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Teachers Matter:

Teachers Supply as a Constraint on the Global Education Transition

By Annababette Wils and Raymond O'Connor

WP-01

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Teacher Supply as a Constraint on the Global Education Transition

Working Paper WP-01

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March 2004

Reviewed by: George Ingram and John Gillies.

Abstract

This paper examines constraints to full enrollment in developing countries and finds that a shortage of human resources, in the form of medium- to highly educated adults, are a significant factor. To date, studies on constraints to full enrollment have focused on finances (national income), population growth, and political commitment, thus missing, this paper suggests, one of the most important limiting factors. In fact, when adult secondary education is taken into account, there is no residual statistical correlation between school enrollment and national income or population growth.

In addition, the paper shows that in counties with very low levels of adult secondary education, two compensating mechanisms often come into play, namely that a larger portion of the well-educated adults is teaching and that class sizes tend to be larger. Both of these mechanisms can significantly raise enrollment levels.

The analysis finally suggests that as a shortage of well-educated adults is a real constraint to full enrollment in many countries, targeted policies and programs need to address human resources, rather than to provide just financial support to education.

Recommended Citation

Wils, Annababette and O'Connor, Raymond, 2004. *Teachers Matter: Teacher Supply As A Constraint On The Global Education Transition*. Working Paper WP-04-01. Education Policy and Data Center, Washington, DC (FHI 360).

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ACKNOWLEDGEMENTS

The authors would like to give many thanks to Robert Kates and Tom Parris for their stimulation of this work and their essential comments, as well as Harvard University for funding the initial phase of this study as part of its Assessment and Decision Support for Global Environmental Change program, and to the Education Policy and Data Center at FHI 360 in Washington DC for material support. The views expressed in the paper are those of the authors alone.

Teachers Matter:
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1. INTRODUCTION

For half a century, education has been a human right. Yet, in 2002 an estimated 113 million children were still not in school (UNESCO 2002) and about 20% of adults in the world still remain illiterate. Among those who can read and write, many have but a rudimentary skill. In two recent papers, the authors have shown that the shortest time to transition from an essentially illiterate state (only 10 percent of the population literate) to effectively complete national literacy (90 percent of the population literate) has been of the order of 35 years, but with most countries requiring at least twice as long (Wils and O'Connor, 2004; Wils, 2004). What has made it so difficult to raise enrollment levels quickly? Has it been a lack of political will or have there perhaps been other causes at work?

The comprehensive background report for the global education conference in Dakar in 2000 identifies lack of stability, political will, and financial resources, coupled with rapid population growth as the most important constraints on high enrollment levels (UNESCO, 2000). The report states that good leadership and national dedication can overcome those constraints. But the report gives virtually no consideration to how human resources affect the education transition, despite describing these resources as critically important ("by consent, the key resource"). Mehrotra (1998), in an influential UNICEF paper on determinants of rapid enrollment rise in ten countries, names mainly financial variables, including income and the proportion of GNP spent on primary education. Three other reports on the resource requirements needed to achieve full enrollment (Brossard and Gacougnolie, 2000; Delamonica et.al. 2001; and World Bank 2002) also focus on financial aspects. These studies assume that if financial resources become available, a major constraint to the implementation of programs will be removed. In the analysis presented here, however, we show that this assumption is probably incorrect and that in actuality a critical underlying issue may be a lack of adults well enough educated to serve as teachers, as well as a lack of educated parents who demand their children's education.

That a sufficient proportion of well-educated level of adults is an important, though under-appreciated, determinant of the extent to which children are enrolled in primary schooling is plausible, even without thinking about teachers, because many studies identify overall adult education as an underlying determinant of the constraints identified in the Dakar report. Barro (1991), Psacharopoulous and Patrinos (2002), and the WEI report (2003) all show the impact of education levels on income. Cochrane (1986), Dreze and Muhrti, (2001), Hobcraft (1993), and Schultz (1995) have examined the linkage of education and population growth rates. Finally, Hannum and Buchanan (2003) and BEC (2004) have reviewed the interaction of education and political stability.

In addition, many household studies have found that the education level of parents is an important determinant of the probability that children are enrolled in school (e.g., Bernardo, 2000; Gorman and Pollit, 1997; Lloyd and Blanc, 1996; Lloyd and Hewlett, 2003; Caldwell, 1967; Glewwe, 2002).

One can argue that all of these constraints can be overcome with sufficient financial resources from abroad, were it not that it is only *educated* adults who constitute the pool of potential teachers, wherein a bottleneck lies. Relatively few studies have considered shortage of personnel qualified to enter the education system as an impediment to enrollment growth (Lewin, 2002; Scott, 2001; Elu, 1997), although in those countries losing teachers to AIDS, the shortage of teachers is becoming more acute.

The present paper sets out 1) to disentangle the different effects of various drivers of gross enrollment rates and to structure them into a theory of enrollment 2) to determine the mechanisms by which the level of educated adults impacts enrollment rates 3) to identify what coping strategies, if any, countries with a shortage of educated adults employ to raise enrollment rates and 4) to evaluate whether a shortage of educated adults is a matter of empirical importance today. The paper brings together a wide selection of data, including economic and demographic variables, to provide a broad understanding of the relationships and dynamics behind school enrollment levels. The paper presents descriptive and statistical analyses in support of our conclusions; a dynamic simulation model of the structure identified here will be presented elsewhere.

A simple calculation, of the minimum proportion of a country's population needed as teachers in order to send all children to school, will serve to introduce the thesis that adult education levels must matter. Primary school teaching requires a not insignificant labor effort. The ratios of school age children to adults in various countries range from around 0.15 to 0.50 and are highest in the countries with low adult education. A country with a ratio of primary school-age children to adults of 0.40 would need to employ 1% of the adult population to teach in primary schools if average class size was set at 40. Additional adults will be needed as educational administrators at the local, regional and national levels. But in many of the countries presently with low literacy levels (at least several dozen), not even 10% of the adults have secondary education. That is, in these countries no fewer than one of every ten adults with secondary education would need to be employed in primary teaching to meet the goal of all children in school in classes of size 40. In these countries, the human resources needed to send all children to school are simply very scarce.

