Education Policies to Revive a Stagnant Economy

The Case of Sub-Saharan Africa[*]

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Abstract

In this paper, we argue that the condition of education and the economy of the low performing sub-Saharan African countries can be characterized as a stagnant steady state – a "trap". We present a simple heterogeneous-agent model in which high costs of education relative to income and the skill premium can cause the economy to be trapped in such a steady state with minimal educational attainment. We calibrate the model to available data from the sub-Saharan African countries to study policies that could potentially free these trapped economies and set them on a path to a higher steady state. We find that a tax and subsidy scheme that redistributes resources at the trap from poor households with lower ability children to those with higher ability children can pry the economy out of the trap, thus freeing it from dependence on foreign aid in order to achieve the same goal. In addition to the direct cost, a portion of the indirect cost also needs to be subsidized. Moreover, such a policy outperforms the abolition of child labor and the institution and enforcement of compulsory education laws when expenditure neutral welfare comparisons are made.

Keywords: Dynamic heterogeneous-agent models, Economic stagnation, Education subsidies, Calibration of a trap

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1 Introduction

The state of education in most countries of sub-Saharan Africa (sSA) is perilous. In its assessment of the progress toward universal primary education, the UNESCO document, *Education for All: Year 2000 Assessment*, notes that several regions are far from achieving it, "... and in the case of sSA, actually lagging behind." Similar sentiments are voiced by the Oxfam report, *Education Now.* In the poorest performing countries in this region, enrollments are particularly low, dropout rates high, incomes mostly stagnant, costs of schooling significant relative to income, income inequality high, government expenditure per pupil low, and opportunities of employment for the educated scarce. These indicators have shown little or no improvement in the last two or three decades and in some cases have actually worsened. The AIDS epidemic of the nineties has further exacerbated the situation by decreasing life expectancy in some of these countries.

Popular discussion of policy alternatives to improve the condition of education and the economy of this region, in the above documents and elsewhere, include foreign aid, abolition of child labor, and institution of compulsory education. Is foreign aid the only way these stagnant economies can develop or can domestic funds trigger development? Is universal enrollment possible and even desirable? How effective will the above-mentioned institutional reforms be? These are some of the questions we address in this paper.

We first argue that the worst-performing sSA countries can be characterized as being at a trap, or proximal to one. The word trap is used as a metaphor for a stagnant steady state with a poor economic outcome, rather than a situation in which all outcomes are literally zero.[1] We present a simple model of education attainment with educated and uneducated workers that exhibits a trap when the high cost of education relative to income lowers the return to investment in education. We calibrate this model to economies in this region and then study policies that have the potential to free them from the trap, which allows us to shed some light on the above questions.

We build on the simple heterogeneous-agent, two-period overlapping generations model of education acquisition developed in Caucutt and Kumar (2003); unlike that paper, we model indirect costs explicitly and focus on theoretical conditions that give rise to a trap.[2] A liquidity constrained parent, who is either an "educated" or "uneducated" worker, makes the decision of whether or not to incur the cost of educating a child taking into account the child's ability, which captures both the academic

[1] Indeed, in what follows we normalize the "uneducated" to have two years of education and refer to the steady state in which no one obtains education higher than this as a trap.

[2] In Caucutt and Kumar (2003) we focus on a unique steady state with positive education attainment and calibrate it to the US economy in order to study whether further subsidization of college education is warranted. Needless to say, the calibration strategy and the policies considered in the present paper are completely different from those considered for the US.

ability of the child and unmodeled traits that make some families more functional than others. The probability that a child who is sent to school will become an educated worker the following period depends positively on this ability. Any child who drops out (fails) will remain an uneducated worker next period. The two types of workers are imperfect substitutes in aggregate production.

We develop conditions that give rise to a locally stable "trap" in which all workers remain uneducated. A trap typically occurs when the initial fraction of educated people in the workforce is too low. The wages of the uneducated workers are too low for them to find it profitable to send their children to school. This results in a decrease in the fraction of educated workers next period, which further decreases the wages of the *un*educated workers and reinforces the above-mentioned behavior. We derive intuitive sufficient conditions for this to occur; a trap is more likely when the cost of education relative to the income of the uneducated is high, the wage gain to becoming educated is low, the discount rate is high, and the curvature of the utility function is high.

The method of conducting policy experiments on a calibrated model is particularly useful in the context of a trap, where paucity of good quality data precludes detailed econometric analysis. We calibrate the model using data from several countries in the region, so that a typical economy in this region is close to a trap. We then consider policies that have the potential to free the economy from a trap and set it on a path to higher education attainment and output. Since the behavior of the uneducated poor, who form the vast majority close to the trap, is responsible for the trap, it is natural to consider a policy of subsidizing their direct and indirect costs of education. Two features of the model, heterogeneity in types and heterogeneity in ability, play important roles in these policy experiments. The former allows redistribution from richer to poorer parents. However, in the trap everyone is poor. So the kick-start at the trap comes from the latter heterogeneity, that is, the redistribution from poor, low-ability families to those with higher ability.[3]

The indivisible cost of education, liquidity constraints, and the focus on aggregate welfare give rise to this redistribution motive; if the return to education falls a bit short of the amount required for enrollment to all agents, aggregate welfare could be improved by redistributing and making the return attractive for the most able students. This motivation for redistribution is similar in spirit, for instance, to those surveyed by Aghion et. al. (1999); however the focus of redistribution for us, at least at the trap, is across ability levels rather than income levels.

A tax and subsidy scheme that enables such a redistribution is not only able to set the economy on a path toward a better steady state, but also does better in terms of welfare – both across steady states and including transition – than a scheme that abolishes child labor or one that institutes and

[3]A compulsory education system would override this kind of redistribution. In the next section we provide evidence that compulsory education laws, even if they exist on paper, are not enforced. We also consider, in our policy experiments, the consequences of enforcing such laws.

enforces compulsory enrollment. Under revenue neutrality, these latter policies are unable to reverse the loss of contributions low ability children would have made to their families had they not been forced to attend school.[4]

In one of the experiments, we compute the educational expenditure, as a fraction of GDP, that would be required to transform the stagnant economy to one that is similar to Mauritius, at least as far as educational attainment is concerned. Even though Mauritius is not considered while calibrating the model economy, the model outcome for expenditure-GDP ratio in the above experiment is quite close to the one seen in data for Mauritius. This outcome gives us confidence in using the calibrated model as a vehicle for studying policy changes, and in the efficacy of education policies in reviving a stagnant economy.

These simulations question the stated goal of several agencies of achieving universal enrollment. At the current stage of development of these economies and the quality of their educational systems that are likely to prevail in the near future, policies that guarantee this level of enrollment need not be welfare improving. The experiments also show that the economy need not depend on foreign aid in order to develop.

We are silent in our study on the issues of gender disparities and the AIDS epidemic, for reasons of theoretical and quantitative tractability. While some of the sub-Saharan African countries we examine do have pronounced gender disparities, others do not; it thus does not seem that a gender bias alone can explain the low aggregate enrollment and attainment seen in the region. Increasing life expectancy by addressing the AIDS problem would affect school enrollments and attainment. Better education can, in turn, affect life expectancy through a better understanding of health and hygiene. However, our silence on this aspect is mitigated by the *increase* in life expectancy between 1980 and 1998 seen in several of the countries we focus our attention. Likewise, we do not model fertility choice. However, it seems that the in-kind education subsidy policy we consider is likely to be all the more important in a trap characterized by low education and high fertility. Such a policy would tilt incentives towards the quality of children rather than their quantity.[5]

Clearly, factors other than education contribute to the economic stagnation of the region; therefore, we view our analysis as only one step in understanding the complex economic and educational condition of this region.[6]

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[4] Since the government we consider taxes people only for the sake of financing education, expenditure and revenue neutrality are equivalent.

[5] Incorporating fertility decisions – as done in Becker, Murphy, and Tamura (1990) or Galor and Weil (2000) – in our model, is left for future research. Galor and Weil (2000) view stagnation as a transitory, yet long-lasting, phenomenon and explore the role of human capital in this transition.

[6] Sachs and Warner (1997), for instance, point to lack of openness to international markets and geographical factors as reasons for African stagnation.

There are several models of development traps in the literature. See, for instance, the recent article by Azariadis (1996) and the references therein. Features such as fixed costs and liquidity constraints have been highlighted as potential sources of traps in earlier studies. However, unlike most earlier studies our model features heterogeneity in education and thus earnings.[7] Even if a positive steady state is reached in our model, there will be a mix of educated and uneducated agents. This seems empirically more relevant than having all agents acquire the same level of human capital, high or low, as in a representative agent framework. While a condition for a trap to occur could be equally well derived in a representative agent model, in order to study the "diffusion" of education over time it is necessary to explicitly model the dynamics of heterogeneity. We can also focus attention on those agents whose behavior is responsible for the education trap, the uneducated poor. In contrast, a representative agent model, or similarly our model with linear utility, would assign the same cost of education to all parents making it hard to discern the dynamic effect of the poor parents' behavior in the neighborhood of a trap. Heterogeneity also allows us to shed light on the forces governing inequality in earnings.

Perhaps the most novel aspect of our study is the calibration of a trap to actual economies and policy experiments we conduct to pry them out of the trap. We are thus able to make quantitative assessments in a field of study that has thus far remained mainly qualitative.

The rest of the paper proceeds as follows. In Section 2, we briefly survey the condition of education in sSA to motivate our study and provide the rationale for using a model with a trap to study them. Section 3 describes the model and provides a sufficient condition for a locally stable trap. We turn to calibrating the model to a "typical" sSA economy in Section 4, and present the results of our policy experiments in Section 5. Section 6 concludes.

[7] The work by Galor and Zeira (1993) does feature heterogeneity in bequests, which can be used for human capital investment; they use "warm glow" preferences in bequest to simplify the aggregation problem, while we rely on limited heterogeneity. Unlike their model, enrollment does not mean success is automatic in our model; it is probabilistic and depends on ability. Given the very high rates of dropout observed in sSA this feature is empirically relevant; moreover it leads to the implication that redistribution even among the poor is capable of prying the economy out of a trap. The Galor and Zeira (1993) setup allows one to think of redistribution in the conventional sense – from the rich to the poor – but this channel is inoperative at a trap. In their model exogenous shocks can alter the transition function.

Such an external shock can shift the transition function upward in the representative agent setup of Becker, Murphy, and Tamura (1990) as well. In contrast to these papers we focus on policy measures that would shift the transition function.

2 The Condition of Education and the Economy in Sub-Saharan Africa

The above-mentioned UNESCO document sounds an alarming note about the state of education in sub-Saharan Africa (sSA). It states that while most of the world is on course to achieving universal access to primary education, other parts of the world are actually slipping behind: “The problem is particularly marked in sSA, with an increase in the number of children not in school.” The Oxfam report calls the education situation there “particularly dire.” In this section we highlight some aspects of the condition of basic education and of the economy in this region using data from the above two reports and from other sources. The aim is not to provide a comprehensive description of the state of education in sSA, but enough details to motivate our study as well as to make empirical contact for the model we will be using; we note these connections as we proceed. While trends for the sSA region as a whole are presented, attention is focused on eighteen countries which particularly lag behind in education attainment. Data on selected variables for this sub-sample are presented in Tables 1 and 2.

