The Economic Journal, **115** (*January*), 88–110. Published by Blackwell Publishing, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main Street, Malden, MA 02148, USA.

CHEAP CHILDREN AND THE PERSISTENCE OF POVERTY*

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This paper develops a theory of fertility that offers an explanation for the persistence of poverty within and across countries. If educated individuals have a comparative advantage in raising educated children then parental fertility choice is shown to give rise to a poverty trap, in which the poor choose high fertility rates with low investment in child quality. Moreover, the impact of child quality choice on economic performance is amplified by the diluting effect of higher fertility on physical capital accumulation. The theory proposes insights regarding the effects of inequality, globalisation and life expectancy on economic growth and demographic transitions.

This paper develops a theory of fertility and child educational choice that offers an explanation for the persistence of poverty within and across countries. The joint determination of the quality (education) and quantity of children in a household is studied under the key assumption that individuals' productivity as teachers increases with their own human capital. In contrast, the minimum time cost associated with raising a child regardless of the child's quality – the quantity cost – is not affected by parental education. As a result, the price of child quantity relative to the price of child quality increases with individuals' wages. In particular, for low-wage individuals, for whom the opportunity cost of time is low, children of minimal quality are 'cheap'. This assumption, therefore, generates a comparative advantage for the poor in child quantity, whereas high-wage (educated) individuals have a comparative advantage in raising quality children. Consistent with the well-known evidence, poor households thus choose relatively high fertility rates with relatively low investment in their offspring's education; and therefore, their offspring are poor as well. In contrast, high-income families choose low fertility rates with high investment in education, and therefore, high income persists in the dynasty.

Evidence from the US, provided by Hanushek (1992), suggests that a trade-off between quantity and quality of children does indeed exist. Hanushek argues that movements in family size could explain over half the variance in some test scores, and that the elasticity of achievements with respect to the number of children in the family is −0.03, implying that the annual achievement growth of each child in a family will fall about 2% when a second child is added and about 0.5% when a sixth child is added.[1]

* I wish to thank Daron Acemoglu, Josh Angrist, Ilhem Baghdadli, Abhijit Banerjee, Patricia Crifo, Oded Galor, Eric Gould, Moshe Hazan, Yishay Maoz, Joram Mayshar, Olivier Morand, Avi Simhon, David Weil, Mathias Thoenig, Joseph Zeira, two anonymous referees, and participants in seminars and conferences at the Hebrew University of Jerusalem, MIT, CESifo conference on Economic Growth and Inequality, Munich 2001, and the Israeli Economic Association conference, 2001, for helpful discussions. I am grateful to the Maurice Falk Institute for financial support. This publication has been funded by the Melchior Minerva Center for Macroeconomics and Growth. Minerva is funded through the BMBF.

[1] Rosenzweig and Wolpin (1980) provide consistent evidence from India for the existence of a trade-off between child quality and quantity, and Knodel and Wongsith (1991) show that family size exerts a substantial negative influence on the probability that a child will attend secondary school in Thailand.

Regarding the transmission of poverty across generations and its relationship with fertility, Lam and Duryea (1999) argue that there is a strong negative effect of women's schooling on fertility and a strong positive effect of parental schooling on children's schooling.[2] They find that Brazilian women with zero years of schooling give birth to 6.5 live children, whereas this number declines to 3 for women with 8 years of schooling. Further, they argue that the effect of schooling on fertility, as consistent with the underlying mechanism developed here, works primarily through increased investment in child quality. Lam and Duryea suggest that mothers with more schooling, despite the large increase in their market wages, do not significantly increase their labour supply because of their higher productivity in producing well-educated children. In particular, while the wage rate for women with 8 years of schooling is 3.3 times larger than that of women with no schooling, labour force participation is 37% for women with 8 years of schooling, in comparison to 32% for women with zero schooling. In addition, Behrman *et al.* (1999) find that increases in the schooling of women in India enhance the human capital of the next generation, and argue that a component of the significant and positive relationship between maternal literacy and child schooling reflects the productivity effect of home teaching.[3]

Evidence on the allocation of time in home production, as consistent with the prediction of the theory developed in this paper, suggests that educated parents' time allocation is biased towards child quality. Behrman *et al.* (1999) find that children with mothers who are literate (but not primary-school graduates) study one hour more per day than children with illiterate mothers.[4] In addition, Lynch (2000), based on US data from the National Household Education Survey of 1996, shows that 77% of college graduate mothers read to their 3 to 5 year old children every day, in contrast to only 37% of mothers who do not have a college degree.[5] Phillips *et al.* (1998) argue, moreover, that measures of maternal time input render mothers' IQ and parents' education insignificant in explaining verbal skills, implying that the mechanism generating the correlation between parents' and children's education is highly related to the greater time invested by educated mothers in the quality of their children.

[2] Evidence of the negative correlation between fertility and education is also provided by Kremer and Chen (2002), and evidence of the positive correlation between parents' education and children's education is also provided by Altonji and Dunn (1996) and by Ahituv (2001), among others.

[3] See also the survey of the evidence by Schultz (1993) and by Strauss and Thomas (1995). They show that women's education is strongly negatively correlated with fertility and positively correlated with child quality (education and health), and that fathers' education has a similar effect but of less magnitude. Behrman and Rosenzweig (2002), however, find a marginally negative rather than a significantly positive coefficient for mother's schooling in the determination of child schooling once ability is controlled. They find that increased maternal schooling leads to reduced home time for mothers, implying that the increase in mother's wages more than offsets their increased productivity in child quality. They do find, however, a positive and statistically significant coefficient of father's schooling on children's schooling. Finally, they argue that their findings must be interpreted with care because it is possible that mother's increased schooling leads to increased child schooling elsewhere, as shown by Behrman *et al.* (1999).

[4] However, the relationship is non-monotonic; children of mothers who completed primary school spend more time studying than children of illiterate mothers but less time than children of literate mothers who did not graduate from primary school.

[5] Rebello-Britto *et al.* (2001) provide consistent evidence regarding younger children.

Finally, consistent with the paper's key assumption that increases in market productivity are highly correlated with increases in the productivity of home production of human capital, Psacharopoulos *et al.* (1996) find that teachers in Latin American countries are rewarded for their education similarly to the average reward in the economy. Card and Krueger (1992) argue that schooling rates of return are higher for individuals from states with better-educated teachers, and Angrist and Lavy (2001) find that teachers' training led to an improvement in students' test scores.

In the paper's basic model, dynasties within a country can converge to one of two equilibria; either a low education – high fertility equilibrium, or a high education – low fertility equilibrium. An extension of this basic model captures the diluting effect of fertility on the accumulation of physical capital, amplifying the effect of quality choice on income per capita. Consistent with the negative cross-country relationship between fertility and growth and the positive cross-country relationship between education and growth, countries can converge to two different levels of income per capita. The high-income steady state, in contrast to the low-income steady state, is characterised by high levels of physical and human capital per capita and low rates of fertility.

