

Discussion Papers
Department of Economics
University of Copenhagen

No. 07-18

Reasonable Expectations and
the First Millennium Development Goal:
How Much Can Aid Achieve?

Carl-Johan Dalgaard
Lennart Erickson

Studivstræde 6, DK-1455 Copenhagen K., Denmark
Tel. +45 35 32 30 82 - Fax +45 35 32 30 00
<http://www.econ.ku.dk>

ISSN: 0902-6452 (print) ISSN: 1601-2461 (online)

Reasonable Expectations and the First Millennium Development Goal: How Much Can Aid Achieve?*

Carl-Johan Dalgaard[†]

Lennart Erickson[‡]

September, 2007

Abstract

While a political consensus has emerged to increase aid flows to Sub-Saharan Africa, empirical studies of the effectiveness of aid in stimulating growth and reducing poverty have yet to yield conclusive results. The present paper takes a different approach. Using the standard neoclassical growth model, we ask how much should be expected from aid *a priori*. Using a range of different parameter values and model specifications, we address three questions. (i) How much growth should aid flows have produced in Sub-Saharan Africa over the last 3 decades? (ii) How much aid would be needed to attain the First Millennium Development Goal (MDG#1) of cutting poverty in half by 2015? (iii) Taking proposed aid flows as given, how much would structural characteristics, such as domestic savings rates and productivity, have to change in order to reach the MDG#1? Our analysis indicates that, even under optimistic assumptions for the effectiveness of aid, past and future expectations for aid in fostering growth and poverty reduction have been too high.

JEL Classification Numbers: F35, O11, O19

Keywords: Foreign Aid, Economic Growth, Millennium Development Goals

* We would like to thank Peter Fallon, Aart Kraay, Miguel Messmacher, Genevieve Verdier, and David Weil, as well as seminar participants at the Christian Michelsen Institute, the 2007 Nordic Development Conference, the IMF institute and the University of Copenhagen for comments and suggestions. The usual disclaimer applies. A previous version of this paper appeared as “Solow Versus Harrod-Domar: Reexamining the Aid Costs of the First Millennium Development Goal,” IMF Working Paper No. WP/06/284, 2006. The views expressed in this paper are those of the authors alone and should not be attributed to the International Monetary Fund, its Executive Board, or its management.

[†] Department of Economics, University of Copenhagen. E-mail address: Carl.Johan.Dalgaard@econ.ku.dk

[‡] IMF Institute, International Monetary Fund. Email address: lerickson@imf.org

I. INTRODUCTION

In September of 2000, world leaders met in New York to adopt a new framework for addressing the urgent needs of people in lesser developed countries. This Millennium Summit adopted eight Millennium Development Goals (MDGs), covering a wide range of issues such as health, education, gender equality, the environment and more. The First Millennium Development Goal (MDG#1) sought to “Eradicate Extreme Hunger and Poverty.” A quantifiable target was set to measure progress toward that goal, namely the reduction by half of the global proportion of people living in extreme poverty in 1990 by the year 2015. The purpose of this paper is to offer a basic theoretical framework with which to analyze progress towards this goal.¹

In some respects, this project is on schedule. Sala-i-Martin (2006) conducts an empirical study of the global income distribution and world poverty, concluding that 69% of the MDG#1 has already been achieved. However, this reduction in poverty has not been evenly distributed geographically, with the lion’s share of progress having been made in China and India. Most notably, Africa has lagged behind. Indeed, poverty rates in Africa increased slightly between 1990 and 2000. While justly celebrating the reduction of extreme poverty in many parts of Asia, few observers would feel that the MDG#1 can be said to have been achieved when an entire continent has been left behind. Therefore in our calculations below, regarding the costs associated with the achievement of MDG#1, our focus will be on Sub-Saharan Africa.

One of the fundamental justifications for development aid to poor countries is the potential it has for reducing poverty. Many analysts have proposed that aid can play a crucial role in fighting poverty, particularly in Africa. Of particular note has been the plan put forth by Sachs et al. (2004) and subsequently adopted by the UN. The plan argues that a “big push” is needed to spur growth and reduce poverty in Africa, with concordant increases in aid flows from developed countries. The relationship between growth and poverty is multi-faceted, but many studies have found a strong relationship between increases in per-capita GDP and the lowering of poverty (e.g., Ravallion, 2001; Dollar and Kraay, 2002 and Besley and Burgess, 2003). Therefore, if a “big push” were to

¹ The other target contemplated in the MDG#1 was to, in the same period, reduce by half the number of people who suffer from hunger. This part of the MDG#1 will not be addressed in the present paper.

jump-start growth through a virtuous cycle of increasing income, investment and productivity, one could envision the achievement of the MDG#1 in Africa.

However, the empirical literature on the effectiveness of aid in raising growth is mixed. Hansen and Tarp (2001) and Dalgaard et al. (2004) find modest, though significantly positive, effects of aid. The recent analysis by Clemens et al. (2004) claim a more substantial effect of aid, whereas Rajan and Subramanian (2005) fail to find a positive effect of aid on growth. Accordingly, since debate persists as to whether aid has a significant effect on growth in the first place (or as to the circumstances under which aid has a positive effect) it should be clear that no consensus exist as for the *magnitude* of its effect. It therefore seems infeasible, at this stage, to assess the aid costs of MDG#1 on the basis of the econometric literature.

Consequently, this paper follows a different tack by adopting a theory-based calibration approach. This is in spirit of “development planning” as practiced by Leontieff (1963), Chenery and Stout (1966) and many others, forming the back-bone of theoretical support for aid flows in many development agencies, most prominently the World Bank (see Easterly, 1999). However, our approach differs from the traditional approaches in a number of key respects. To see these differences clearly, consider Figure 1, which illustrates the principles of the development planning technique.

We begin by assuming the economy in question is proceeding along a balanced growth path, at a constant (possibly very low) growth rate. The trajectory is labelled “old growth path” in Figure 1. A development planner would then either set a new target growth rate directly, or alternatively, a target income level to be reached within a specified amount of time (say T years from now, $y(T)$) thus implying a required target growth rate, given the initial condition ($y(0)$). Next, assume the aggregate production technology is linear in capital input, as in a Harrod-Domar model when capital is believed to be the limiting factor, or in an endogenous growth model of the AK-variety (e.g. Rebelo, 1991). Whatever its justification, this assumption entail that a permanent increase in the investment rate translates into permanently faster growth, i.e. increases the slope of the growth path permanently. As illustrated in Figure 1, the aid requirements would then correspond to the additional investments needed to put the economy on the “new growth path”, which ensures the target income level is reached within the stipulated time frame.

A recent example of the use of this methodology is Deverajan et al. (2002). The authors determine a target GDP per capita level required to reach MDG#1 in 2015, and proceed to calibrate aid requirement for individual countries in the manner described above. The end result is an estimated global “aid requirement” of between \$40-70 billion per year.

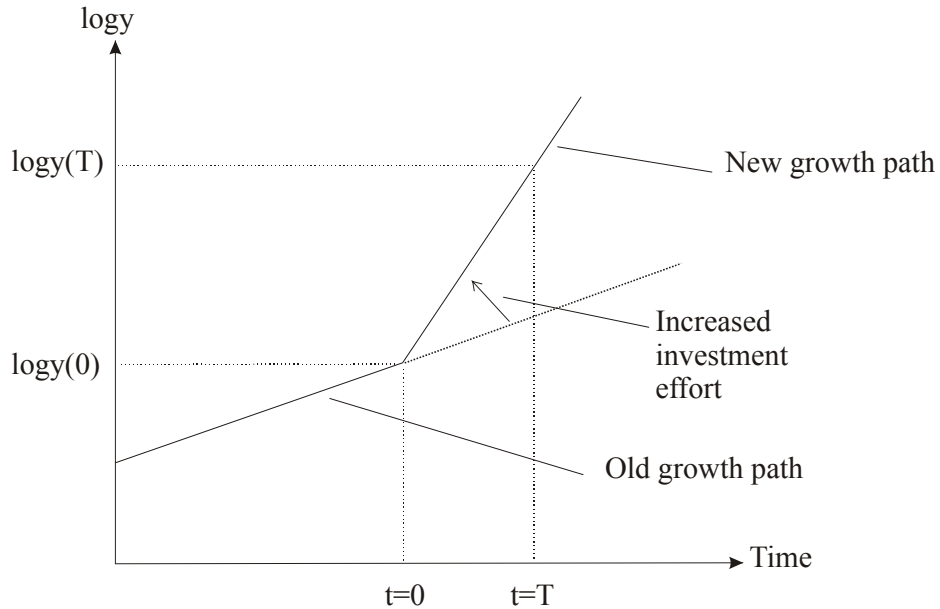


Figure 1: Development Planning

It should be clear that a higher “aid investment rate” only leads to a permanently higher growth rate because the production technology is assumed to be “AK”, i.e. because of the absence of diminishing returns. This assumption was criticized almost immediately after the inception of development planning (see Allais (1963) comments on Leontieffs (1963) calculations). Much later, Jones (1995) launched an empirical attack on the AK theory of endogenous growth, observing that in the OECD economic growth has been very persistent over the last century, whereas investment rates have increased. Performing various time-series tests Jones reject the implied linear association between investment rates and economic growth. More recently, Easterly (1999) extends the critique

using data from the poorest countries of the world.² Easterly performs counterfactuals under the assumptions that aid-financed investments actually went into capital, and capital enabled higher income levels in the manner suggested by the linear technology. He finds that poor countries today are much too poor to be consistent with such a scenario.

