, Lorgelly and Owen (2000), that "investment's share in physical capital and the stock of female human capital (with education or health) are significant determinants of income per worker, while the implied elasticities a, b_f and j_f are also found to be significant" (Lorgelly, 1999, p.85). These relationships are found to be robust for a wide range of sensitivity analyses, including the exclusion of outliers and the inclusion of a measure of base-period technology. The models are also estimated using non-averaged data and she finds, like Knowles, Lorgelly and Owen, that the "significant relationship between female human capital and labour productivity is more conclusive when the data are averaged over a long time span, which is consistent with the view that long time averages are more informative about long-run effects" (Lorgelly, 2000, p.124).

Lorgelly, however, admits that the female and male health capital measures she uses are highly correlated (a pairwise correlation of 0.981 is reported). While she further admits that the quality of the gender-separate data may be dubious, noting that Sen (1990) has expressed concern about the accuracy of the female life expectancy data: "[t]here are problems in interpreting the available [life expectancy] data and difficulties at arriving at firm conclusions … [f]or example the World Bank's most recent *World Development Report* [1990] suggests a life expectancy [in China] of sixty-nine years for men and sixty-six years for women (… [while] the same *Report* also suggest an average life expectancy of seventy years for men and women put together)" (Sen, 1990, p.65). Aside from these data issues, Lorgelly makes a initial attempt at investigating the varying contributions of female and male health capital to the growth process (she employs a theoretical model, conducts sensitivity analyses and allows for the possibility of endogeneity), and it will hopefully lead into further research in this area.

4. CONCLUSION

Despite the fact that "the accumulation of human capital … has consistently emerged as an essential feature of economic growth and development" (Birdsall, Ross and Sabot, 1995, p.180), there is a great deal of ambiguity surrounding the exact role that this accumulation has in the growth process. Some researchers have found that the accumulation of education and health capital stock is an important factor in achieving growth (Mankiw, Romer and Weil, 1992; Barro, 1991; Knowles and Owen, 1995, 1997), while other researchers report evidence of a negative or insignificant relationship between educational capital and growth (Knight, Loayza and Villanueva, 1993; Islam, 1995). There is also some dispute regarding the direction of causality between health capital and growth (e.g. Knowles and Owen, 1995, 1997; Pritchett and Summers, 1996).

Further ambiguity exists among research that includes gender-separate education as a determinant of economic growth. One of the most influential empirical studies (Barro and Lee, 1994) finds that female education has a negative effect on growth while male education has a positive effect (a relationship which is also found in later work by Barro (Barro and Sala-i-Martin, 1994; Barro, 1996a, 1996b) and by Perotti (1996)). However, Caselli, Esquivel and Lefort (1996) and Forbes (1998) find, using a panel data approach, the opposite. Hill and King (1993, 1995) also find support for a positive relationship between female education and income per capita and, in addition, find that narrowing the gender gap between female and male education will also enhance income per capita, a finding which is also supported by the research of Klasen (1999) and Knowles, Lorgelly and Owen (2000). Lorgelly (1999) reports additional evidence of a positive relationship between female health capital and income per capita, such that improving female health will increase labour productivity.

The contradiction and ambiguity in the literature appears to be due to a variety of factors. It appears to matter whether the focus is on the short-run or long-run relationship between human capital and economic growth. Researchers that use panels of data with short time spans and/or difference the data (e.g. Caselli, Esquivel and Lefort, 1996), are not strictly focusing on the long-run, and, therefore, may not be picking up long-run growth effects. Similarly, it also appears to depend on whether human capital is measured in the base year or not. Research which includes initial human capital measures (e.g. Barro and Lee, 1994, Barro and Sala-i-Martin, 1995) reports a negative coefficient on female education, while, research that averages female and male human capital over time (e.g. Knowles, Lorgelly and Owen, 2000; Lorgelly, 1999) reports a positive and significant role for female education and health. The former result may be due to the influence of certain countries who had very low levels of educational attainment, and subsequently experienced a rapid increase. Following Stokey's (1994) suggestion that perhaps the four East Asian Tigers are such a group of countries, Lorgelly and Owen (1999) found using influential observation analysis that this is indeed the case, suggesting that a robust finding is dependent on whether influential observations are taken account of. Further, it appears to matter what educational data are used. Barro (1997, 1998, 1999) use the updated Barro and Lee (1996) data set and no longer find a significant (or even negative) role for female education. Finally, finding an unambiguous result could depend on whether the relationship between gender-separate human capital and growth is estimated within the bounds of a theoretical model. Employing a theoretical model allows Knowles, Lorgelly and Owen to interpret the coefficients on their female and male education variables in an explicit context, and they are able to further postulate on the role of gender gaps in education.