Ahituv (2001) finds that the cross-country distribution of fertility is characterised by a twin-peak structure; in 1965, a mass of low-income countries, with a GDP of less than $1,000 per capita, had average fertility rates of 6.5 children per woman, as opposed to 3.7 in the high-income group with a per capita GDP above $2,500. During the same period, only 6% of the relevant school-age children were enrolled in secondary school in the low-income countries, compared to 49.2% in the high-income countries. The picture in 1985 was very similar; the average fertility rate in the low-income countries was still above 6, and in the high-income group the average had declined to 2.4. During the last decade, data from the United Nations Statistical Yearbook shows that fertility rates have been dropping in most countries around the world and many of the poor countries have experienced a demographic transition in which fertility has declined dramatically. Nevertheless, despite the decline in the number of countries belonging to the high-fertility club, with birth rates above 5 children per woman (all characterised by low levels of education), a twin-peak structure still characterises the distribution of fertility in the year 2000. In addition, as suggested by Barro (1991), fertility rates and education levels are related to economic growth. He argues that economic growth is positively correlated with human capital and countries with higher human capital also have lower fertility rates and higher ratios of physical investment to GDP.[6]

Economic growth models of fertility designed to explain the possibility of multiple equilibria – a poverty-trap equilibrium and a high-income equilibrium – go back to Nelson (1956). He shows that in an environment in which fertility and saving rates increase with income, an underdevelopment trap with low savings is plausible. In this trap, even if capital is accumulated, the population

[6] See also Kelley and Schmidt (1995) regarding the negative correlation between economic growth and population growth.

rises at an equal rate. More recently, Becker *et al.* (1990), developed a representative agent model in which individuals face the trade-off between the quality and quantity of their offspring. Their model generates multiple steady states consistent with the cross-country relationship between fertility, education and growth. The source of multiplicity of equilibria in their model is the assumption that the return to education is lower in poor economies. In particular, they assume that the return to human capital increases with the aggregate level of education in society. Their approach suffers from both theoretical and empirical limitations. The poverty-trap equilibrium is a result of a market failure in a framework in which education has a positive externality, where existing evidence contradicts the underlying assumption of increasing returns to education with income or education.[7] Furthermore, while fertility decisions in the analysis of Becker *et al.* (1990) may amplify the negative impact of low education investment on income per capita, they are not the source of multiple equilibria.[8]

In this paper, in contrast, a simple dynamical system generates multiple steady states that emerge from the comparative advantage of educated workers in the production of educated children. The model is not based on restrictive assumptions concerning preferences, or on any non-convexity in the production of final output and human capital. Moreover, the model generates a testable prediction regarding the correlation of education and income within a dynasty. It suggests that individuals with a high level of human capital would invest highly in their offspring's education, even in poor economies. In contrast, the model developed by Becker *et al.* (1990) implies that in poor economies, where human capital is scarce, the investment in human capital is low due to its low return, regardless of the parents' level of human capital. That is, their model implies that in poor economies all families eventually converge to a low-education equilibrium and in rich economies, all families eventually converge to a high-education equilibrium. In contrast, according to my model, poverty can persist in wealthy countries, and wealthy (educated) individuals can exist in the long run in poor countries.

The micro-foundations of this paper follow the concept of a trade-off between child quality and child quantity analysed by Becker and Lewis (1973). Their principal observation is that the cost of an additional child increases with the desired level of child quality. Therefore, under the assumption that both child quantity and child quality are normal goods, a rise in income has two opposite effects on the quantity of children. While the increase in income has a direct positive effect on the quantity of children, it also increases their quality and thus their cost, negatively affecting their quantity. Becker and Lewis show, therefore,

[7] See, for instance, Psacharopoulos (1994), Angrist (1995), Acemoglu and Angrist (2000), Ciccone and Peri (2002), Rudd (2002) and Moretti (2004).

[8] Tamura (1996) also generates two development regimes based on a rising rate of return to human capital investment and a conditional external effect in human capital investment. Hazan and Berdugo (2002) generate a poverty trap based on child labor and high fertility. See also Barro and Becker (1989) who offer an explanation for the negative cross-sectional relation between income and population growth based on the effect of the trade-off between the size of the real transfer to each child and the number of children on the unique steady state of their model.

that in spite of the normality of the demand for children, if preferences are non-homothetic, the observed relationship between the quantity of children and income can be negative.

In this paper, as in Becker and Lewis (1973), the cost of an additional child increases with the desired level of child quality, and the cost of quality increases with the number of children, generating a non-convex budget set. However, in contrast to Becker and Lewis, here the key assumption is that individuals' productivity in educating children increases with their own human capital, whereas the fraction of the individual's time endowment that is required in order to raise a child, regardless of quality – the quantity cost – is equal across all individuals. For instance, while all individuals are equally able at feeding a child, their effectiveness in helping children with homework increases with their own level of education. This assumption implies that the ratio between the price of quantity and the price of quality increases with the individual's wage, which generates a comparative advantage for the poor in child quantity and a comparative advantage for the wealthy in raising quality children. The impact of changes in wages is amplified by the non-convexity of the budget set, bringing about the negative correlation between income and fertility, and multiple equilibria.

On a more intuitive level, the mechanism generating multiple equilibria is based on a 'multiplier effect'. A decline in parental education, and hence in their income, leaves less resources for the children's education. The increased fertility, due to the lower time cost, further reduces resources for education, which are in addition divided between more children. Therefore, differences in parents' education can be amplified when it comes to differences in offspring education, generating multiple equilibria. Interestingly, the poor in each generation can choose to invest highly in education, at the expense of their fertility rate and allow their offspring to escape the poverty cycle. However, they prefer not to. The endogenous fertility framework, with a trade-off between quality and quantity, raises an inherent conflict of interest between parents and offspring. Parents care about both the quality of each child and the quantity of children, whereas children prefer less siblings and more human capital. Because parents make the decisions in the household, poverty may persist.

This paper is also related to the literature on the effect of income inequality on economic growth – a line of research that has received a lot of attention in the last decade.[9] Due to mobility constraints, poor dynasties remain poor, leading economies to an underdevelopment trap. Banerjee and Newman (1993), Galor and Zeira (1993), Benabou (1996), Durlauf (1996*a*), Piketty (1997), Maoz and Moav (1999), Ghatak and Jiang (2002) and Mookherjee and Ray (2003), among others, show that credit constraints combined with non-convexities in the technology prevent investment by the poor, generating persistence of poverty and

[9] The impact of economic growth on income inequality, while highly related, is beyond the focus of this paper. Galor and Tsiddon (1997), Acemoglu (1998), Caselli (1999), Galor and Moav (2000), Eicher and Gracia-Penalosa (2001), Gould *et al.* (2001), Aghion *et al.* (2002), Gould (2002), Violante (2002) and Rubinstein and Tsiddon (2004), among others, have recently contributed to the theoretical study of the effect of technological progress and economic growth on wage inequality.

thereby an impact of the initial wealth distribution on the long-run steady-state equilibrium.[10]

In this paper, the dynamic system generates a poverty trap along with a high-income (high human capital) equilibrium. Poor dynasties with income below a threshold level converge to the low-income steady state, whereas dynasties with income above the threshold level converge to a high-income steady state. Therefore, if the initial average income in society is above the threshold, then in a more equal society, more individuals are above the threshold and more dynasties converge to the high steady state. Hence, consistent with evidence offered by Perotti (1996) and Barro (1999), and the quantitative analysis of de la Croix and Doepke (2003),[11] inequality affects economic growth negatively via its interaction with fertility choice.[12] Moreover, in contrast to the existing literature, the result of a long-run impact of the initial wealth distribution is generated in spite of convex human capital and final good production technologies and convex homothetic preferences.[13] Inferences from the model, discussed in the concluding remarks, suggest that inequality has an additional direct negative effect on economic growth via its effect on the relative reward to human capital and physical capital.