Let us expand this thinking before moving to the empirical analysis. One of the standard measures of progress in education is the gross enrollment rate, G, the proportion of primary school pupils P among the total population of children C i.e.

$$G = P/C \qquad \text{(Equation 1)}$$

by definition. To include the impact of adult education, w first re-write this equation algebraicly by dividing both numerator and denominator by the quantity TS/A, where T is the number of primary teachers, S is the size of adults with secondary education (a proxy for high education levels) and A is the size of the adult population to get

$$G = (PA/TS)/(CA/TS) \qquad \text{(Equation 2)}$$

On re-arranging this becomes

$$G = (S/A)(A/C)(P/T)(T/S) \qquad \text{(Equation 3)}$$

But the term S/A is just the proportion of the population with secondary education; A/C is the inverse of child-adult ratio; P/T is the pupil-teacher ratio; and T/S is the proportion of adults with secondary education who become primary teachers. That is, these algebraic manipulations show how the enrollment ratio is mathematically equivalent to the product of these four terms, thus integrating different human resource variables into the enrollment equation..

Of these four variables, the first two – proportion of population with secondary education and the child-adult ratio - are demographic variables that change only slowly under the long momentum of many demographic processes. But the proportion of the educated population employed as primary teachers and the pupil-teacher ratio are both malleable by policy, and can be changed quickly. They are however, constrained by limits on maximum levels. In 1996, for example, the highest value for T/S was 22% for Tanzania, and it is difficult to imagine that much higher levels are possible, because well-educated adults are also needed for management, policy making, and other vital tasks. The pupil:teacher ratio, P/T is also limited by declining effectiveness of teachers as class size gets larger. The education budget of the country additionally constrains the number of teachers that can be hired, and thus impacts both variables.

This re-casting of the definition of gross enrollment rate in terms of the four human resource components can be used to decompose changes in enrollment rates into contributions from changes in the age-structure, in the adult education levels, in the proportion hired as teachers, and the pupil:teacher ratio. Doing this provides a conceptual framework consistent with the definition of enrollment rate. That is, equation 3 shows that a hypothetical doubling of the child-adult ratio in a country necessarily halves the gross enrollment rate, all else being equal. Whether a two-fold difference in child-adult ratio between any two countries in our sample is actually associated with a halving of enrollment rate depends on the validity of the *ceteribus* clause and is therefore an empirical issue to be determined from the data. We proceed here, therefore, by determining the extent to which these four factors actually influence enrollment rates in a large sample of country-specific data, and then relate these to the theoretical constraints suggested by the equation. We also incorporate some financial data (the proportion of government income spent on education, per capita income) into the analysis to allow us to investigate whether the implied predominance of financial limits is supported when the alternative factors are evaluated alongside them.

2. DATA

Virtually all of our data comes from the international datasets of the UNESCO, the World Bank, and the Barro and Lee (1996) International Education achievement dataset. The quality assurance for each dataset is as specified by the respective compilers. The data have not been altered in any way. The individual datasets are not perfect and are subject to a variety of errors, some of which are discussed in the remainder of this section, against the effects of which the principal protection is the relatively large numbers of countries included in the analysis. The data used in this study

include the four human resource indicators discussed above, to a measure of school participation for which we suggest gross enrollment rates, as well as economic and financial measures.

School enrollment (UNESCO, 1999) has often been cited as an ambiguous indicator of school participation, and often contains multiple errors. Lloyd and Hewlett (2003) recently compared school enrollment data to Demographic and Health Survey (DHS) results on school participation. They found that the gross enrollment rate often inflates the estimate of the proportion of a particular cohort of children actually attending school, in part because of erroneous reporting and partly because of other factors such as early withdrawal and over-age school attendance. Other indicators, such as the proportion of particular cohorts finishing a certain level of schooling, or reporting no schooling, as measured by the DHS or in population censuses, may be better measures of how much schooling is actually received by a particular cohort. However, enrollment remains the most easily available index of school participation, and gross or net enrollment are generally used as a compact indicator of school participation. The present paper uses gross enrollment, rather than net, to include the large proportions of children in many countries who are over-age for their class.

Two of the measures used in this paper rely on population census data, with or without short projections, namely, the *adult level of education* and the *population age-structure* used for the child: adult ratio. The population census is a comprehensive survey of size, age, and the distribution of the population, but it also contains information on a number of other characteristics, such as the education level of each individual. In most censuses, some portion of the population is omitted, and there are errors of content also (Fosu, 2001). A number of demographic techniques have been developed to deal with such errors (Fosu, 2001), but the databases used provide information neither on what censuses have benefited from such analyses nor on the approximate error in the data presented.

Barro and Lee (1996) compiled a database of *adult levels of education* using data from 1960-1990, for 127 countries, with the results categorized by the major education sectors (primary, secondary, and higher). The main drawback of this database is that schooling sectors differ between nations, as does how much is learned, on average, in each level. As an example of the former differences, in West Germany in 1990 (before reunification) only 33 percent of the adults were reported to have complete secondary education, while in Canada it was 85, a gap that certainly comes from variations in how "complete secondary education" is defined.

The *age-structure of the population* is also based on population census counts, but for years in which no census took place it is the result of population projections, which include assumptions about mortality, migration and birth rates. These rates can change unexpectedly. For example, Mozambique at the time of the 1997 census had 10% less population than projected, probably because emigration and mortality had been higher than anticipated, in part due to the rising AIDS epidemic (Gaspar, census report).

The economic measure used here, namely *GDP per capita* (in purchasing power parity) (UNESCO, 1999), has its own problems as well. GDP per capita is subject to error both on the income accounting side and in the population size estimate. Accounts

of GDP generally include many estimates, including parts of the formal economy that have not been reported, approximations of the informal sector of the economy, and may or may not include estimates of the black, or illegal, sector. In some countries, the last two sectors can make up a sizeable portion of total income. GDP does not account for man-made or natural capital depreciation or destruction. In addition, countries differ with regards to the estimation procedures. Prices for products can differ greatly between countries, so to give a better account of the actual value of GDP it is adjusted to reflect purchasing power parity. This adjustment is subject to the correctness of price information and of the relative weight assignments to each product or service group in the economy. All of this says that accounts of GDP should be used with caution, realizing that the numbers reflect only a rough picture of economic production.