Another problematic, and theoretically related, assumption nested in development planning relates to the speed of adjustment from one steady state to the next. In development planning, changes in investment rates and aid flows induce the economy to instantaneously “jump” to a new steady state trajectory without any transitional dynamics, as represented by the “kink” in the figure. In other words, the assumption of past calibrations is that of an *infinite* rate of convergence to steady state. There is by now overwhelming empirical evidence that convergence is gradual (see e.g. Mankiw et al. , 1992; Caselli et al., 1996; Bond et al., 2001, Arellano, 2003).

In light of this criticism, we modify the underlying growth framework. Our approach recognizes that capital is likely subject to diminishing returns. We also take into account that convergence from one steady state to the next is unlikely to be instantaneous. So while we perform an analysis with the same aim as development planning, the underlying theoretical framework is different. Instead of the Harrod-Domar/AK model, we adapt the Solow (1956) model as our organizing framework.

Our baseline calibrations reveal that “aid requirements” are considerably larger than those commonly advertised. For Sub-Saharan Africa alone, the “price-tag” is easily twice the global requirements calculated by Deverajan et al. (2002). However, the analysis also indicates that aid requirements will vary, depending on the structural characterizes of the economy in question. For example, aid requirements will depend on domestic resource mobilization and the underlying productivity trend. As a result, we also perform calibrations with fixed flows of aid and ask how structural characteristics need to change, given those fixed amounts, in order to achieve the MDG#1. These exercises complement the recent debate about whether poor countries are in a “poverty trap” or not (e.g. Sachs et al., 2004; Kraay and Raddatz, 2006). Our analysis has no bearing on whether such traps exist or not. However, it can be informative about how “deep” they

² Strictly speaking Easterly attacks the “two-gap” model, which has the Harrod-Domar framework at its base, rather than endogenous growth models. But since the underlying structure of the two models is the same, one could equally well see it as a criticism of “pure” AK models. That is, an endogenous growth model where the marginal product of capital is constant *at all points in time*.

would have to be in order for the amounts of aid given to be able to reach the target of cutting poverty into half within the next decade. That is, if indeed aid pushes the economy out of, say, a “savings trap”, then how much of an increase in domestic investment effort would *as a minimum* be required, together with aid flows, to reach MDG#1? A similar exercise can be made with respect to a “productivity growth trap”.

The plan for the paper is as follows. Section 2 provides a description of the calibration; derivations are found in the appendix to the paper. Section 3 then uses the Solow model to examine the effectiveness of *past* aid donations, in the context of Sub-Saharan Africa. The Solow framework is shown to predict a rather modest impact from past aid donations. This resonates far better with actual experience on the continent than the dramatic impact suggested by the AK-approach. We then go on to present our baseline calibrations of future aid requirements for Sub-Saharan Africa, using a range of parameter values for key structural characteristics. In Section 4, we conduct calibrations examining under which circumstances changing domestic fundamentals along with aid inflows together may allow for a halving of poverty by 2015. Hence, in this section we allow for changes in structural characteristics like investment rates and the growth trend. Such changes could be motivated on the basis of theories that suggest Africa is stuck in a poverty trap, which could be broken upon a sufficient infusion of aid. Section 5 briefly discusses various extensions of the analysis, including the consequence of introducing endogenous savings. Section 6 offers concluding remarks.

II. BASIC FRAMEWORK

Figure 2 shows how the aid calibration works when a Solow model is used as the underlying theoretical framework. As in development planning, we assume the economy initially is in steady state, labelled “old steady state trajectory”. The underlying rate of productivity growth, g , is kept exogenous and can be varied in the calibration.

We begin by calibrating an increase in income per capita which ensures that the headcount ratio (i.e., the fraction of population living under the 1\$ a day threshold) is reduced by half. The Solow model allows for the study of the evolution of mean income. Hence, the first thing we need to do is to specify an association between the headcount ratio and GDP per capita. Following the empirical literature on the topic of poverty reduction (e.g., Ravallion, 2001; Bourguignon, 2002), we assume

that an increase in GDP per capita of 1 percent leads to a decrease in the headcount rate by π percent. For example, Ravallion (2001) find across a sample of developing countries that $\pi \approx 2$. But estimates of the “poverty elasticity” vary across countries and time, so we will invoke a range of them in the calculations below.³ This procedure provides a target level of GDP per capita, which is to be reached within $T=10$ years, i.e. delivers the distance between $\log y(0)$ and $\log y(T)$ in Figure 2.

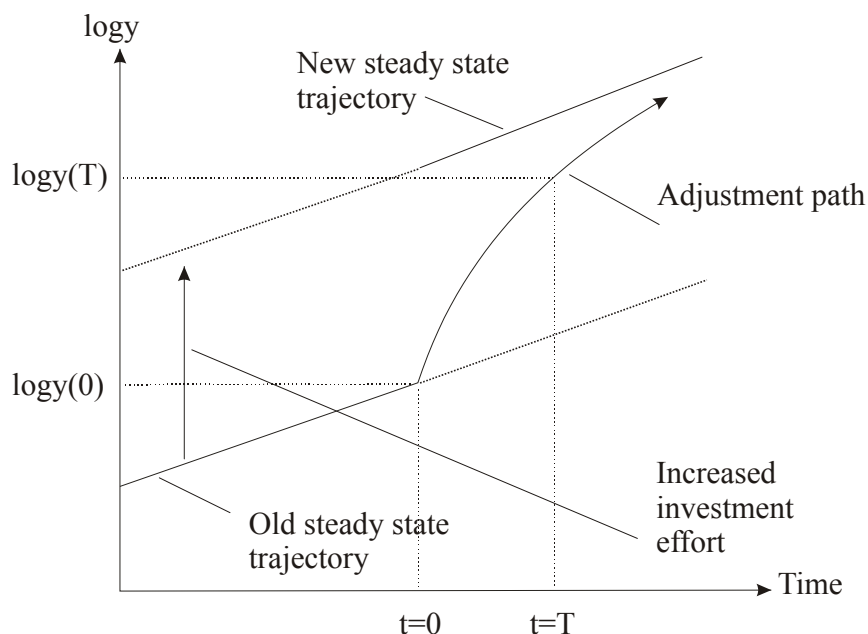


Figure 2. An alternative approach to calibrating aid requirements

In contrast with development planning, we do not assume that the economy instantaneously move from one steady state to the next; convergence is gradual. Consequently, we make use of the theoretically predicted path of GDP per capita *off steady state*, under the Solow model (labelled “adjustment path”). By pinning down parametrically how large a fraction of the distance between

³ As pointed out by Bourguignon (2002), the elasticity will in general depend on the characteristics of the underlying income distribution and the level of GDP per capita. Assuming a lognormal distribution of income, Bourguignon shows that the elasticity is increasing in the standard deviation of log income, and in the ratio between the poverty line and GDP per capita. Hence, whether the elasticity rises or declines in the medium run (the focus of our analysis) would depend on the changes in both the mean and variance of the distribution.

the initial steady state and the future steady state which is traversed each year by the economy (i.e., the rate of convergence), we can work out exactly how big a “push” the economy will need so as to end up at the target level of GDP per capita, within a 10 year window. That is, we can calibrate the required increase in steady state income (labeled “new steady state trajectory” in Figure 2) which ensures the economy reaches the target, $\log_y(T)$, in transition.

Finally, we assume foreign aid comes in the shape of investment. This mirrors the assumption made in development planning exercises. In the Solow framework more investment will increase long run GDP per capita. How big of an increase in steady state labor productivity a given investment hike can produce depends on the extent of diminishing returns, which is parametrically fixed since we employ a Cobb-Douglas production function. As a result, we can back out how much additional aid investment is needed (in percent of GDP) to attain the target level of GDP per capita by $t=T$, and thereby the poverty target (labelled “increased investment effort”).