Recent literature on population and growth offers explanations for a demographic transition and a take-off from economic stagnation to sustained economic growth. Galor and Weil (2000) assume that a rise in the rate of technological progress increases the rate of return to human capital, inducing parents to substitute child quality for child quantity. They show that a positive interaction between population and technology gradually increased the rate of technological progress, inducing investment in human capital that led to a demographic transition and sustained growth. Galor and Moav (2002) develop a unified evolutionary growth theory that captures the interplay between the evolution of mankind and economic growth. They suggest that prolonged economic stagnation, prior to the transition to sustained growth, stimulated natural selection, which shaped the evolution of the human species and eventually brought about the take-off from stagnation to sustained growth.[14] In Galor and Weil (2000), as well as in Galor and Moav (2002), technological progress brings about an increase in the return to education, triggering a demographic transition and an escape from a temporary

[10] In the model developed by Piketty (1997), the effort level, rather than capital investment, is indivisible. Mookherjee and Ray (2003) show that while inequality persists irrespective of the divisibility of human capital, the multiplicity of steady states requires indivisibilities in the return to education.

[11] de la Croix and Doepke (2003) provide a related mechanism regarding the effect of inequality on economic performance. In the presence of inequality, families who provide less education, have more offspring, and thereby have an impact on the future education distribution which is larger than their current weight in the population.

[12] Banerjee and Duflo (2003), however, argue that this is a result of a 'Latin American effect'.

[13] Moav (2002), demonstrates that increasing saving rates with income can replace the role of non-convexities in the technology in generating multiple steady states. In addition, regardless of non-convexities in the technology, Benabou (2000) shows that multiplicity of equilibria arises through the feedback from the income distribution to the political determination of redistribution and Castelló-Climent and Doménech (2002) generate multiple equilibria by combining endogenous life expectancy and schooling decisions.

[14] Long-run growth models with endogenous population also include the work of Kremer (1993), Galor and Weil (1996), Dahan and Tsiddon (1998), Morand (1999), Jones (2001), Hansen and Prescott (2002), Doepke (2004) and Lagerloef (2003), among others.

poverty-trap steady state. Here, in contrast, because labour is a factor in the production of human capital, the cost of education increases with wages and hence the model's multiple steady states are robust to technical progress. Thus, while technology is (at least partly) available to less developed economies,[15] the model offers an explanation for the observed persistence of poverty accompanied by high fertility in many countries around the world.

1. The Basic Model

Consider an overlapping-generations economy in which activity extends over infinite discrete time. In every period, the economy produces a single homogeneous good, in a constant-returns-to-scale technology, using human capital as a single input. The supply of human capital is determined by households' decisions in the preceding period regarding the number of their children and the level of education investment in each child.

1.1. *Individuals*

In each period a generation of individuals, who each has a single parent, is born. Individuals live two periods: in childhood they acquire human capital; in adulthood they are endowed with one unit of time, which they allocate between child rearing and participation in the labour force.

The preferences of members of generation t (born in $t-1$) are defined over consumption as well as over the quality and quantity of their children, where quality is measured by their offspring's full income (potential income). Preferences are represented by the utility function

$$u_t^i = (1-\beta)\log c_t^i + \beta(\log n_t^i + \theta \log w h_{t+1}^i), \tag{1}$$

where $\beta \in (0, 1)$ captures the relative weight given to children (quality as well as quantity) and $\theta > 0$ captures the relative weight given to child quality in the utility function. c_t^i is the consumption in the household of a member i of generation t, n_t^i is the number of children in this household, w is the wage rate per efficiency unit of labour,[16] and h_{t+1}^i is the level of human capital of each child measured in efficiency units.[17]

[15] See Basu and Weil (1998) and Acemoglu and Zilibotti (2001).

[16] As follows from the assumption of a single production factor in a CRS technology, the wage rate per efficiency unit of labour, w, is constant over time. This assumption is relaxed in the next section where both physical and human capital are employed in the production process. The inclusion of the wage rate in the utility function implies that parents care about offspring income. Removing the wage rate from the utility would allow for a different interpretation – that schooling is valued for its own sake – with no impact on the model's results.

[17] Defining preferences over the quality of each child, rather than the average quality, and thus implicitly restricting parents from treating children unequally, is not a binding constraint in the context of this model. Children are identical with respect to their human capital production technology, which is characterised by decreasing returns, and therefore, parents provide equal education to all their children under both specifications.

1.2. *The Formation of Human Capital*

In the first period of their lives individuals devote their entire time to the acquisition of human capital (measured in efficiency units of labour). The acquired level of human capital increases if their time investment is supplemented by investment in education. However, even in the absence of investment in education, individuals acquire one efficiency unit of labour – basic skills. The level of investment in education of individual i born in period t, e^i_{t+1}, is measured in efficiency units of labour, capturing the model's key assumption that individuals' productivity as teachers increases with their own human capital. Since e^i_{t+1} is measured in efficiency units of labour, the real cost of the investment in education is we^i_{t+1}, whether this is viewed as a direct cost of hiring a teacher or an opportunity cost of teaching one's own children.[18] The resulting number of efficiency units of labour of individual i in period $t+1$, h^i_{t+1}, is a strictly increasing, strictly concave function of investment in education in period t, e^i_{t+1},

$$h^i_{t+1} = h(e^i_{t+1}), \tag{2}$$

where $h(0) = 1$, $\lim_{e \to 0^+} h'(e^i_t) = \gamma$, $\lim_{e \to \infty} h(e^i_t) > 1/\tau\theta\gamma$,[19] and $\lim_{e \to \infty} h'(e^i_t) = 0$. The assumption that the slope of the production function of human capital is finite, along with individuals' ability to supply some minimal level of labour regardless of the investment in human capital (beyond time), ensure that under some conditions, raising quality children is not optimal. The frequently postulated assumption that the return to human capital is infinitely high at the lower limit (i.e., the Inada conditions), is designed to simplify the exposition by avoiding corner solutions but it is surely not a realistic assumption and, as clearly evident from Becker (1975), it is not the rule in either theoretical or empirical analyses. Indeed, following Mincer (1974), many empirical estimates of the returns to education do not assume or find slopes that are infinitely large (e.g., Psacharopoulos, 1994). The assumption that $h(0)$ is strictly positive is reasonable. It implies that when parents invest the minimal level in each child (captured by τ), children can supply some labour when they become adults. An alternative approach, commonly employed in the literature about poverty traps and credit constraints, assumes indivisibilities in the production of human capital. Following this approach, i.e. adding non-convexities to the investment technology, would generate multiple equilibria in a rather trivial manner, as demonstrated, for instance, by Galor and Zeira (1993).

[18] The assumption that individuals' productivity as teachers increases with their level of human capital and therefore with their market productivity by more than their increased productivity in child quantity (providing children with the necessities that are less related to education) drives the model's results. It generates a comparative advantage in child quality to high-income individuals. The specific formulation implies that human capital increases the productivity in educating exactly as much as it increases the productivity in the labour market. This is just a simplifying assumption that enables circumventing the explicit modelling of the market for teachers. Alternatively, individuals within some range of human capital would have a comparative advantage as teachers, and those individuals who have a comparative advantage in producing the final good would hire teachers for their children. This has no qualitative impact on the analysis, as, under the existing structure, individuals are indifferent between buying education or providing it directly.