Given the above points, if it is the long-run relationship that is of interest and if education is not measured in the base year, then the majority of the research would suggest that there are gender-separate human capital effects on growth; further, it appears that female educational capital and health capital have a greater impact on economic growth than male human capital stocks.

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Appendix

Table 1 Summary review of the (gender-neutral) growth literature

The following table summarizes a selection of empirical studies which include gender-neutral human capital as a determinant of growth across countries. An asterisk (*) indicates the explanatory variables which are significant at the 1% or 5% level of significance.

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Barro (1991)	1960-1985	98 developed and developing countries	Annual average growth rates of per capita real GDP	Real GDP per capita*, Secondary school enrolment rate*, Primary school enrolment rate*, Ratio of average real government consumption to real GDP*, Revolutions per year*, Assassinations per million*, Deviations of the PPP value for the investment deflator (a market distortions proxy)*	OLS estimation	"Moreover, given the level of initial per capita GDP, the growth rate is substantially positively related to the starting amount of human capital. Thus, poor countries tend to catch up with rich countries if the poor countries have high human capital per person (in relation to their level of per capita GDP), but not otherwise." (p.437)
Gemmell (1996)	1960-1985	98 countries	Average annual per capita GDP growth	Log of initial GDP per worker*, Log of investment to GDP ratio*, Log of labour force growth*, Log of the initial stock of primary*, secondary and tertiary human capital, Growth rate of primary, secondary and tertiary human capital stock	OLS estimation and 3SLS with an investment equation	"[T]he use of school enrolment rates (or literacy) rates as human capital measures cannot distinguish these two effects and are, in any case, very limited proxies for the conceptual variables they are meant to measure. The human capital measures proposed here provide a better (through still imperfect) means of separating stock and accumulation effects and are conceptually better than school enrolment rates. The evidence … provides considerable support for a role for *both*

	initial stocks and subsequent growth of human capital in fostering faster income growth." (pp.23-24)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Islam (1995)	1960-1985	79 non-oil countries	Log of per capita GDP	Lagged income per capita*, Log of investment to GDP ratio*, Log of total population growth rate*, Log of average years of schooling for total population aged 25 and over	Cross-sectional, pooled and panel estimation	"What this implies is that incorporation of the time dimension of the human capital variable into the analysis annihilates the effect that the cross-sectional variation in human capital had on the regression results." (p.1152)
Knight, Loayza and Villanueva (1993)	1960-1985	98 non-oil countries	Log of GDP per worker (5 year difference)	Log of initial income*, Log of investment to GDP ratio*, Log of working-age population growth rate*, Log of percentage of working-age population in secondary school*	Panel data estimation using Chamberlain technique	"We find that the estimated coefficient on this [human capital] proxy is now significantly negative for both samples… Our explanation for this result is that when we incorporate time series data on education for each country we use not only the cross-country differences in the relation between education and growth but also the effect of *changes* in the human capital proxy over time in each. This temporal relationship has been negative over the years, especially in developing countries … Apparently, this time series relation is strong enough to override the cross-sectional effects in the estimation." (p.532)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Knowles and Owen (1995)	1960-1985	84 non-oil countries	Log difference in GDP per worker	Log of investment to GDP ratio*, Log of working-age population growth rate*, Log of shortfall of average life expectancy at birth from 80 years*, Log of average number of years of schooling for total population aged 25 and over, Log of initial income*	OLS and 2SLS estimation	"The results reported are consistent with the existence of a strong and (for the range of models examined) relatively robust relationship between life expectancy, as a proxy for the health capital stock, and income per capita. By contrast the relationship between income per capita and educational human capital … is surprisingly 'fragile' … when both health capital and base-period income per capita are included." (pp.105-106)
Mankiw, Romer and Weil (1992)	1960-1985	98 non-oil countries	Log of GDP per worker and Log difference in GDP per worker	Log of investment to GDP ratio*, Log of working-age population growth rate*, Log of percentage of working-age population in secondary school*, Log of initial income*	OLS estimation	"More generally, our results indicate that the Solow model is consistent with the international evidence if one acknowledges the importance of human as well as physical capital. The augmented Solow model says that differences in saving, education, and population growth should explain cross-country differences in income per capita." (p.433)
Pritchett (1996)	1960-1985	91 coun tries	Per annum growth of GDP per worker	Growth rate of physical capital per worker*, Growth rate of educational capital per worker, Log of initial GDP per worker	OLS and instrumental variable estimation	"Estimates of the impact of growth in educational capital on growth of per worker GDP are consistently small and negative." (p.7) "Recently created data on the growth of years of schooling provide no support at all for the proposition that more rapid rates of growth of educational capital produce greater output growth." (p.41)

