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WHY ARE POOR COUNTRIES POOR? A MESSAGE OF HOPE WHICH INVOLVES THE RESOLUTION OF A BECKER/LUCAS PARADOX

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ABSTRACT

Why are Poor Countries Poor? A Message of Hope which Involves the Resolution of a Becker/Lucas Paradox*

The Paper attempts to explain why single factor explanations of the poverty of nations are usually found to be unsatisfactory. Poor countries outside Africa, for instance, have an income per head that stands at about one third of the rich countries' income per head. Yet each of the three items of the Solow model, namely human capital, physical capital (appropriated weighted) and total factor productivity, are each equal to about 70% of the corresponding levels of the rich countries. But 70% to the power of three is 35%! Multiplying small or relatively benign handicaps can yield dramatic effects on a country's income. The Paper then moves on to explain each of the three items. It argues that the Lucas paradox on why capital is scarce can readily be solved, once market prices rather than PPP prices are used to assess the return to capital mobility, and on the same ground it argues that PPP calculations bias downwards the TFP of poor countries. It then argues that human capital is lower in poor countries because of the fact that the returns to human capital are non-concave so that the marginal propensity to turn one additional year of life expectancy into higher education is lower in poor countries than in the rich. The message of hope is that 'transpiration' strategies *à la* Singapore may work elsewhere.

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Keywords: education, growth, life expectancy and Lucas paradox

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INTRODUCTION

Why are poor countries poor? A deep question to which a wide ranging number of answers have been offered. Within the Solow framework, three usual suspects have been round up. Physical capital, first, has been rapidly disregarded on the ground that no externalities seem to be present and that capital mobility worldwide should be there to fill the gap (see among others Easterly (1999)). Human capital has been also progressively disregarded: again, few externalities appear to manifest themselves (see Heckman and Klenow, or Kruger and Lindahl) and the contribution of human capital to growth appear to be too small to explain the gap between rich and poor nations (see among others Bils and Klenow, 1999). One could also add that migrant workers earn much more in rich countries than in their home countries, so that human capital cannot be, in isolation, the reason why poor countries are poor (an *a contrario* argument that Lucas (1988) has used in order to explain why externalities on human capital must be important). Eventually, only one suspect appears to remain: total factor productivity, the famous residual, which lends itself to the analysis of other kinds of inputs such as institutions or "social infrastructure" as they are called in Hall and Jones (1999). Before returning to each of these three items, it is useful to compute first what the Solow model exactly has to say of the gap between rich and poor nations. Our preferred specification (we discuss alternatives in the text) amounts to write output per head as the product of three terms: human capital, physical to human capital with an exponent of one third and a total factor productivity residual, when taking the rich countries a numeraire for each of these items. We reach the following results.

	Output per head	Human capital	Physical Capital	Total factor productivity
Rich countries	1	1	1	1
Poor countries without Africa	0.35	0.65	0.69	0.75
Africa	0.11	0.49	0.41	0.48

Table 1:
Contribution of human and physical capital and total factor productivity to Income
according to the decomposition $Q/L = A(K/H)^{1/3} H/L$ *in which Q/L is output per head, H is human capital, K is physical capital: each term is divided by the average of the rich countries' levels. Source for Human Capital: Cohen and Soto (2001); Easterly (2000) on physical capital.*

This table is an amazing illustration of the power of multiplication. While the poor countries outside Africa stand at about one third of the rich countries' income per head, each of the three items contributing to their income per head are at about 70% (only) of the level of the rich countries. But 70% to the power of three is 35%! Similarly the African countries stand at about one tenth of the rich countries. Yet each of the three explanatory variable are worth about 50% of the rich countries level… This is reminiscent of Michael Kremer's O Ring model although this is couched here in the simpler framework of a neoclassical model. Multiplying small or relatively benign handicap can yield dramatic effect on a country's income. This decomposition explains, in our view, why single factor explanations of the poverty of nations are usually found to be unsatisfactory. Neither human or physical capital alone can explain much, which is why, by default, many authors have argued that difference in total factor productivity is the explanatory variable. This decomposition explains instead why the "transpiration" strategy of Singapore, focusing on human and physical capital, worked: by fixing two out of three items, a country can go a long way towards solving its development problem. It also explains why migrant workers do well abroad; their human capital allows them to double their income as they move from poor countries outside Africa to rich countries, and to multiply it by five if they come from Africa.