[19] Where τ, formally defined below, is the time cost for raising a child.

1.3. *Budget Constraint*

Let τ be the minimum time cost required for raising a child; additional time allocated to children positively affects their quality. That is, τ is the fraction of the individual's unit of time endowment that is required in order to raise a child, regardless of quality.[20] Following Becker and Lewis (1973), Rosenzweig and Wolpin (1980) and Galor and Weil (2000), it is assumed, for the sake of simplicity, that the 'quantity cost' per child does not vary with family size. The economic force behind the fertility gap between rich and poor is the lower quantity cost faced by the poor. Therefore, incorporating a range of decreasing quantity costs would increase the marginal cost difference faced by poor and rich, amplifying the fertility gap and thus strengthening the paper's results. Increasing returns to investment in quality would work in the opposite direction but, up to a limit, should not have a qualitative effect on the model's results.

As will become apparent, fertility rates are bounded from above by β/τ and, therefore, it is assumed that $\tau < \beta$. It is further assumed that τ is sufficiently small so that individuals with a low level of human capital choose the corner solution of zero investment in child education,

$$\tau < 1/\theta\gamma. \tag{A1}$$

Consider an adult member i of generation t who is endowed with h_t^i efficiency units of labour at time t, where $h_t^i = h(e_t^i)$. Full income, wh_t^i, is divided between expenditure on child rearing (quantity as well as quality) and consumption, c_t^i. The (opportunity) cost of raising each child, regardless of quality, is equal to $w\tau h_t^i$, and the cost of quality of each child is equal to we_{t+1}^i. The cost of raising n_t^i children, with an education level of e_{t+1}^i, is given, therefore, by $n_t^i(w\tau h_t^i + we_{t+1}^i)$, and the individual faces the budget constraint

$$n_t^i w(\tau h_t^i + e_{t+1}^i) + c_t^i \leq wh_t^i. \tag{3}$$

As captured by the budget constraint given in (3), the cost of child quantity, $w\tau h_t^i$, in contrast to the cost of child quality, we_{t+1}^i, increases with the level of human capital of the individual, h_t^i. This is a result of the assumption that individuals' productivity as educators, in contrast to their productivity in child quantity, increases with their own human capital.

1.4. *Optimisation*

Members of generation t choose the number and quality of their children, and their own consumption, so as to maximise their utility function, subject to the budget constraint. It follows from the optimisation that consumption is

[20] It is implicitly assumed that the time cost of raising a child cannot be reduced by child-care employment. As suggested by Mincer (1962) '… substitutes for a mother's care of small children are much more difficult to come by than those for food preparation or for physical maintenance of the household'. Leibowitz and Klerman (1995) show that mothers of infants under 1 year old in the US were less likely to be labour-force participants than mothers of older children, supporting Mincer's speculation.

$$c_t^i = (1-\beta)wh_t^i = (1-\beta)wh(e_t^i). \tag{4}$$

That is, a fraction $1-\beta$ of full income is devoted to consumption and hence a fraction β of full income is devoted to child rearing in terms of quality and quantity. Furthermore, the optimisation with respect to child quality, e_{t+1}^i, implies that[21]

$$\frac{\theta h'(e_{t+1}^i)}{h(e_{t+1}^i)} - \frac{1}{\tau h(e_t^i)+e_{t+1}^i}\begin{cases}\leq 0 & \text{if } e_{t+1}^i = 0;\\ = 0 & \text{if } e_{t+1}^i > 0,\end{cases} \tag{5}$$

where it is assumed that θ is sufficiently small such that the optimal investment, e_{t+1}^i, does not approach infinity.[22] In particular it is assumed that

$$\eta''(e_{t+1}^i) < 0, \tag{A2}$$

where $\eta(e_{t+1}^i) \equiv [h(e_{t+1}^i)]^\theta$.

Lemma 1 *Under assumptions* (A1) *and* (A2) *there exists a single valued function,* $\phi(e_t^i)$, *such that*

$$e_{t+1}^i = \phi(e_t^i)\begin{cases} = 0 & \text{if } e_t^i \leq \hat{e};\\ > 0 & \text{if } e_t^i > \hat{e},\end{cases}$$

where $\phi'(e_t^i) > 0$ *for* $e_t^i > \hat{e}$ *and* $\hat{e} > 0$ *is unique and given by* $1/\theta\gamma = \tau h(\hat{e})$.

Proof. Define $G(e_{t+1}) \equiv h(e_{t+1})/\theta h'(e_{t+1})$. It follows from (5) that

$$G(e_{t+1}^i) \geq \tau h(e_t^i) + e_{t+1}^i. \tag{6}$$

As follows from (A1), $\partial G(e_{t+1}^i)/\partial e_t^i = 0$, $\partial[\tau h(e_t^i) + e_{t+1}^i]/\partial e_t^i > 0$, and $G(0) = 1/\theta\gamma > \tau h(0) = \tau$, and as follows from the properties of (2), $G(0) = 1/\theta\gamma < \lim_{e\to\infty} \tau h(e_t^i)$, and $h'(e_t^i) > 0$. Therefore, as follows from the intermediate value theorem, there exists a unique $e_t^i = \hat{e} > 0$, given by $1/\theta\gamma = \tau h(\hat{e})$, such that $G(0) = \tau h(\hat{e})$ and $G(0) > (<)\tau h(e_t^i)$ for all $e_t^i < (>)\hat{e}$, implying that $\phi(e_t^i) = 0$ for all $e_t^i \leq \hat{e}$ and $\phi(e_t^i) > 0$ otherwise.

As follows from implicit differentiation of the first-order condition of the maximisation problem as given by (5), noting that under A2 the second-order condition holds for a maximum, $\phi(e_t^i)$ is single valued, and for $e_t^i > \hat{e}$, $\phi'(e_t^i) > 0$.

[21] Which is consistent with the standard condition of setting the marginal rate of substitution between quality and quantity equal to the price ratio (or larger in the case of a corner solution)

$$\frac{h(e_{t+1}^i)}{\theta n_t^i} - \frac{\tau h(e_t^i)+e_{t+1}}{n_t^i/h'(e_{t+1}^i)}\begin{cases}\geq 0 & \text{if } e_{t+1}^i = 0;\\ = 0 & \text{if } e_{t+1}^i > 0,\end{cases}$$

where $h(e_{t+1}^i)/\theta n_t^i$ is the marginal rate of substitution between quality and quantity, $[\tau h(e_t^i) + e_{t+1}]w$ is the cost of an additional child and $wn_t^i/h'(e_{t+1}^i)$ is the marginal cost of children's quality (human capital). The wage rate has no bearing on the optimisation since both the quality and quantity costs are its products.

[22] Alternatively, a strictly positive lower limit to the number of children can be postulated. This is a reasonable restriction since children come in natural numbers and zero is ruled out by the optimisation. Under this restriction, there is a threshold level of education above which individuals choose a corner solution of having the lowest possible number of children and the accordingly high investment in education, with no qualitative impact on the model's results.