Table 1

The condition of education in a sub-sample of sub-Saharan African countries

country	% no education	% prim. complete	% sec. complete	prim. sch. years	sec. sch. years	prim. gross enrollment	sec. gross enrollment	apparent intake	surv. rate to grade 2	surv. rate to grade 6	prim. drop rate	sec. rep. rate	exp / GNP	exp / student (dollars)
Angola						91.7	12.3	75.8			66		4.9	
Benin	71.8	4.7	1.1	1.43	0.3	58.1	11.9	75.9	84	45	60	31	3.2	
Burkina Faso						33.3	7.2	32.5	93	69	29	19	2.7	84
Burundi						72.8	5.6	68.3	83	61	23	14	3.4	69
Central African	64.5	6.7	1.2	1.47	0.32	65	11.7	59.5	69	17	38	29	2.2	73
Chad						54.4	7.8	55.2	85	44	29	20		36
Djibouti						38.1	11.9	35.9	100	88				
Guinea						37.1	10	43	87	52	33	23	2	
Guinea-Bissau	77.2	2.1	0.5	0.54	0.11	67.9	9	84.5			92	20		137
Malawi	50.4	9.2	1.3	2.53	0.15	67.9	7.7	101	92	53	58	2	3.4	31
Mali	87.3	2	0.5	0.8	0.06	26.5	7	26.7	94	70	50	26	2.2	207
Mozambique	67.7	7.1	0.4	0.83	0.08	66.9	7.6	73.3	75		60	27	4.1	163
Niger	84.2	2.9	0.4	0.66	0.15	28.8	6.6	27.4	93	57	18	19	3.2	
Rwanda	56.3	8.1	0.6	1.67	0.15	63.1	8	94.1	85	52	50	6	2.7	107
Somalia						13.6	8						0.5	
Tanzania	43.3	9.6	0.1	2.44	0.15	69.7	4.9	78	94	83	27		3.4	
Uganda	60.1	6.7	0.3	1.6	0.15	74.5	13.2				24.3		1.5	
average	66.3	5.9	0.6	1.4	0.2	54.7	8.8	62.1	87.2	57.6	43.8	19.7	2.8	100.8
median	66.1	6.7	0.5	1.45	0.15	63.1	8	68.3	87	55	38	20	2.95	84

Sources:
All data (unless otherwise noted) is for the year 1990 or closest year for which data is available.
% of population (over 15) with no education: Barro & Lee (1996)
% of primary school complete in population over 15: Barro & Lee (1996)
% of secondary school complete in population over 15: Barro & Lee (1996)
Average years of primary schooling in population over 15: Barro & Lee (1996)
Average years of secondary schooling in population over 15: Barro & Lee (1996)
primary gross enrollment rate: World Education Indiactors (WEI), UNESCO
secondary gross enrollment rate: WEI, UNESCO
apparent intake rate (% of primary eligible students enrolling in the first grade regardless of age): WEI, UNESCO
survival ratio to grade 2: WEI, UNESCO
survival ratio to grade 6: WEI, UNESCO
primary school droput rate: Barro & Lee (1996)
secondary repetition rate: Barro & Lee (1996)
public education expenditure as a % of GNP: WEI, UNESCO
primary expenditure per student in $: Barro & Lee (1996)

- **Low enrollment rates:** Most educational indicators for sSA have either been stagnant at or declining from already poor levels. While the gross enrollment ratios in primary education having been increasing between 1990 and 1998 and approaching 100% in regions such as Latin America, the Caribbean, and East Asia, this ratio has seen little change over the period in sSA, hovering around 75%. For our sub-sample of countries, the average gross enrollment rate was much lower, at about 55%. The median net intake rate – the new entrants in the first grade of primary education who are of the official primary school entrance age, expressed as a percentage of the population of the corresponding age – was 34% in sSA as late as 1998.[8] In the vicinity of the trap in our calibrated model, enrollments are likewise low.

  Over the last decade, the number of out-of-school children has continued to increase in this region. The region has the largest proportion of out-of-school children, at about 40%; in a third of the countries, 60% or more of children are not in school. Evidently, compulsory schooling laws, even where they might exist in paper, are not enforced.

- **Low attainment:** While the trends indicate decline, the *level* of educational attainment for the sub-sample of sSA countries is already very low. In the year 1990, the average figure for percentage of population over 15 with no education (computed from Barro and Lee (1996)) was over 66%, the percentage who *completed* primary education was less than 6%, while the percentage who completed secondary education was negligible, at 0.6%. Moreover, from Barro & Lee (1996) we can see that for most of these countries there was a drop in % of population with primary attainment between 1985 and 1990. The average attainment as measured in years of education was about 1.4 at the primary level and at 0.15 was negligible at the secondary level. We use this data to motivate our definition of "uneducated" workers in the model.

- **High dropout rates:** Among those who do attend, the dropout and repetition rates have continued to be high. From Barro and Lee (1996) we see that the average primary school dropout rate in our sub-sample was close to 44%, with Guinea-Bissau having a rate of 92%. While the dropout rate dropped from about 58% in 1970 to about 48% in 1975, improvements since then have been rare, with an increase between 1980 and 1985. The primary repetition rate decreased in 1990 relative to the rate in 1965 for only two countries, and either increased

[8] Pritchett (1996) argues that sSA's educational capital grew at a rapid rate between 1960 and 1985. While he draws this conclusion based on data for the entire sSA region, we concentrate on the poorest performing economies. Moreover, a small increase in the years of education in a region with a very low level of initial attainment translates into a large rate of increase. His aim is to argue that growth in education has not translated into economic growth worldwide, while our focus is on steady state levels. His data on educational share of the wage bill, which at 26.3% is the lowest in sSA, concurs well with the evidence presented in this section.

or was the same for all other countries. Among the students who go on to the secondary level, the repetition rate is about 20%. Such poor performance is probably not surprising given a steady deterioration in quality of schools, with the highest pupil-teacher ratios in the world; this already high ratio of 50 in 1990 for Central and Western Africa rose to 52 in 1998.

Such dropouts will be an integral part of our model. Our strategy of holding constant the quality of the educational system in the policy experiments is driven by the above-mentioned sluggishness in indicators of school quality.

- **High costs:** In spite of government involvement in primary education, the cost of schooling to parents is significant. The Oxfam report discusses the various types of direct costs incurred by parents – official fees such as tuition, levies imposed by schools and parent-teacher associations, unofficial fees charged by schools, out-of-pocket payments for uniforms, textbooks, pencils, transport, and meals, and community contributions in cash or kind. The report states that in Zambia, over 70% of the recurrent budget for education is now financed by households. From the figures reported by Ablo and Reinikka (1998) for Uganda, we compute that more than 66% of school expenses are borne by parents, amounting to about 5.3% of their income.

  The opportunity costs are also significant, and are related to loss of work both within and outside the household. Caring for animals, pounding grain, caring for siblings, fetching wood and water, are only some of the activities school-aged children engage in. Even in the relatively affluent Botswana, Bigala and Moorad (1998) report that the single largest reason (40.4%) for children not attending formal school is "looking after cattle." Based on a detailed survey done in Madagascar, Bredie and Beeharry (1998) estimate the opportunity cost of attending school is more than 20 hours per week. The Oxfam report cites surveys from Kenya, Zimbabwe, Ghana, and Cote d'Ivoire to suggest that children did not attend school because it was "too expensive."

  We model direct and indirect costs explicitly. As we show in the theoretical section, a high education cost is one of the factors responsible for a trap.

- **Low government expenditures:** The government expenditure on education as a fraction of GNP for the sSA sub-sample we consider was 2.8% in 1990 (WDI 2000). This seemingly healthy figure is a result of the low GNP of these countries rather than high expenditures. This is corroborated by per pupil expenditure figures. As the Oxfam report notes, "... sub-Saharan Africa allocates 25 per cent more of its GDP to education than Latin America, but achieves a per-capita spending level which is 80 percent below." From the data in Barro and Lee (1996) we can see that the real government current educational expenditure per pupil decreased from 135.6 international dollars in 1960 to 79.8 international dollars in 1990 in our sub-sample.

We find in our calibration that the prevailing level of government expenditure is insufficient to move the economy out of the trap.

Table 2

Economic and other variables in the sub-sample

country	per capita GDP	growth rate (1965-98)	life exp. at birth '80	life exp. at birth '98	gini index
Angola	701		41	47	
Benin	921	0.1	48	53	
Burkina Faso	519	0.9	44	44	48.2
Burundi	532	0.9	47	42	33.3
Central African Republic	585	-1.2	46	44	61.3
Chad	412	-0.6	42	48	
Djibouti	370			50	
Guinea	775		40	47	40.3
Guinea-Bissau	698	-0.1	39	44	56.2
Malawi	519	0.5	44	42	
Mali	531	-0.1	42	50	50.5
Mozambique	760	0.5	44	45	39.6
Niger	505	-2.5	42	46	50.5
Rwanda	756	0	46	41	28.9
Somalia	775				
Tanzania	534		50	47	38.2
Uganda	554		48	42	39.2
average	614.5	-0.15	44.2	45.8	44.2
median	554	0	44	45.5	40.3
Sources:					
All data (unless otherwise noted) is for the year 1990 or closest available year.					
Real per capita GDP in 1985 international $: Penn World Tables (Mark 5.6)					
% annual growth in per cap. GNP (1965-98): World Dev. Indicators (WDI)					
life expectancy at birth in 1980: WDI 2000					
life expectancy at birth in 1998: WDI 2000					
Gini index (various years in the 90s): WDI 2000					

- **Stagnant economies:** Incomes have been stagnant over long time periods. The average annual per capita GNP growth rate between 1965-98 was -0.3% for sSA; the corresponding figure for the growth rate of consumption during 1980-98 was -1.3%. The median growth rate of income in our sub-sample was zero. Capturing the economic situation of this region via a trap, as we do, seems empirically justified.

  The opportunities of employment for the educated are not abundant in this region. The average annual growth rate of industrial output for sSA in the 1990-98 period was 1.3%, compared to the 10.8% for all low income countries, and virtually unchanged from the 1980-90 rate of 1.2% (*World Development Indicators* 2000). The figures for the manufacturing output are very similar. Value added in manufacturing during 1998 was 15% of GDP, down from 16% in 1980. One would expect the wage premium for educated labor to be very high in an economy which has a severe shortage of such labor. However several estimates of the premium, which we will present in detail in the section on calibration do not exceed 2.5, which can be interpreted as indirect evidence on lack of suitable employment opportunities for the educated.[9]

- **High inequality:** The countries in our sub-sample exhibit a high degree of inequality. The average Gini index is 44.2, with the Central African Republic having a figure of 61.3, which is higher than that of Brazil. The average ratio of income (consumption) of the top 20% of the population to the bottom 20% is a whopping 12.8 with Guinea-Bissau and the Central African Republic having ratios of 28 and 32.5. One should further expect the impact of the costs of education presented above to vary with income. Indeed, the OXFAM report notes that in Tanzania, the schooling expenditure as a share of income for the poorest 20% of households is four times as much as the wealthiest households; evidently, modeling income heterogeneity is important in gaining an understanding of the condition of education in sSA.

- **Health & political factors:** Can the poor state of education in sSA be mostly explained by the decrease in life expectancy brought about by the AIDS epidemic that has ravaged the area since the 80s? After all, theory predicts that schooling moves in the same direction as life expectancy (an increase in expectancy increases returns to schooling by increasing the time horizon over which education costs are amortized) and there is empirical evidence consistent with this.[10] Without trivializing the epidemic which clearly deserves it own attention, from the table presented we can see that the average life expectancy in our sub-sample actually increased from 44 years in 1980 to 45.5 years in 1998 in spite of the decrease in life expectancy for six countries. The percentage increase in primary school-age population since 1980 has also been the highest in sSA. It appears that while the epidemic might contribute significantly to the poor state of education in the region, there are other forces at work, with the stagnation pre-dating the crisis in several countries.[11]

[9] The premia calculated from Bigsten et. al. (2000) are particularly low. Inequality of income measured by the Gini index can be high even if the skill premium which incorporates *earnings* of the educated is low. The income inequality presumably arises from highly skewed distribution of land and scarce capital.

