

Achieving the Millennium Development Goals in Sub-Saharan Africa: A Macroeconomic Monitoring Framework

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3,000 Africans die every day of a mosquito bite. Can you think about that, malaria? That's not acceptable in the 21st century and we can stop it. And water-borne illnesses – dirty water takes another 3,000 lives – children, mothers, sisters . . . If we're to take this issue seriously, and we must, because in 50 years, you know, when they [G-8 Heads of State] look back at this moment . . . they'll talk about what we did or didn't do about this continent bursting into flames. It is the most extraordinary thing to watch people dying three in a bed, two on top and one underneath, as I have seen in Lilongwe, Malawi. I mean, it is an astonishing thing. And it's avoidable. It's an avoidable catastrophe. You saw what happened with the tsunami. You see the outpouring, you see the dramatic pictures. Well, there's a tsunami happening every month in Africa, but it's an avoidable catastrophe. It is not a natural calamity.

(Bono, Lead singer of U2, on NBC's *Meet the Press*, 16 June, 2005).

1. INTRODUCTION

IN May 1996, development ministers from the member countries of the OECD Development Assistance Committee (DAC) issued a report, *Shaping the 21st Century: The Contribution of Development Co-operation*, in which they presented their vision for development progress into the next century. They formulated a strategic framework aimed at achieving seven goals set up mainly to promote social development and combat widespread poverty in low-income countries (LICs). Subsequently,

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the need to monitor and report on progress toward the goals led to establishing quantified targets for each objective and specifying indicators for measuring progress. The publication of the report *A Better World for All: Progress Toward the International Development Goals* in June 2000 formally paved the way for establishing a monitoring process for the Millennium Development Goals (MDGs).

In September 2000, during the United Nations (UN) Millennium Summit, the international community adopted the Millennium Declaration and the MDGs as strategic indicators by which poor countries and the donor community could measure progress toward reducing poverty and improving the quality of life at the horizon 2015. LICs were called on to adopt the MDGs in the context of their Poverty Reduction Strategy Paper (PRSP) and monitor progress toward meeting the goals. In March 2002, at the International Conference on Financing for Development in Monterrey, Mexico, the international community established a framework for global partnership between developed and developing countries to combat widespread poverty around the world. Later that same year, at the World Summit on Sustainable Development in Johannesburg, South Africa, UN member states reaffirmed their commitment to meeting the MDGs.

However, recent assessments of the status of the MDGs in LICs reveal that progress in achieving them has been mixed and slow. In its report published in January 2005, the Millennium Project (developed under the auspices of the United Nations) noted that although several countries are on track to achieve some of the goals, many others are falling way short – particularly so in Sub-Saharan Africa. The report issued by the Commission for Africa (2005) in March 2005, and the more recent reviews of progress toward achieving the MDGs by the United Nations (2005) and the IMF and the World Bank (2005b), also provide a bleak picture for the region.

Several of these recent reports have recognised that growth is a key requirement for improving living standards in Sub-Saharan Africa, and emphasised the need for a ‘big push’ in public investment in education, health and infrastructure in order for African countries to meet the MDGs. Many PRSPs in the region have recognised the role that infrastructure can play in stimulating growth, particularly those aimed at improving productivity and reducing production costs in agriculture (see OECD, 2004). The development of transportation networks is also viewed as particularly important for the numerous landlocked countries in the region to stimulate trade – both domestically and internationally. A joint report by the Bretton Woods institutions (see World Bank, 2005b) and the Bank’s recent *Action Plan for Africa* (see World Bank, 2005c) called for a doubling of spending on infrastructure (both for ‘new’ investment and operation and maintenance) in Sub-Saharan Africa, from 4.7 per cent of GDP in recent years to more than nine per cent over the next decade, to fill severe gaps in the region.¹ To finance this

¹ How this number is arrived at is, however, not entirely clear.

big push, and given the limited ability of most countries in the region to raise domestic resources through taxation or borrowing, donors have been called upon to provide generous debt relief and scale up official development assistance.