It follows from Lemma 1, (3) and (4) that the number of children of a member i of generation t, n_t^i is given by

$$n_t^i = n(e_t^i) = \begin{cases} \beta/\tau & \text{if } e_t^i \leq \hat{e}; \\ \beta h(e_t^i)/[\tau h(e_t^i) + \phi(e_t^i)] & \text{if } e_t^i > \hat{e}, \end{cases} \tag{7}$$

where $\beta/\tau \geq \beta h(e_t^i)/[\tau h(e_t^i) + \phi(e_t^i)]$. That is, fertility rates among low-education individuals ($e_t^i \leq \hat{e}$), who choose not to invest in the quality of their children, are higher than those among individuals with higher education levels who choose to invest in the education of their children. However, depending on the properties of the human capital production function, fertility rates may decrease or increase with the level of human capital for $e_t^i > \hat{e}$.

The effect of non-wage income is straightforward. A change in income, which is not related to a change in individuals' human capital, has no effect on the quality-quantity price ratio, or on the consumption price. Therefore, due to the assumption that preferences are homothetic, it will give rise to a proportional increase in resources allocated to consumption, quality and quantity. That is, the education of each child is not affected, implying that (5) and Lemma 1 hold for the general case in which individuals' income is not restricted to labour.

1.5. *The Dynamic System*

Figure 1 depicts the dynamic system, $\phi(e_t^i)$. Assumption (A1) ensures the existence of a low-education steady state, $\phi(0) = 0$. However, in order for $\phi(e_t^i)$ to generate a

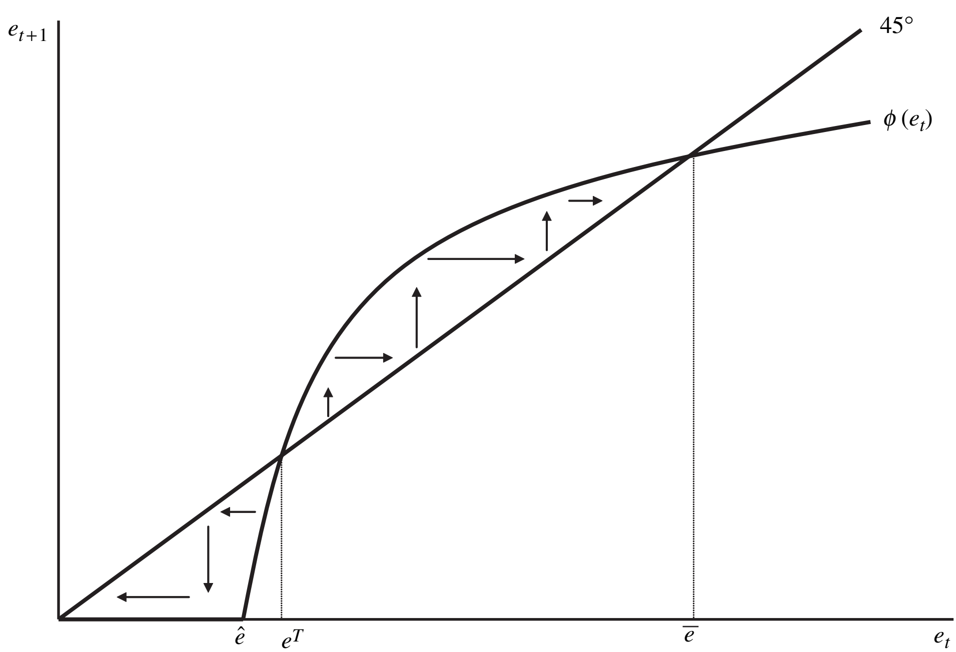

Fig. 1. *The Evolution of Education*
Offspring level education e_{t+1} is uniquely determined by parental education e_t

high-education steady state, there must exist a range of e_t^i in which $\phi(e_t^i)$ is sufficiently sensitive to changes in e_t^i, i.e. a range in which small changes in the parent's education bring about large changes in the offspring's education and as a result, $\phi(e_t^i) > e_t^i$ for some e_t^i.

PROPOSITION 1 *For a sufficiently large θ, there exists a human capital production function that satisfies assumptions* (A1) *and* (A2), *and the properties of* $h(e_t^i)$ *in* (2), *such that the dynamic system,* $\phi(e_t^i)$, *is characterised by multiple steady states.*

Proof. The proof follows from an example. Consider the following human capital production function

$$h_{t+1}^i = h(e_{t+1}^i) = \begin{cases} 1+\gamma e_{t+1}^i & \text{if } e_{t+1}^i < \bar{e}; \\ 1+\gamma\bar{e} & \text{if } e_{t+1}^i \geq \bar{e}, \end{cases} \tag{8}$$

where $\bar{e} > (1-\tau\gamma)/\tau\gamma^2$. It follows from the optimisation problem of a member i of generation t, endowed with $h(e_t^i)$ efficiency units of human capital, that for $\theta = 1$,[23]

$$e_{t+1}^i = \bar{\phi}(e_t^i)\begin{cases} = 0 & \text{if } e_t^i < \hat{e}; \\ \in [0,\bar{e}] & \text{if } e_t^i = \hat{e}; \\ = \bar{e} & \text{if } e_t^i > \hat{e}, \end{cases} \tag{9}$$

where, as follows from (8) and Assumption (A1), $\hat{e} = (1-\tau\gamma)/\tau\gamma^2 > 0$ and therefore $\bar{e} > \hat{e}$. The dynamic system $\bar{\phi}(e_t^i)$ is characterised by two stable steady states, $\bar{e}$ and 0, and an unstable steady state $\hat{e}$, which is the threshold level of education. The proposition thus follows from continuity considerations.[24]

1.6. *Steady States and Implications of the Basic Model*

As depicted in Figure 1, a dynasty i, with a given initial level of education, e_0^i, will converge to a high-education, high-income, and low-fertility steady state if $e_0^i > e^T$.[25] Otherwise, the dynasty will converge to a low-income, low human capital, and high-fertility steady-state. The mechanism generating multiple steady

[23] For $\theta > 1$, $1+\gamma e_{t+1}^i$ and $1+\gamma\bar{e}$ are replaced by $(1+\tilde{\gamma}e_{t+1}^i)^{1/\theta}$ and by $(1+\tilde{\gamma}\bar{e})^{1/\theta}$. It is straightforward to confirm that this specification satisfies (A2), and the proof follows, noting that $h'(0) = \tilde{\gamma}/\theta \equiv \gamma$.

[24] While the model is not designed to perform calibrations, a numerical illustration reveals that reasonable parameters, in particular the lifetime dollar return for each dollar invested in education, as given by γ (Psacharopoulos, 1994), can generate multiple equilibria. In particular, for $\gamma = 2$, $\theta = 1$, $\tau = 0.15$, $\beta = 1/2$ and $\bar{e} = 1.5$, earnings at the high-income equilibrium are four times higher than earnings at the low-income, and fertility rates are 1.9 children per household (of two parents) in the high-income equilibrium and 6.6 at the low-income equilibrium. Note that multiplicity will hold for any set of parameters restricted by (A1), (A2) and $\bar{e} > \hat{e}$. An alternative example, more closely related to the commonly assumed Cobb-Douglas human capital production satisfies concavity; see, for instance, (Heckman *et al.* 1998). Suppose $h(e) = \alpha^{-\alpha\gamma}(\alpha+e)^{\alpha\gamma}$. It is straightforward to verify that the properties of (2) are satisfied. Under this specification multiplicity arises if, for instance, $\gamma = 2$, $\theta = 1$, $\tau = 0.15$, $\beta = 1/2$, $\alpha = 0.45$, and an upper limit to e of 2.5 or higher is imposed. Note that the simple Cobb-Douglas function implies that Inada conditions hold, and thus will be inconsistent with this paper's assumptions.