This being said, the puzzles that have been addressed by the literature remain. Why is it that despite capital mobility across the world, physical capital has not moved to the poor countries, a question usually coined as the Lucas paradox. Why is it that the reduction of world wide inequalities regarding life expectancy has not been channelled into a convergence of education patterns across the world, a Becker paradox, as we shall call it? Finally a word will also have to be said on total factor productivity.

The first question that we shall address is to understand the reason why capital does not flow to the poor countries, while the output per unit of capita appears to be relatively high in poor countries. We argue that the question itself arises from a misinterpretation of the usefulness of the Summers-Heston data. While these data are obviously quite useful for analysing income per head, they are not meaningful for analysing the return to capital, for which current prices (not PPP prices) should be used. No foreign capital will (should) be invested in hairdressing in La Paz, although at PPP, this could be gauged to be useful. As we shall review in section 1, at market prices, the capital output ratios are actually amazingly similar across the world. In other words, there is simply no Lucas Paradox when the returns to capital are appropriately measured (at market prices).

The next question is why is it that the convergence of life expectancy has not been channelled into a convergence of education? Over the past 40 years 45% of the increase of life expectancy in the rich countries has been translated into higher education, but only 23% in the poor countries. The answer is relatively straightforward: both the theory and the data point to a non-linear relationship between education and life expectancy. We outline both in section 1. Following a standard Mincerian approach, we first demonstrate that education is a convex function of life expectancy. We then show afterwards that education appears to only start rising significantly after the age of 50. As a result, the poorest countries are only in the early stage of their education pattern.

Finally, one additional implication that we shall also draw from this analysis will regard total factor productivity itself. We shall argue growth accounting based on Summers-Heston data are likely to bias the measurement of TFP. Indeed, to the extent that the efficient allocation of resources in a poor country is channeled towards the sector which have a high market price, they do not appear to maximize the value that can be extracted from PPP values. The inefficiency revealed by TFP may then be exaggerated.

The message of hope that one may then draw from this paper is that a virtuous circle may well be starting sometime soon in the poor countries. The progress of life expectancy, if (a big if) it was to be maintained, would pull education achievement. This would have larger effects on human capital accumulation than it did in the past as non linearities would start operate in favor of the poor countries. Furthermore, as these countries would get richer, the price of non traded goods would rise, attracting then more capital from abroad.

The paper then proceeds as follows. We give in section 1 our interpretation of the Lucas paradox. We then offer a reason why human capital has not been a factor of convergence in section 2. We finally discuss the role of TFP and relate briefly our findings to earlier studies such as Hall and Jones (1999) and Easterly and Levine (2001).

1 – The Lucas Paradox

In order to grasp the essence of the Lucas Paradox, let us write aggregate output (Q_{it}) of country i at time t as a Cobb-Douglas function of human and physical capital (H_{it}. and K_{it}. respectively) and total factor productivity (A_{it}.):

$$Q_{it} = A_{it} K_{it}^{\alpha} \; H_{it}^{1-\alpha} \qquad (1)$$

In a companion paper (Cohen and Soto (2001) hereafter CS) we discuss the validity of this model. When human capital is measured as in Mincer (1974), and when measurement errors on the data are taken into account, we argued that the model did a good job in accounting, both in levels and in first difference, for the distribution of income across the world. We also argued that private and social returns to human and physical capital appeared to be fairly identical. In our empirical application we shall rely on the data presented in CS, assuming a return to human capital of 9.5%.