To begin the calibrations, the assumption made regarding the poverty elasticity is clearly paramount in that it pins down the required increase in GDP per capita. Intuitively, as this elasticity is reduced the required increase in aid financed investments goes up.

Second, the position of the initial steady state matters as well. In a standard Solow model an increase in the investment rate of 1 percent, will induce an increase in steady state GDP per capita by $\frac{\alpha}{1-\alpha}$ percent, where α measures the curvature of the (Cobb-Douglas) production function; given competitive markets α can be associated with capital’s share in national accounts. In the present case, however, total investment comprises both an aid component and a component deriving from domestic resource mobilisation. The two forms of investment are assumed to be perfect substitutes. As a result, in order to produce a required increase in total investment of, say, x percent *by way of foreign aid alone*, it will matter how much the economy in question was investing to begin with. Intuitively, if domestic resource mobilisation were substantial, a larger increase in the aid investment rate is necessary, so as to obtain a required increase in the *total* investment rate (domestic plus aid financed) of x percent.

In the appendix we show how this initial condition can be expressed in terms of parameters (population growth, productivity growth, depreciation) and the (initial) marginal product of capital (MPK). If initial domestic resource mobilisation is “small” the implied initial marginal product will be “large” (due to diminishing returns), and so less additional aid will be required. Conversely, a high initial rate of domestic resource mobilisation implies an initially “large” capital stock and therefore a low marginal product of capital. In this case, a relatively larger increase in aid investments will be needed. Of course, once we pick a marginal product a level of domestic resource mobilization is implied.

Third, the curvature of the Cobb-Douglas production function matters since it stipulates how big of an increase in long-run income a given increase in investment will yield.

Fourth, the assumption made regarding the underlying rate of productivity growth is directly important. After all, if the economy is growing rapidly along its original steady state trajectory it may be that no additional investment effort is needed. In the case of Sub-Saharan Africa, however, there is little evidence to suggest that productivity growth is substantial.

Finally, the rate of convergence greatly influences calibrated aid requirements. Figure 3 illustrates this by depicting two scenarios involving “fast” and “slow” convergence, respectively. As can be seen, if convergence is “slow” (the adjustment path is less steeply sloped), steady state income per capita will need to be raised more for a given income target to be reached in time, compared with the case where convergence is rapid. Importantly, the rate of convergence is not an exogenous constant in the Solow model (see e.g. Mankiw et al. 1992). It is analytically pinned down by the curvature on the production function, as well as productivity growth, population growth and the rate of capital depreciation. Hence, both α (capital’s share) and g (productivity growth), which will be varied in the calibrations below, also have an important indirect effect on aid requirements. Faster productivity growth will induce faster convergence to steady state. Accordingly, faster trend growth will be doubly useful in reaching poverty targets. It reduces the need for outside stimulus, as explained above, and it increases the rate of convergence, implying that less of an increase in steady state income is needed for a given income objective to be reached in time. Likewise, the rate of convergence is lowered if the tendency for diminishing returns is dampened, i.e. if the production function is less sharply curved.

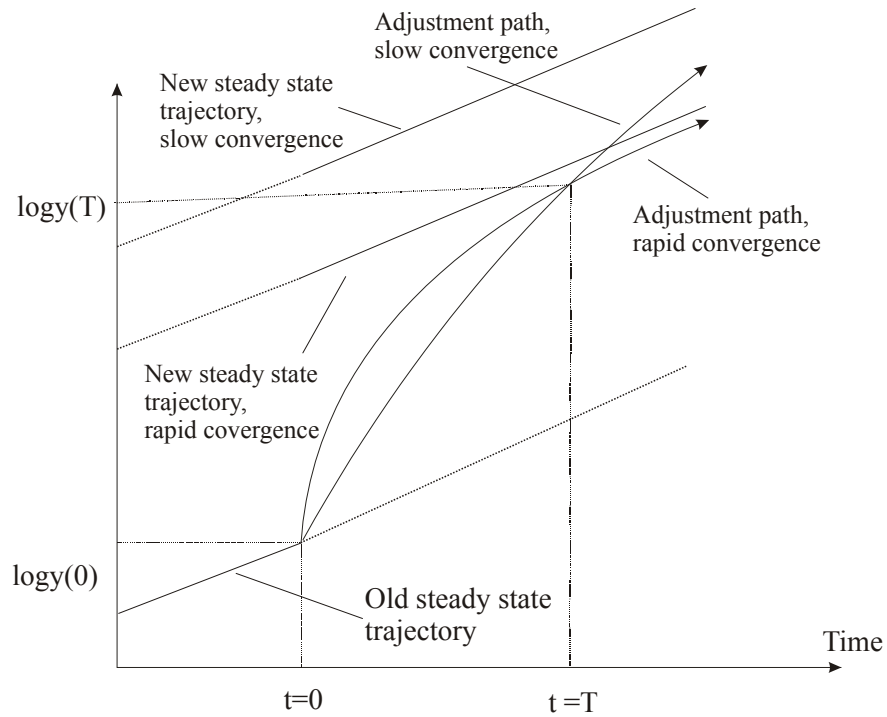


Figure 3. The impact of changes in the rate of convergence on aid requirements.

As a point of reference, the formula for aid requirements derived in the appendix⁴ is:

$$\frac{dF}{Y} = \left[e^{\frac{-\frac{1}{\pi} \log\left(\frac{1}{2}\right) - gT}{1 - e^{-\lambda T}}} - 1 \right] \left[(1 - \alpha) \frac{n + \delta + g}{MPK^* \varpi} \right]. \quad (1)$$

The notation, which we refer to below, is the following: dF/Y is the change in aid (dF) as a fraction of GDP (Y), π is the poverty elasticity, g is the productivity growth rate, T is set to 10 in the calibrations below, λ is the rate of convergence, α is capital's share, n is population growth, δ is the rate of capital depreciation whereas MPK is the marginal product of capital in the initial steady state. The rate of convergence, λ , is formally related to the parameters of the model in the following way: $\lambda = (1 - \alpha)(\delta + n + g)$. Finally, our model allows for parts of the aid flow to potentially be

⁴ See also Dalgaard and Erickson (2006).

“wasted”. This is captured by ϖ . Accordingly, $\varpi=1$ means that all aid flows are turned into investments. If instead $\varpi<1$, then some part of aid does not go towards capital formation; it could be dead-weight loss, it could go towards socially undesirable consumption (e.g., corruption by government officials) or to socially desirable consumption (e.g., disaster relief which doesn’t increase the capital stock).

III. BASELINE CALIBRATIONS

A. Evaluating the impact of past aid flows

Before we start calibrating aid requirements for the future, it seems like a prudent check of the framework to do a little “back casting”. As demonstrated by Easterly (1999), the AK-based approach over predicts actual GDP per capita of aid-recipients to a rather extreme extent. Is the same true for the present Solow - based framework?

To answer this question we focus on the Sub-Saharan region, where growth over the last 3 decades has been dismal, in spite of continuous infusions of aid. Figure 4 illustrates these facts.

The figure comprises 30 Sub-Saharan African countries for the period 1970-2000, and shows the evolution of GDP per capita (constant 2000 US\$) and the aid to GDP ratio. The countries are chosen based on the criterion that data is available for all years.⁵ GDP per capita in any year is defined as the sum of GDP in the 30 countries, divided by the sum of populations. Total aid in any given year is similarly calculated as the inflow to all the 30 countries. In effect, therefore, we treat this group of countries as “one big country”. As seen, the period in question can be described as one of stagnation in living standards; GDP per capita actually fell slightly by roughly 2%.

Simultaneously, aid inflows rose from about 2% of total GDP in 1970 to about 10% in the mid-90s after which it fell to around 5% of GDP as the millennium came to a close – roughly the average for the period.

⁵ The data source is the 2005 edition of World Development Indicators. “Aid” refers to ODA. The 30 countries are: Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Gabon, The Gambia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritania, Niger, Nigeria, Rwanda, Senegal, Seychelles, Sierra Leone, Sudan, Swaziland, Togo, Uganda, Zambia, and Zimbabwe.