A key issue therefore for LICs is to examine how debt relief and increases in aid affect the MDGs, and account for these effects in designing their poverty-reduction strategies. Understanding these effects, and quantifying them, is also important for donors to enhance the quality and depth of the policy debate.² Indeed, the need to strengthen the quality of technical assistance to countries involved in the PRSP process is widely recognised by development institutions (see World Bank, 2002, 2004 and 2005a) and other observers. Unfortunately, current thinking on how to achieve the MDGs has largely failed to provide a tractable quantitative macroeconomic framework that captures key linkages between foreign assistance, the composition of public investment, and the supply side – in addition to the ‘conventional’ fiscal and balance-of-payments effects associated with foreign aid.

Partly as a result, many existing exercises aimed at determining requirements for meeting the MDGs, as carried out in the context of PRSPs, have taken the form of a costing exercise of programmes to be implemented during a given time frame. This ‘micro’ approach to achieving the MDGs has paid insufficient attention to several key aggregate linkages between foreign aid, medium-term expenditure frameworks, growth and the MDGs. Recent evidence suggests that such linkages may take the form of large positive externalities (for instance, between public investment in health and educational attainment, or between capital outlays in infrastructure and literacy), which can be accounted for only in a macroeconomic framework.³ Ignoring these linkages implies that ‘micro’-based approaches to MDG costing can be highly inaccurate and lead to over-estimation of foreign assistance needs.

² Two papers by Rajan and Subramanian (2005a and 2005b) appear to cast doubt on the view that aid may stimulate growth in low-income countries, essentially because of an adverse Dutch disease effect. Unfortunately, these studies suffer from several methodological and conceptual flaws. For instance, the authors fail to distinguish, in their empirical estimation, between fixed and floating exchange rate regimes. Under a flexible exchange rate regime, an aid-induced nominal appreciation will put downward pressure on the price of imported inputs (a key feature of the production structure in developing countries) and thus domestic inflation, thereby mitigating the inflationary effect of aid through the demand side. In addition, to the extent that aid leads to better infrastructure, it will improve competitiveness in the longer run (also by reducing production costs), even if the real exchange rate appreciates in the short run. Because the time profile of these effects may vary significantly across countries, panel data regressions provide misleading results on the dynamic effects of aid on the real exchange rate. For a more general (and sceptical) assessment of the econometric literature on aid and growth, see Doucouliagos and Paldam (2005).

³ In a comprehensive review of the PRSP approach, the German Development Cooperation agency (2005) identified the need to enhance linkages and consistency between the PRS, the medium-term expenditure framework and government budgets as one of the key priorities for enhancing the effectiveness of the approach. A similar emphasis was placed by the World Bank (2005b) in its five-point agenda for accelerating progress toward the MDGs.

This paper builds on the operational model developed by Agénor, Bayraktar and El Aynaoui (2006), and extended by Pinto Moreira and Bayraktar (2006), to develop a macroeconomic approach to monitoring achievement of the MDGs in Sub-Saharan Africa. The model accounts explicitly for the links between aid, public investment and the supply side, and provides some essential ingredients for understanding key trade-offs in the design of poverty-reduction strategies.⁴ Specifically, we embed the model into a broader framework that incorporates cross-country regressions for Sub-Saharan African countries. This approach allows us to link directly policy and endogenous variables (such as public spending on health or income per capita) to the MDGs. Although in this setup we cannot account for all the MDGs (such as maternal mortality, or the plight of the poor living in city slums), we do explain the behaviour of several important indicators – including the poverty rate, malnutrition, the infant mortality rate, the percentage of population with access to safe drinking water, the literacy rate and life expectancy at birth.

The remainder of the paper is organised as follows. Section 2 describes the methodology. Section 3 presents the baseline scenario for the country that we use to illustrate the functioning of our framework, Niger. Section 4 discusses the effects of an increase in foreign aid (namely, grants) on the MDGs, under the assumption that public investment is relatively efficient.⁵ Section 5 examines the same policy experiment in the alternative case where public investment is less efficient. Section 6 provides some final remarks.