In order to analyze the Lucas paradox, it should first be emphasized that, in the Cobb-Douglas formulation, it does not matter how one interprets A_{it} (provided, as we postulate, that there are no externalities). Depending on whether technical progress is Harrod, Solow or Hicks Neutral, the interpretation will differ on which remedies are called for. Yet, the return to capital accumulation will always be simply driven by the derivative of output with respect to aggregate capital, i.e. as:

$$r_{it} = \frac{\partial Q_{it}}{\partial K_{it}} = \alpha \frac{Q_{it}}{K_{it}}$$

In the Cobb Douglas case, as is well known, differences on the rate of return of to capital accumulation are simply reflected in differences in average values of the output to capital ratio. In such framework, the potential for capital mobility is simply given by the comparison of the inverse of the capital output ratio. The relevant data are shown in table 2 below.

	Physical output to physical capital
Rich countries	1
Poor without Africa	1.86
Africa	3.77

Table 2: **The average productivity of capital** (rich countries as reference)

As one sees from table 2, the ratio of output to capital is almost twice larger in the poor countries outside Africa than in the rich countries. In the case of Africa, the corresponding number is almost four times larger. if the return to physical capital are so much larger why are the capital inflow into the poor countries so low? This is the question asked by Lucas, to which a number of papers have been devoted. Lucas himself pointed at the role of externalities, while many other papers have analyzed the role of risk of capital expropriation (see Gertler and and Rogoff (1990)). The interpretation that we want to suggest comes as follows. Aggregate data in output such as measured by Summers and Heston data (and which usually serves as a basis for tables such as the one reported above) are not appropriate. What matters indeed is to compare the cost of capital to the true (uncorrected for price differences) market value of output. Take for instance the cost of capital goods as a numeraire and call $p(Q_{it})$ the market value of the goods produced by country *i*. Assume that in the rich countries $p(Q_{it})$ =1 (= the price of capital goods) but assume that in the poor countries $p(Q_{it})$ <1. This will be the case for instance if the distance of the periphery to the centre makes the good less valuable either because of the sheer cost of transportation or because of the consumers' tastes. In that case the return to investing one unit of capital good is

$$r_{it} = p(Q_{it})\frac{\partial Q_{it}}{\partial K_{it}} = \alpha . p(Q_{it})\frac{Q_{it}}{K_{it}}.$$

In other words, in order to assess the return to capital one needs to weight the physical productivity of capital (such as measured in table 2) by the price of goods relative to the price of capital. This relative price is given in the following table.

	Relative price of capital to output
Rich countries	1
Poor without Africa	1.50
Africa	3.32

One sees the wide variation of the relative price, which in part the sheer reflection of the Balassa/Samuelson effect that Summers and Heston intended to correct. In order to assess how much capital can flow into a given country, it is however critical to take account of these price differences. This is done below, using Easterly-Levine figure for physical capital, and correcting with the relative price of physical capital to output.

Table 3: **Return to capital**

Rich	1.0
Poor without Africa	0.98
Africa	1.10

Output per unit of capital, measured at market values

We see here that the relative price of capital is the main driving force behind the discrepancy of the output to capital ratio. Once the correction is made, we see that the return to capital (measured as output per unit of capital, at market prices) are fairly equivalent in our three groups, being only marginally higher in Africa; but well within the measurement errors of such type of exercise.

2 – A Becker Paradox

Let us now move to the question of investigating why education has not converged across the world despite the worldwide improvement of life expectancy. Table 4 below presents the raw data.

Table 4a: **Life expectancy** (At birth)

	1950	1999
Western Europe	67	78
US	68	77
Japan	61	81
Latin America	51	69
Asia	40	66
Africa	38	52

As one sees there has been a broad convergence of life expectancy across the world, both in relative and in absolute levels (as we argue below absolute levels are what matter). The poorest nations in Africa lagged 29 years behind the rich countries in 1950, they caught up 6 years; in Asia, the outcome is more spectacular: the discrepancy with the rich countries narroed from 27 years to 9 years over the second half of the past century. Compared to this pattern of broad convergence, education still lags behind the rich countries in the poorest nations (see Cohen and Soto, 2001).