Table 2 Summary review of the (gender-separate) growth literature

The following table summarizes recent empirical work which include gender-separate human capital as a determinant of growth across countries. An asterisk (*) indicates the explanatory variables which are significant at the 1% or 5% level of significance.

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Barro (1996a)	1960-1990	89 countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary and higher school attainment for females aged 25 and over *, Average years of secondary and higher school attainment for males aged 25 and over *, Log of life expectancy at birth*, Log of GDP x human capital variables*, Log of the total fertility rate*, Government consumption spending to GDP ratio*, Government education spending to GDP ratio*, Black-market premium on foreign exchange*, Rule-of-law index*, Growth rate of terms of trade*, Investment to GDP ratio, Democracy index and its square*, Democracy index dummy*	Instrumental variable analysis of a system with 3 equations	"The results on education show the puzzling pattern described in Barro and Lee (1994) in which the estimated coefficient on male attainment is significantly positive, 0.015 (0.004), whereas that on female attainment is significantly negative, -0.014 (0.005). A possible interpretation is that the gap between male and female schooling is an indicator of an economy's backwardness and that greater backwardness induces a higher growth rate through the familier [sic] convergence mechanism." (p.6)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Barro (1996b)	1960-1990	89 countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary and higher school attainment for females aged 25 and over *, Average years of secondary and higher school attainment for males aged 25 and over *, Log of life expectancy at birth*, Log of GDP x human capital variables*, Log of the total fertility rate*, Government consumption spending to GDP ratio*, Government education spending to GDP ratio, Black-market premium on foreign exchange*, Rule-of-law index*, Growth rate of terms of trade*, Investment to GDP ratio, Democracy index* and its square*, Inflation rate*	Instrumental variable analysis of a system with 3 equations	"Since the general pattern of results has been considered elsewhere [Barro (1996a)], I will provide only a brief sketch here and will focus the main discussion on the effects of inflation." (p.157) "Growth tends also to be increasing in the initial levels of human capital in the forms of education (average years of school attainment at the secondary and higher levels [for males only]) and health (proxied by the log of life expectancy at birth)." (p.158)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Barro (1997)	1960-1990	87 countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary and higher school attainment for males aged 25 and over *, Log of life expectancy at birth*, Log of GDP x male education variable*, Log of the total fertility rate*, Government consumption spending to GDP ratio*, Rule-of-law index*, Growth rate of terms of trade*, Democracy index* and its square*, Inflation rate*, Continental dummies	Instrumental variable analysis of a system with 3 equations	"More surprisingly, female education at various levels is not significantly related to subsequent growth … Thus, these findings do not support the hypothesis that education of women is a key to economic growth. (Footnote 11: In earlier results, Barro and Lee (1994) found that the estimated coefficient on female secondary and higher schooling was significantly negative. With the revised data on education, the estimated female coefficents [sic] are essentially zero.)" (pp.20-21)
Barro (1998)	1960-1995	87 countries	Growth rate of real per capita GDP for each decade	Log of GDP per capita* and its square*, Government consumption spending to GDP ratio*, Rule of law index*, Democracy index and its square, Inflation rate*, Male years of schooling*, Log of total fertility rate*, Investment to GDP ratio*, Growth rate of terms of trade*	IV and 3SLS	"Female schooling at the secondary and higher levels turns out not to have significant explanatory power for growth … [n]ote, however that female education has a strong negative effect on fertility rates, and the fertility variable is already held constant in the growth panel. If fertility is not held constant, then female schooling appears somewhat more important for growth (with a coefficient that is roughly zero, rather than negative." (p.19)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Barro (1999)	1960-1995	87 countries	Growth rate of real per capita GDP for each decade	Log of GDP per capita* and its square*, Government consumption spending to GDP ratio*, Rule of law index*, Democracy index and its square, Inflation rate*, Male years of schooling*, Log of total fertility rate*, Investment to GDP ratio*, Growth rate of terms of trade*, Gini coefficient, Quintile based inequality*	IV and 3SLS	"Growth is positively related to the stock of human capital at the start of each period, as measured by the average years of attainment at the secondary and higher levels of adult males. (Growth turns out to be insignificantly related to secondary and higher attainment of females and to primary attainment of males and females.)" (p.15)
Barro and Lee (1994)	1960-1985	95 non-oil countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary school attainment for females aged 25 and over*, Average years of secondary school attainment for males aged 25 and over*, Log of life expectancy at birth*, Investment to GDP ratio*, Government spending to GDP ratio*, Log of (1 + the black-market premium on foreign exchange)*, Average number of revolutions per year*	SURE technique (with 2 equations) and instrumental variable estimation	"A puzzling finding, which tends to recur, is that the initial level of female secondary education enters negatively in the growth equations … One possibility is that a high spread between male and female secondary attainment is a good measure of backwardness, hence, less female attainment signifies more backwardness and accordingly higher growth potential through the convergence mechanism." (p.18)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Barro and Sala-i-Martin (1995)	1960-1985	97 non-oil countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary school attainment for males aged 25 and over*, Average years of secondary school attainment for females aged 25 and over*, Average years of higher school attainment for males aged 25 and over, Average years of higher school attainment for females aged 25 and over*, Log of life expectancy at birth*, Log of (GDP x human capital variables)*, Government education spending to GDP ratio*, Investment to GDP ratio*, Government consumption spending to GDP ratio*, Log of (1 + the black-market premium on foreign exchange)*, Average number of revolutions and political assassinations per year*, Growth rate of the terms of trade*	SURE technique (with 2 equations) and instrumental variable estimation	"The school attainment variables that tend to be significantly related to subsequent growth are average years of male secondary and higher schooling and average years of female secondary and higher schooling … A puzzling finding is that the initial levels of female secondary and higher education tend to enter negatively in the growth-rate equations." (p.431) "The negative coefficient on the interaction term is significantly negative … The negative coefficient means that the growth rate is more sensitive to log(GDP) when overall human capital - the total effect from educational attainment and life expectancy - is higher." (p.432)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Benavot (1989)	1960-1985	96 countries	Log of GNP per capita	Female primary enrolments* or male primary enrolments*, Female secondary enrolments or male secondary enrolments, Lagged dependent variable*, Dummy for mining and oil exporting countries, Export commodity concentration*, Total fertility rate*, Participation rate of females in industrial and service* sectors	OLS estimation of a panel	'Shows that the primary enrolment rates of both females and males have strong positive effects on economic growth and that these effects weaken only slightly when fertility and labor force measures are included." (p.24) 'In a subsample of all less-developed countries … the primary education of both males and females has strong positive effects on economic growth. The parameter associated with the primary education of females (.0064) is higher than that associated with the primary education of males (.0056)." (p.26)