Public expenditure on schooling as reported by the national governments (UNESCO, 1999) is used in the present study as an indication of a government's dedication to public schooling. Therefore, some of the drawbacks to this indicator -- it does not reflect capital already built (such as school buildings), it includes large differences in teacher pay, and type of school materials used, and it excludes private (household or NGO) expenditure on education – are not relevant. Public dedication to education can be measured by other things than financial commitment, such as the cohesiveness of the national education plan, community participation, education monitoring systems (Loos, 2003). These limitations notwithstanding, we follow earlier authors e.g., Mehrotra (1998) in using expenditure to approximate public school dedication.

The caveats imposed by such data limitations mean that the results should be interpreted with some caution, as all international comparisons, and that we should look for particularly robust relationships. Below, the paper proceeds to undertake an international comparison of proximate determinants of enrollment rates, and to begin to formulate a theory of education from those results. We begin with a broad analysis that includes financial, demographic and human resources indicators, and then proceed to a more detailed analysis of the supply of teachers.

3. ADULT EDUCATIONAL ATTAINMENT AS THE PRIMARY DRIVER OF SCHOOL ENROLLMENT

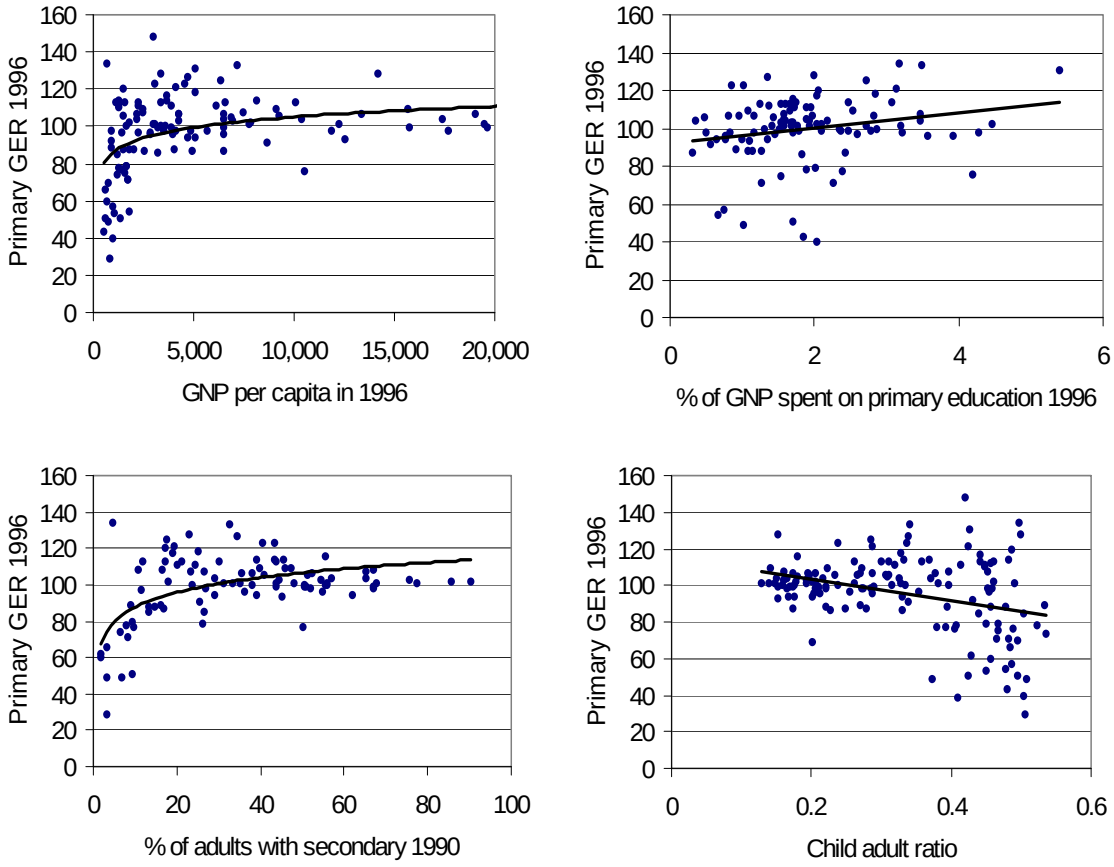
As described above, commonly accepted proximate determinants of the gross enrollment rate include national income, the proportion of income spent on education, the population growth rate, political stability and national commitment (UNESCO 2000, Loos 2003). The neglect of social and demographic variables in the macro studies is at odds with the strong influence of those variables found in household level surveys, with some available evidence as to bottlenecks created by a shortage of teachers and well-educated administrators (see above), and with the rationale for equation 3 as the definitional equivalent of enrollment rate. The present analysis of proximate determinants therefore includes demographic and human resource variables alongside metrics of income and political commitment, but sets aside at this time the issues of stability and national commitment.

The four of the variables considered here as proximate influences on enrollment are 1) the proportion of adults with secondary education, indexing the human teaching resources available and the level education among parents 2) GNP per capita, serving also as a proxy for average household income 3) the proportion of GNP spent on primary education, providing also a proxy for national dedication to education, and 4) the ratio of children aged 6-14 years old to adults, a proxy measure for effects of population growth rate and of number of siblings. Two other variables that appeared in Equation 3 above are also considered: these are the proportion of the educated population employed in primary teaching, and the pupil-teacher ratio.

Figure 1 shows how the gross primary enrollment rate varies with the first four of these four macro determinants. Gross enrollment ratio is clearly non-linearly correlated with the percentage of adults with secondary education, increasing steeply over the 0-20% range and leveling off thereafter (Figure 1a: $r = 0.343$, $P<.001$). Enrollment also increases in this way with per capita income, steeply over the first $1,000 or so, and relatively level thereafter (Figure 1b: $r = 0.232$, $P<.01$). Enrollment rate was negatively correlated with the ratio of children to adults (Figure 1c; $r = -0.323$, $P<0.001$) and the effect of proportion of GNP spent on education was rather weak (Figure 1d; $r = 0.174$, $P\sim0.06$).