Table 4b: **Schooling**

	1930	1960	1990
Rich	5.8	8.0	10.8
Poor outside Africa	2.3	3.2	6.2
Africa	0.9	1.3	3.1

Years of Schooling; source Cohen and Soto (2001)

In absolute terms (which is what counts, see below), the discrepancy between rich and poor nations hardly changed over the past fifty years. The reason why is summarized in table 5 below: at the margin the effect of the benefits of life expectancy on education in the richest nation has been much larger than in the poorest.

	1960-1990
Rich	0.45
Poor except Africa	0.22
Africa	0.18

Table 5:**Variation of education/variation of life expectancy**

The next question is: Why is that so? There are obviously many explanations, one on which we want to focus here being due to the benefit of accumulating human capital. Economists usually portray the relationship between an input ant an output as a concave function of the former upon the latter. This is not true of human capital however. If one follows the steps of Mincer, human capital is an exponential function of the number of years of study, so that the more you invest the more you get rich, and the more you receive. This has dramatic implications: if it was not for the fact that life is finite, you would like to keep educating yourself forever. With a finite life, this would not be quite as useful since you need to work some time in order to reap the benefits of your improved abilities. Nevertheless, one sees why the implication of rising life expectancy need not be the same for the rich and the poor. The longer your time horizon and the larger it might be that you wish to educate yourself. This reasoning is explained in appendix 1 in which we analyze how the effect of an increased life expectancy can be expected to be translated into higher years of studies and how the rich/poor divide is playing a role.

More specifically, the model that we solve is the following. Call T the life expectancy a person and consider a child who wishes to spend x years at school and $T - x \equiv X$ units of time on the labor market (in our model we assume that retirement yields the same payment as salaries through a pay as you go system; otherwise T would only measure the lifetime of the worker while working). While at school she foregoes the wage that she could earn by working full time. The benefit, on the one hand, of staying at school is that she can expect to earn a higher wage out of the education that she received. Call δ the return to schooling. A worker who stays x years at school will get paid:

$$w(x) = w_o \exp \delta x$$

in which we take wage to be an exponential function of education, as demonstrated in the literature which followed the pioneering work of Mincer.

The worker will decide optimally of her decision to go school so as to maximize her life time earning. Assume that, while at school, the worker still generates a product which is worth bw_0 (housekeeping, value of leisure, pleasure to the parents…). Call r the discount factor, so that e^{-rt} is the present discounted value of a pay-off which is forthcoming at time t. We can then write the problem that is solved as:

$$\underset{x}{Max} \left\{ b \int_0^x e^{-rt}\,dt + \exp\ \delta x \int_x^T e^{-rt}\,dt \right\} w_0 \qquad (2)$$

in which, to repeat, x is the time spent at school, T is the time horizon, δ is the return to school (we think of δ as 10%).

The details are shown in appendix, in which we reach the following conclusions. First consider the specific case when b=0 which corresponds to the "pure" case under which the time spent at school is a pure opportunity cost. In that case the corresponding value of X*, the time spent at work, is simply a constant, which means that –however long the life horizon- the lengthening of life is entirely channeled into education: the more you live the more you educate yourself. Of course, this only happens when the conditions are such that the solution to the model are an interior solutions. There is a critical lifetime T* below which no education ever take place, and above which it gradually rises until the potential for working life is exhausted.

In the case b>0, which will be our preferred hypothesis, one gets a non linear relationship between life expectancy and education which is such that the marginal propensity to educate oneself gradually rises towards one: asymtotically, the prediction corresponds to the limiting case where b=0: you eventually end up channelling all the benefits of life expectancy onto education. The picture of marginal improvements then comes as in figure 1.

[figure 1 here]

There is a critical value T* below which life expectancy is entirely channeled into work life: no schooling takes place. Above T* the level of education rises with life expectancy. For large values of life expectancy, all additional increases in the number of years of gets entirely translated into additional increase life in the number of years education.

Empirically, we present in appendix 1 a number of econometric evidences that all point strongly to a non-linearity between life expectancy and schooling.