Birdsall, Ross and Sabot (1997)	1960-1985	108 developed and developing countries	Annual average growth rates of per capita real GDP	Real GDP per capita*, Secondary school enrolment rate*, Female primary school enrolment rate, Male primary school enrolment rate, Ratio of average real government consumption to real GDP*, Deviations of the PPP value for the investment deflator (a market distortions proxy)	OLS estimation	'Our results … indicate no significant difference between the coefficient values for males and females. This suggests that increasing primary school enrollments for girls is just as effective in stimulating growth as increasing primary enrollments for boys." (p.100)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Caselli, Esquivel and Lefort (1996)	1960-1985	93 non-oil countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary school attainment for males aged 25 and over*, Average years of secondary school attainment for females aged 25 and over*, Investment to GDP ratio*, Government spending to GDP ratio*, Log of (1 + the black-market premium on foreign exchange)*, Average number of revolutions per year*, Log of life expectancy at birth, Average number of assassinations per population*, Growth rate of terms of trade*	GMM estimation	"Barro and Lee obtain a significantly negative coefficient on female education and a significantly positive one on male education. We find the exact opposite … However, it often has been documented that there is a strong negative relationship between female education and fertility rates, and an equally strong negative relationship between fertility rates and growth rates. Hence, our interpretation is that the female education variable captures both (positive) fertility effects, and (negative) human capital effects, and the former outweighs the latter. Male education, on the other hand, only represents a human capital effect." (p.379)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Dollar and Gatti (1999)	1975-1990	127 developed and developing countries	Growth of real GDP per capita	Log of GNP per capita and its square, Rule of law index, Fertility rate*, Average number of revolutions per year*, Black-market premium on foreign exchange), Log of life expectancy, Percentage of male (female) population over 25 where primary (secondary) school is the highest level of attainment, Continental dummies*	Pooled OLS and 2SLS	"A second main finding is that gender inequality in education is bad for economic growth. In the more developed half of our data set, a robust result is that there is a significant positive coefficient on female secondary attainment and an insignificant negative one on male attainment." (p.21)
Durham (1999)	1960-1989	105 developed and developing countries	Growth rate of real per capita GDP (five-year averages)	Effective party/constitutional framework, Log initial GDP*, Investment to GDP ratio*, Male education rate, Female education rate, Population growth rate*, Openness to trade*, Government spending to GDP ratio*, Continental dummies*	GLS random effects	"Also, the proxy for male education rates is positive, and female education rate is negative, consistent with previous finds. But both human capital measures are insignificant." (p.97)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Engelbrecht (1998)	1971-1990	61 developing countries	TFP growth (5-year changes)	Foreign R&D capital stock*, Ratio of machinery and equipment imports to GDP, Average years of schooling in total population*, or Average years of schooling in male population*, or Average years of schooling in female population*, Interaction between R&D capital stock and average years of schooling*	Pooled weighted least squares	"Surprisingly given the often reported negative coefficient for female human capital in the literature (e.g. Barro and Lee, 1994), 'average schooling years in the female population' has a stronger impact on growth than male schooling. Both its coefficient estimates and semi-elasticity are larger." (p.17) "Moreover, in comparison to other Barro and Lee human capital variables, primary schooling, particularly that of females, seems to have the strongest impact on TFP growth." (p.19)
Forbes (1998)	1965-1995	45 countries excluding Sub-Saharan Africa	Average annual growth rate of real per capita GNP	Income inequality measured by the gini coefficient*, Log of initial GNP per capita*, Average years of secondary schooling for females aged 25 and over, Average years of secondary schooling for females aged 25 and over*, Market distortions proxied by the price level of investment*	Panel data estimation using fixed effects, random effects and method of moments technique	"The coefficient on male education is negative (although not significant), and that on female education is positive and significant. Although this pattern of signs may not support traditional human capital theory, these coefficients (including that on initial income) are similar to those found in other growth models estimated using the same technique [Caselli, Esquivel and Lefort, 1996]." (p.13)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Hill and King (1993, 1995)	1975-1985	127 developed and developing countries	Log of GNP	Female/male enrolment ratio*, Female secondary enrolment rate*, Log of capital stock*, Capital stock x enrolment*, Log of the labour force*, Labour force x enrolment, Dummy variables for year and regions	Pooled OLS estimation of a recursive model	"The findings are consistent with others in that the level of education is found to have a strong positive effect on GNP … The GNP estimation also includes indicators for the gender disparity in education … large gender disparities in educational attainment appear to reduce GNP." (p.29) [similarly for 1993, p.19]
Klasen (1999)	1960-1992	108 developed and developing countries	Average annual rate of growth of GDP per capita	Average investment rate, Average annual rate of population growth*, Average annual rate of labour force growth*, Average years of schooling for the total (male) population aged 15 and over*, Annual growth in average years of schooling for total (male) population aged 15 and over*, Female-male ratio of average years of schooling*, Female-male ratio of the growth in average years of schooling*, Average openness of the country*, Log of income per capita*, Regional dummy variables*	OLS and 2SLS estimation	"[T]he initial female-male ratio of schooling achievements (Red60) as well as the female-male ratio of expansions in the level of schooling (Gred) has a significant positive impact on economic growth." (p.16) "[I]t appears that gender inequality in education does impede economic growth. It does so directly through distorting incentives and indirectly through its impact on investment and population growth." (p.21)