[10] See, for instance, Kumar (forthcoming). That paper also addresses the issue of causality – an increase in education can in turn cause an improvement in life expectancy through better understanding of nutrition and hygiene – by using climatic variables as instruments.

[11] However, caution needs to be exercised in interpreting the policies we study for this region. They are intended to work in conjunction with policies developed to address the AIDS crisis. Indeed improvements in life expectancy can only improve the educational outcomes of the policies studied.

While some of the countries in the sub-sample we concentrate have had their share of wars and strife in the last few decades, for instance, Angola, Somalia, and Uganda, most of them, such as Burkina Faso, Guinea, and Tanzania have been relatively free of turmoil. Therefore, it does not seem obvious that war and political chaos alone could account for sSA's stagnant condition, though political stability is clearly desirable for economic well-being.

In summary, sSA is characterized by economic and educational stagnancy and decline, a low quality of education, high costs of education relative to income, a high degree of inequality, a paucity of opportunities for the educated, and low and decreasing government expenditure per pupil on education. In the next section, we will outline a model of education financed mostly by families that features income heterogeneity, dropouts, and the possibility of a trap steady state, one that will be suitable to analyze the situation of sSA countries.

2.1 Mauritius: A Success Story

The island economy of Mauritius, classified as a sub-Saharan African country, stands in stark contrast to the countries mentioned above. We briefly summarize the education and economic condition of Mauritius since we will experiment with policies that aim to replicate this country's performance, at least on the educational front. In 1990, Mauritius had a per capita GDP of \$5,838, more than ten times the per capita GDP of the worst-performing sSA countries. Its annualized growth rate between 1965 and 1998 was 3.8%. More important for us is the data from Barro and Lee (1996) that indicates the percentage of population who attended secondary school was 36.5% in 1990 and the percentage who completed secondary school was 28.1%. We will therefore analyze policies for the other sSA countries that will result in a steady state close to a 30% level of educational attainment.

While the real government current expenditure per pupil at the primary and secondary levels have been trending downward in the worst-performing sSA countries, they have been moving upward in Mauritius. The average primary expenditure per pupil for the sSA countries discussed above was \$135.6 in 1960 in the Barro and Lee database, but only \$79.8 in 1990; the average secondary expenditure per pupil declined from \$1682.1 in 1960 to \$339.3 in 1990. On the other hand Mauritius increased its per pupil primary expenditure from \$256 in 1960 to as high as \$544 in 1980; this figure dipped to \$392 in 1990, which is still nearly five times that of the other countries. Its secondary expenditure per pupil started out lower than the other countries at \$373 in 1960 and increased to \$949, nearly three times the figure for the rest. The public education expenditure as a fraction of GDP was higher for Mauritius in 1990 at 3.6% when compared to the average of 2.8% for the rest; the true outlays are larger than these figures would suggest, as the ratios for the poor sSA countries are inflated by their low GDPs. These data suggest exploration of education subsidies as a policy instrument.

The opening up of Mauritius to foreign technologies and investment is also often cited as a reason for its development (though the state of its education began to improve *before* the effects of sustained openness could be felt).[12] While our model primarily focuses on policies related to education, we will be able to quantify the improvement required in the aggregate technology in the backward sSA countries in order to stimulate economic development there on a scale comparable to that of Mauritius.[13]

3 A Model with an Education Trap

As mentioned earlier, we build on the model developed in Caucutt and Kumar (2003); unlike that paper we distinguish between direct and indirect costs of education and also develop conditions that give rise to a trap (in Section 3.1). The economy is populated by a continuum of two-period lived agents in an overlapping generations setup. The size (measure) of each generation is normalized to one. Agents are children in the first period and parents in the second. Children are born "uneducated" and the central decision of their parents is whether or not to enroll them in school. Completion of school ensures that the child will be an "educated" worker next period. If the child is not enrolled, or enrolled but fails (drops out) the child will be an uneducated worker in the following period. Each of these workers becomes a parent next period, has an uneducated child, and the economy continues. Altruism provides the intergenerational linkage. We use "rich" and "educated" interchangeably, as we will "poor" and "uneducated".

At an abstract level we only need to label workers as educated or uneducated. However, for the calibration we take the stance that all children are "born" with two years of education (our definition of "uneducated") and successful education involves completion of a further eight years of schooling (our definition of "educated" is thus ten years of education). From the data discussed in the previous section, we can see the average years of primary attainment among the worst performing countries is 1.4 years, which motivates our baseline level of education. Secondary schooling indicators are often used in cross-country growth studies and completion of education at this level is considered to be the minimum level needed for a worker to perform well in the modern economy, which motivates our definition of educated workers.[14]

[12] See, for instance, Romer (1993) and English (1998).

[13] Acemoglu, Johnson, and Robinson (2002) focus on the other success story of Africa, Botswana. They conjecture that the presence of institutions aligned with the interests of the elite made rich by diamond mines is responsible for Botswana's sucess. Mauritius appears more relevant for educational policies we consider, and also more replicable in other countries.

[14] As in Galor and Zeira (1993), human capital investment is indivisible. Given that educational qualification is viewed

Children differ in their ability to become educated. In addition to innate talent, these ability differences are intended to capture unmodeled heterogeneity in all those traits that make a family "well-functioning". We assume that, conditional on being enrolled, a child with ability a completes education with probability $\pi(a)$; with probability $(1-\pi(a))$, the child drops out and becomes an uneducated worker. The probability function satisfies: $\pi(0)=0$, $0<\pi(a)\leqslant 1$, $\forall\, a\in(0,1]$, $\pi'(a)>0$, $\forall\, a\in[0,1]$.[15] The function π can be used to capture the quality of the educational system. Even low ability students in several developed countries are given a meaningful education through special programs; one would therefore expect the π functions for the developed economies to dominate those of poor economies such as those in sSA.

Let $F(\cdot)$ denote the distribution function for ability on the support $[0,1]$, and $f(\cdot)$ the corresponding density function. The distribution is identical across types and within parents of the same type; ability draws are independent of each other.

Enrolling a child involves a real cost of e_d units of consumption. This is intended to capture direct costs such as tuition, uniforms, and other school material. A parent cannot borrow to finance her child's education. The economies we are studying have poorly developed capital markets and the liquidity constraint assumption seems relevant, especially for financing education. If a child is not enrolled she can work and add $\underline{w}$ to the family's consumption. We have in mind tasks such as tending livestock, fetching water, and helping in the fields – activities in which children in poor countries are typically involved – in addition to supplying labor outside the family. These activities are not readily valued by the market wage. For this reason, and for sake of simplicity we have modeled the child's contribution as a fixed quantity unaffected by market conditions. If the child is enrolled in school, she can contribute only $\varphi\underline{w}$ to the family, where $0<\varphi<1$. Define $e\equiv e_d+(1-\varphi)\underline{w}$ to be the total cost of education, which includes both the direct and the indirect cost. Education costs could be subsidized to the level s; if so, it is netted out of the cost e. We will present the analytical discussions without the subsidy and introduce the subsidy explicitly when we discuss calibration.

Let the fraction (measure) of educated workers entering the labor force at any time be denoted by n_e. This is the only aggregate state variable in this economy. Let $\widetilde{w}_e(n_e)$ denote the wage earnings of an educated parent as a function of the aggregate state n_e, and let $\widetilde{w}_u(n_e)$ denote the wage of an

by firms and other economic agents in discrete terms – primary complete, secondary complete, etc. – this assumption seems intuitive. Moreover, Bigsten et. al. (2000) report that the return to education in five African countries is highly non-linear, with the return to primary education as low as 2% for Cameroon, but with a substantially higher return for secondary education (a minimum of 7%); this further lends support for modeling secondary schooling as the minimum acceptable level of education.

[15] When we calibrate the model and conduct policy experiments, we use different probability functions for the children of educated and uneducated parents, $\pi_e(a)>\pi_u(a)$, $\forall\, a\,\epsilon\,[0,1]$ to capture unmodeled advantages that children of rich parents have in pre-school care and in schooling.

uneducated parent. Define, $w_j(n_e) \equiv \widetilde{w}_j(n_e) + \underline{w}$, $(j = e, u)$, to be the potential (or "full") earnings of a household of type j. It is then easy to see that the earnings of a household that does not enroll its child is $w_j(n_e)$ and one that does is $w_j(n_e) - e$ (which amounts to $\widetilde{w}_j + \varphi\underline{w} - e_d$).

Workers inelastically supply their unitary time endowment. Since we expect the tax rate required to finance education to be low, not modeling labor distortion is likely to be a less than egregious omission.

Consider a parent of type j, $(j = e, u)$, who has a child of ability a. If $V_j(a; n_e)$ is the value of this parent who optimally decides whether or not to enroll the child, her Bellman equation is:

$$\begin{aligned} V_j(a;n_e) &= \max\left\{enroll,\ don't\ enroll\right\} \quad (1)\\ &= \max\left\{\begin{array}{c} u(w_j(n_e)-e)+\beta\left[\pi(a)EV_e(a';n_e')+(1-\pi(a))EV_u(a';n_e')\right], \\ u(w_j(n_e))+\beta EV_u(a';n_e') \end{array}\right\},\ j=e,u. \end{aligned}$$

Here, $EV_j(a';n_e') = \int_0^1 V_j(a';n_e')dF\left(a'\right)$, $j = e, u$, is the child's expected utility, which depends on whether the child enters adulthood as a educated or uneducated worker. We take β to be an intergenerational discount (altruism) factor, and the decision is between enrolling and not enrolling. The aggregate state that will prevail when the child enters the labor force is denoted by n_e'. All parents posit that the law of motion for the aggregate state follows $n_e' = \Phi(n_e)$, which they assume to be outside their control. We assume a standard utility function, with $u' > 0$, and $u'' < 0$.

There is a single consumption good produced using educated and uneducated labor as inputs. The CES production function is:

$$Y = A\left[\theta\left(N_e + \gamma N_u\right)^{\nu} + (1-\theta)(N_u + \varepsilon N_e)^{\nu}\right]^{\frac{1}{\nu}}, \quad (2)$$

where $0 < \gamma$, ε, $\nu < 1$, and $\gamma \leqslant \varepsilon$.[16] The first term within the square brackets can be thought of as "brain" and the second term as "brawn". Here, N_e is the number of educated workers employed by the firm, while N_u is the number of uneducated workers employed. Educated workers are the primary suppliers of "brain". The weight of uneducated workers in this factor, γ, is small and keeps wages bounded even at a trap. Both types of workers contribute toward "brawn". The mere hiring of a particular type of worker contributes to both factors in the proportion shown above. In a competitive labor market, the wage rates $\widetilde{w}_e$ and $\widetilde{w}_u$ would be the appropriate marginal product and decreasing in N_e and N_u respectively.

We characterize the behavior of parents in detail in Caucutt and Kumar (2003) and provide only a summary of the results here and move quickly to the new results on a trap steady state, the focus of this paper. An examination of (1) suggests that parents' decisions are driven by a threshold ability

[16] See Stokey (1996) for a similar production function.