2. AN MDG MONITORING FRAMEWORK

As indicated earlier, at the heart of our framework is the macroeconomic model developed by Agénor, Bayraktar and El Aynaoui (2006) and extended by Pinto Moreira and Bayraktar (2006). The model captures key linkages between foreign aid, the level and composition of public investment (disaggregated into education, health, infrastructure), the supply-side effects of public capital, growth and poverty. It is designed to examine how debt relief, as well as increased aid and aid-funded levels of public investment – possibly coupled with changes in the allocation of public expenditure – can stimulate growth and lead to sustained poverty reduction. Because it contains only one category of households, the model is silent on distributional issues. However, this is very much by design; the fundamental premise of our approach is that the ability to engage in substantial

⁴ The emphasis on public investment and the supply side in these models dwells on the more advanced class of IMMPA models, described in the collection of studies edited by Agénor, Izquierdo and Jensen (2006).

⁵ The Working Paper version of this article describes another experiment, a complete write-off of Niger's external public debt (see Agénor et al., 2005).

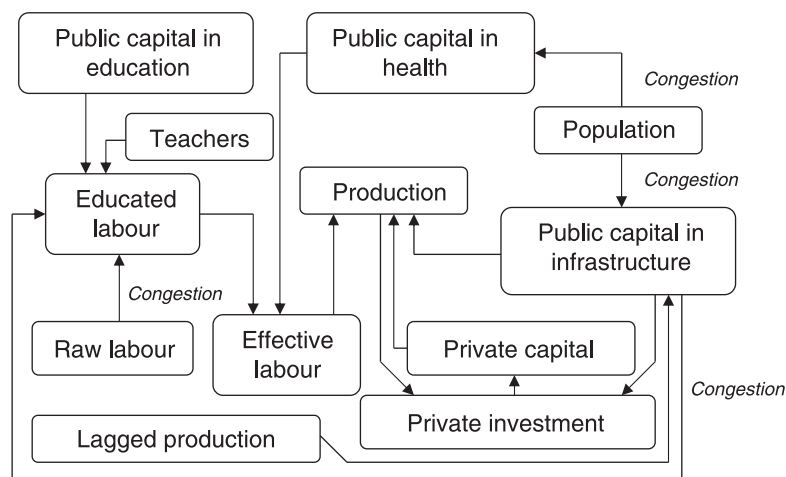
income or asset redistribution in Sub-Saharan Africa is limited for a variety of reasons (including the low level of income to begin with), and that the key to achieving the MDGs is a sustained increase in growth rates.⁶

The first part of this section describes the macro model and how it is related to poverty. The second part explains how macroeconomic variables (namely, income and consumption per capita), as well as poverty, are linked with the other MDG indicators.

a. The Macro Component

We begin by describing the production side of the macro model, which is summarised in Figure 1. The economy produces one composite good, which is imperfectly substitutable to an imported good. Domestic production requires effective labour, private capital and public capital in health and infrastructure (namely, transport, energy, water supply and sanitation, and telecommunications). The stock of private capital is calculated by applying the standard formula associated with the perpetual inventory method. In the case of public investment, however, we account for the possibility that a fraction of the resources invested in investment projects may not have a positive impact on the public capital stock – a point emphasised by Pritchett (1996) in the context of developing countries

FIGURE 1
Public Capital and Production



⁶ Moreover, many observers have failed to note that redistribution may actually *hurt* the poor – for instance by reducing savings and investment rates, or by hampering the ability to pledge collateral for borrowing. See Agénor (2005c) for a more detailed discussion.

in general. Specifically, we follow the linear specification proposed by Arestoff and Hurlin (2005) and relate the stock of public capital in sector h at period t , denoted $K^h(t)$, to the flow of investment in h , denoted IG^h , through the modified formula:

$$K^h(t) = (1 - \delta^h)K^h(t-1) + \alpha^h IG^h(t-1), \quad (1)$$

where $\delta^h \in (0, 1)$ denotes the rate of depreciation of capital h and $\alpha^h \in (0, 1)$ is the efficiency parameter. The case of 'full efficiency' corresponds to $\alpha^h = 1$. In the experiments reported below, we will consider only cases where $\alpha^h < 1$.