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
Knowles, Lorgelly and Owen (2000)	1960-1990	72 developed and developing countries	Log of GDP per worker	Log of investment to GDP ratio*, Log of growth rate of the labour force, Log of average number of years of schooling for female population aged 15 and over*, Log of average number of years of schooling for male population aged 15 and over, Log difference between male and female average years of schooling*, Log of shortfall of average life expectancy at birth from 85 years*, Log of base period technology*	OLS and 2SLS estimation	"Our empirical results suggest that female schooling has a statistically significant positive effect on labour productivity. The role of male schooling is less clear … Our results on the role of female education are robust to a variety of sensitivity analyses including testing for the effect of influential observations and using instrumental variables to allow for the possibility of simultaneity bias. The difference in our results compared to, for example, Barro and Lee (1994) appears to be due to their use of base-period values of human capital stock measures …" (p.26)
Lorgelly (1999)	1960-1990	72 developed and developing countries	Log of GDP per worker	Log of investment to GDP ratio*, Log of growth rate of the labour force, Log of average number of years of schooling for female population aged 15 and over*, Log of average number of years of schooling for male population aged 15 and over, Log of shortfall of female average life expectancy at birth from 85	OLS and 2SLS estimation	"To conclude, it appears that female education and female life expectancy (as well as aggregate life expectancy) have a positive effect on the long-run level of income per worker, the role of male human capital, however, is less clear. Note that this significant relationship between female human capital and labour productivity is more conclusive when the data are averaged over a long time span, which is consistent with the view that long