– a parent of type j enrolls her child if $a \geqslant a_j^*(n_e)$, and does not otherwise. For a parent whose child is at the threshold ability, we can examine the two options of (1) and write:

$$\beta\pi(a_j^*(n_e))\Lambda(\Phi(n_e)) \leqslant g_j(n_e), \; j = e, u \tag{3}$$

where we define $\Lambda(n_e) \equiv EV_e(n_e) - EV_u(n_e)$, as the value of education, and $g_j(n_e) \equiv u(w_j(n_e)) - u(w_j(n_e) - e)$, as the utility cost to a parent of enrolling a child. The above expression holds with equality if $a_j^*(n_e) < 1$. If it holds as an inequality even when $a_j^*(n_e) = 1$, even the most able child will not be enrolled. The enrollment rate of type j children, given by $\left(1 - F\left(a_j^*(n_e)\right)\right)$, is then zero.

A competitive equilibrium is defined in the usual way as a collection of functions $\widetilde{w}_j(n_e)$, $a_j^*(n_e)$, $j = l,\ i$, $\Lambda(n_e)$, and $\Phi(n_e)$, on $[0,1]$, such that the parents' optimality conditions and production optimality conditions are satisfied, the labor market clears, and $\Phi(n_e)$ and $\Lambda(n_e)$ are consistent with parental decisions. In particular, the law of motion for n_e (the transition function) satisfies:

$$\Phi(n_e) = n_e \int_{a_e^*(n_e;\Phi)}^{1} \pi(a)\, dF(a) + (1 - n_e) \int_{a_u^*(n_e;\Phi)}^{1} \pi(a)\, dF(a). \tag{4}$$

From the labor market clearing condition of $N_e = n_e$, $N_u = 1 - n_e$, and the production function (2) we have $\widetilde{w}_e^{'}(n_e)$ and thus $w_e^{'}(n_e) < 0$, and $\widetilde{w}_u^{'}(n_e)$ and thus $w_u^{'}(n_e) > 0$. Together with the concavity of u, this implies $g_e^{'}(n_e) > 0$ and $g_u^{'}(n_e) < 0$. Given the liquidity constraint, the intuitive result that the richer parents can afford to enroll even children of lower ability while the poorer parents can afford to enroll only higher ability children follows from (3); that is, $a_e^*(n_e) < a_u^*(n_e)$, for $n_e \in [0,1]$. This also implies $a_e^*(n_e) < 1$. Put differently, the enrollment rates are higher among the rich.

Definition 1 *A steady state is a competitive equilibrium with* $n_e = n_e^* \in [0,1]$, *which satisfies* $\Phi(n_e^*) = n_e^*$.

On a steady state, the wages, reservation abilities, expected utilities, and the fraction (measure) of educated workers are all constant over time. Manipulating the consistency conditions from (1) we get:

$$\Lambda(n_e) = x(n_e) + \left[\beta \int_{a_e^*(n_e)}^{a_u^*(n_e)} \pi(a)\, dF(a)\right] \Lambda(\Phi(n_e)), \tag{5}$$

where,

$$\begin{aligned} x(n_e) \;\equiv\; & [F(a_e^*(n_e))u(w_e(n_e)) + (1 - F(a_e^*(n_e)))u(w_e(n_e) - e)] - \\ & [F(a_u^*(n_e))u(w_u(n_e)) + (1 - F(a_u^*(n_e)))u(w_u(n_e) - e)]. \end{aligned} \tag{6}$$

Here, x is extra contemporaneous (*ex ante*, expected) utility an educated parent gets, taking into account the endogenous effect of a higher wage parent having a higher probability of enrolling a child.

The value of being educated has two components – a contemporaneous utility gain and a discounted future value. Equations (3) through (5) are four functional equations in the four functions Λ, Φ, a_e^*, and a_u^*, and completely describe the dynamics of the model. When n_e is replaced by n_e^*,we can solve for the four steady state quantities.

Intuitively one would expect the value of education to decrease with the measure of educated people. One would similarly expect the measure of educated workers in the next period to increase with the measure of educated workers this period. In Caucutt and Kumar (2003) we provide conditions that ensure $\Lambda(n_e)$ is decreasing and $\Phi(n_e)$ is increasing.

We will see below that the dynamic behavior of the economy around the origin is governed mainly by the utility cost of uneducated rather than educated parents. Rich parents always enroll a positive fraction of their children and especially so when their wages are very high ($n_e \to 0$). But given that they are a very small fraction of the labor force when n_e is close to zero, their behavior matters little to the dynamics of the economy. Whether the fraction of educated workers continues to grow in the vicinity of $n_e = 0$, and if so whether it grows at a rate that can sustain a long run equilibrium with a positive fraction of such workers, depend on the behavior of the poor parents. This insight would be obscured by a representative agent model.[17]

Definition 2 *A trap is a locally stable steady state at $n_e^* = 0$.*

We turn to a formal analysis next, and provide a sufficient condition for a trap to occur.

3.1 Conditions for a Trap

Lemma 1 *A necessary condition for a trap is $a_u^*(0) = 1$ (the poor do not enroll their children). This condition is sufficient if additionally, $a_u^* = 1$ in a neighborhood of $n_e = 0$.*

Proof. First we prove necessity. Suppose a trap exists; therefore, $\Phi(0) = 0$. From (4), we can see that at $n_e = 0$, we have $\Phi(0) = \int_{a_u^*(0)}^1 \pi(a)\, dF(a)$. Given the assumptions on π, $\Phi(0) = 0$ only if $a_u^*(0) = 1$.

Next we show sufficiency. If $a_u^*(0) = 1$, (4) implies $\Phi(0) = 0$ so $n_e^* = 0$ is indeed a steady state of the dynamic system. Since $a_u^* = 1$ also in $N_r(0)$, for some $n_e = \varepsilon$ in this neighborhood, (4) implies,

[17] It is clear that the fixed nature of the goods cost of education is responsible for the trap. One could envision an alternate setup in which the time cost of an old agent (the "teacher") is the cost of education. If the teacher is the parent of the child herself, the cost of educating the poor would be very low when the wages of the poor are low, and a trap is unlikely. However, if the cost of educating the child is the time cost of an *educated* worker, which seems more plausible, a trap is likely to obtain. In fact, the situation would be exacerbated since the wages of the educated are highest when the wages of the uneducated are at their lowest.

$\Phi(\varepsilon) = \varepsilon \int_{a_e^*(n_e;\Phi)}^1 \pi(a)\, dF(a) < \varepsilon \int_0^1 \pi(a)\, dF(a) < \varepsilon$ given the assumptions on π. $\Phi(n_e) < n_e$ in the neighborhood of $n_e = 0$ implies the steady state is locally stable. ■

What are the conditions that could yield $a_u^* = 1$ in $N_r(0)$ and hence a trap? It is useful to first consider linear utility, $u(c) = c$, since the condition is very intuitive in this case and will help us better understand the condition for the more general isoelastic utility function. Moreover, equation (3) implies that $a_e^* = a_u^*$ when utility is linear, and the model has the flavor of a representative agent model, in enrollment if not in income.

Lemma 2 *When $u(c) = c$, a sufficient condition for $a_u^*(0) = 1$ and hence a trap is $e > \beta(w_e(0) - w_u(0))$.*

Proof. With $u(w) = w$, the dynamic system becomes:

$$\begin{aligned} g_e &= g_u = e;\ a_e^* = a_u^* \equiv a^* \\ \beta a^* \Lambda(\Phi(n_e)) &\leqslant e,\ w.e.i,\ a^* < 1 \\ \Phi(n_e) &= \int_{a^*}^1 \pi(a)\, dF(a) \\ \Lambda(n_e) &= x(n_e) = w_e(n_e) - w_u(n_e). \end{aligned} \tag{7}$$

The value to being educated does not have a dynamic component here and the economy jumps to the steady state immediately. For this steady state to be zero (i.e. a trap), as argued above a^* needs to be one; that is, no one is enrolled. So a sufficient condition for a trap, from (7) is $\beta \cdot 1 \cdot (w_e(0) - w_u(0)) < e$, or:

$$e > \beta(w_e(0) - w_u(0)). \tag{8}$$

Since the economy jumps to the zero steady state right away from any starting n_e, stability readily obtains. ■

Since w_e is decreasing in n_e and w_u is increasing, the wage gap between the educated and the uneducated workers is maximum at zero. The above condition states that if the cost of education is greater than the maximum possible discounted gain, a trap will result. In other words, if the maximum possible discounted return to investment in education is less than one a trap results.

Lemma 3 *For a more general utility function, a sufficient condition for $a_u^* = 1$ in a neighborhood of $n_e = 0$ is $\frac{u(w_u(0)) - u(w_u(0)-e)}{u(w_e(0)-e) - u(w_u(0)-e)} > \frac{\beta}{1-\beta\int_0^1 \pi(a)\, dF(a)}$.*

Proof. As mentioned earlier, it can be shown that $a_e^*(n_e) < a_u^*(n_e)$. From (6) we can therefore show (dropping the argument n_e for notational simplicity):

$$\begin{aligned} x &< [F(a_e^*)u(w_e) + (1 - F(a_e^*))u(w_e - e)] - \\ &\quad [F(a_e^*)u(w_u) + (1 - F(a_e^*))u(w_u - e)] \\ &= F(a_e^*)(u(w_e) - u(w_u)) + (1 - F(a_e^*))(u(w_e - e) - u(w_u - e)). \end{aligned}$$

Given the concavity of u, it follows that $u(w_e - e) - u(w_u - e) > u(w_e) - u(w_u)$. Therefore, in the above convex combination we have:

$$\begin{aligned} x &< u(w_e - e) - u(w_u - e) \\ &< u(w_e(0) - e) - u(w_u(0) - e), \end{aligned}$$

given $w_e^{'}(n_e) < 0$ and $w_u^{'}(n_e) > 0$. (Together with the concavity of u this also implies that the largest g_u can be is $u(w_u(0)) - u(w_u(0) - e)$.) The dynamic factor in (5) can be bounded by $\beta \int_0^1 \pi(a)\, dF(a)$, and therefore the whole expression can be used to write:

$$\Lambda(n_e) < \frac{u(w_e(0) - e) - u(w_u(0) - e)}{1 - \beta \int_0^1 \pi(a)\, dF(a)}.$$

The observation made earlier that $\Lambda(n_e)$ is decreasing and $\Phi(n_e)$ is increasing, which implies $\Lambda(n_e) > \Lambda(\Phi(n_e))$ has been used to derive this. From (5), a sufficient condition for $a_u^*(0) = 1$ is:

$$\frac{u(w_u(0)) - u(w_u(0) - e)}{u(w_e(0) - e) - u(w_u(0) - e)} > \frac{\beta}{1 - \beta \int_0^1 \pi(a)\, dF(a)}. \tag{9}$$

By evaluating the numerator at a positive value of ε in $N_r(0)$, we can ensure $a_u^* = 1$ in a neighborhood of $n_e = 0$. ■

To better understand this result, note that when we use $u(c) = c$ in the above expression, we retrieve the condition $e > \beta(w_e(0) - w_u(0))$ as in the earlier lemma (noting that the dynamic factor in the linear utility case is 0 instead of $\beta \int_{a_e^*(n_e)}^{a_u^*(n_e)} \pi(a)\, dF(a)$, since $a_e^* = a_u^* \equiv a^*$). The numerator of the left hand side in the general condition above is now the *utility* cost of education to the poor parent instead of the goods cost found in the condition for linear utility. This cost was the same for both types under linear utility, as it would have been in a representative agent model. The contribution then of the heterogeneous agent setup is to identify the cost squarely with the *poor* agents in the economy. The denominator of the left hand side is now the utility gap of the two types of agents (adjusted for the cost of education) instead of the wage gap; it can be viewed as the utility gain from education.