While public capital in infrastructure improves the productivity of the private factors used to generate output, public capital in health improves the quality of labour employed in production. Effective labour is a composite input, which is produced by the actual stock of educated labour and public capital in health. In order to take into account congestion effects in the provision of health services, the stock of public capital in health is scaled by the size of the population. To account for congestion effects associated with domestic production activity, lagged output is used as an indicator of the intensity of use of (or pressure on) public capital in infrastructure. Domestic output is allocated between exports and domestic sales, based on relative prices.

Population and 'raw' labour grow at the same constant exogenous rate. The transformation of raw labour into educated labour takes place through the education system, which provides schooling services at no charge. A key input in this process is a composite public education input, which is defined as a function of the number of teachers and the stock of public capital in education. In addition to teachers and public capital in education, production of educated labour requires also access to infrastructure capital. This is a crucial feature of the model. As documented by Brenneman and Kerf (2002) and Agénor and Moreno-Dodson (2006), many recent microeconomic studies have found a positive impact of infrastructure services on educational attainment, both directly and indirectly (through an improvement in health indicators). A better transportation system and a safer road network (particularly in rural areas) help to raise school attendance. Electricity allows more time to study and more opportunities to use electronic equipment that may improve the learning process. Greater access to safe water and sanitation enhances the health of individuals, thereby increasing their ability to learn. As far as we know, our model is the first to account for these effects in a quantitative macroeconomic framework.⁷ This adds an important channel of transmission of public investment to growth, through human capital accumulation.

⁷ See Agénor (2005c and 2005d) for a formal analysis of the implications of this specification in endogenous growth models. As formally discussed by Agénor (2005f) and Agénor and Neanidis (2006), infrastructure may also have a significant impact on the production of health services.

A congestion effect is introduced in the stock of public capital in education through raw labour, which captures pressure on the education system. Educated workers are employed either in the production of goods or in government, some of which (teachers) in the provision of education services.

Income from production is entirely allocated to a single household, which holds domestic public debt and receives interest payments on it. It also receives government wages and salaries, unrequited transfers from abroad, and pays interest on its foreign debt. Disposable income is obtained by netting out direct taxes from total income. In turn, total private consumption is a constant fraction of disposable income. The assumption that consumption depends on current (rather than permanent) income reflects the large body of evidence for low-income countries, which emphasises either tight liquidity constraints or short planning horizons (see Agénor, 2004, Ch. 2).

Private investment is a function of the rate of growth in domestic output, private foreign capital inflows and the stock of public capital in infrastructure. The latter variable captures the existence of a complementarity effect – by increasing the productivity of private inputs, or by reducing adjustment costs, a higher stock of public capital in infrastructure raises the rate of return on capital and leads to an increase in private investment.⁸

Total demand for goods sold on the domestic market is the sum of private and public spending on final consumption and investment. Private demand for goods bought and sold on the domestic market is a combination of imported goods and domestically-produced goods. Because the domestic good is imperfectly substitutable with the foreign good, its relative price is endogenous. As a result, the model allows us to analyse potential Dutch disease effects that may be associated with large aid flows.

Aid, defined only as grants, is linked to the government budget through various channels (see Figures 2 and 3). The government collects taxes and spends on salaries, goods and services, and interest payments. It also invests and accumulates public capital. Aid is accounted for ‘above the line’; it is therefore a potential substitute to domestic sources of revenue. The deficit is financed through domestic borrowing and foreign borrowing (concessional or not). Taxes are defined as the sum of direct, domestic indirect and international (import) taxes. Total public investment is allocated (using fixed fractions) between health, education and infrastructure. The effective direct tax rate is negatively related to the aid-to-GDP ratio, and positively to total government expenditure. The effective indirect tax rate is also negatively related to the aid ratio. These formulations therefore capture an

⁸ See Agénor, Nabli and Yousef (2005) for a detailed discussion of these effects and a review of the empirical evidence for developing countries. Turnovsky (1996) and Agénor and Aizenman (2006) provide a formal analysis of the impact of infrastructure on adjustment costs and private investment.