[25] Note that the threshold level of education that is sufficient to converge to the high human capital steady state, e^T, is higher than the threshold level that generates a strictly positive investment in human capital, $\hat{e}$.

states is based on the effect of parental education on child quantity cost. The lower the parents' education, that is the cheaper the parents' time, the cheaper the children and the parents' choice shifts to higher fertility rates and lower investment in offspring's human capital. Note that a decline in parental education, and hence in their income, leaves less resources for children's education. The increased fertility further reduces investment in education which is, in addition, divided among more children. Therefore, consistent with Proposition 1, differences in parental education can be amplified when it comes to differences in offspring education.

The dynamic system generates predictions on the effect of income inequality on economic growth. If initial average income and the corresponding average level of human capital are above the threshold, e^T, then growth in the economy will be higher the more equal the society, since more dynasties converge to the high steady state. Hence, consistent with evidence (Perotti, 1996; Barro, 1999), income equality generates higher output via its interaction with fertility choice.

The effect of changes in the quantity cost parameter, τ, on the dynamic system and its steady states follows from (5) and Lemma 1. An increase in τ increases the relative cost of quantity, inducing a shift to child quality. Hence, it reduces the level of the threshold below which individuals choose not to purchase any education for their offspring, $\hat{e}$, and increases the level of human capital, $\phi(e_t^i)$, above $\hat{e}$. This implies that the dynamic system depicted in Figure 1 shifts upward, the threshold level, e^T, declines and the high-income steady-state, $\bar{e}$, increases.

The effect of changes in the cost of education is not that straightforward. An analysis of public schooling on fertility and education, which is the most relevant question regarding policy implications, follows.[26] Assume that the government supplies free-of-charge schooling at a level e_t^g, which is financed by foreign aid or taxation.[27] It follows from (5) that if $\phi(e_t^i) < e_t^g$, parental investment in education would be zero, or otherwise it would equal $\phi(e_t^i) - e_t^g$. Public schooling has, therefore, a positive effect on offspring's level of education (for all i such that $\phi(e_t^i) < e_t^g$) but it also reduces parental expenditure on education (for all i such that $\phi(e_t^i) > 0$) and therefore gives rise to a reallocation of resources for increased fertility. In the long run, however, if $e_t^g > e^T$, public schooling will shift dynasties to a path of increased education and income and reduced fertility.

2. The Extended Model

In this Section, endogenous physical capital accumulation is introduced, allowing the model to capture the diluting effect of fertility on capital per worker, which amplifies the effect of quality choice on economic growth. This Section, therefore, focuses on the impact of fertility on the economy rather than on poverty within an economy, offering an explanation for cross-country income differences and club convergence.

[26] The analysis abstracts from the potential effect of public schooling on the quantity cost.

[27] An indirect consumption tax, for instance, will not have an impact on the quality and quantity choice of individuals.

The basic model is enriched by allowing individuals to bequeath capital to their offspring, in addition to the investment in child quality. Final output is thus produced by two factors of production: physical and human capital. The aggregate supply of production factors is determined by individuals' choice of physical capital bequest, educational expenditures, and fertility in the previous period. For the sake of simplicity, the parameter θ in the utility function is set to 1 and, given the Section's focus, the analysis assumes homogeneous individuals.

2.1. *Production*

Production occurs within a period according to a neoclassical, constant-returns-to-scale, Cobb-Douglas production technology. The output produced at time t, Y_t, is given by

$$Y_t = F(K_t, H_t) \equiv H_t f(k_t) = H_t A k_t^{\alpha}; k_t \equiv K_t/H_t, \tag{10}$$

where K_t and H_t are physical and human capital employed in production in period t.

Producers operate in a perfectly competitive environment and therefore production factors are paid according to their marginal products,

$$\begin{aligned} w_t &= (1-\alpha)Ak^{\alpha} \equiv w(k_t); \\ r_t &= \alpha A k^{\alpha-1} \equiv r(k_t), \end{aligned} \tag{11}$$

where w_t is the wage rate per efficiency unit of labour in time t, and r_t is the capital rate of return, where physical capital fully depreciates at the end of each period.

2.2. *Optimisation*

Members of generation t choose the number, n_t, and quality, e_{t+1}, of their children, the quantity of physical capital they transfer to each child, s_{t+1}, and the household consumption, c_t, so as to maximise their utility function,

$$u_t = (1-\beta)\log c_t + \beta[\log n_t + \log(w_{t+1}h_{t+1} + r_{t+1}s_{t+1})], \tag{12}$$

subject to the human capital production technology, $h_{t+1} = h(e_{t+1})$, and the budget constraint,

$$n_t(w_t \tau h_t + w_t e_{t+1} + s_{t+1}) + c_t \leq w_t h_t + r_t s_t, \tag{13}$$

where $w_t h_t + r_t s_t$ is the full income of each individual in period t, and $h_t = h(e_t)$. Defining preferences over the income of each child implies that investment in education is optimal in the standard form of equalising the marginal returns to human and physical capital in any interior solution. It follows from the optimisation that individuals consume a fraction $(1-\beta)$ of full income,

$$c_t = (1-\beta)(w_t h_t + r_t s_t),$$

and a fraction β of full income is devoted to children's quality, quantity, and capital transfers. In particular, the optimisation with respect to capital transfers, s_{t+1}, is given by

$$\frac{h(e_{t+1})w_{t+1}}{(\tau h_t + e_{t+1})w_t} - r_{t+1}\begin{cases} > 0 & s_{t+1} = 0; \\ = 0 & s_{t+1} \in [0, \infty); \\ < 0 & s_{t+1} \to \infty, \end{cases} \tag{14}$$

where $s_{t+1} \to \infty$ implies that $n_t \to 0$. In equilibrium, however, since individuals are identical within each generation, it follows from (14) that

$$\frac{h(e_{t+1})w_{t+1}}{(\tau h_t + e_{t+1})w_t} = r_{t+1}. \tag{15}$$

Otherwise, if the left-hand side is larger (smaller), there is no physical (human) capital in period $t + 1$, and the left-hand side is smaller (larger) in contradiction. Given (15), it follows from the optimisation with respect to e_{t+1} that[28]

$$\frac{h(e_{t+1})}{\tau h_t + e_{t+1}} - h'(e_{t+1})\begin{cases} \geq 0 & \text{if } e_{t+1} = 0; \\ = 0 & \text{if } e_{t+1} > 0, \end{cases} \tag{16}$$

which is the condition derived in (5) in the basic model section for $\theta = 1$. That is, for $\theta = 1$, the introduction of endogenous wages and capital bequest does not alter the optimal level of education parents choose for each child and therefore, as follows from Lemma 1, the dynamic system governing the evolution of education is given by $e_{t+1} = \phi(e_t)$.[29]