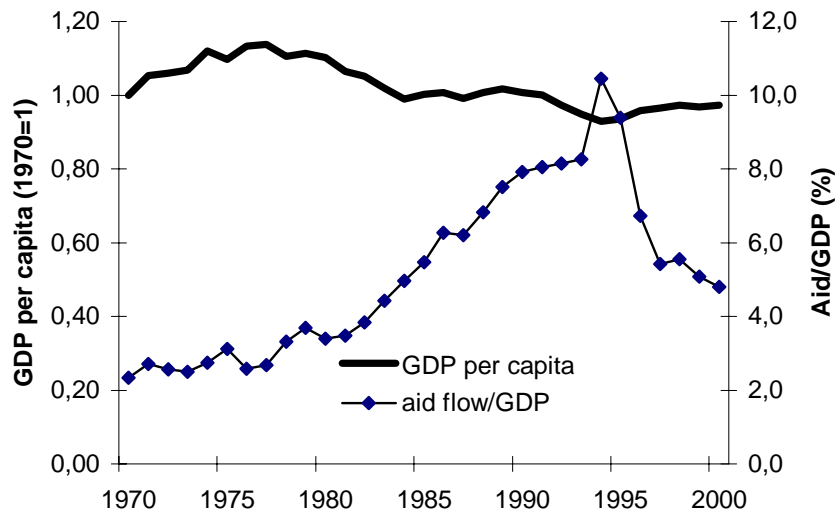


Figure 4. Aid inflows and growth in Sub-Sahara Africa

To assess the growth implications of aid for this “country”, we begin by calculating the impact on steady state GDP per capita from a permanent increase in “aid investments” to 5 percent, starting at 2 percent of GDP. We thereby match the initial “aid investment rate” and the average aid/GDP ratio for the period. Assuming the economy initially is in steady state, we can then project GDP per capita in 2000, using the predicted time path for GDP per capita, under the Solow model. Based on available data for the sample of countries under consideration, we employ a 3 percent rate of population growth (the average for 1970-2000), put $g=0$, $\delta=0.05$ and impose $s=0.12$ (the domestic component of investment). The latter assumption implies, when $\omega=1$, that the GDP share of gross capital formation at the end of the period is 0.17, in accordance with the evidence. Finally, suppose capital’s share is fairly large: $\frac{1}{2}$. These assumptions imply a rate of convergence of 4 percent, which matches the finding of Hoeffler (2002) who fit the augmented Solow model to data pertaining to Africa in isolation.

The “predicted” gain in GDP per worker from observed aid flows over the last 30 years is only slightly more than 7 percent. If we reduce capital’s share to $\frac{1}{3}$, the gain in GDP per capita falls to a mere 4 percent, or, what amounts of an acceleration in average GDP per capita growth of roughly 0.1 percent. Obviously, if parts of the aid inflow is not invested (so that ω is smaller than 1), the predicted gain is further reduced.

It is disturbing that GDP per capita has stagnated in Sub-Saharan Africa. But the above calculations suggest that under the neoclassical growth model this stagnation does not necessarily lead us to believe we are faced by an “aid effectiveness” puzzle. In the end, the amounts of aid given should not have been expected to make a dramatic difference, seen through the lenses of the neoclassical growth model.

We believe these calculations illustrate that the Solow model is a plausible tool for forming priors about the impact from aid in an African context. Looking forward, we can ask how the model can inform us about the effects of future aid. Specifically, what combination of aid flows and parameters values that will enable the MDG #1 to be reached in Sub-Saharan Africa.

B. Calibrating aid requirements for the future

Of the set of necessary parameters to be chosen, the expected population growth rate is probably the easiest to pin down. Throughout, we will use UN’s population growth projections for the period 2005-2015 for Africa. Regardless of which variant we choose (low, medium, high), the population growth rate is about 1% per year on average.

A second key input is the trend growth rate, g . As should be clear from Figure 3, there is little evidence of persistent growth in total factor productivity (TFP) in Sub-Saharan Africa, over the past 30 years (see also Young, 2005). This would suggest that assuming a constant level of TFP would be a reasonable baseline assumption, which we therefore adopt. However, in the next section we will explore the consequences of an increase in the underlying productivity trend.

A third input parameter to be chosen is the *aggregate* marginal product of capital (MPK) in Sub-Saharan Africa. In this regard, we are not faced with an abundance of evidence on which to rely. However, a recent paper by Caselli and Feyrer (2006) calibrate marginal products for a cross section of countries, including 6 Sub-Saharan African countries: Botswana, Burundi, Congo, Cote d’Ivoire, South Africa and Zambia. Without adjustments for natural capital, the MPKs fall in range from 8 % (Burundi) to 24% (Botswana). If part of the compensation for capital in national accounts is assumed to be remuneration for natural resources, Caselli and Feyrer show that the MPKs are reduced to a range from 1% (Burundi) to 14% (Botswana). These estimates presume competitive

markets and price taking behavior on the part of producers. If externalities are important, the private MPK and the social MPK can be different. (As discussed in Section 5, equation (1) remains valid if externalities are present.) In order to detect such effects, direct estimation is necessary. Such an analysis is conducted in Dalgaard and Hansen (2005), where the *average* aggregate marginal products across time and countries is estimated for a group of aid receiving countries, based on an observable (modified) growth accounting equation. According to this analysis, the average marginal product falls in a range from 20 to 30%. Dalgaard and Hansen find no evidence that “aid financed investments” are less productive than those financed by other sources (domestic resource mobilization, FDI). As a result, for the calibrations below we assume MPKs in a range from 10 to 30 %, capturing the findings of these two studies in broad strokes.

The fourth important input variable is capital’s share, which in theory parameterizes the curvature of the aggregate production function. The standard assumption in macroeconomics is to allow α to fall in a 1/3 to 0.4 range. However, in a recent study Kraay and Raddatz (2006) argue that somewhat higher values are appropriate for poor countries; they explore values of α in a .5 to .6 range. The studies by Gollin (2002) and Caselli and Feyrer (2006) detect substantial cross-country variation in capital’s share, though not variation that seems to be systematic to levels of development. Accordingly we will allow α to fall in the range 1/3 to 0.6.

Fifth, for our main calibrations we need to choose a poverty elasticity. A recent paper by Besley and Burgess (2003) is the most appropriate for present purposes, as it estimates π using poverty rates and GDP per capita. They find $\pi = 0.75$, with a standard deviation of 0.25, using data for the entire less developed world. When they confine attention to Sub-Saharan Africa the elasticity falls to 0.49 (0.23). Hence, using the full sample estimate, Besley and Burgess’ study would suggest allowing π to fall in a range from 0.25 to 1.25, which engulfs the point estimate for Sub-Saharan Africa taken in isolation. Larger poverty elasticity’s are found in the literature, but typically when expenditures, rather than GDP per capita, are used as right hand side variable in the regression. Even though this does not correspond exactly to our specification, for completeness we will allow π to go as high as 3, which is the upper limit to the estimate found by Ravallion (2001) on data including both income and expenditures.

Table 1 shows the results of the aid calibrations. In all cells we maintain a set of assumptions, which are reported at the bottom of the table. Notice in particular that we maintain $\varpi=1$ and $MPK=0.2$ in all reported calibrations. The reason is simply that an interested reader quickly can assess the consequences of changing these assumptions, as evident from equation (1). Both parameters enter the denominator of the expression, which means that simple multiplication of the reported aid requirements in the table is sufficient to get new results. For example, if $\varpi=0.5$ were to be considered more appropriate, all numbers in the dF/Y column should be multiplied by 2. Likewise, if $MPK=0.3$ is thought to be more relevant, all aid requirements should be multiplied by $2/3$.

>Table 1<

In the first 18 rows the rate of convergence is endogenous. Accordingly if capital's share is changed, the rate of convergence also responds. The implied rates of convergence are broadly consistent with Hoeffler (2002) estimates for Africa. Nevertheless, in the last 6 rows we decouple this link to see the effects of varying assumptions about λ .

Turning to the results, it is clear that aid requirements are rather steep, especially if we use the poverty elasticity estimated by Besley and Burgess (0.75). If the poverty elasticity rises to its perceived upper limit, aid requirements are dramatically lowered, though remain large. For example, with a poverty elasticity of 2, dF/Y falls in a 37-49% range depending on the assumption about capital's share. This amounts to a required increase in aid inflows to what Sachs et al. (2004) label "Tropical Sub-Saharan Africa" of between 76 and 100 billion US\$ in the first year; total flows will subsequently have to increase over time so as to keep pace with GDP and maintain a constant aid to GDP ratio.⁶

Comparing the results for varying assumptions about α , it might at first seem odd that as capital's share is increased, aid requirements *increase*. The explanation is, however, simple. A larger capital's share will, on the one hand, imply less diminishing return to capital, which tends to make additional investment more able to expand long run income. On the other hand, however, less diminishing returns lowers the rate of convergence, which implies that the economy need a bigger

⁶ This range for aid requirements is based on pooled GDP data for 2002. Specifically, the countries included are: Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Eritrea, Ethiopia, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Togo, Uganda, Zambia, and Zimbabwe.