FIGURE 2
Impact of Foreign Aid

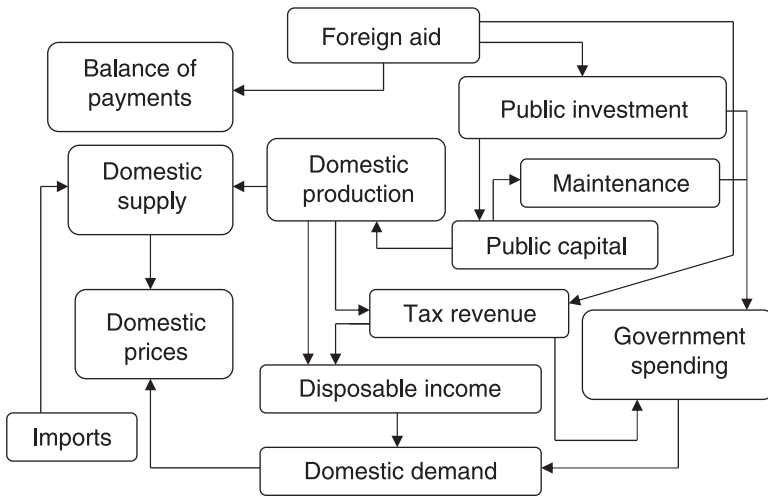
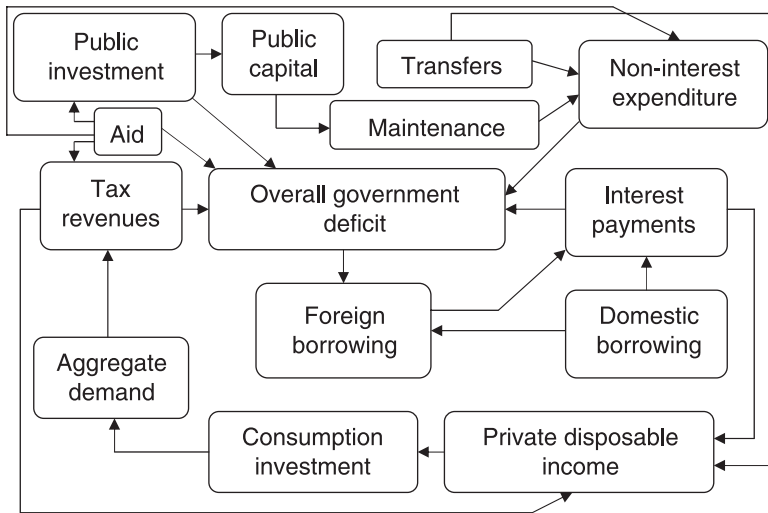


FIGURE 3
Government Budget



adverse (moral hazard) effect of foreign assistance on incentives to collect taxes, as emphasised in ‘fiscal response’ models (see, for instance, Franco-Rodriguez, 2000). Current non-interest expenditure on goods and services is assumed to be constant as a proportion of GDP.

Total public investment is positively related to both tax revenue (a measure of the capacity to raise domestic resources) and foreign aid. To account explicitly

for the implications of a higher capital on stock on recurrent spending (and thus financing needs), maintenance expenditure is related to depreciation of all stocks of public capital.⁹ Accounting explicitly for 'required' maintenance outlays as we do is important because inadequate funding for maintenance has been a chronic problem in many developing countries – resulting in rapid decay of public capital, such as roads and power grids.

The financing constraint of the government implies that the budget balance is financed through domestic and foreign borrowing. From the household budget constraint, private savings is determined by a constant saving rate and disposable income.

The balance of payments is obtained by subtracting foreign interest payments and changes in net foreign assets of the central bank from the sum of net exports, private and public capital flows, aid and unrequited transfers from abroad. The stocks of private and public foreign debt are obtained by adding the current period capital inflow to the debt level of the previous period.

The price of the composite good is a function of the price of the domestically-produced good and the domestic-currency price of imports (defined as the product of the nominal exchange rate and the world price of imports, inclusive of tariffs). Market equilibrium requires equality between total supply of goods on the domestic market and aggregate demand for these goods, which in turn determines the equilibrium (composite) price. The price of the domestic good on the domestic market is assumed to adjust gradually to its equilibrium value. Finally, the domestic-currency price of exports is equal to the exchange rate times the world price of exports.