[figure 2 here]

Our preferred estimation takes the following form:

$$Schooling = 0.015.[T - 2*50].T \qquad \text{R2=0.67}$$

in which T is life expectancy after 5. With this formulation schooling only starts rising (at the margin) when life expectancy after 5 is above 55. When it is worth 80 (rich countries today), the equation predicts that 45% of life improvement will be channeled into schooling. When life expectancy is worth 65 (poor countries except Africa in 1960) the number falls to 22.5%. When it is worth 60 (Africa in 1960) the number falls to 15%, all numbers which are very much in line with the results presented in table 5.

3. On the role and nature of TFP

The decomposition that we offer gives a lower role to TFP than most reader of the Hall and Jones (1999) (HJ) paper would expect. One first reason is that our decomposition is slightly different from the one which is presented in Hall and Jones who prefer to take the capital output ratio as a left hand side variable and write:

$$Q_{it} / L_{it} = A_{it}^{1/1-\alpha} (K_{it} / Q_{it})^{\alpha/1-\alpha} (H_{it} / L_{it})$$

Tables 6: **Decomposition à la Hall-Jones**

	Q/L	$(K/Q)^{0.5}$	H	$A^{1.5}$
Rich	1	1	1	1
Poor without Africa	0.35	0.81	0.65	0.67
Africa	0.11	0.60	0.49	0.35

Although not widely different, Hall and Jones decomposition gives a larger weight to role of total factor productivity for the simple reason that raising total factor productivity has implicitly two effects: one is to raise directly output another one is to raise capital through the implicit assumption that the capital output ratio can be held constant *ceteris paribus*. As our discussion of the Lucas paradox shows this is not quite the case. Besides, any improvement of *H* would also have a multiplier effect on *K*. At any rate, our decomposition is in line with the interpretation that a single producer in a poor countries could make of its discrepancies with a corresponding firm in a rich country: why does it take to raise my output: more human capital, more physical capital to put in their hands, and a better total factor productivity (a better organization of labor..).

Another reason why our results appear to be at odd with the intuition that is provided in HJ is that they provide an excellent fit of the relationship between TFP and output worker. Repeating the same exercise with human capital shows however that quite similar results:

Table 7: R2 of Q/L explained by TFP or H/L (in logs)

	A	H/L
R2	0.72	0.73

These variance decompositions say obviously little of the causalities involved, but they certainly discard the hypothesis that there is simply not enough variation of H in the data to explain the dispersion of income.

Another influential paper by Easterly and Levine (2001) has argued that TFP is the driving force behind growth. Rather than analyzing the dispersion of income at one given point in time as in HJ, they analyze the pattern of growth on a longitudinal basis. Without entering here into the details of their analysis, let us just point here at two stylized fact that they present in their paper. One has to do with the role of factor accumulation in Solow . They present selected growth accounting results from individual countries our of which they draw the conclusion that "detailed growth accounting examinations suggest that TFP growth frequently accounts for the bulk of growth in output for worker". The non OECD countries for which they present these growth accounting exercise are given in table 8 below.

Tables 8: **Growth accounting:**
% of growth explained by Factor Accumulation and by TFP

	Growth explained by Factor Accumulation	Growth explained by TFP
Latin America (1940-1980)	71%	29%
East Asia (1966-90)	85%	15%

Latin America: Argentina, Brazil, Chile, Mexico, Venezuela
East Asia: Hong-Kong; Singapore, South Korea, Taiwan.
Source Easterly and Levine (2001) and authors' calculations.

It is hard to argue from these numbers that TFP is the sole driver of economic growth in the non-OECD countries. In fact the decomposition appears quite similar (for Latin America) to the role that we obtain in levels for TFP among the non African poor countries. Another argument by Easterly and Levine on why factor accumulation cannot be the driver of growth is that factor accumulation is highly serially correlated over time, while growth is not (see Easterly *et al*., 1993). In itself this result does not tell us more than the fact that what we call TFP is quite volatile on a decade long basis: it may be driving the volatility of growth and not its secular trend. Indeed when averaged over three decades, we do get higher correlation between growth and factor accumulation than we find with TFP.