It can be shown that the left hand side of (9) is increasing in e and decreasing in $w_e(0)$ for a given $w_u(0)$; the right hand side is decreasing in β. Therefore, as in the linear utility case, the above trap condition is more likely to be satisfied when the cost of education is high, the wage gap is low, and the discount factor is low. Additionally, the curvature of the utility function also matters now. For instance, with an isoelastic utility function $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, $\sigma \geqslant 0$, (with the $\sigma = 1$ case interpreted as $\log(c)$), the left hand side is increasing in σ. Therefore, the likelihood of a trap increases with the curvature of the utility function. Thus the above sufficient condition identifies all the intuitive forces that make a trap more likely in our setup.

4 Calibration

Recall our definition of educated and uneducated workers – an uneducated worker has two years of education and an educated worker has ten years of education. In this section we describe the choice of model parameters that allows us to produce outcomes that are broadly consistent with the sSA countries being close to a trap; that is, with the fraction of workers with education beyond two years close to zero. The quality of data on these countries is not comparable to that of the US. By targeting the average performance of a group of countries discussed in Section 2, we hope to avoid the pitfalls of calibrating to a single country with a particularly low quality of data or one that suffers from an idiosyncratic institutional failure. The aim is to get a set of parameters with which it is sensible to conduct policy analysis.

We assume agents are born at age 6 and are "young" until the age of 25; they become adults at the age of 26, have a child, and die at the age of 45. The model period is thus 20 years. The life-span corresponds closely to the life expectancy of the sSA countries considered (see Table 2).

We start by assuming values for certain parameters that are commonly used in the literature. The generational discount factor is set at $\beta = 0.6676$, which corresponds to a yearly discount factor of 0.98 compounded over 20 years. We set $\nu = 0.35$, which corresponds to an elasticity of substitution between educated and uneducated labor of 1.54. Autor, Katz, and Krueger (1998) report that the emerging consensus on the elasticity between skilled and unskilled labor is approximately 1.4 to 1.5.[18] In the absence of direct evidence, we set $\varepsilon = 0.1$, (each unit of skilled labor counts 10% of unskilled labor toward brawn) and leave $\gamma < \varepsilon$ as a free parameter; this makes our choice of ε a normalization of sorts.

We assume $u(c) = \frac{c^{1-\sigma}}{1-\sigma}$, $\sigma \geqslant 0$. As we have seen in the previous section, the likelihood of a trap increases with σ. We use this result and existing arguments for a negative relationship between relative risk aversion and wealth (see, for instance, Ogaki and Zhang (2001)), to set σ at a higher value of 3.5 instead of the usual 2. We assume a uniform ability distribution in $[0, 1]$; that is, $F(a) = a$.

The remaining parameters are particular to the production functions for output and human capital. They are chosen to broadly match target data on education costs, the wage premium, and enrollment and dropout rates. The erratic nature of data availability, their variability across sources, and the processing required to map available data into corresponding model equivalents warrant a detailed discussion of these targets.

Skill premium: Bils and Klenow (2000) present Mincer regression coefficients on schooling for a few sSA countries: 0.207 for Cote d'Ivoire, 0.126 for Botswana, and 0.067 for Tanzania. When we compute

[18] Their definition of skill, however, corresponds to college education.

$\exp(coeff * 8)$ for these three countries, we obtain premia of 5.24, 2.74, and 1.71 respectively.[19] When the figures reported in Bigsten et. al. (2000) are used to compute the premium for our education definition, we obtain a value of 1.42.[20] The World Development Indicators (2000) states that the ratio of manufacturing to agricultural wage was 5 for Botswana during 1980-84 and 2.36 during 1995-99.[21] Verner (1999) presents evidence that the wage gap is 56% in Ghana between secondary graduates and those with no education, and 186% if the education is at the university level – premia of 1.56 and 2.86 respectively. Bredie and Beeharry (1998) cite evidence from Mason and Khandker (1996) that when hourly wages in the formal sector are used as a measure of benefits, the private return to education is 7.9% in Tanzania; this translates into a premium of 1.9 when calculated as above. The premium therefore spans the rather wide range of 1.42 to 5.24 for the African countries on which we have evidence.

Parental cost of education: We next turn to the direct cost of education and subsidies. Ablo and Reinikka (1998) present data on parental and government spending in Uganda for 1991 through 1995. Parental expenses include tuition, Parent-Teacher Association levies and salaries; governmental expenses include capitation grants and salaries. For instance, in 1991 total parental expenditure per pupil was 9,498 Ugandan Shillings, and governmental expenditure was only 3,590. In 1995 the figures were 12,781 and 8,676, reflecting a decrease in the share of expenditure borne by parents.[22] In conjunction with the per capita GNP figures, we compute the annual share of income that is spent on education and the parental share of this cost, averaged over 1991-95. If we denote per capita income by y, then $\lambda_1 \equiv \frac{\text{total direct cost}}{y} = 8.1\%$, $\lambda_2 \equiv \frac{\text{govt. cost}}{y} = 2.7\%$, and therefore $\lambda_1 - \lambda_2 = \frac{\text{parent's cost}}{y} = 5.4\%$. This implies the ratio of subsidy (s) to direct cost of education (e_d), $\frac{s}{e_d} = \frac{2.7}{8.1} = \frac{1}{3}$.

For details on indirect costs, we turn to Bredie and Beeharry (1998), who present time use data of school-aged children in Madagascar and conclude that the opportunity cost for boys in school is 20 hours per week, with an adjusted measure for girls a bit higher.[23] We assume this is half the adult work week; non-schoolgoing children work half an adult week and schoolgoing children work none. We impute the average wage in the economy to this time; in other words, we set $\underline{w}$ such that it is

[19] Mincerian regressions use log wages, which explains the exponentiation. The number of years of schooling that is relevant for us is 8. See Knight and Sabot (1990), Chapter 13, for the need to exercise caution in interpreting return estimates that ignore the effects of policy-induced wage differences between the public and private sectors.

[20] We use their coefficients from regression (3) in Table 7 to compute wages for 2 and 8 years of education. Their production function approach would yield lower values.

[21] See Table 2.6.

[22] See their Table 5.

[23] See their Annex A. They compare hours spent by schoolgoing and non-schoolgoing children in several categories – water collection, firewood collection, household tasks, and independent agricultural and non-agricultural activities – to arrive at the opportunity costs.

equal to $0.5y$, where y is the average wage earnings.[24]

Consider the income of a family in which the child does not go to school. The present value of the parent's annual income y over 20 years at an 8% rate of discounting is $10.6y$. The present value of the child's income is half this at $5.3y$. If the family does send the child to school, the present value of the annual parental cost of education $(\lambda_1 - \lambda_2)\, y$ over the eight schooling years is calculated as $6.2\,(\lambda_1 - \lambda_2)\, y$. If the child goes to school, it is assumed that after the first 8 years, the child can work the rest of his youth years with annual earnings of $0.5y$; that is, we assume that the increased earnings on account of education are not realized until adulthood.[25] The present value of these earnings works out to be $2.2y$. Therefore, we calculate:

$$\varphi = \frac{\text{Earnings of schoolgoing child}}{\text{Earnings of non-schoolgoing child}} = \frac{2.2}{5.3} = 0.415.$$

We calculate the direct education expenditure net of government subsidies as a fraction of GDP, which is a calibration target, as:

$$\frac{e_d - s}{Y} = \frac{6.2\,(\lambda_1 - \lambda_2)\, y}{10.6y} = 0.0316.$$

Enrollment and dropout rates: Finally we calculate the enrollment and dropout rates to target. A "naive" measure of enrollment rate can be obtained by taking a simple average of the primary and secondary enrollment for each country in Table 1 and then taking the average across countries. This works out to 31.8%. However, this does not exactly correspond to the model enrollment rate where the education is really from the beginning of the third year to that of the eighth year. Using the intake rate at the first year and the year-to-year survival rates from the World Education Indicators, it is possible to calculate enrollment rates conditional on students surviving the first two years of education. The average of this enrollment data is 22.9%. The "naive" dropout rate can be obtained as above as an average of the primary dropout rate and secondary repeat rate (which we use as a proxy for the secondary dropout rate on which data is not readily available); it works out to 32.3% for the countries we are interested in. We can also calculate the dropout rate conditional on students surviving the first two years of their education as 13.5%. Since data for this latter calculation is not available for all countries, with the poorest performing countries most likely to have missing data, this dropout rate is likely to be underestimated.

We parametrize the human capital production function with the properties of π we had assumed earlier: $\pi(0) = 0$, $\pi'(a) > 0$. We now allow for the possibility that these functions can differ across the

[24] Note that at the trap $y = w_u$.

[25] By making this assumption we attempt to account for the experience premium which we have not explicitly modeled. If the effect of education is realized in the first period of an individual's life itself, φ is likely to be higher. However, the earnings of those students who fail to become educated will be unaffected by the timing assumption. We discuss the importance of φ in the section on sensitivity analysis.

two types of families, to account for the advantages educated families might have in the production of human capital. The parametric form we use is:

$$\begin{aligned}\pi_i(a) &= k_i\left(4a^3\right), \ \forall\ a\ \epsilon\ [0,1/2] \\ &= k_i\left(1-4\left(1-a\right)^3\right), \ \forall\ a\ \epsilon\ [1/2,1].\end{aligned}$$

This convex-concave parametric form was chosen because it allows us to better match the enrollment and dropout rates in the vicinity of the trap. It must be emphasized that such a shape is not *required* to get a trap in the first place. The curvature of the utility function and costs play a bigger role in causing the trap. We normalize $k_e = 1$.