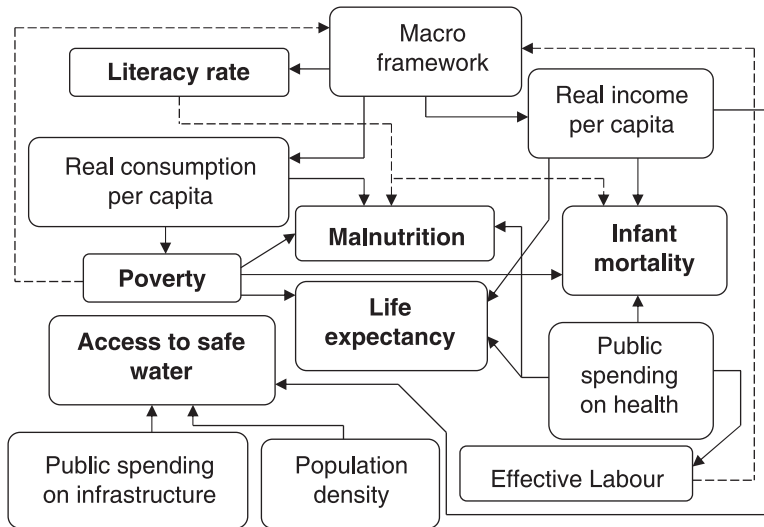
b. Link with the MDGs

The link between the macro model and the MDGs is summarised in Figure 4. Six of the MDG indicators are integrated in this framework: the poverty rate, the literacy rate, infant mortality, malnutrition, life expectancy and access to safe water. A key feature of our approach is that the MDG indicators also interact with each other, as captured through our cross-country regressions.

The poverty rate is linked directly to the macroeconomic model. Specifically, the model is linked to poverty through either partial growth elasticities relating poverty indicators to consumption, or a household survey. The first method consists of relating the poverty rate (as measured by the headcount index, for

⁹ We do not account here for 'feedback' effects of maintenance expenditure, most notably on the rate of depreciation of the public capital stock, as well as possibly on the durability of private capital (all depreciation rates are assumed constant). The key idea in the latter case is that maintaining the quality of roads, for instance, enhances the durability of trucks and other means of transportation used by the private sector to move labour and goods. See Agénor (2005e) for a formal analysis of the implications of endogenising depreciation rates.

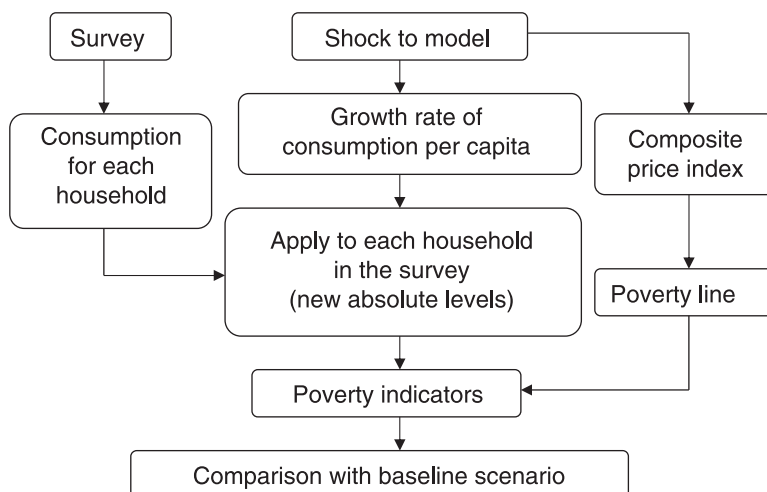
FIGURE 4
Monitoring the MDGs: A Macroeconomic Approach



instance) to the growth rate of real private consumption or income per capita, as derived from the model. In the absence of more precise country estimates (as in the case of Niger discussed later), we use three partial elasticity values: a ‘neutral’ or central value of -1 , a ‘low’ value of -0.5 , and a ‘high’ value of -1.5 . These values are consistent with the range of evidence on the ‘growth elasticity’ of poverty for Sub-Saharan Africa and can, of course, be changed. For instance, the value -0.5 is close to the estimate obtained by Besley and Burgess (2003, Table 2) for Sub-Saharan Africa, and by Christiansen et al. (2003, Table 4) for Ethiopia and Zambia. In addition, we also use the ‘adjusted’ elasticity formula proposed by Ravallion (2004, pp. 12–13). With a Gini coefficient equal to 50.5 for Niger, the formula gives an elasticity of -1.13 .