All of the correlations are in the expected direction and statistically significant, although it is clear that much variation exists. The dataset includes 160 countries for which 1996 data on the gross enrollment level were available. Note that many countries had enrollment rates above 100, reflecting the presence of some inflation of the metric (Lloyd and Hewlett 2003).

Figure 1. Cross-tabulation of primary gross enrollment rates with a) average income per capita in purchasing power parity in 1996 b) the proportion of GNP spent on primary education, c) the proportion of adults with secondary education in 1990, and d) the ratio of 6-14 year olds to adults age 15+.



Sources: For primary GER, income per capita, proportion of GNP spent on education, and age group ratios UNESCO online database (2002) and for proportion of adults with secondary education, Barro and Lee (1996).

Regarding the correlation of adult secondary education with gross enrollment, in only three of the 15 countries with enrollment rates below 80 did more than 10% of the adults have some secondary education. These countries were the Democratic Republic of Congo, Ghana, and Kuwait. Conversely, in only two of the 82 countries with enrollment rates above 80 did less than 10% of the adults have secondary education (Malawi, United Arab Emirates). This implies that some minimum frequency of adult education (or some quality very closely correlated thereto) is closely associated with, and is perhaps necessary in all but exceptional cases for, high enrollment.

These links of enrollment ratio to the four independent variables considered involve considerable confounding of effects. Secondary education was well correlated positively with per capita income ($r = 0.779$, $P<0.001$, on double logarithmic scales) and negatively with the child adult ratio ($r = -0.752$, $P<0.001$). This latter relationship, proved to be of particular importance (below). Per capita income and child-adult ratio were themselves mutually correlated ($r = -0.729$, $P<0.001$). Only the percentage GNP variable was largely independent of the other three (education $r = 0.112$, n.s.; income $r = 0.054$, n.s.; and children-to-adult ratio $r = - 0.013$, n.s.) and contributed little to predicting enrollment ratio ($t=1.103$, not significant, in a multiple regression analysis). We therefore examined the extent of partial correlations that corrected for these confounding effects

The enrollment ratio continued to be well correlated with secondary education levels once income was held constant ($r_p = 0.422$, $P<0.001$) but the correlation of enrollment ratio with per capita income disappeared almost completely ($r_p = -0.038$, not significant) when level of secondary education in the country was controlled for. Enrollment ratio therefore is directly related to secondary education rate and only indirectly (through the cross-correlation of income and secondary education) with income.

The corresponding analysis with child-adult ratio as the confounding variable gave parallel results: enrollment ratio continued to be correlated with secondary education once the effects of the cross-correlation with child-adult ratio was removed ($r_p = 0.489$, $P<0.001$) but the link between enrollment and child-adult ratio disappeared once the influence of secondary education was removed ($r_p = 0.067$, not significant).

In summary, the level of secondary education is clearly the strongest independent driver of the gross enrollment level, with the role of the other variables merely the result of cross correlations. If adult education levels are in this way both an ultimate and a proximate driver of the enrollment ratio, an obvious policy is to raise adult education levels. But this leads to a chicken and egg problem – to raise adult education, high prior enrollment rates are necessary, which in turn, require high adult education.

4. HOW COUNTRIES COMPENSATE FOR LOW ADULT EDUCATION

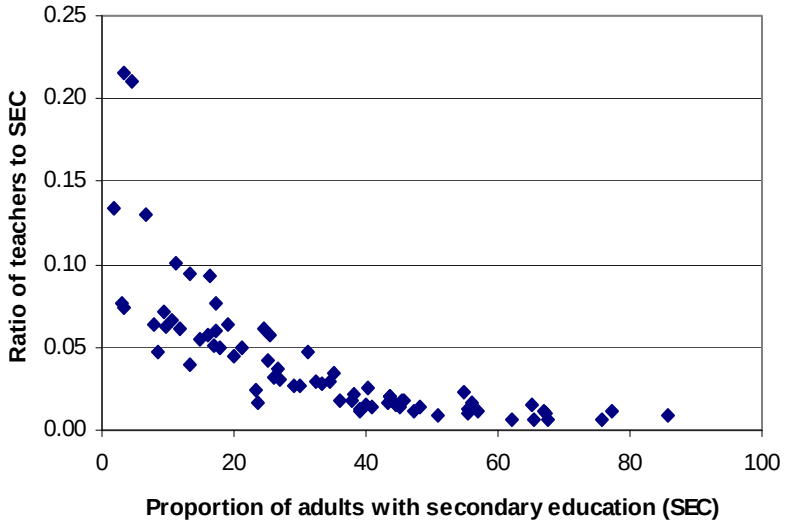
At least three mechanisms are available by which countries can break this children and egg quandary. First, educated adults can be brought into the country from outside its boundaries. Second, the educational requirements demanded of primary

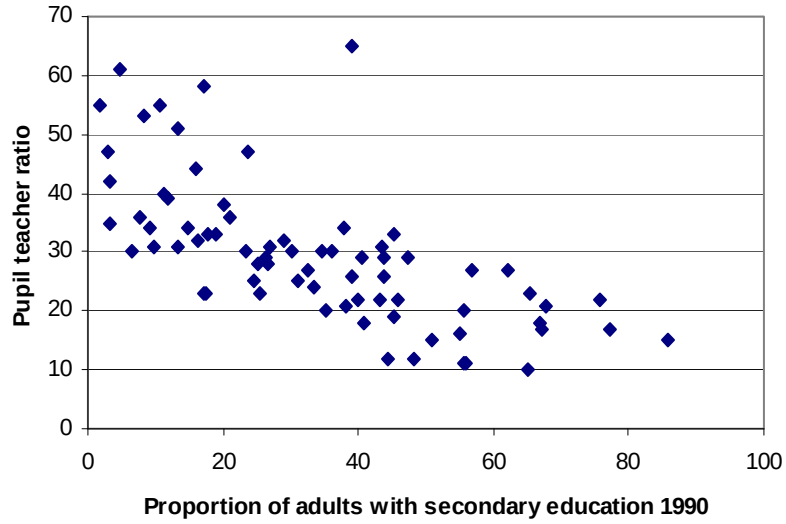
school teachers can be lowered. Third, the supply of educated adults can be focused disproportionately into the education sector in order to reach more children. The first of these has some historical precedent, for example in Botswana, which brought in teachers from South Africa and managers from around the globe in the effort to strengthen its teaching capital. The high enrollment rates in the United Arab Emirates relative to their educated population noted above may also have been achieved by bringing teachers from abroad (and the UAE certainly had the financial means to do so). The second mechanism is being tried in many successful experiments with alternative schools, although even in these experiments, the teachers, young and uncertified they may be, are expected to have at least a few years of secondary schooling. However, it is the third mechanism that is most widely used.