To summarize, the seven parameters that remain – production parameters (A, θ, γ), the earnings of a non-schoolgoing child $\underline{w}$, expenditure variables (e_d, s), and the probability (human capital production) function parameters (k_u) – are chosen to broadly match the following seven targets:

Empirical Target	**Value / Range**
n_e^*	0 (trap)
$\underline{w}/Y$	0.5
$\frac{s}{e_d}$	1/3
$\frac{e_d - s}{Y}$	0.0316
$\widetilde{w}_e/\widetilde{w}_u$	1.42-5.24
Enrollment rate	22.9-31.8%
Dropout rate	13.5-32.3%

The parameters arising from this calibration are summarized below:

$$\begin{aligned}\text{Production} &: \quad A = 2,\ \theta = 0.48,\ \nu = 0.35,\ \varepsilon = 0.1,\ \gamma = 0.05, \\ \text{Preference} &: \quad \beta = 0.6676,\ \sigma = 3.5, \\ \text{Education} &: \quad e_d = 0.0326,\ s = 0.0109, F(a) = a,\ \underline{w} = 0.3439,\ \varphi = 0.415,\ k_e = 1,\ k_u = 0.85.\end{aligned}$$

The resulting total cost of education parameter, $e\ (= e_d + (1-\varphi)\,\underline{w})$, is 0.234; in other words, the direct cost is only 14% of the total costs. Therefore, the return to investment in education is dramatically different when indirect costs are ignored than when they are included – by a factor of 7.18 ($= e/e_d$). Low enrollment in the face of high returns to education calculated from Mincerian regressions is seen as a puzzle; Psacharopolous (1994), for instance, reports an average rate of return of 13.4% in sSA for the first few years of education. Appleton, Hoddinott, and Mackinnon (1996) and Bigsten et. al. (2000) question the validity of such high reported returns; therefore, one approach to resolving the puzzle is to question its very existence. Focusing on the return to investment in education and factoring indirect costs, which our framework allows us to do, provides another possible resolution of the puzzle; this return is much higher when calculated using only the direct cost of education than the total cost which includes children's contribution to family consumption. In other words the assumption implicit in the Mincerian interpretation that, "...for each educational level, the opportunity cost is the wage that would have been obtained with the education level one below the completed level," is questionable in a setup where non-market contributions play a big role.[26]

With these parameters, a trap results. That is, $n_e^* = 0$. The first four of the above targets are directly met. A skill premium of 4.96 results, which is within the above-mentioned range seen in data, though close to the upper end. Exactly at the trap, there is no enrollment; $a_u^* = 1$, and even though $a_e^* = 0.12 < 1$, there is a zero measure of these educated people at the trap. Therefore, we examine the average dropout and enrollment rates in the "vicinity" of the trap ($n_e = 0.00 - 0.15$), with the interpretation that these economies are headed toward a trap if they are not already in it. The enrollment rate is in the range of 0 to 21%, which is a bit lower than the range given above but in the ballpark of the enrollment rate calculated conditional on students surviving past the second year, while the dropout rate is in the range of 24 to 43%, overlapping considerably with the range seen in data.[27]

We assume that the government education expenses are met by taxing all workers. The government balances its budget according to:

$$\left[n_e(1 - F(a_e^*)) + (1 - n_e)(1 - F(a_u^*))\right] s = (n_e \widetilde{w}_e + (1 - n_e)\widetilde{w}_u)\, \tau. \tag{10}$$

Any student, rich or poor, who goes to school gets subsidies and all workers are taxed; this is the only type of tax-and-subsidy scheme we will consider throughout this paper.[28]

In the next section we compare the efficacy of various policies in prying this economy out of the trap.

[26] The quote is from Bigsten et. al. (2000).

[27] The aggregate enrollment and dropout rates are calculated using the following formulae:

$$\begin{aligned} enr.\ rate &= n_e\,(1 - a_e^*) + (1 - n_e)\,(1 - a_u^*) \\ drop.\ rate &= \frac{n_e\,(1 - a_e^*)\, d_e + (1 - n_e)\,(1 - a_u^*)\, d_u}{n_e\,(1 - a_e^*) + (1 - n_e)\,(1 - a_u^*)}, \end{aligned}$$

where,

$$d_i = \frac{\int_{a_i^*}^{1} (1 - \pi_i(a))\, dF(a)}{1 - a_i^*}.$$

[28] Need-based subsidy is not widely prevalent in basic education, especially in poor countries, so assuming uniform subsidies appears reasonable. Progressive taxes would be a non-starter at the trap, where there are no rich people. One could assume progressive taxes and the ability to borrow abroad initially (when everyone is poor) as a way of prying the economy from the trap, but uniform taxes seems a simpler starting point.

5 Policy Experiments

We consider the following policy alternatives, suggested by popular policy discussions as well as by the economic forces we have captured in our model, to spur development in sSA – a tax and subsidy scheme, foreign aid, abolition of child labor, enacting and enforcing a compulsory education law, and infrastructural improvements that lead to an increase in A. We treat the welfare-maximizing case of the first alternative as our benchmark policy. For the remaining alternatives, we first consider the alternate policy in isolation to study it in detail and later adjust the subsidy level so as to equate equilibrium expenditure to that in the tax and subsidy scheme that maximizes transitional welfare; this allows us to make "revenue neutral" comparisons.

In all experiments, we hold the π functions at their trap configuration; that is, we do not make any adjustment for the quality of the education system. There are several reasons for this move. We do not have enough data on quality, especially from this region, to calibrate π according to the level of development. We also expect the quality of educational institutions to move upward more sluggishly than enrollment.[29] In fact, the increase in enrollment we expect our policies to induce would worsen the already high student-teacher ratios in these economies.

5.1 A Tax and Subsidy Scheme

The lesson learned from the sufficient conditions, (8) and (9), is that high education costs can cause an economy to move to a trap in the long run. At the prevailing subsidy level, as calibrated above, the net educational cost is high enough to cause a trap. An obvious policy alternative is to find a subsidy level that can cause the economy to not only emerge from the trap, but also results in a desirable long run outcome. As mentioned in Section 2.1, one economy we aim for is one with $n_e^* = 0.3$, which is roughly the education attainment in Mauritius. We will assume that the government budget constraint, (10), holds at every instance and seek the subsidy level s that will cause such a steady state to be attained. The level of subsidy is held constant, and the tax rate τ is varied so as to balance the government budget.

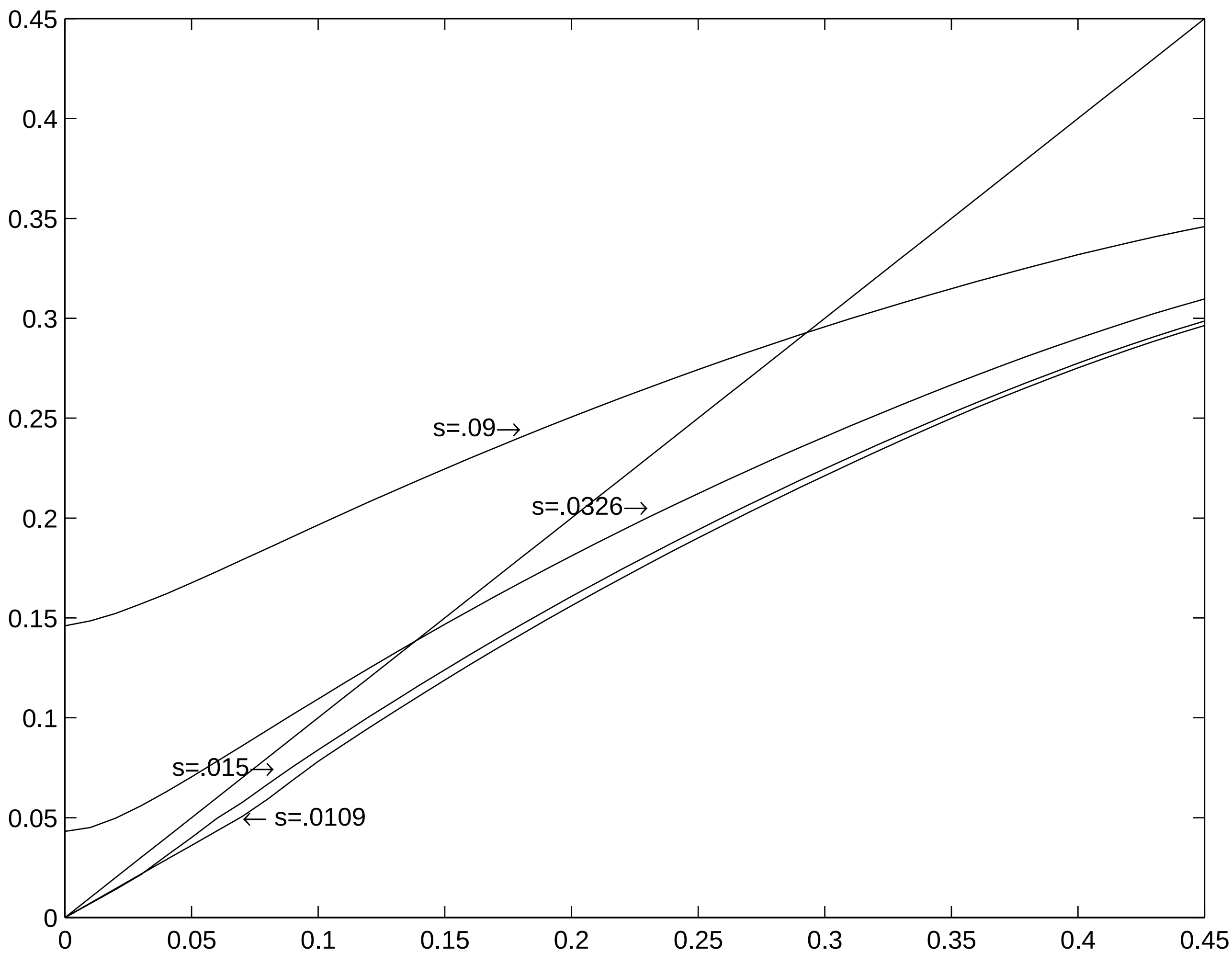
Before we search for the subsidy that guarantees such a steady state, we present a graph of the transition function Φ for various subsidy levels in Figure 1. We can see from this plot that the subsidy has to be high enough for the economy to get on to a transition path that will take it to a non-trap steady state; for instance, $s = 0.015$ (which is 6.4% of the total cost and 46% of the direct cost) will not get the economy out of the trap. In particular, note that subsidizing the direct cost of $e_d = 0.0326$

[29] Hanushek (1995), for instance, concludes that correcting inefficiencies in the educational system is not simple: "There is no blueprint for a model school that can be reproduced and handed out to policymakers, and such a blueprint is unlikely to be developed in the near future."

alone will get the economy out of the trap, though the resulting fraction of educated workers, n_e^*, is only 13.8%.

Figure 1

Transition Function – $\Phi(n_e)$ *vs* n_e



Since everyone pays taxes, but only families who enroll their children get benefits, there is a redistribution from the poor families with low ability children to poor families with high ability children in the initial period while the economy is still at the trap. This is the fundamental force that allows this policy to pry the economy out of the trap. Redistribution is typically viewed in terms of the rich and the poor, but in this context it is the redistribution from families with low ability children to those with high ability children that is important.[30] Once the process of development starts, and there are some educated rich parents in the economy, the redistribution could potentially be from the low to high ability families of both types, as well as between the rich and the poor.

[30] Of course, legally mandating school attendance and enforcing such a law, will also be able to provide this impetus. We study compulsory education in a latter subsection.

In practice it might not be necessary to levy new taxes to subsidize education. For instance, military expenditure as a fraction of GNP was 3.1% in sSA in 1992; diverting part of it to education might suffice.[31]

We compare the outcomes in the new and old steady states in Table 3.

Table 3

A simple tax and subsidy scheme

Variable	**Interpretation**	1. **Trap**	2. **subsidy 1**	3. **subsidy 2**
n_e^*	Fraction of educated workers	0%	30%	38%
s	Subsidy level	0.0109	0.090	0.157
τ^*	Tax rate	0%	3.2%	7.0%
Y^*	Output	0.69	1.03	1.06
$\frac{\widetilde{w}_e^*}{\widetilde{w}_u^*}$	Skill premium	4.96	1.54	1.28
$n_e\left(1-a_e^*\right)+\left(1-n_e\right)\left(1-a_u^*\right)$	Enrollment rate	0%	36.2%	47.2%
$\frac{n_e(1-a_e^*)d_e+(1-n_e)(1-a_u^*)d_u}{n_e(1-a_e^*)+(1-n_e)(1-a_u^*)}$	Dropout rate	0%	19.2%	19.7%
ω_{ss}	SS welfare (cons. equiv.)	–	20.3%	23.6%
ω_{tran}	Trans. welfare (cons. equiv.)	–	6.6%	8.1%

As seen in column numbered 2, a subsidy level of 0.09, which is 38.5% of total costs, is needed to take the economy to a steady state of $n_e^* = 0.3$. In other words, it is not enough for the government to subsidize only the direct costs of education, which is only 14% of the total cost; it would have to defray part of the child's contribution to the family income that is lost by sending the child to school. At steady state a tax rate of 3.2% needs to be levied on all workers to meet the cost of subsidies. Since all workers are taxed at the same rate, the ratio of government expenditure to GDP will also be 3.2%. This is close to the 3.6% figure cited earlier for Mauritius and thus appears to be an achievable target.[32] As mentioned in the introduction, the closeness of the model outcome to data from a country that was not originally part of the calibration, lends support to the validity of the calibrated model as well as to the use of education subsidies in reviving a stagnant economy.