Authors	Date of Data	Countries Included	Growth Measure	Explanatory Variables	Method of Analysis	Findings
				years*, Log of shortfall of male average life expectancy at birth from 85 years		time averages are more informative about long-run effects." (p.124)
Lorgelly and Owen (1999)	1960-1985	85 non-oil countries	Growth rate of real per capita GDP for each decade	Log of initial GDP*, Average years of secondary school attainment for females aged 25 and over, Average years of secondary school attainment for males aged 25 and over, Log of life expectancy at birth*, Investment to GDP ratio*, Govt spending to GDP ratio*, Log of (1 + the black-market premium on foreign exchange)*, Average number of revolutions per year*	SURE technique (with 2 equations)	"All the results we obtain highlight the fragility of both the puzzling significant negative coefficient in the BL [Barro and Lee (1994)] model. The statistical significance of the education variables in BL's equations is heavily dependent on their decision to include male and female educational attainment proxies separately and on the influence of the Asian Tigers [Singapore, Taiwan, Hong Kong and Korea]. Statistical significance that is dependent on the inclusion of a handful of countries should obviously be treated with a good deal of caution." (p.554)
Perotti (1996)	1960-1985	67 countries	Average rate of growth of income per capita	Middle class of income distribution*, Initial per capita GDP*, Average years of secondary schooling of the female population*, Average years of secondary schooling of the female population*, PPP value of the investment deflator, Continental dummy variables	OLS and 2SLS estimation	"Note also the opposite signs on the coefficients of MSE [male secondary education] and FSE [female secondary education]. The explanation offered by Barro and Sala-i-Martin (1995) … is that a lower initial female attainment, for a given male attainment, indicates more backwardness and therefore faster subsequent growth as the economy converges toward its steady sate." (p.159)

Sadeghi (1995)	1950-1989	93 non-European countries	Per capita GNP growth 1980-1989	Ratio of female to male (primary or secondary) enrolment rates or literacy rates*, Dummy variable for OPEC countries* and EAC countries*	OLS estimation	"The relationship of narrowing gender gap of either primary of secondary enrollment ratios, measured as the ratio of female-to-male enrollment rates, G_{ci}, to per capita GNP growth was also positive and significant." (p.6)

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