“push” to reach a given income target within 10 years time. Accordingly, with slower convergence more aid is needed for the fulfillment of MDG#1. As it turns out, the latter effect dominates, which explains why assuming a larger share of capital does not bring down the calibrated costs of halving poverty.

The last 6 columns show the “pure” influence from the rate of convergence on the aid costs of MDG#1, in a setting where capital’s share is favorably chosen (from the perspective of aid effectiveness). The rate of convergence is an important variable, in that fast convergence at 10% lowers aid requirements considerably. The last row provides an example where λ is very large, mimicking one aspect of traditional development planning; immediate convergence.⁷ This assumption would, in its own right, lower aid requirements significantly. This shows the importance of taking convergence into account when calibrations such as these is performed, and illustrates how the traditional assumption of infinitely fast adjustment have lead researchers and practitioners to overestimate the impact of aid on growth.

The calibrations are useful in highlighting which structural characteristics are important for aid effectiveness in the context of poverty reduction. For example, our calculations are not very sensitive to assumptions about the extent of diminishing returns (α). Instead, the poverty elasticity is a key input. Accordingly, getting an accurate estimate for this parameter is of practical importance when forming reasonable priors about the impact from aid on poverty reduction in a specific context.

The conclusion from these exercises is that aid inflows of realistic magnitudes are unlikely to ensure a halving of poverty in Sub-Saharan Africa, over the course of 10 years. As explained in the next section, currently contemplated aid flows to Tropical Sub-Saharan Africa amounts to an increase of about 12% of GDP, or 25 billion US\$, well short of the 20-23% requirement calibrated above as a “best-case” scenario involving a poverty elasticity as high as 3.

To get a sense of the difference between these two numbers, in terms of poverty reduction, we can calibrate the poverty reduction a 12% increase in the aid to GDP ratio might “buy”. In order to do

⁷ When $\lambda=0.5$, the term $[1-e^{-\lambda T}]$ in equation (1) is 0.99; associating this case with an “infinite rate of convergence” (where the term is 1 exactly) is therefore fairly reasonable.

so, we begin by simulating the expected increase in GDP per capita, from 2005 to 2015, using the approach from Section 3A. In 2002 Tropical Sub-Saharan Africa received about 18 billion \$ in aid, which amounts to roughly 9% of total GDP. Accordingly, suppose the aid component of invest increases from 9% to 21%, the domestic component is put at 0.1, $n=0.01$, $g=0$, $\alpha=0.5$, $\omega=1$ and $\delta=0.05$ (the implied initial MPK is 20%). Under this set of assumptions we find an increase in GDP per worker, within the 10 year window, of roughly 14 percent. Accordingly, given a very high poverty elasticity of 3, the reduction in poverty is 32%, rather than the 50% target. However, if the poverty elasticity is 0.75, the 12% increase in the aid/GDP ratio will only be associated with a 9% reduction in the headcount ratio, *ceteris paribus*.

IV. DOMESTIC ADDITIONAL EFFORT, POVERTY TRAPS AND “TAKE OFF”

In the calibrations above we assume that nothing changes in the aid receiving nations when aid flows into the country. That is, domestic savings, productivity growth, etc., remained unaffected by the outside stimulus. However, there are circumstances under which one, in theory, would expect aid inflows to induce change in key structural characteristics.

Increased aid donations could be associated with some form of conditionality. As an example, one could imagine donors requesting reforms, aimed at stimulating private investment efforts; these could perhaps involve institutional reform aimed at providing more secure property rights, a crack-down on corruption and so on. Increased domestic investment effort would naturally reduce the aid requirements for the attainment of MDG#1. Conversely, the amount of additional domestic effort needed (on top of managing aid inflows of course), would be a function of how much foreign assistance will be forthcoming. Hence we can do a simple calibration to assess this scenario, as illustrated in Figure 5.

The basic idea is to infuse a fixed aid-investment rate into the economy. This means that we need priors about how much aid is likely to be forthcoming in the future, and we return to this issue below. For now, simply think about aid flows as exogenously given. Moreover, suppose this aid inflow is insufficient so as to ensure the economy reaches the target at time T, as illustrated in Figure 5. Then we can back out the needed increase in *domestic* investments which, together with aid, would allow the economy to reach $y(T)$. Technically, this increase can be computed, using

equation (1), as the discrepancy between the fixed aid inflow and the required increase in investment effort, as given by the expression on the right hand of equation (1).

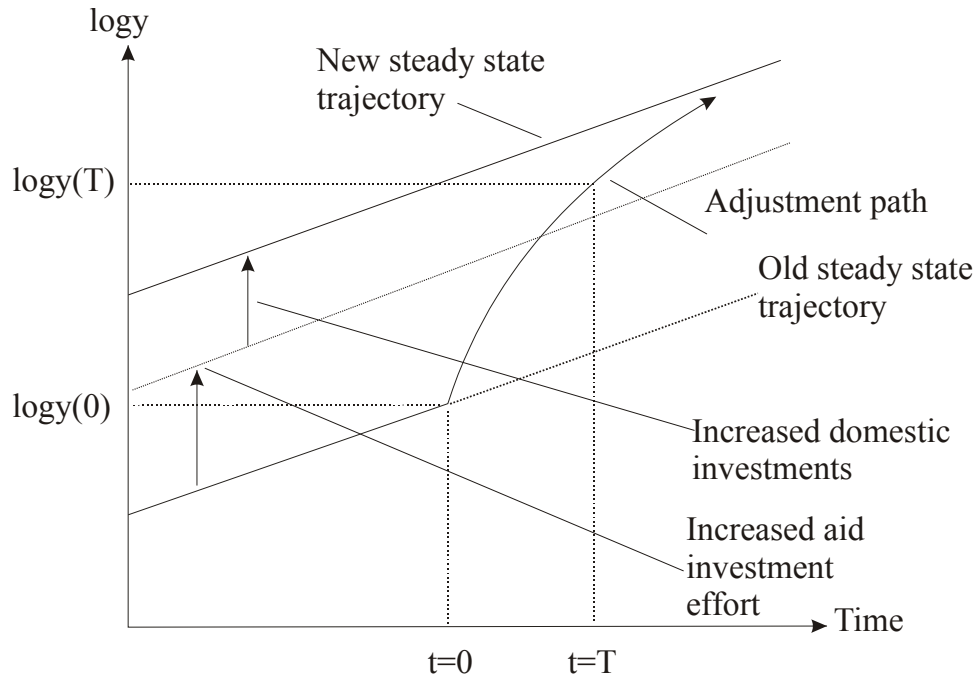


Figure 5. Division of labor: aid and domestic additional investment effort as partners in achieving MDG#1

Observe that this calibrated increase will be a *minimum* requirement. The reason is that the calibration assumes that the domestic investment rate *immediately* rises to its new level. If reforms are gradual and only take effect over time, the required increase in the domestic investment rate would be greater for MDG#1 to be achieved within a fixed number of years.

Aside from policy reform, there could be another cause for a sudden change in domestic investment effort. The most frequently cited reason is the existence of poverty traps. A plausible example would be the “savings-trap”. The idea is that, due to the presence of subsistence consumption, poor people save nothing, or next to nothing. As this implies a stagnating capital stock (at best) and therefore stagnating standards of living, the initial situation of low income and savings is perpetuated. This vicious circle can be broken, however, if income rises sufficiently (even if temporary). A higher level of income, perhaps attained through foreign aid, leads to savings, capital accumulation and rising income: the beginning of a virtuous circle. This idea has recently been advanced as a key element in explaining Africa’s dismal growth performance over the last half

century and as a reason why aid inflows could have a large impact on prosperity (Sachs et al., 2004). This diagnosis, however, has also been questioned (see Easterly, 2005; Kraay and Raddatz, 2006).

While our approach has no bearing on whether poverty traps exist or not, the present framework can address a related question. Supposing that Africa *is* in a poverty trap, how “deep” must that trap be in order for a given increase in aid inflows to be sufficient to cut poverty in half on the continent?

From the perspective of the calibration discussed above, there is fundamentally *no* difference between an assumed increase in s due to policy reform, and an assumed increase in s because a country exits a poverty trap.⁸ Hence, another way of interpreting the calibration depicted in Figure 5 is that the additional domestic investment effort appears as the result of an escape from the poverty trap. The calibration therefore tells us how big of an increase would be necessary for aid, along with an escape-of-the-trap induced investment spurt, to allow the MDG#1 to be reached. Again, note that the calibrated “jump” in investments is an immediate one. So the experiments amount to asking the following question. Suppose aid is given and the economy immediately shifts into a high savings regime; how much of an increase in domestic savings and investments would be needed for the economy to achieve MDG#1, for given aid flows?