This policy will increase output by close to 50%. The ratio of the subsidy (expenditure per pupil) to per capita GDP is 8.75%. The increase in n_e will decrease $\widetilde{w}_e$ and increase $\widetilde{w}_u$ to cause the premium

[31] See *2000 World Development Indicators*, Table 5.7.

[32] The Oxfam report cited earlier states that a "minimum requirement for progressing toward the 2015 target," of achieving universal primary education is education expenditure amounting to 3% of GDP. Our simulations show that at a figure close to this, the enrollment rate is not 100%. Simulations presented later show that about 7% of GDP has to be spent on education to ensure 100% enrollment.

to drop considerably, to 1.54; most of this is driven by the drop in skilled wages.[33] The economywide enrollment rate is 36.2%, which masks the relatively high enrollment of 61% for educated parents. The dropout rate is close to 20%.

In the second to last row, we present the equivalent increase in consumption each agent would have to be given in the trap in order to make an aggregate welfare measure, in which current generations are equally weighted and a discount factor of β is used for future generations, the same as that in the new steady state. Each household needs to be given 20.3% more consumption every period in the trap. When the costs of transition (increased taxes and educational investment when uneducated workers' wages are still low) is taken into account, the gain in welfare is much lower; as seen in the last row, it amounts to an equivalent increase of 6.6% of the trap consumption, which is still very significant. The economy is very close to the steady state in four to five model periods.[34]

Next we seek the subsidy level that maximizes the transitional welfare. An increased subsidy increases enrollment and succeeds in moving a greater fraction of the population toward the higher utility educated category. However, higher taxes needed to finance this subsidy drain income from liquidity constrained parents who are poor during the transition and yet invest more in education in the aggregate. These opposing forces suggest that there is a subsidy level that is optimal. As shown in column 3, a subsidy level of $s = 0.157$ (about 67% of total educational cost), maximizes transitional welfare.[35] At this higher subsidy level, the new steady state tax rate is higher at 7%; output inches up and the premium drops further, to 1.28. Enrollment is substantially higher, at 47.2%, which results in a steady state educational attainment of 38%. Both the steady state and transitional consumption equivalents are higher, at 23.6% and 8.1% respectively, with the latter at its maximum possible value. Henceforth, we shall refer to this level of subsidy as our benchmark policy.

The main conclusions we draw from this experiment is that a "simple" tax and subsidy scheme, can alter the transition function and put the economy on a path toward development. Such a scheme increases welfare significantly even when transition costs are taken into account; the subsidies would however have to go beyond direct costs and cover part of the indirect costs as well.[36]

[33] Bils and Klenow (2000) do not report the Micerian coefficient for Mauritius, but do present data on Malaysia, a country of comparable educational and economic development. Their coefficient of 0.094 translates to a skill premium of 2.1 in our context. Therefore, we might be overestimating the drop in the premium.

[34] The fact that the absolute welfare figures are high is interesting in their own right; however, the relative ordering of policies according to welfare is probably more important for our purpose.

[35] If taxes were distortionary, this maximum would occur at a lower level of subsidy.

[36] The *Progresa* program instituted in Mexico does subsidize indirect costs.

5.1.1 Political Economy Considerations

A natural question to ask at this juncture is why we do not see such schemes put in place in practice. Even though ours is not a model of political economy, our simulations allow us to speculate on this question.

There is a drop in wages of the educated, $\widetilde{w}_e$, of about 61% going from the trap to the first subsidy level and a drop of 67% to the second subsidy level. Even though the measure of educated workers in the trap is vanishingly small, one can still examine whether such workers would prefer to be in a trap or in the above steady state in column 3. We find (in figures omitted for brevity) that they prefer the trap, and in all experiments the currently uneducated prefer subsidies more than the currently educated do, at least across steady states. There is therefore an incentive for the educated "elite", who often occupy key policy making positions in these countries, to *not* subsidize education and preserve the monopoly they enjoy for their children who are more likely to be educated. If this incentive effectively causes subsidization to be blocked, the economy will remain in a trap.[37]

Why would the poor who do not enroll their children support the taxation scheme? We find that this segment of the population also benefits from the subsidy scheme. A poor household with the ablest possible child $(a = 1)$, which will enrolls its child for sure, needs an equivalent consumption measure of 8.6% at the trap to equate welfare to the one in the subsidy scheme. A household with a low ability child who is not enrolled also prefer the scheme; their equivalent consumption measure is 7.7%. Even though the unenrolled child will stay poor next period, since the wage of the uneducated increases, the expected value to being poor increases and this feeds into the welfare of today's parent.[38] The subsidy scheme which improves the future economic condition of the low ability individuals also provides present-day parents insurance against their grandchildren's ability, partially completing a market that has been assumed to not exist.

5.2 The Question of Foreign Aid

The Oxfam report mentioned in the introduction recommends an increase in foreign aid to sSA countries as well as an increase in the portion of this aid devoted to basic education. Indeed several of the sSA countries already receive considerable amounts of foreign aid. Given their low GDPs, aid

[37] The decrease in *relative* wages of the skilled, that is, the skill premium, is more crucial for this explanation. A simulatenous increase in total factor productivity could increase absolute skilled wages even as increased education attainment decreases the skill premium. Absolute wages for the skilled in Mauritius, for instance, have not decreased relative to other sSA economies that are closer to a trap.

[38] Knight and Sabot (1990) are pessimistic that an expanded education system would improve intergenerational mobility, but do find an increase in the *absolute* wages of the less educated in Kenya, due to productivity gains attributable to the expansion. See their Chapter 10.

as a percentage of GDP for some of these countries is high; it is 5.65% for Malawi, 7.65% for Mali, 5.38% for Niger, 4.44% for Somalia, and 5.86% for Tanzania.[39] However, not all of this aid is likely to be devoted to basic education. Moreover, international outlays for foreign aid have been dwindling. Burnside and Dollar (2000) state, "...in 1997 OECD countries gave less, as a share of GNP, than they have in decades." They also find that aid has a positive impact on growth in developing countries with good policies, but little effect on those with poor policies.

The previous experiment suggests that even an economy locked into a trap need not be dependent on foreign aid to trigger development. It is welfare improving to tax workers and raise the funds for subsidizing education locally. Indeed one of the complaints donors of foreign aid have is that the funds are frittered away and rarely reach intended targets. When the funds are generated within the poor country via taxation the chances of local monitoring and political accountability of funds might improve.

Despite these considerations, we conduct an experiment that mimics foreign aid. The workers in the poor country are not taxed; instead foreign aid is expected to cover the subsidies that are needed to take the economy to the same steady state as the benchmark policy of $n_e^* = 0.38$. The elimination of taxes causes little change to the economic aggregates such as output, the skill premium, and enrollment rates.[40] The subsidy level is a bit lower than before at 0.152; workers earn slightly higher income without taxes and thus need a lower subsidy to induce them to enroll their children. Needless to say, welfare is higher when the subsidies are met from foreign aid instead of domestic taxes. Each agent would have to be given 30% more consumption every period in the trap to equate aggregate welfare to the one that obtains in the foreign aid regime. When transition is factored in, this figure reduces to about 14%; this is about 42% higher than the equivalent figure in the tax and subsidy scheme.

As a fraction of GDP, subsidy expenditures are a bit higher than 6.8%. It appears inconceivable that countries will be willing to donate this amount in foreign aid in perpetuity for providing basic education; as a fraction of the pre-subsidy GDP, a figure that can be compared to the aid-to-GDP ratios given above, the aid has to be as high as 10.4% for education alone. Given that a welfare improving domestic taxation scheme is possible, it seems more prudent for an sSA economy to institute such a policy than wait for uncertain foreign aid. There is nothing in our analysis, however, to indicate foreign aid could hurt economic prospects.

If the government can borrow on a long-term basis from other countries or development agencies to finance increased education expenditures during the transition, thereby not forced to balance its budget in the short run, the resulting increase in welfare will be in between the figures given in Table

[39] This data is from Burnside and Dollar (2000) and is averaged over available data for the period 1970-1993.

[40] There might be a more perceptible increase if labor distortion of taxes is modeled.

3 and the ones reported in this subsection where donor countries give outright aid instead of loans.

5.3 Abolition of Child Labor

Since indirect costs are a significant proportion of the total cost of primary education, it appears reasonable to consider a policy that abolishes child labor; this would reduce the cost perceived by parents. That is, in addition to ethical reasons, there may be economic reasons for such an abolition. However, there is a loss of family income, and it will be interesting to examine the overall effect on welfare.

We consider different variants of this experiment. We initially assume that abolition of child labor amounts to zero contribution from the child to the family income. This might seem extreme since the child could do work within the house or in the family farm if not outside. So, we also consider a case where the child contributes $\varphi \underline{w}$ irrespective of whether the child goes to school or not (in earlier experiments the child who does not go to school earns the full $\underline{w}$). In other words, the indirect cost is zero under both assumptions, but the family income is higher in the second case. Under either assumption, we consider the abolition of child labor in isolation with the subsidy level kept at the trap level, as well as with subsidies that would result in the same outlays by the government as in the benchmark tax-and-subsidy scheme in column 3, Table 3; i.e. we make a revenue neutral comparison. Table 4 summarizes the outcomes of these experiments, where column 1 repeats the trap outcome for sake of convenience.

Table 4

Abolition of child labor

Variable	1. **Trap**	2. **Abolish** (0)	3. **Abolish+sub.** (0)	4. **Abolish** ($\varphi \underline{w}$)	5. **Abolish+sub.** ($\varphi \underline{w}$)
Fraction of educated workers	0%	43.4%	46.0%	43.5%	46.0%
Subsidy level	0.0109	0.0109	0.0741	0.0109	0.0741
Tax rate	0%	0.6%	6.9%	0.6%	6.9%
Output	0.69	1.07	1.07	1.07	1.07
Skill premium	4.96	1.14	1.09	1.14	1.09
Enrollment rate	0%	60.4%	100%	60.4%	100%
Dropout rate	0%	28.1%	54.1%	28.1%	54.1%
SS welfare (cons. equiv.)	–	1.2%	0.67%	15.1%	14.5%
Trans. welfare (cons. equiv.)	–	-18.0%	-19.1%	-3.1%	-4.1%

If the child's contribution to the family is zero after the abolition of child labor goes into effect (column 2), the fraction of educated workers and the output increases more than they do with the tax and subsidy scheme presented in Table 3; n_e^* is now 43.4% instead of 30% and Y^* is 1.07 instead of 1.03. The cost of education goes down from 0.234 to $e_d = 0.0326$, an 86% decrease. Therefore even though family income goes down right after the abolition, enrollment increases, causing n_e^* to increase – the utility cost of rich parents, g_e, drops by 37%, and that of poor parents, g_u, drops by 46%. The increase in attainment causes the premium to decrease even more than it did earlier.