Growth accounting à la Solow can be misleading however: they may over/underestimate the effects of factor accumulation when private returns exceed/fall short of social returns. Altogether, the prima facie case seem to be that either for physical or for human capital they are, in average, roughly similar. (We explore this question in more details in Cohen (2002) and Soto (2002)). Growth accounting are also misleading inasmuch that they may fail to grasp the determinants of factor accumulation. Our analysis of the Lucas paradox do point to the view that growth feed physical capital. Human capital, through life expectancy (in the model that we presented in section 2) is also clearly related to the level of economic development. But obviously TFP itself is in part the outcome of economic development (see e.g. Acemoglu and Zibilotti (1998) for a view on how technology may be adapted in the poor countries, as a function of their human capital). Our interpretation of the Lucas paradox suggests one additional reason why this may also be the case, at least from a statistical perspective, that we now explore.

Explaining TFP?

We highlighted in section 1 the simple fact that the efficient allocation of resources in a poor country is channeled towards the sector which have a high market price. Summers-Heston (SH) data accounting, which use other prices will necessarily point to a lower efficiency in the poor countries, simply because the allocation of ressources in a poor country will always appear to be sub-optimal at SH prices since, to repeat, these are not the true prices under which the country operate. Imagine for instance that the economy consists of two sectors, one which is traded (say manufacturing) and one which as not traded internationally. Summers and Heston data put a uniform number of the relative price of these two sectors, the idea being that a hairdresser performs the same task in New-York and in Rio. Yet, if the market price of hairdresser is low, because the country is itself poor, the return to investing physical capital in hairdressing will be low as well: the hairdressing sector will be capital poor, and so will labor productivity be. At SH prices, this will be counted as poor TFP, when it needs not be. We explore in appendix 2 the implications of a two sector model on the analysis of growth accounting framework such as the one that is written in equation (1). Under one calibration exercise that is presented in the appendix, total factor productivity might be biased downwards by a factor of 15%, about half the value which has to be explained (from table 1).

Conclusion

Poor countries are poor because they are poor, used to say Myrdal some time ago. The flavor of this paper goes somehow in this direction. Because non traded activities are not valued at the price that they would receive in a rich country, capital inflows are low, and aggregate productivity is lower than it would then be. One implication of our analysis is that it highlights the merit of the 'transpiration' model that has been pursued by Singapore (Young (1995) and Krugman (1996)). By raising human and physical capital accumulation, countries can go a longer way than is usually expected. There may be other ways of course. Indeed, the message of hope that we reach is that despite the huge difference across countries, a typical firm in a developing country is not as far as it may appear from a firm in a rich country: not far from the frontier of total productivity, not far from the level of human or physical capital either: only far as it needs to solve all three problems together.

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Appendix 1

EDUCATION AND LIFE EXPECTANCY

We seek to

$$\underset{x}{Max} \left\{ b \int_0^x e^{-rt}\, dt \; + \; (\exp \quad \delta x \int_0^T e^{-rt}\, dt \right\} w_0 \qquad (1)$$

Let us define X=T-x, which we interpret as active life. Implicitly, if one retires before T, we assume that the pensions are equal to the wage earned while working.

The first order condition can be written as:

$$e^{-(r+\delta)X} = \frac{\delta - r}{\delta} e^{-\delta X} + b\frac{r}{\delta} e^{-\delta T} \qquad (1)$$

This is the value of an interior solution, which obviously requires $x \geq 0$ or equivalently $x \leq T$.

In the simple case when b=0, this happens if and only

$$e^{-rT} \leq \frac{\delta - r}{\delta}, \text{ that is :}$$

$$T \geq -(1/r)Log\left(1 - \frac{r}{\delta}\right)$$

In the general case when $b \neq 0$, the condition is relaxed if $b \geq 0$, and strengthened if b<0. Let us now compute how the variable X varies with T by computing $\frac{\partial X}{\partial T}$. From (1), We can write $(r+\delta)e^{-(r+\delta)X} . \frac{\partial X}{\partial T} = (\delta - r)e^{-\delta X} \frac{\partial X}{\partial T} + bre^{-\delta X}$.