To do these calibrations we need to specify an inflow of aid. This choice is unavoidably somewhat arbitrary. Given that many different levels of aid have been proposed, we will rely on aid flows called for by the most prominent plan for development of Africa, namely that of Sachs and associates, mentioned above. That is, we increase aid by \$25 billion in Tropical Sub-Saharan Africa. Sachs et al. (2004) argue forcefully that Sub-Sahara Africa is in a savings poverty trap, and that this infusion of aid should allow the region to reach (among other goals) the MDG#1. Accordingly, our exercise can be viewed as delivering the required size of the poverty trap, so as to make this argument internally consistent under the assumptions of the basic neoclassical growth model.

⁸ In practice, of course, there is a major difference: In the former case some actual effort on the part of the government is required in the sense of reforms, in the latter case the investment increase will appear by itself.

It should be emphasized that under the plan laid out in Sachs et al (2004) this \$25 billion would not be used exclusively for direct capital accumulation. The plan contemplates myriad expenditures on education, health, etc., which we do not take into account here. Therefore, in using the \$25 billion figure in this exercise we are effectively modeling an upper bar for the direct effect of the “Sachs plan” in capital accumulation. It is conceivable that some of the alternative uses of the \$25 billion could have important indirect effects on capital accumulation. Accordingly, the calibrated increase in the domestic investment rate may be interpreted as resulting from these indirect effects, from exiting the poverty trap, or a combination of the two.⁹

We use data for 32 countries situated in what Sachs et al. (2004) refer to as Tropical Sub-Saharan Africa; this set excludes South Africa. Following the same procedure as in Section 3A, we pool all countries with respect to GDP and aid flows. Upon doing so we find that these countries received aid in what amounts to about 9 percent of total GDP in 2002. This corresponds to total aid flows of \$18 billion. Accordingly, we assume this number is raised to \$43 billion and is increased thereafter to maintain a constant ratio of aid to GDP of roughly 21%.

Finally, we need to choose parameters from the ranges discussed in Section 3B. Accordingly, we set the marginal product at the highest value we consider (30%) and capital’s share to the lowest value in its range, 1/3. Thus, we are choosing values for these parameters which would generate the greatest reduction in poverty in response to aid flows, *ceteris paribus*. The other variables are set at the level assumed in Section 3, as summarized at the bottom of Table 2. The implied initial domestic savings rate and the implicit rate of convergence are also reported.

> Table 2<

Unsurprisingly, in light of our calibrations from Section 3, we generally find that the required increase in domestic savings/investment intensity is large. Staying within the range of poverty elasticity’s consistent with Besley and Burgess (2003) estimate, the smallest (minimum) increase in domestic investment effort is around 46%.¹⁰ But if the poverty elasticity is considerably larger, reaching the upper limit of Ravallion’s (2001) findings, the required increase shrinks to 2 %. It is

⁹ Alternatively one could view expenditures on health and schooling as accumulation of another capital good, human capital. In Section 5 we discuss how our calibrations are affected if multiple capital goods are introduced.

¹⁰ The calibrations are unrestricted, as can be seen from row 1 of the table; it goes without saying that an increase in s of anything close to (or in excess of) 100% is meaningless for practical purposes.

important to recall, however, that we assume aid flows are turned into savings/investment on a 1:1 basis. Hence the last case would require a *total* increase in the savings/investment rate of 14% (aid flows plus additional domestic effort).

How big of an increase in savings is *a priori* plausible? Rodrik (2000) examines the contours of what he labels “saving transitions”. That is, periods during which the savings rate of an economy rises to a sustained higher level. Rodrik define a saving transition as a scenario where (a three year moving average of) the savings rate increases by at least 5 percentage points over a 10 year period. Using this filter, Rodrik detects 20 such transitions (when excluding natural resource abundant economies from the sample), for the 1965-87 period. In this sample of countries, the median savings rate increases from 14 to 23 percent within a 5 year period, and further to 25% within a 10 year window. The most spectacular case, however, would be that of Lesotho in the 1970s, with an increase from 9 to 22 percent. Hence, there are no cases of savings transitions involving increases of more than 12-13 percentage points and taking place over relatively short periods of time during the second half of the 20th century.

As a result, we are inclined to believe that increases in domestic savings, of the magnitudes reported in Table 2, are unlikely to occur, poverty traps or not, since it would require a savings transition in the entire Sub-Saharan African region of historically unseen proportions.¹¹

However, one can imagine further changes to occur, in domestic structural characteristics, following an infusion of aid. A more dramatic poverty traps story could involve the trend growth rate itself (g). That is, perhaps Sub-Saharan Africa is caught in a zero productivity growth trap, but upon a sufficient infusion of aid, productivity growth is ignited. One can imagine many possible channels by which this could occur: strengthening governance and the rule of law, greater technology transfer from developed countries or improvements in health or education.¹² Returning to the example of Sachs et al. (2004), many of the policies advocated are explicitly or implicitly

¹¹ Rodrik (2000) finds evidence that aid inflows stimulate savings. According to his estimates roughly half the inflows are turned into savings. This could be taken to suggest that $\varpi=0.5$ would be roughly appropriate, rather than $\varpi=1$ as we assume in Tables 1 and 2.

¹² Here, we would only be considering improvements in health or education which would operate through increases in productivity. Alternatively, such improvements could be modeled as improving the stock of health or human capital. These will be discussed in Section 5.

justified by appealing to their possible effects of productivity. As with savings-based poverty traps, Kraay and Raddatz (2006) find scant evidence for the existence of productivity-based poverty traps in Africa. Once again, whether or not such traps exist is well beyond the methodological scope of the present paper. However, we can examine the impact of a productivity take-off on the required savings hike, and thus the prospect of reaching MDG#1.

Accordingly, we maintain the 12% of GDP increase in aid flows to Sub-Saharan Africa suggested in Sachs et. al. (2004). We then allow for productivity take-off's of varying magnitude and calculate how these varying assumptions influences the required (immediate) increase in domestic investment effort. Accordingly, the present calculation can be seen as either a scenario where aid increases both the growth trend and the savings rate as a result of an emergence from a "generalized" poverty trap, or as the result of some deliberate policy choices in recipient countries.

> Table 3<

Results are reported in Table 3. As in Tables 1 and 2, we allow the poverty elasticity to vary. If π is about .75, one would need very large growth accelerations. As seen, increasing the underlying growth trend by 2% points is not sufficient for the simultaneously-required investment hike to fall to a reasonable size. That is, saving transitions of a magnitude which has been observed in poor countries during the last half of the 20th century. However, if π is 2 a growth acceleration of about 1.0%, combined with a total investment increase of about 12 percentage points would be enough to ensure MDG#1, under the model. This, at least, would correspond to a savings/investment boom of magnitudes observed in recent history.

It is of course an open question whether the growth trend can be lifted in Sub-Saharan Africa as a result of aid inflows. The above calculations show that such acceleration would be critically important for the attainment of the stipulated goal of halving poverty in Sub-Saharan Africa within the next decade. If the trend does not move, the required saving transition becomes implausible for the contemplated increases in aid inflows. Moreover, reaching MDG#1 in Sub-Saharan Africa also critically depends on a strong relationship between growth and poverty reduction. A poverty-elasticity around 2 is required.

V. EXTENSIONS

In the preceding sections, we limited our analysis to the simpler versions of the Solow-model. What would be the effect of enriching this basic model to incorporate other effects? For example, suppose that there exist productivity externalities; greater investment leads to increases in productivity. Alternatively, the model could be extended to include multiple capital goods, such as physical and human capital, or public and private capital. However, modifying the basic model to include either of these features is essentially the same as increasing the capital share, α , in the basic Solow model, with corresponding increases in the marginal product of capital. Such changes are, however, unlikely to lead to substantially different results than those reported in Section 3 and 4. As demonstrated in Section 3, the results are not very sensitive to the assumed share of capital, which we had varying from 1/3 to 0.6.

Another possibility would be to offer a fuller, micro-founded account for savings behaviour: how would the effect of aid change if savings were determined endogenously? To consider this question, we first turn to the *Ramsey-Cass-Koopmans* (RCK) model, in which a social planner or representative agent chooses an optimal consumption and savings path over time. It can be shown that allowing for endogenous savings in this form has dire implications for the effect of aid flows. If the rate of savings is already set to its optimal level, then new infusions of aid will simply be consumed and, hence, there will be no effect on growth or long-run poverty reduction. Alternatively, one could model endogenous savings using an Overlapping Generations Model (OLG) of the type pioneered by Diamond (1965). In this model, capital accumulation arises from the younger generation saving for retirement. If aid enters directly as extra capital, then the effect of aid on growth would be essentially the same as in the simple Solow model. However, if aid enters into the budget constraint the young, then some of the aid will be consumed and not saved; this would be equivalent to having a greater level of “waste” in the Solow model.