4.1 Higher proportions of educated adults working as teachers

In many of the countries with a low proportion of adults with secondary education, an unusually high proportion of those adults work as teachers. This compensating measure (whether voluntary, in the sense of being promoted as public policy, or involuntary, as the outcome of inadequate alternative employment) is very consistent in the international comparison shown in Figure 2a: the proportion of adults with secondary education who are employed in teaching decreases as a power function of secondary education in the country (Pearson $r = -0.842$, $P<0.001$, double log scale). However, other factors must also be involved here, for two reasons. First, this solution can only be used within limits because, even in a weak economy, the scarce educated adults are also needed for managerial and government tasks. Thus among our sample the highest proportion observed was 22% (in Tanzania), committing nearly one of every four educated adults to teaching. Second, even among countries with a low proportion of educated adults there was as much as a four-fold variation in the proportion in teaching, and some other factor is needed to account for this vertical spread.

Figure 2. Cross tabulation of the proportion of adults with secondary education to a) the number of teachers, and b) the pupil:teacher ratio.





Source data from UNESCO (2002) and Barro and Lee (1996) databases.

That a policy of hiring more teachers while the pool of well-educated adults is small can have large impacts on the gross enrollment ratio is well illustrated by some specific country examples. Table 1 shows six countries with similar, very low proportions of secondary educated adults. Three of those countries hired a large portion of secondary education adults as teachers in 1990; three did not. In Tanzania in1990, some 22% of the adults with secondary education were working as teachers; in Uganda it was 19%; and in Mozambique it was 14%. In contrast, the corresponding numbers in Mali, Niger and Afghanistan were 10, 10 and 5% respectively. The effects are seen in enrollment rates 2.5 times as high in the former countries compared to the latter.

Table 1. Proportion of adults with secondary education teaching primary in 1990, the proportion of adults with secondary education in 1990, and the GER in 1990.

Country in 1997	% of educated adults working as teachers	% of adults with secondary education	Gross primary enrollment ratio
Mozambique	14	2	67
Tanzania	22	3	70
Uganda	19	7	74
Afghanistan	5	7	27
Mali	10	3	26
Niger	10	3	29

4.2 Larger class sizes

The second very consistent pattern present where educated adults are scarce is for average class sizes to increase, that is, for pupil-to-teacher ratios to increase (Figure 2b). Again the relationship is a power function rather than a linear one and strongly significant (Pearson r = -0.701, P<0.001, double log scale). This relationship has greater variance than Figure 2a, with two- to three-fold variation in class size at any given level of secondary education among adults. Again, there is a limit to this compensating mechanism because the effectiveness of learning decreases with increasing class size. The highest national pupil:teacher ratios found for 1996 were 71 in Mali and 70 and the Congo (Figure 2b). Economic limits probably underlie the lower limit to class size (10-15) observed.

The dynamics of raising the pupil:teacher ratio are well illustrated by taking one of the six countries above, Mali, as an example. In 1990 the gross enrollment rate was only 26 but by 1997 it had risen to 48. Too little time elapsed for this rise to be attributed to any increase in the pool of adults with secondary education. Instead, the increase is due to more hiring and to recourse to larger classes. By 1997 there were 50% more teachers than in 1990, the result of an aggressive hiring policy in the interim, and the pupil:teacher ratio had risen from 47 to 71 (the highest ratio in 1996). The authors calculations show that the two changes - larger class size and larger teacher pool - contributed about equally to the rapid rise in enrollment. Ultimately what this example from Mali shows is that policy can be a significant driver of short-term change in these two compensating mechanisms.

4.3 The relationship between, teachers, class size, and enrollment

The results to this point show clearly that there are two correlates of low adult education levels that routinely change with improvement in those levels. The relationships between changes in class size and changes in the differential recruitment of teachers and the spread of secondary education are empirically important and need to be part of a theory of enrollment causes. We note also that demographic increases in the child-adult ratio is a further factor that may intervene in these processes. What has not yet been considered explicitly is the extent to which the observed patterns are related to GER. This is tricky to disentangle because the proportion teaching and class size are so closely correlated with adult secondary education. For example, a four-fold increase in secondary education levels in a hypothetical society with a stable population size and age distribution and a fixed proportion of the educated population entering primary teaching would result in a four-fold reduction in pupil-teacher ratios.

We therefore further investigated whether a) the proportion of educated people in primary teaching and b) the pupil-teacher ratio influenced the enrollment ratio independently of the dependence on education level already presented. To do this we computed the residuals around the trends in Figure 1a and Figure 2a and Figure 2b.

$$G = G_0/(1+ \exp(-K (x - x_0)))$$

where G is enrollment rate, G_0 is the asymptote, x is the proportion of the population with secondary education, and x_0 is the inflection point, parameterized as

$$G = 105.6/(1+ \exp(-0.208 (sec – 2.101)))$$

This curve is shown fitted to the data in Figure 1a. Residuals were then calculated by subtracting the value G thus computed from the observed enrollment rate. The other two functions calculated were both power functions. For the proportion in primary teaching P the fitted equation was

$$P = 0.257\ x^{-0.636}$$

where x is again the level of secondary education in the country. Similarly for the pupil-teacher ratio in 1996 R we found

$$R = 80.166\ x^{-0.326}$$

In both cases residuals were computed by subtracting the calculated values from the observed value. These three residuals in effect compute the variation in enrollment, related to the proportion of adults with secondary education in primary teaching (T/S) and to pupil:teacher ratios (P/T) (respectively) after the effects of secondary education level have been accounted for i.e., they allow us to quantify any additional impact of T/S and P/T on enrollment ratio by comparing the relationships between enrollment residual and the residuals in T/S and in P/T. In the event neither turned out to have an overall effect (T/S r = 0.148; P/T r = 0.170, both not significant). However, because both primary teacher proportion and pupil-teacher ratio decreased with secondary education (Figure 2) it was possible that they served as alternative compensatory processes: tolerating higher class sizes, for example, might free educated people to meet a country's needs for skilled workers in areas outside teaching. The data showed correlation between the two variables neither globally (r = -0.036, not significant) nor in countries with negative enrollment residuals (i.e. with lower enrollment rtes than one would have expected for the country's level of secondary education) (r = -0.045, not significant). On the other hand, among the 38 countries doing better in enrollment than expected (on the basis of their education level) there was a weak negative correlation (r = -0.343, $P<0.05$). That is, countries achieving greater enrollment than expected tended to have either larger than expected class sizes *or* proportionately more of their educated population in primary teaching, but not both.