If the economy could jump to the new steady state right away, the increases in average wage and the fraction of workers in the educated category with higher utility compensate for the loss of children's income and increase welfare. The equivalent compensation is 1.2% of the trap consumption, lower than that in the tax and subsidy scheme. However, once the transition, with increased educational investment (in the aggregate) coupled with a loss in family income, is taken into account there is a huge negative effect on welfare; each worker is willing to pay 18% of their consumption to stay at the trap.

In column 3, we study how the outcome changes relative to column 2, when in addition to the abolition of child labor, the government gives subsidies to equate government expenditure to the one in the benchmark tax-and-subsidy scheme. The entire direct cost is subsidized; there are enough tax revenues left over to partly compensate each family for lost children's contributions. With no indirect costs, a complete subsidy of direct costs implies utility cost $g_i = 0$, which in turn implies $a_i^* = 0$ and thus a 100% enrollment for both types. But given the tax rate of 6.9% compared to the 0.6% in column 2, the welfare is even lower.[41] The equivalent compensation for a jump to the new steady state is only 0.67% of consumption; when the transition is included, each household is willing to pay nearly 20% of its consumption at the trap to avoid this policy.

Columns 4 and 5 consider the less severe assumption of a child's contribution to family income of $\varphi \underline{w}$. The aggregate outcomes of column 4 are same as those of 2, and column 5 same as those of 3, except for welfare. Given the assumption that *all* children contribute $\varphi \underline{w}$ to their families, the perceived indirect cost is still zero; the enrollment behavior and attainment are therefore unchanged. However, the steady state welfare is much higher and the loss when the transition is factored in is lower. Transitional welfare is never higher relative to the trap.

Note the high dropout rates when enrollment is driven to 100%. Unless the quality of education as captured by the π_i functions improves, an increase in enrollment, which draws students from the lower end of the ability distribution, will inevitably raise the likelihood of failure.

In summary, the abolition of child labor with or without added education subsidies yields higher enrollment rates and educational attainment than the tax-and-subsidy scheme, but yields lower welfare than the trap once transition is factored in. Even when welfare comparisons are made across steady

[41] Nearly the same tax rate is not able to produce a 100% enrollment in the tax and subsidy scheme presented in Table 1. For enrollment decisions it is the perceived costs of education that matter, and by eliminating indirect costs, child labor abolition is able to achieve higher enrollment rates.

states, this scheme fares worse than the tax and subsidy scheme.

5.4 Compulsory Education

Instead of leaving the enrollment decision to the parent, what if the sSA economies institute and enforce a law that mandates all children should compulsorily attend school and subsidize their direct cost, thereby claiming a 100% enrollment?[42] Note that in this case, n_e evolves mechanically according to:

$$\Phi\left(n_e\right) = n_e \int_0^1 \pi_e(a)\, dF(a) + (1 - n_e) \int_0^1 \pi_u(a)\, dF(a).$$

The optimality conditions that characterize enrollments are now irrelevant. Table 5 presents the outcome in this case.

Column 1 shows the outcome with compulsory education alone, while column 2 does the revenue neutral experiment. The steady state welfare gain in column 1 is substantial, but is still lower than that in Table 3. Once transition is factored in, there is a welfare loss. Since all children, even those whose parents would not have found it profitable to send to school in the absence of the compulsory education law, are forced to go to school and suffer a loss in income of $(1 - \varphi)\, \underline{w}$, aggregate welfare decreases.

Table 5

Compulsory Education

Variable	**Trap**	**1. Compulsory**	**2. Compulsory+sub.**
Fraction of educated workers	0%	46.0%	46.0%
Subsidy level	0.0109	0.0326	0.0741
Tax rate	0%	3.0%	6.9%
Output	0.688	1.07	1.07
Skill premium	4.96	1.09	1.09
Enrollment rate	0%	100%	100%
Dropout rate	0%	54.1%	54.1%
SS welfare (cons. equiv.)	–	16.0%	14.5%
Trans. welfare (cons. equiv.)	–	-3.4%	-4.1%

Since compulsory education leaves the children's contribution at $\varphi\underline{w}$ for all families and direct costs are fully subsidized, the revenue neutral outcome in column 2 is identical to the revenue neutral case where the abolition of child labor is assumed to give all families an income of $\varphi\underline{w}$ from children (Table 4, column 5). In both cases the subsidy is high enough to guarantee 100% enrollment in the steady state. The transitional welfare continues to be lower than that in the trap.

[42] In the absence of evidence on enforcement costs, we assume free enforcement of laws. For arguing that the compulsory education scheme does not perform as well as the tax-and-subsidy scheme, this assumption is conservative.

In conjunction with results from the previous experiment, the above outcome seems to imply that the sSA economies have to be cautious in aiming purely for the maximization of enrollment or attainment. The loss of children's contribution to family income can decrease aggregate welfare. Moreover, unless the quality of education is improved, increases in enrollment draw students from the lower end of the ability pool thereby increasing the rate of failure.[43]

5.5 Improvements in Infrastructure

Can the sSA economies emerge from the trap due to an increase in the total factor productivity, A? As mentioned earlier, Mauritius is credited for opening up its economy to foreign technology to spur development. From the point of view of the trap condition (8), it can be shown that $(\widetilde{w}_e - \widetilde{w}_u)$ is increasing in A, whenever $\widetilde{w}_e > \widetilde{w}_u$, making it less likely that a trap will result. That is, instead of changing the educational costs through subsidies, can the return to education be increased and the incentive to become educated be provided by an improvement in the production function? We look at potential improvements in infrastructure that can increase A as there is more direct evidence on this. If one views A as I^{ζ}, where I is the stock of infrastructure and ζ is an elasticity parameter, one can ask by what factor I will have to increase in order to take the economy to the same steady state that results in the tax-and-subsidy case.

The *World Development Report 1994* surveys the estimates for ζ found in literature as well as addresses the issue of causality.[44] We use $\zeta = 0.4$, which is at the upper end of the range of reported estimates, and close to the one reported by Aschauer (1989). We find that to get close to the benchmark $n_e^* = 0.38$, the value of A has to increase from 2 to 5. Using the above value for ζ then implies that the infrastructure stock has to increase by a factor close to 10.[45]

In the absence of clear evidence connecting infrastructure expenditure and the stock we do not attempt to estimate the tax rate that will be needed to finance this increase and the concomitant effect on welfare. It suffices to note that a massive increase in infrastructure is required to achieve the same effect that can be obtained by altering the *composition* of the workforce (with the same production function) through a relatively painless tax and subsidy scheme.

[43] In contrast to the way we have modeled it, if ability of the child is unknown even to the parents, and enrolling a child in school is the only way to learn this ability, compulsory education might have a value that we are unable to capture. In that case, compulsory education might have a more positive welfare effect than we have credited to it.

[44] See Box 1.1.

[45] The *World Development Report 1994* states that the slope of the infrastructure stock vs per capita GDP is roughly 1. Given that the Mauritian per capita income is about 10 times the median of our sSA sample, its infrastructure capital is 10 times higher, in line with the required increase in I we estimate.

5.6 Sensitivity Analysis

Is our result that the tax and subsidy scheme is superior to other schemes driven purely by the parameters assumed? It is the loss of contribution from low-ability children, with little chance of educational success, that contributes to the poor performance of the compulsory education scheme and the abolition of child labor. We have already addressed the sensitivity to assumed contribution from children by examining incomes of 0 and $\varphi \underline{w}$ in Table 4. While a higher assumed contribution does move this policy toward the tax and subsidy scheme in welfare terms, any further increase in this assumed contribution would call into question the very effectiveness of abolition. Likewise, in the abolition and in the compulsory education scheme, we have conducted revenue neutral experiments relative to the tax and subsidy scheme and find they still do not dominate in terms of welfare.

One other check we perform is altering the human capital production function for the uneducated, π_u, to make it identical to the one for the educated, π_e. We present the welfare figures, in consumption equivalents relative to the initial condition, for this experiment in Table 6.

Table 6

Welfare Comparisons with identical π functions

Variable	**1. Subsidy**	2. **Abolish** (0)	3. **Abolish** ($\varphi \underline{w}$)	4. **Compulsory**
SS welfare (cons. equiv.)	10.5%	-8.1%	4.4%	3.5%
Trans. welfare (cons. equiv.)	4.3%	-17.8%	-4.7%	-5.6%

The relative welfare ranking is unchanged. The subsidy scheme (with $s = .09$ as in column 2, Table 3) does best with the abolition of child labor with zero assumed contribution from children the worst; abolition with some contribution from children and compulsory education lie in between. The absolute welfare figures for the subsidy are lower than those in Table 3, but still substantial; as mentioned earlier, the relative ranking of the schemes is probably more important than the absolute numbers. In results omitted for brevity, we find that the improvement in quality reduces the dropout rate and increases attainment.

We have focused primarily on decreasing e, and later increasing A, to trigger development in these economies. We also verify that altering the parameters suggested by our theoretical conditions (an increase in β and a decrease in σ) would result in similar development, though it is unclear how policy could be used to alter these parameters. As noted earlier, our assumption that a higher wage from education does not materialize until the second period has implications for the value of the indirect cost. We search for the minimum value of φ that will get the economy out of the trap; it is 0.44 as opposed to the baseline value of 0.415. A higher value for φ decreases the opportunity cost of education and makes the trap less likely. For our purposes, whether an economy is exactly at a trap matters less than how well the various policies for development perform. And for a wide range of parameter values the tax and subsidy scheme yields the best welfare.[46]

6 Conclusion

In this paper, we have presented details on the condition of education and the economy of the low performing sub-Saharan African countries. These economies can be characterized by a simple heterogeneous-agent model in which the high cost of education relative to income and the skill premium results in a low steady state with minimal educational attainment. Policy experiments on a calibrated model suggest that a tax and subsidy scheme that redistributes resources at the trap from poor households with lower ability children to those with higher ability children can pry the economy out of the trap, thus freeing it from dependence on foreign aid in order to achieve similar outcomes. This policy is superior, in welfare terms, to the abolition of child labor and the institution and enforcement of compulsory education laws, whether the transition is taken into account or not. Under revenue neutrality, these latter policies are unable to reverse the loss of contributions low ability children would have made to their families had they not been forced to attend school. These simulations question the stated goal of several agencies of achieving universal enrollment. Given the current stage of development of these economies and the quality of their educational systems that are likely to prevail in the near future, polices that guarantee this level of enrollment need not be welfare improving. How increases in enrollment and attainment are achieved seems to matter crucially.

While we have identified the policy that appears to perform best, we have been silent on political economy considerations and difficulties in implementing reforms; these deserve more serious attention. Further work is also warranted in assembling better data in order to refine the calibration process. This is especially needed in order to study improvements in the quality of education, which is subsumed in our probability functions. An improvement in the quality of education (the π function) will alter welfare comparisons by boosting the schemes that result in 100% enrollment. In other words, our policy conclusions should not be viewed as an argument for keeping school enrollment permanently low in sub-Saharan Africa; such an argument would never be made for developed economies. Rather, they highlight the pressing need to improve the quality of education in order to successfully implement ideas such as universal enrollment.

One could model the education sector explicitly and study the quality of teachers as well as indices such as teacher-student ratios to address quality improvements. These are the topics of ongoing research.

[46] For instance, irrespective of the value of φ, abolition of child labor implies an indirect cost of zero, and the relative welfare ordering obtained for the baseline value of $\varphi = 0.415$ continue to obtain.

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