2.3. *The Dynamic System*

It follows from Lemma 1 and (11), (15) and (16) that the dynamic system is uniquely determined by the sequence $\{k_t, e_t\}_{t=0}^{\infty}$ such that

$$\begin{cases} e_{t+1} = \phi(e_t); \\ k_{t+1} = \psi(e_t, k_t) = \alpha A k_t^{\alpha}[\tau h(e_t) + \phi(e_t)]/h[\phi(e_t)], \end{cases} \tag{17}$$

where k_0 and e_0 are given. Note that k_t is the physical human capital ratio and that physical capital per worker is equal to $h(e_t)k_t = s_t \geq k_t$. Output per worker, y_t, as follows from (10), is therefore uniquely determined by the dynamic system

$$y_t = h(e_t)Ak_t^{\alpha} = Ah_t^{1-\alpha}s_t^{\alpha}.$$

2.3.1. *The kk locus*

Let *kk* be the locus of all pairs (k_t, e_t) such that physical capital per efficiency unit of labour, k_t, is in a steady state: $kk \equiv \{(k_t, e_t){:}k_{t+1} = k_t\}$. As follows from (17), there exists a function

[28] Individuals' optimisation, regardless of the homogeneity assumption and therefore regardless of equation (15), ensures efficient investment in education:

$$r_{t+1} - \frac{h'(e_{t+1})w_{t+1}}{w_t}\begin{cases} \geq 0 & \text{if } e_{t+1} = 0; \\ = 0 & e_{t+1} > 0. \end{cases}$$

[29] Resources allocated to capital transfers come at the expense of the fertility rate.

$$k^{kk}(e_t) = \left\{ \frac{\alpha A[\tau h(e_t) + \phi(e_t)]}{h[\phi(e_t)]} \right\}^{1/(1-\alpha)}, \tag{18}$$

such that if $k_t = k^{kk}(e_t)$, then $k_{t+1} = \psi(e_t, k_t) = k_t$, i.e. the *kk* locus consists of all the pairs $\{k^{kk}(e_t),\ e_t\}$.

LEMMA 2 $\mathrm{d}k^{kk}(e_t)/\mathrm{d}e_t > 0$. *That is, as depicted in Figure* 2, *the kk locus is strictly increasing in the plane* $(e_t,\ k_t)$.

Proof. For $e_t \leq \hat{e}$, as follows from Lemma 1, $\phi(e_t) = 0$, and, therefore, $h[\phi(e_t)] = 1$, and as $h'(e_t) > 0$, it follows that $\mathrm{d}k^{kk}(e_t)/\mathrm{d}e_t > 0$ for $e_t \leq \hat{e}$.
For $e_t > \hat{e}$, it follows from (16) and Lemma 1 that $h[\phi(e_t)]/[\tau h(e_t) + \phi(e_t)] = h'[\phi(e_t)]$. Furthermore, as established in Lemma 1, $\phi'(e_t) > 0$ for $e_t > \hat{e}$, and as $h''(e_t) < 0$, it follows that $h[\phi(e_t)]/[\tau h(e_t) + \phi(e_t)]$ is strictly decreasing with e_t, and therefore $\mathrm{d}k^{kk}(e_t)/\mathrm{d}e_t > 0$ for $e_t > \hat{e}$.

2.3.2. *The ee locus*
Let *ee* be the locus of all pairs $(k_t,\ e_t)$ such that the level of investment in human capital per capita, e_t, is in a steady state: $ee \equiv \{(k_t,\ e_t){:}e_{t+1} = e_t\}$. However, as follows from (17), the evolution of e_t is independent of the evolution of the physical human capital ratio and hence $ee \equiv \{e_t : \phi(e_t) = e_t\}$. As follows from the properties

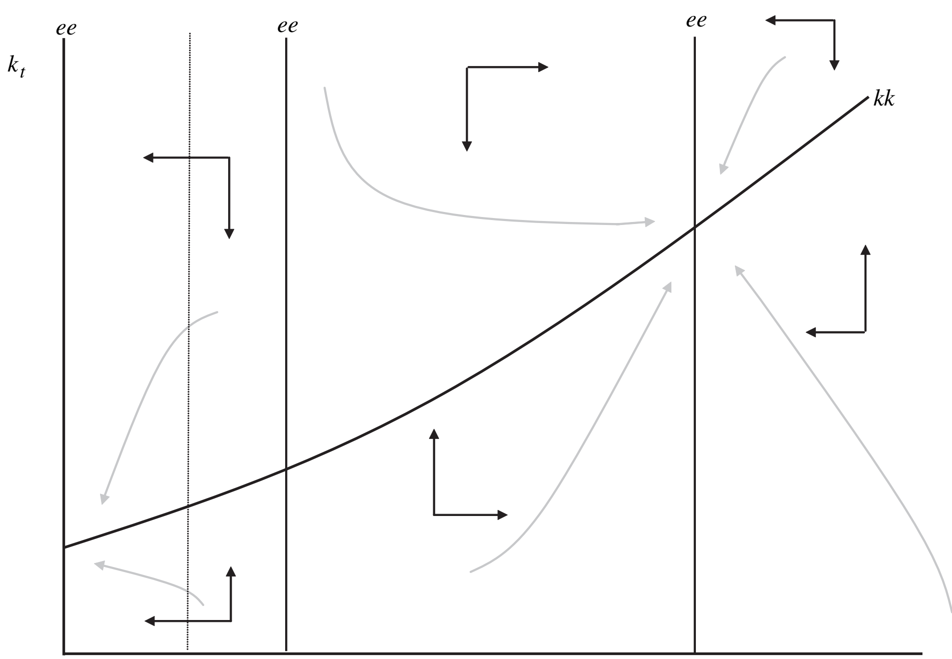

Fig. 2. *The Dynamic System*
The co-evolution of education and the capital/labour ratio

of $\phi(e_t)$, as depicted in Figure 1, $e_t = \phi(e_t)$ for $e_t = 0$, $e_t = e^T$ and $e_t = \bar{e}$, and, therefore, the *ee* locus consists of three vertical lines, depicted in Figure 2: $e = 0$, $e = e^T$ and $e = \bar{e}$.

The evolution of e_t, as follows from (17) and depicted in Figure 1, is given by $e_t = \phi(e_t)$. Therefore, as depicted in Figure 2, $e_{t+1} > e_t$ for all $e_t \in (e^T, \bar{e})$, whereas $e_{t+1} < e_t$ for all $e_t < e^T$ and all $e_t > \bar{e}$. The dynamics of k_t follow from (17). As depicted in Figure 2, $k_{t+1} > k_t$ for all $k_t < k^{kk}(e_t)$ and *vice versa*. Hence, k_t is increasing below the *kk* locus and decreasing above it.

2.4. *Steady States and Implications of the Extended Model*

The model generates two locally stable steady states. If the initial level of education is above the threshold level, $e_0 > e^T$, the economy converges monotonically to the high-capital labour ratio, high-education steady state, characterised by a low fertility rate. If, however, $e_0 < e^T$, the economy converges to the low-capital labour ratio, low-education steady state – the poverty trap – that is characterised by a high rate of fertility.[30]

It is interesting to note that in the context of a closed economy, the low-output steady state is not a result of capital market imperfections or any other market failure and resource allocation is dynamically efficient – the marginal return to education is not higher than the marginal return to physical capital. Hence, even if individuals could borrow to finance their own education, they choose not to. A shift of the economy from the low to the high-output steady state can be achieved only if one generation gives up child quantity in favour of child quality and suffers a utility cost. Of course, if countries differ from each other, in particular, if some economies are in the high-output steady state, then the low-output steady state is an outcome of imperfection in international capital markets (taken to the extreme of closed economies in the model).