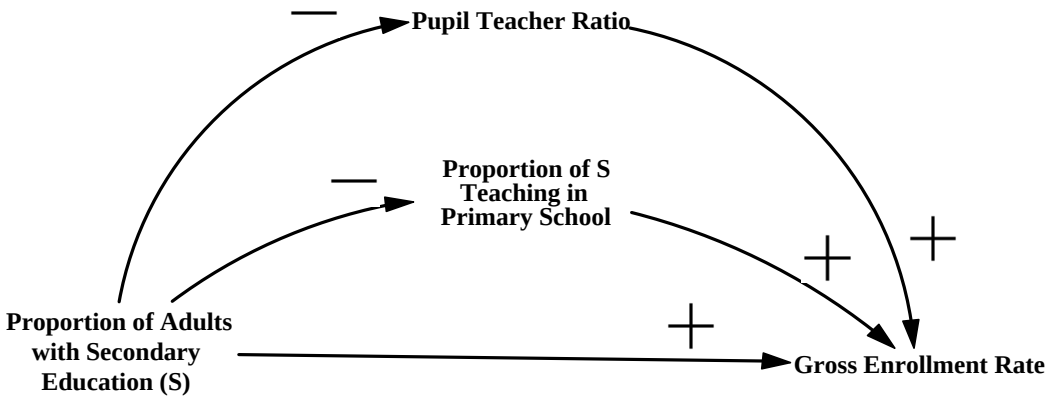
We examined this further by dividing the data set into four quartiles from low to high enrollment (absolute, not residuals) and examined the changing influence of these residuals. We also considered the influence of child-adult ratio because changes in this ratio affect pupil-teacher ratios. We found that greater than expected enrollment was strongly correlated with the residual for primary teacher proportion (r = 0.721, $P<0.001$) in the lowest enrollment quartile and again in the highest quartile (r = 0.495, $P< 0.02$) but with weaker, non-significant effect in the intermediate two quartiles (r = 0.217 and 0.380, not significant). These results imply that when enrolment is especially low or especially high, an increase in primary teachers beyond that normally associated with the country's level of secondary education may boost enrollment. A further analysis showed that such boosts were statistically associated with high child-adult ratios in all four quartiles (r = 0.550, 0.681. 0.778, and 0.631, all significant at $P<0.02$ or higher).). Variation in class size residual, on the other hand, had little effect in boosting enrollment beyond that

expected (correlations of 0.036, -0.078, 0.101, and 0.320, all non significant). Even so, larger than expected pupil-teacher ratios were associated with high child-adult ratios in all but the first quartile (r= 0.086, n.s.; r = 0.448, 0.451, and 0.513, all significant at $P<0.05$). These correlations were not accompanied by any correlation between the residual in enrollment and child-adult ratios, suggesting that the larger class sizes were entailed as a response to the larger population of children. Implicit in this argument is the idea that the larger classes helped hold the line against a slump in enrollment and not that larger classes were ineffective. A reasonable summary of the implications of these results, therefore, may be that adjustment of class size beyond that typical of a given level of secondary education appears to be a relatively minor mode of adjustment (perhaps particularly valuable in responding to population growth).

5. A DYNAMIC THEORY OF ENROLLMENT

Figure 3 presents a schematic figure that accommodates the findings from the previous sections. First, the level of secondary education in a country is the primary determinant of enrollment rate and at low levels of secondary education large class sizes and a large fraction of the educated population engaged in primary teaching are the rule. As secondary education spreads, both these variables decrease. Secondly, the presence of large child-adult ratios in a country both reduces the level of secondary education and requires persisting with high class sizes and a high proportion of educated people in primary teaching. Third, countries with enrollment higher than expected on the basis of their secondary education are characterized by the continued use of large class sizes *or* of disproportionate employment of the educated work-force in primary teaching (but not both). The overall picture of process that emerges, therefore, is one of enrollment driven largely by the spread of secondary education in a country, with class size and differential employment in primary teaching used either to offset the adverse effects of child-adult ratio or to boost the rates of enrollment beyond that supported by the level of secondary education in the country. Discussion of enrollment typically expresses ideas in terms of the drivers behind the phenomenon of interest, but here understanding is better promoted by thinking at times in terms of constraints rather than of drivers. The proportion of well-educated adults is a direct proximate constraint on the total availability of teachers and the disproportionate investment of educated adults into teaching and the deliberate increase in class sizes as discussed above make most sense when described as policy options that by-pass this constraint. On the other hand, a low proportion of well-educated adults is typically correlated with young age structure and with rapid population growth within the country, both of which tend to increase the pool of children needing education and therefore constraining the ability of a country to provide education for all.

Figure 3. Schematic representation the Teacher Theory of the underlying and proximate drivers of the Gross Enrollment Rate. Bold lines represent relationships for underlying or underlying *and* proximate drivers, while dotted lines proximate drivers *only*.