The bottom line is that the inclusion of externalities, multiple capital goods or endogenous savings in the model does not make aid more effective at stimulating growth and reducing poverty. Indeed, in some cases the inclusion of these features actually diminishes the effectiveness of aid.¹³

¹³ For a rigorous analytical treatment of these extensions, see Dalgaard and Erickson (2006).

VI. CONCLUDING REMARKS

This paper has proposed a simple framework for examining the link between aid, growth and poverty reduction. The calibration approach is based on a Solow model. Using this framework to “back-cast” the effect of past aid flows to Sub-Saharan Africa fits the historically observed growth outcomes better than the alternative approach, which draws on the Harrod-Domar growth model.

Under a range of reasonable parameters, the aid costs of ensuring the achievement of MDG#1 by 2015 are very high. Even after augmenting the Solow model to consider savings-based poverty traps and productivity accelerations, we still find the prospect for achieving a reduction of poverty following the proscribed deadline and aid donations difficult. To reach the target income it is necessary for trend growth to rise substantially combined with a large increase in domestic investment effort. Even this scenario requires that all aid is invested without “waste” and that the marginal product of capital is high. We demonstrate that these results are robust to different micro-foundational assumptions and to the inclusion of externalities and multiple capital goods.

These results are not encouraging. The burden of poverty in Africa and other low-income countries is immense and our findings that aid may not be as effective in reducing that burden as other analyses have suggested is no cause for celebration. However, it would be a mistake to interpret our results as showing that aid is simply ineffective. Rather, our analysis suggests that aid does have the potential to have positive impacts on both growth and poverty. While these impacts may be modest in absolute terms, for very poor people small improvements in their material conditions may have much larger impacts on welfare. Moreover, the present paper by design does not consider potential effects of aid which do not lead to higher levels of growth but which nonetheless might have substantial welfare-improving outcomes. As an illustration, even if it were the case that eliminating malaria in a country had no effect on growth or poverty, surely an aid project which accomplished such a feat should not be judged a failure.

The analysis offers, we believe, an improved framework for the debate on the effectiveness of aid and the prospects for achieving the MDG#1. By examining the combinations of models and parameter values which generate different levels of poverty reduction, we can illustrate the background assumptions implicit in varying claims for the effectiveness of aid. We believe that

making those assumptions explicit, and therefore subject to evaluation, is important in its own right. In terms of direct policy implications, our methodology offers no definitive prescriptions, but does point towards some possible avenues for further investigation. Given reasonable parameters across a range of models, the direct effect of aid on capital accumulation to growth, with then growth leading to poverty reduction, does not by itself seem sufficient to reach the MDG#1 in Sub-Saharan Africa. A more promising avenue would be if aid were to enhance productivity growth, though whether such an effect could be achieved is open to doubt. Our results show a great sensitivity to varying the elasticity of poverty reduction to growth. Thus, perhaps further attention should be paid to focusing aid on projects which directly reduce poverty, either through targeting aid flows towards poor individuals or towards decreasing inequality.

Possible extensions of this paper would include a richer modeling of the key relationship between inequality, growth and poverty reduction. Besley and Burgess (2003) find large effects of inequality in reducing poverty. If aid could have a effect on inequality (or if inequality falls as a country develops), the scope for poverty reduction could be strengthened. Thus, a potential extension to our approach would be to consider the effect of aid not just on mean income but also on the dispersion of income, following e.g. Stiglitz (1969).

Finally, it bears some thought to revisit the empirical studies of aid discussed above in light of the paper's findings. Our results indicate that the potential overall effect of aid on growth likely is modest. In terms of how aid is apportioned by donors, there is a clear and understandable tendency to allocate aid to countries which are most in need of it: poor, slow growing, countries. Of course, the empirical studies try to address this selection-bias in aid disbursements, but there are no easy solutions to the identification problem. Thus, under the assumption that this selection bias can not be completely controlled for and that the actual effect of aid on growth is relatively small, empirical estimations that aid has no effect on growth should come as no surprise. Indeed, they would be consistent with a positive, yet modest, effect of aid on growth.

References

- Allais, M., 1963. Comment on Leontief. In "The Econometric Approach to Development Planning". North Holland, Amsterdam.
- Arellano, M., 2003. Modelling Optimal Instrumental Variables for Dynamic Panel Data models. CEMFI working paper 0310.
- Besley T. and R. Burgess, 2003. Halving Global Poverty. *Journal of Economic Perspectives*, 17, 3-22.
- Bond, S., A. Hoeffler and J. Temple, 2001. GMM estimation of Empirical Growth models. Working paper (University of Bristol)
- Bourguignon, F., 2002. The growth elasticity of poverty reduction : explaining heterogeneity across countries and time periods. Working paper (DELTA)
- Caselli F, G. Esquivel and F. Lefort, 1996. Reopening the Convergence Debate: A new look at cross-country growth empirics. *Journal of Economic Growth*, 1, 363 - 389
- Caselli, F. and J. Feyrer, 2006. The Marginal Product of Capital. *Quarterly Journal of Economics* (Forthcoming)
- Chenery H.B and A. M. Stout, 1966. Foreign Assistance and Economic Development. *American Economic Review*, 56, 679-733.
- Clemens, M., Radelet, S. and Bhavnanni, R. 2004 Counting Chickens When They Hatch: The Short Term Effect of Aid on Growth. Working Paper No. 44, Centre for Global Development.
- Dalgaard, C-J., H. Hansen and F. Tarp, 2004. On the Empirics of Foreign Aid and Growth. *Economic Journal*, 114, F191-F216
- Dalgaard C-J. and H. Hansen, 2005. The Return to Foreign Aid. Working Paper (University of Copenhagen)
- Dalgaard, C-J. and L. Erickson, 2006. Solow vs. Harrod-Domar: Re-examining the Aid Costs of the First Millennium Development Goal. *IMF Working Paper No. WP/06/284*.
- Deverajan S., M.J. Miller and E.V. Swanson, 2002. Goals for Development: History, Prospects and Costs. Working paper (World Bank)
- Diamond, P. (1965). 'National debt in a neoclassical growth model', *American Economic Review*, 55, 1126-50.
- Dollar, D. and Kraay, A., 2002. Growth Is Good for the Poor. *Journal of Economic Growth*, 6, 95-225
- Easterly, William. 1999. "The Ghost of Financing Gap: Testing the Growth Model Used in the International Financial Institutions." *Journal of Development Economics* 60, 23-38.
- Easterly, W., 2005. Reliving the 50s: The Big Push, Poverty Traps and Takeoffs in Economic Development. Working Paper (New York University)

- Gollin, D., 2002. Getting Income Shares Right. *Journal of Political Economy*. 110, 458-74
- Hansen, H. and Tarp, F., 2001, Aid and Growth Regressions, *Journal of Development Economics*, 64: 547-70.
- Hoeffler, A., 2002. The Augmented Solow Model and the African Growth Debate. *Oxford Bulletin of Economics & Statistics* 64, 135-158.
- Jones, C., 1995. Time series test of endogenous growth models. *Quarterly Journal of Economics*, 110, 495-525
- Kraay, A. and C. Raddatz, 2006. Poverty Traps, Aid and Growth. *Journal of Development Economics* (Forthcoming)
- Leontieff, W., 1963. The Rates of Long-Run Economic Growth and Capital Transfer from Developed to Underdeveloped Areas. In "The Econometric Approach to Development Planning". North Holland, Amsterdam
- Mankiw G., D. Romer and D. Weil, 1992. A Contribution to the Empirics of Economic Growth. *Quarterly Journal of Economics*, 107, 407-37.
- Ravallion, M, 2001. Growth, Inequality and Poverty: Looking Beyond Averages. *World Development*, 29, 1803-1815.
- Rajan R. and A. Subramanian, 2005. Aid and Growth: What Does the Cross-Country Evidence Really Show?, *IMF Working Paper* WP/ 05/127
- Rebelo, 1991. Long-run Policy Analysis and Long-Run Growth. *Journal of Political Economy*, 99, 500-21.
- Rodrik, D., 1994. Getting Interventions Right: How South Korea and Taiwan Grew Rich. *NBER Working Paper No. 4964*.
- Rodrik, D., 2000. Saving Transitions. *World Bank Economic Review*, 14, 481-507.
- Rodrik, D. and Subramanian, A., 2004. From "Hindu Growth" to Productivity Surge: The Mystery of the Indian Growth Transition. *IMF Working Paper* WP/04/77
- Sachs, J., J. W. McArthur, G. Schmidt-Taub, M. Kruk, C. Bahadur, M. Faye and G. McCord, 2004. Ending Africa's Poverty Trap. *Brooking Papers on Economic Activity*, 2004 (1).
- Sala-i-Martin, X., 2006. The World Distribution of Income: Falling Poverty and ... Convergence, Period. *Quarterly Journal of Economics*.(Forthcoming)
- Solow, R., 1956. A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics*, 70, p. 65-94
- Stiglitz, J., 1969. Distribution of Income and Wealth Among Individuals. *Econometrica*, 37, 382-97
- Yeh, C. K., China's Economic Growth: Recent Trends and Prospects. In Shuxun Chen, S. and Wolf, C., 2005. *China, the United States, and the Global Economy*, Rand.
- Young, A., 2005. The Gift of the Dying: The Tragedy of AIDS and the Welfare of Future African Generations. *Quarterly Journal of Economics* 120: 243-266.