As argued previously, the mechanism generating multiple steady states is based on the effect of parental education on child quantity cost. Lower parental education implies lower time cost and therefore cheaper children. Hence, lower parental education brings about a reallocation of resources from child quality to quantity. The effect of quality choice on output per capita is amplified in the extended model by its consequence on fertility and the diluting effect fertility has on capital accumulation. In the poverty trap, therefore, the high fertility rate yields a low capital-labour ratio.

An increase in the quantity time cost, τ, reduces the threshold for purchasing education, $\hat{e}$, and raises the level of education, $\phi(e_t)$, above $\hat{e}$. This implies that $\phi(e_t)$, depicted in Figure 1, shifts upward, the threshold level, e^T, declines, and the high-income steady state, $\bar{e}$, increases. Therefore, the *ee* locus, depicted in Figure 2, shifts accordingly, i.e. the vertical line at $\bar{e}$ shifts to the right, while the vertical threshold line at e^T shifts to the left. Furthermore, because $\phi(e_t)$ increases with τ for $e > \hat{e}$, it follows from Lemma 1, the concavity of $h(e_t)$, (16) and (18), that the *kk*

[30] In the poverty trap, the level of education is zero and as follows from (18), the capital labour ratio is $(\alpha A \tau)^{1/(1-\alpha)}$.

locus depicted in Figure 2, shifts upward with an increase in τ. Hence, in the extended model, the impact of changes in the cost of child quantity are amplified by the diluting effect on physical capital (the shift along the *kk* locus as a result of the change in the *ee* locus in addition to the change in the *kk* locus). Furthermore, because the threshold level of education, e^T, declines with τ, a sufficient increase in the quantity cost can facilitate a demographic transition and release the economy from the poverty trap.

3. Concluding Remarks

This paper presents a model of fertility and child educational choice based on the reasonable and empirically supported assumption that individuals' productivity as teachers increases with their own human capital. The model offers an explanation for the persistence of poverty within and across countries, consistent with the negative relationship between fertility and education, and the cross-country relationship between education, fertility and economic growth. In contrast to the existing literature, the model generates multiple steady states based on the trade-off between child quality and quantity, without imposing any restrictive assumptions concerning preferences, the return to human capital, or any non-convexity in the production process.

The theory developed in this paper provides testable hypotheses as well as policy implications. An increase in the cost of quantity – the cost of a child regardless of the child's quality – induces a reallocation of resources to child quality. It reduces, therefore, the level of the threshold below which individuals choose not to purchase any education for their offspring, and increases investment in education above this threshold. Hence, an increase in the quantity cost would positively affect economic growth and could, furthermore, release an economy from the trap of poverty, setting the stage for a demographic transition and economic growth. This result is testable and bears policy implications. Variations in policies that reduce the quantity cost, such as tax discounts for large families, child allowances, subsidized day care and meals, and unregulated child labour, can be exploited to uncover the effect of child cost on fertility and education decisions. According to the theory, these policies have a negative effect on income in the long run since they encourage households to increase fertility rates and reduce the quality investment and physical capital transfer to each child. Therefore, the policy implications, though not all in harmony (at least in the short run) with a humanitarian approach, are straightforward. Cancelling, or even reversing policies that reduce child quantity cost will contribute to per-capita income in the long run.[31] In particular, the theory predicts that child labour regulation that generates a significant negative impact on children' participation in the labour force would generate a reduction in fertility and increased investment in child quality, since less labour options for children imply a higher quantity cost and a lower quality

[31] The normative justification to tax children follows from the pecuniary externality – population growth dilutes capital per capita. Of course, while negatively influencing income in the long run, the effect of some policies could be favourable to growth in the short run. For instance, day care can increase women's labour force participation.

cost (forgone income). This prediction of the theory is consistent with the findings of Doepke (2004) who shows that child labour regulations play a crucial role in fertility decline.

Furthermore, because public schooling can release the economy from the poverty trap, growth-encouraging policies include reallocating government or foreign aid resources from quantity-cost reduction measures to the financing of schools. Note that providing education to a fraction of the population would have a positive effect on the economy. In contrast, according to Becker *et al.* (1990), only policies that provide education to a large fraction of the population may have a positive long-run influence on the economy, since otherwise the returns to human capital will remain low. The finding that a temporary improvement in education opportunities could have a permanent effect on the distribution of skills has been established in previous literature. The contribution of this paper, in this respect, is the linking of education to fertility, amplifying the economic consequences of the education policy.

The model offers explanations for cross-country output differences and for the phenomenon of club convergence. Consistent with the evidence, as shown for instance by Quah (1997), countries in the club of the rich converge to a high-income-per-capita steady state, whereas countries in the club of the poor converge to a low-income level.[32] The poor countries, as consistent with the observation of Cohen (1996), fail to catch up with the rich because of insufficient progress in education, which, as argued here, is due to high fertility rates. According to the theory, the only difference between members of the two clubs is in the initial conditions.

However, an important element in the explanation offered here, as well as in other club convergence theories, is missing. Since today's most developed economies were once poorer than most of today's poor economies, and since the dynamical system is constant over time and across economies, how did the developed economies pass the threshold level of income to form the club of the rich? The theory developed in this paper offers insight into the resolution of this puzzle. Technological spill-over from the advanced economies to the poor ones may alter the quality-quantity price ratio, and hence, change the dynamic path, potentially generating a poverty trap. Furthermore, the model implies that capital flows from advanced economies to the poor induce a reallocation of resources, increasing fertility rates and reducing capital transfers to each child. Finally, increased demand for child labour, following demand for low skilled goods from advanced economies, will reduce the relative price of quantity, encouraging parents to increase fertility on the account of educating their children.

Inferences from the extended model suggest that inequality has a negative effect on economic growth via the interaction between the rich and the poor. The relatively high fertility rates of the poor positively affect the return to physical capital. Therefore, the wealthy, who are more educated, reduce fertility and possibly education investment, and increase physical capital accumulation. On the other

[32] See Azariadis (1996) and Galor (1996) for surveys of the theoretical and empirical literature and the summery by Durlauf (1996*b*).

hand, due to the comparative advantage in child quantity, the increased physical capital accumulation by the wealthy turn the poor away from savings to increased fertility. The wealthy, therefore, specialise in accumulating wealth, while the poor specialise in high fertility rates, both negatively affecting the average level of human capital and output per capita in the economy.

Finally, the model sheds light on the role of increased life expectancy on the demographic transition. The rise in the potential return to investment in child quality due to the prolongation of the productive life is not as straightforward as it may appear. In fact, if a longer productive life increases life-time earnings proportionally to all skill levels, then the return to quality relative to the return to quantity is unchanged and therefore it will not generate a change in parental investment in child quality.[33] Indeed, consistent with evidence surveyed by Galor (2004), life expectancy in England and Western Europe increased at a stable pace for more than a century prior to significant increases in schooling and the demographic transition that occurred in the second half of the nineteenth century. Similarly, in the less developed economies during the twentieth century the decline in fertility, if occurred, lagged significantly behind the increase in life expectancy. The theory developed in this paper offers an alternative mechanism that can link increases in life expectancy with a demographic transition in a way that is consistent with the evidence. An increase in life expectancy, while having no effect on parental choice between quality and quantity, induces individuals to increase their own human capital (via more on the job training for instance). Eventually, once life expectancy has increased significantly, it will generate a sufficient level of self investment in human capital bringing about lower fertility and higher investment in child quality, triggering the demographic transition.

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Date of receipt of first submission: March 2001
Date of receipt of final typescript: March 2004

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