This can again be illustrated by contrasting two countries with low enrollment rates, Mozambique and Banglasesh (Table 2). Both countries had low levels of gross enrollment, 60 in Mozambique and 72 in Bangladesh; both had similar primary school age child to adult ratios (0.24 and 0.28 respectively); and both had high pupil:teacher ratios (58 and 63 respectively). With respect to the proportion of adults with secondary education, and how many of them were working as primary school teachers, the two countries are near mirrors of each other. Mozambique had very few (less than 2 per cent) adults with secondary education in 1997 whereas Bangladesh, in contrast, had 16 percent. However, in Mozambique, about one in every 8 of these well-educated adults was employed in primary school where only one in 50 was so employed in Bangladesh. The contrast shows simply and clearly that Bangladesh has ample human resources to expand its primary education system whereas Mozambique was already stretched by its commitment to education. Thus, the two countries require quite different policy interventions: in Bangladesh a larger education budget (domestic or from foreign aid) could help the situation but in Mozambique the shortage of human resources needs to be addressed.

Table 2. Proximate drivers of enrollment and gross enrollment rates in Mozambique, 1990 and Bangladesh, 1990.

	Mozambique 1990	Bangladesh 1990
Gross enrollment	60	72
CH:AD	0.24	0.28
SEC/AD	0.02	0.16
T/SEC	0.14*	0.02*
P/T	55	63

6. ARE THERE ENOUGH TEACHERS FOR EFA?

In its recent monitoring report, UNESCO (2002) concluded that many countries are unlikely to reach the goal of full primary school enrollment by 2015. To help them, a number of these countries are slated to receive early assistance from the World Bank Development Group in a large-scale effort called the Fast Track Initiative, which focuses mainly on financial incentives and policies. Such initiatives may be well suited to addressing the situation of countries such as Bangladesh above, where a simple increase in the size of the country's education budget may be all that is needed to bring about an adequate increase in the size of the teaching work force. They are far less suited to addressing the constraint imposed by a shortage of teachers within a country.

Table 3 presents the results of a *Gedanken* or thought experiment in which human resource availability is estimated by calculating the consequences of basic assumptions about class size and availability of educated people. We begin by asking what proportion of well-educated adults would be needed to teach in the target country if there is to be full primary enrollment i.e., G=1 in equation 3. In accordance with other international studies, a satisfactory pupil:teacher ratio (P/T above) is assumed to be 40. It then follows that the number of teachers needed is the number of children of school age, all of whom are to be in primary school, divided by 40. This number of teachers has to be drawn from the pool of potential teachers, taken to be adults of age 15-64 who have received secondary education. This is not known exactly, for want of suitable statistics. Still, we can approximate the T/S variable of equation 3 by the proportion of secondary education shown for all adults age 25 and over[1]. The calculation does not include any educational administrators, nor does it include teachers for the secondary school system – the actual number of people necessary to run the school system is therefore approximately double the number here. The remaining element in equation 3 needed before we can compute

[1] In general, because education profiles decline with age in developing countries, people age 15-24 are better educated than those age 25+, causing an under-estimate, on the other hand, those age 65+ are less educated than the age group 15-64, which compensates.

the intensity of commitment to primary teachers needed is the child-adult ratio and this we treat as an empirical statistic for each country.

Table 3. Estimated proportion of adults with secondary education who are needed to teach primary school if there is to be full primary enrolment and a pupil teacher ratio of 40. These figures do *not* include estimates of the staff needed to administer the school system and teach higher levels.

Country	% SEC needed to teach	country	% SEC needed to teach
Guinea Bissau	0.37	Senegal	0.09
Mozambique	0.33	Tanzania	0.09
Rwanda	0.29	Afghanistan	0.09
Mali	0.28	Sierra Leone	0.09
Niger	0.27	Lesotho	0.08
Ethiopia	0.27	Sudan	0.08
Malawi	0.26	Liberia	0.07
Burundi	0.25	Papua New Guinea	0.07
Mauritania	0.16	El Salvador	0.07
Central African Republic	0.11	Gambia	0.07
Uganda	0.10	Cameroon	0.06
Benin	0.10	Guatemala	0.06
Kenya	0.10	Haiti	0.06
Senegal	0.09	Nepal	0.05
Tanzania	0.09	Oman	0.05

Applying this thinking to each country for which the data were available yields an estimate of the proportion of adults with secondary education needed to teach in each country. Table 3 presents the results for those countries for which at least 5 per cent of the educated adults would be needed as teachers. This 5 per cent threshold is a full order of magnitude beyond the one half of one percent of adults with secondary education who are teaching, typical of industrialized countries. In effect we have arbitrarily assumed that countries within an order of magnitude of the industrialized countries value should be able to make adequate progress; while those outside the order of magnitude need assistance to boost their teaching capacity[2].

Table 3 shows that in 1990 there were at least 30 countries where more than 5 percent of the well-educated adults would need to be committed to primary teaching in order to meet the goals of full primary enrollment and a pupil teacher ratio of 40. In most of these countries, enrollment was below 80. By 2003, these numbers will have

[2] Empirically, the use of this cut-off excluded listing in Table 5 all countries with more than 20% of adults already with secondary education and allowed inclusion of only three countries with gross enrollment in 1990 of above 80.

improved, although in general adult education levels change slowly. Many of the countries in the table for 1990 would still be in a similar table for 2003 and some additional countries for which data were not available no doubt also belong. This result implies that a shortage of educated adults is a limiting factor in a significant number of countries presently experiencing low enrollment rates and may, in fact, be a real impediment to attaining universal primary education globally.

7. CONCLUSION

Growth mechanisms for education systems have been the subject of much debate and research. There are high stakes related to the answers: education levels among adults are now seen as one of the most important drivers of economic growth, of better health, of smaller families and lower population growth, and perhaps even political empowerment and democracy. If education is so key, it is important to get our understanding of the driving mechanisms of enrollment right, so that countries with presently weak or immature school systems can move forward efficiently and expediently. Where other authors (UNESCO, 2000; Mehrotra, 1998; Brossard and Gacougnolie, 2000; Delamonica et.al. 2001; and World Bank 2002) have looked at financial and demographic supply-constraints and at demand-constraints, this paper examined the basic mechanisms surrounding the availability of teachers. As a result of our inquiry, we propose a theory for enrollment growth that revolves around the availability of teachers relative to the size of the school age population. We conclude, in the light of our analyses, that the education level of adults, who ultimately form the pool of teachers and parents deciding to send children to school, is the single most important determinant driving the transition from low to universal enrollment. All of the conclusions presented here apply to the phase of the education system transition where enrollment rates are *progressing towards* or have just reached completion. In those countries where full enrollment has been the norm for at least some decades, and where at least 20% of the adult population has had secondary education or more, human capital resources are not a constraint full enrollment, and other mechanisms apply to the education system.