Plugging (1) into the value of $e^{-(r+\delta)X}$ on the LHS, we reach:

$$\frac{\partial X}{\partial T} = \frac{\delta b r^{-\delta T}}{b(r+\delta)e^{-\delta T} + (\delta - r)e^{-\delta X}}$$

Recalling that $x \equiv T - X$ is the number of years of schooling, we can also write:

$$\frac{\partial X}{\partial T} = \frac{b\delta}{b(r+\delta) + (\delta - r)e^{+\delta x}}$$

We get the particular case that is apparent from (1). When b=0, $\frac{\partial X}{\partial T} = 0$, which means that any increase in life expectancy is channeled into education. Clearly $\frac{\partial X}{\partial T}$ is a decreasing function of T. When T increases, so does x, so that $\frac{\partial X}{\partial T}$ decreases. Asymptotically, for large values of T and x, $\frac{\partial X}{\partial T} = 0$, which means that any marginal increase of T is channeled one for one into education.

2. Empirical estimates

Let us now move on analyzing empirically the relationship between education and life expectancy.

Table A1.1

Dependent variable is years of schooling of population 25-29 in 1990

	OLS (1)	OLS (2)	GMM (3)	GMM (4)
Observations	84	84	83	83
Constant	53.233 (25.870)	34.738 (2.069)	49.291 (155.87)	49.682
$L5_{1980}$	–1.863 (0.772)		–1.671 (4.532)	
$(L5_{1980})$^2	1.717e-2 (0.571e-2)		1.523e-2 (3.268e-2)	
$L5_{1980}$×($L5_{1980}$ - C)		1.314e-2 (0.099e-2)		1.534e-2 (0.291e-3)
R^2	0.678	0.683	0.668	0.668
F-statistic (Prob. value)			<1%	<1%
Sargan (Prob. value)				17.2%

Standard errors in parenthesis. Instruments for GMM are: constant, latitude, and lagged change in life5. C = 100 in column (3) and 109.7 in column 4.

Table A2.1 presents results for the estimation of equation:

$$YS_{it} = \pi_0 + \pi_1 L5_{it-10} + \pi_2 L5^2_{it-10} + \eta_i + u_{it} \quad \text{(A1.1)}$$

where YS_{it} is years of schooling of population aged 25-29, L_{it} is life expectancy at age 5, n_i is a country-specific effect and u_{it} is a time-varying residual. The equation is estimated for t = 1990. In most of the regressions life expectancy is highly significant. The OLS estimates of column 1 suggest that, on average, countries reach a minimum level of education when life expectancy at 5 is 54. To better illustrate these results, consider the case of Sudan. This country had in 1980 one of the lowest levels of life expectancy at 5 (55.6) in the sample. Ten years later, YS in 1990 is estimated at 3.2, whereas the predicted value from column 1 is 2.8. The constrained estimates of column 2 –where the threshold for L5 yielding minimum education levels is set at 50– do not vary substantially.

Yet, OLS estimates are likely to be biased upwards (in absolute value) since they do no account for the presence of the country specific effect □$_i$. Arguably, □$_i$ is correlated with $L5_{it}$, hence the source of inconsistency in OLS estimates. Column 3 reports results obtained by GMM estimation. In addition to a constant, the instruments used are latitude and the 10-year change of $L5_{it-10}$. The rationale for selecting the latitude of a country as an instrument is that countries with lower latitudes are prone to tropical diseases, an important factor determining life expectancy. At the same time, it is hard to imagine that the latitude may have an impact on years of schooling other than through the effect on life expectancy. So latitude is likely to be a suitable instrument (which is tested later).

The other instrument is the change in life expectancy at 5. Taking life expectancy in differences removes the country-specific effect and so the source of endogeneity present in this variable disappears. Since the change in life expectancy is correlated with its level, changes are suitable instruments for levels. We also tried $L5_{i-20}$ as an instrument, but its exogeneity was rejected by Sargan tests. This is a clear sign that country-specific effects are present in the dynamics of L5.