TABLES:

Table 1: Aid Requirements for MDG#1

Poverty elasticity (π)	Capital share (α)	dF/Y (% GDP)	Domestic inv.rate	λ
0.75	0.6	901	0.18	0.024
1	0.6	297		
1.25	0.6	149		
1.5	0.6	93		
2	0.6	49		
3	0.6	23		
0.75	0.4	365	0.12	0.036
1	0.4	160		
1.25	0.4	95		
1.5	0.4	65		
2	0.4	39		
3	0.4	21		
0.75	0.33	310	0.10	0.04
1	0.33	144		
1.25	0.33	88		
1.5	0.33	61		
2	0.33	37		
3	0.33	20		
1.25	0.6	244	0.18	0.02
1.25	0.6	53		0.04
1.25	0.6	29		0.06
1.25	0.6	21		0.08
1.25	0.6	17		0.1
1.25	0.6	9		0.5

Assumptions: $g=0, n=0.01, \delta = 0.05, \varpi=1, MPK=0.2, T=10$

Table 2: Required increase in the domestic investment rate

Poverty elasticity (π)	Change in dom. Inv. Rate (% GDP)
0.75	195
1	84
1.25	46
1.5	29
2	13
3	2

Assumptions: $g=0$, $n=0.01$, $dF/Y=0.12$, $\varpi=1$, $\alpha=1/3$,
 MPK =0.3, T=10.
 Implicit initial $s=0.07$,
 implicit rate of convergence= 0.04.

Table 3: Take-off, Savings Poverty Trap and MDG#1

Poverty elasticity (π)	Growth take-off (%)	Change in dom. Inv. Rate (% GDP)
0.75	0	195
0.75	0.5	135
0.75	0.75	114
0.75	1	96
0.75	1.5	70
0.75	2	52
1	0	84
1	0.5	58
1	0.75	48
1	1	40
1	1.5	28
1	2	19
2	0	13
2	0.5	6
2	0.75	3
2	1	*
2	1.5	*
2	2	*

Assumptions: $n=0.01$, $dF/Y=0.12$, $\varpi=1$, $\alpha=1/3$,
 MPK = 0.3, T=10, $s=0.07$. * Indicates that
 MDG#1 would be achieved without any change in S

APPENDIX: DERIVING EQUATION (1). We begin by assuming a simple link between the head count poverty rate (p), and income per capita (y)

$$p \propto y^{-\pi}, \quad (1)$$

where π is a parameter which specifies how much poverty declines. This equation gives a target increase in income per capita, to be attained within T periods (or years):

$$\frac{y(T)}{y(0)} = \left(\frac{1}{2}\right)^{-1/\pi}. \quad (2)$$

Assume next, that the economy in question is in a vicinity of its future steady state, and it utilizes an aggregate production function of the Cobb-Douglas variety. Under these circumstances, it is well known (see e.g. Mankiw et al., 1992) that the evolution of GDP per *efficiency* units of labor, \tilde{y} , follows:

$$\log \tilde{y}(T) = (1 - e^{-\lambda T}) \log \tilde{y}^* + e^{-\lambda T} \log \tilde{y}(0), \quad (3)$$

where λ is the rate of convergence to steady state and \tilde{y}^* is steady state GDP per efficiency units of labor. We note that the rate of convergence is given by: $\lambda = (1 - \alpha)(n + \delta + g)$, where α is the capital-output elasticity from the (Cobb-Douglas) production function, n is the rate of population growth and δ is the rate of capital depreciation. We can rearrange equation (3) so as to yield:

$$\frac{\log \left(\frac{y(T)}{y(0)} \right) - gT}{1 - e^{-\lambda T}} = \log \left(\frac{\tilde{y}^*}{\tilde{y}(0)} \right). \quad (4)$$

To obtain equation (4) we have assumed that technological progress expands at a constant rate $g = \dot{A}(t)/A(t)$, and that $\tilde{y}(t) \equiv y(t)/A(t)$. Equations (2) and (4) tells us how much income per capita will have to increase, in the steady state, so as to reach the poverty target: $\tilde{y}^*/\tilde{y}(0)$ can be interpreted as the required increase in steady state income (per efficiency units of labor), which ensures that the income target, and therefore poverty target, is reached within T years.

That is, the transition equation for the capital stock, $K(t)$ can be written

$$\dot{K}(t) = I(t) + \varpi F(t) - \delta K(t), \varpi \leq 1, \quad (5)$$

where $I(t)$ is domestically generated investments and $F(t)$ is the aid inflow. The parameter ϖ is introduced to capture the potential for “waste”. Accordingly $\varpi=1$ means that all aid flows are turned

into investments. Next, assume $I(t)$ (and savings) are given as a constant fraction s of total income, that the population grows at a constant rate n , and that the economy is closed (except to foreign assistance, of course). We also assume that the amount of foreign assistance is kept constant as a fraction of GDP, $F(t) = f \cdot Y(t)$, so that we can treat f as the “aid investment rate”. Restated in efficiency units of labor the transition equation for capital reads

$$\dot{\tilde{k}}(t) = (s + \varpi f) \tilde{y}(t) - (n + g + \delta) \tilde{k}(t),$$

where $\tilde{k}(t) \equiv K(t) / A(t)L(t)$. To complete the model, recall production function is Cobb-Douglas. Specifically: $Y(t) = K(t)^\alpha (A(t)L(t))^{1-\alpha} \Leftrightarrow \tilde{y}(t) = \tilde{k}^\alpha(t)$. It is now straight forward to derive the steady state level of GDP per efficiency units of labor.

$$\tilde{y}^* = \left(\frac{\varpi f + s}{n + g + \delta} \right)^{\frac{\alpha}{1-\alpha}}, \quad (6)$$

where $\frac{\varpi f + s}{n + g + \delta}$ is the steady state K/Y ratio. The sum $\varpi f + s$ is total investment to GDP. We can

now examine the impact of increasing aid investments on long run prosperity. Log differentiation of equation (8) with respect to investment effort yields:

$$\frac{d\tilde{y}^*}{\tilde{y}^*} = \frac{\alpha}{1-\alpha} \left(\frac{\varpi}{\varpi f + s} df + \frac{1}{\varpi f + s} ds \right). \quad (7)$$

Now, suppose domestic resource mobilization is kept constant, so that $ds = 0$. We can then restate equation (7) in the following manner

$$df = \frac{dF}{Y} = \frac{d\tilde{y}^*}{\tilde{y}^*} \left[\frac{1-\alpha}{\alpha} \frac{\varpi f + s}{\varpi} \right] \quad (8)$$

which relates changes in the aid to GDP ratio to changes in long-run GDP per efficiency units of labor, and parameters of the model. To produce the formula stated in the text we insert the marginal product of capital, evaluated in the initial steady state:

$$MP_K = \alpha \left(\frac{Y}{K} \right)^* = \alpha \left(\frac{n + \delta + g}{\varpi f + s} \right) \Leftrightarrow \varpi f + s = \frac{\alpha(n + \delta + g)}{MP_K}$$

If we substitute the last expression into equation (8) we get

$$\frac{dF}{Y} = \frac{d\tilde{y}^*}{\tilde{y}^*} \left[(1-\alpha) \frac{(n + \delta + g)}{MP_K^* \varpi} \right] \quad (9)$$

Finally, observe that $d\tilde{y}^* / \tilde{y}^* \approx [\tilde{y}^* - \tilde{y}(0)] / \tilde{y}(0)$. Substituting equation (4) we obtain the equation stated in the text.