In the first analytical section of the paper, the correlations of gross enrollment rates with two constraining factors proposed in the literature, namely GDP per capita (income) and youth ratios, and with the proportion of secondary-educated adults, were tested for 160 countries. All three independent variables were correlated with enrollment in the expected direction, at statistically significant levels, but were also auto-correlated themselves. The decomposition analysis using partial correlation suggests the availability of secondary-educated adults is the sole underlying determinant of enrollment, with income and youth ratios having no impact on enrollment once secondary education levels were accounted for.

The mechanisms for this are the following. As a direct, proximate impact, low levels of adult secondary education can actually cause a shortage of people who can teach (even using the broad category of “all who have secondary education” as potential teachers, rather than the more narrow definition of those who are certified), thus acting as

a constraint. In addition, the adult education profile is an underlying driver. Adult education is well-recognized to be an important determinant of economic productivity, thus underlying income, as well as child-bearing decisions, thus underlying population growth and youth ratios. In our analysis we found that income and the incidence of secondary education were mutually correlated and that income had no effect on enrollment rate independent of this correlation. Our suggested explanation is that income creates the public and private resources, which pay for private costs of education and public costs of school systems, and in this way contributes to the spread of secondary education through the population, while greater education in turn contributes to the ability to earn higher income. However, greater income *per se* is not sufficient to overcome the constraint imposed by a limited supply of primary teachers.

However, countries with low human capital predictably utilize two balancing mechanisms – a larger portion of the secondary-educated adults is applied to teaching in primary schools, and class size is, on average, increased. Recourse to these mechanisms thus offsets some of the consequences of having too few educated people in the country to handle the education needs of a large population of children. As secondary education spreads over time, easing the human capital constraints, both of these variables decrease. The mechanisms for this relationship could be the result of conscious policy planning, but can also arise "involuntarily" in a situation where, for example, there is little alternative employment to primary school teaching, or, where no limits are placed on class size and schools fill up to have large classes naturally because of a scarcity of schools.

The statistical analysis found that enrollment rates can be raised through an *independent* effect of hiring more teachers and increasing class size beyond that which would be "expected" given the portion of secondary-educated adults. This mechanism explains why countries, with similar proportions of adults with secondary education can still differ significantly with regards to their actual enrollment rates. As the anecdotal examples from the paper show, that difference can be as high as a factor of three – in Uganda, gross enrollment in 1997 was almost three times as high as in Afghanistan despite similar proportions of adults with secondary education. Our statistical analysis suggests that changes in class size are primarily a constrained response to large numbers of children to be educated whilst changes in the proportion of primary teachers may be either a similarly constrained response or may be the outcome of a deliberate policy decision. Both variables increased in countries with large ratio of children to adults but once enrollment rates increased, a negative correlation emerged between the two: countries either lowered class size at the cost of a high proportion of educated people in primary teaching or tolerated large class size with a lower proportion of primary teachers. Because the default result of an increase in the population with secondary education is a reduction in the proportion in primary teachers, the former pattern necessarily reflects a policy decision. That is, even if alternative (to primary teaching) employment is unavailable, recruitment of additional teachers has to be at least allowed by, and possibly be encouraged by, government policy. In contrast, the spread of education can reduce the proportion of the population in primary teaching whilst leaving class sizes large even if the government has no policy response to the change.

There is one instance where adult education levels may not impact enrollment and that is where a pandemic, such as HIV/AIDS, hollows out the adult population. In the

case of a pandemic that kills adults more than children, a country may end up with low human resources, a high youth ratio, and a decline in income, all effects that would place the country at lower than "expected" levels of gross enrollment than based on the proportion of adults with secondary education alone.

As a matter of empirical significance, a shortage of secondary educated adults is apparent in many countries with low gross enrollment rates and may be a real impediment to reaching global EFA. Strategies to deal with this problem include a concerted effort to recruit teachers internally, with a strategy to overcome the likely shortage, or temporarily bringing in teachers from abroad. Countries, which have successfully employed the latter strategy include Botswana, Bahrain, and Oman. All of these are relatively small nations, which also have higher foreign exchange income from natural resources (diamonds or oil). However, it is far too early, based on such anecdotal evidence, to suggest that this strategy can only be applied when the numbers are small and money is abundant.

Regarding the former strategy, to recruit teachers internally through a focused strategy to overcome a shortage, there are a number of examples one might want to explore for insights, if not necessarily for exact mimicking. Tanzania raised enrollment far beyond what could be expected based on the adult secondary education through a major policy focus, but this success was also a symptom of the failure in the economy to produce any alternative jobs for those with higher levels of education. It remains to be seen whether Tanzania's temporary economic sacrifice will pay off in terms of future faster economic growth thanks to its higher levels of education. China is another country where enrollment rates increased very quickly, also in the context of an economy that was focused more on social services than on material growth. Mozambique is an example of a non-socialist country that is taking advantage (if one will) of its low levels of economic opportunity, to hire large numbers of uncertified as well as certified teachers, and is close to universal primary education despite one of the lowest rates of adult secondary education in the world.

In another non-socialist setting, some regional examples of alternatives to raise enrollment where teachers are scarce are coming up in the form of community schools. In Balochistan (Pakistan), Northern Ghana, Bangladesh, rural Columbia[3], and other remote regions, various community school programs, based on the employment of local, village people as teachers are raising enrollment far beyond what would be expected (Hartwell and Farrel, 2003). Certainly this, as well as the other strategies suggested above, which focus on getting teachers to the classroom, open windows to raise enrollment in places where money is not enough.

In summary, the analysis of this paper challenges prevailing wisdom concerning constraints on education systems at below-complete primary enrollment rates, and suggests that adult education levels are key, rather than financial limits. Adult education is known to affect parents decisions to send children to school (creating a demand factor), but less known, and explored in this paper, is its impact on teachers and the constraint it can pose to full enrollment.

[3] Girls Schools in Balochistan; School for Life in Ghana; BRAC NFPE in Bangladesh; Escuela Nueva in Columbia.

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