Column 3 presents unrestricted estimates of equation (A2.1). As expected, the coefficients are lower than those obtained with OLS, but they are not significant. In fact, the GMM estimation reported in column 3 is exactly the same as the one that would be obtained by a standard instrumental variable approach (i.e., an estimation without computing an optimal weighting matrix for the instruments). This is so because the equation in column 3 is exactly identified or, in other words, there is the same number of instruments as regressors. As a consequence, the estimation reported in column 3 is inefficient.

Column 4 presents the constrained version of equation A2.1, where the threshold life expectancy is set at 55 years (this value is obtained from column 3). The constrained estimation reduces the number of regressors and makes possible an efficient estimation. As a result, the coefficient on $L5_{it-10}$ is now highly significant. An F-test for the first stage instrumental variable regression shows that the instruments used are also significant. Finally, a Sargan test shows that the instruments are exogenous.

Appendix 2:

TOTAL FACTOR PRODUCTIVITY

IN A 2 SECTOR MODEL

Let us adopt a two sector model, one traded –one non-traded. Assume that the traded sector production function is

$$Q_1 = AK^{\alpha} H_1^{1-\alpha}$$

while non traded sector is:

$$Q_2 = AX^{\alpha} H_2^{1-\alpha}$$

in while X is a factor-specific input (cities…) which we take to be identical in rich and poor countries (in per capita term). Call p the (market) price of the non traded sector. Total output can be written as:

$$Q = Q_1 + pQ_2$$

First order conditions regarding the allocation of human capital yield:

$$\frac{K}{H_1} = p^{1/\alpha} \frac{X}{H_2}$$

as substituting X for the corresponding value this yield :

$$Q_t = A_t \left[K_t^{\alpha} H_{1_t}^{1-\alpha} + K_t^{\alpha} H_{2_t}^{1-\alpha} \right]$$
$$= A_t K_t H_t^{1-\alpha} \left(\frac{H_{1t}}{H_t} \right)^{-\alpha}$$

We then see that the more concentrated in sector 1 will be human capital (a result of low market value to the non-traded sector) the less productive the economy will appear to be.

Given the exponent $\alpha = 0.33$, it would take large deviations to manifest themselves. To reach the discrepancy that is written in table 1, it would take

$$\frac{H_1}{H} = 2.40$$

If one simply takes as a benchmark for the non traded sector the service sector we get a ratio of labor into the traded good (manufacturing and agriculture) which is about 1.6 times larger in the poor countries. This generates a TFP differential worth 15% somehow half the value that we have to explain.

Figure 1

Incremental Schooling to Life expectancy

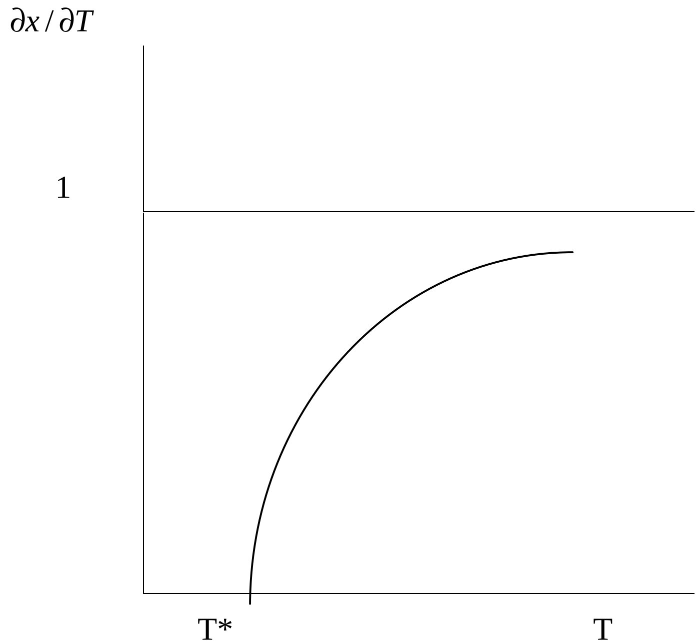

Figure 2: **Life expectancy and Schooling**