The second methodology involves linking the model to a household survey. It dwells on the IMMPA approach described in Agénor, Izquierdo and Jensen (2006) and involves several steps (see Figure 5). First, using a representative income and expenditure survey, the value of consumption spending (or income) for each household is extracted; given the poverty line, the initial poverty rate is calculated. Second, following a policy or exogenous shock, the growth rate in private consumption per capita is generated in the macroeconomic model, up to the end of the simulation horizon (say, N periods). Third, this growth rate is applied to the consumption expenditure data for each household in the survey. This gives new consumption levels for each unit, for periods $1, \dots, N$. Fourth, the poverty line is updated by using the growth rate of the consumer price index generated by the macroeconomic model. Finally, using the new data on nominal consumption

FIGURE 5
Link with a Household Survey



per household and the poverty line, ‘post-shock’ poverty indicators are calculated and compared with initial indicators to assess the poverty effect of the shock.

The literacy rate, which is defined as the ratio of educated labour to total population, is also a direct output of the model. However, it is only an approximation to the conventional definition, which refers to the proportion of the population aged 15 years and over that is literate.

All other MDG indicators (malnutrition, infant mortality, life expectancy and access to safe water) are linked to the model through cross-country regressions, which allow us to alleviate the lack of observations at the level of individual countries. We use a cross-section estimation technique, in order to focus on long-run relationships. Given that all the MDG indicators considered here tend to change slowly over time, this appears to be a more sensible strategy than using, say, dynamic panel techniques. These regressions are discussed in some detail in the Appendix.

Malnutrition prevalence is linked to the model through real consumption per capita, the poverty rate and public spending on health.¹⁰ While increasing consumption per capita and public spending on health reduces the incidence of malnutrition, an increase in the poverty rate raises it. Infant mortality is related

¹⁰ See Broca and Stamoulis (2003) for a more general discussion of the micro- and macro-determinants of malnutrition. Our results are consistent with those of Smith and Haddad (2000), who used data from 63 countries in five regions (covering 88 per cent of the developing world’s population over the period from 1970–95) to analyse the determinants of child malnutrition, as measured by the percentage of underweight children under five. They found that growth in per capita national income (which is closely correlated with consumption per capita) contributed to half the reduction in child malnutrition over this period.

negatively to poverty and positively to real income per capita and public spending on health.¹¹ Thus, declining poverty may not be sufficient to decrease infant mortality if public investment in health is not increasing sufficiently.¹²

Public spending on health also has a positive effect on life expectancy, which can be viewed as a 'summary' indicator of the goal of combating diseases. Besides public investment in health, lower poverty rates and higher real income per capita also tend to increase life expectancy. Our evidence on the impact of income is consistent with the results obtained by Baliaoune and Lutz (2004) in a larger sample of countries.¹³

The share of population with access to safe water is taken to be a function of population density, real income per capita and public spending on infrastructure. The effect of population density on access to safe water is positive because the cost of building infrastructure capital tends to drop with higher density. Similarly, increasing real income per capita raises the share of population with access to safe water, possibly as a result of 'demand' pressures. And naturally enough, public investment in infrastructure raises access to safe water – both directly and indirectly, through its impact (captured in the model) on real income per capita.

To provide a synthetic view on progress toward achieving the MDGs, we also calculate a *composite MDG index* by taking an unweighted geometric average of all the individual indicators defined earlier – the literacy rate, life expectancy, access to safe water, as well as the inverse of the poverty rate (as obtained in the 'neutral elasticity' case), malnutrition prevalence and infant mortality. Thus, a rise in the index indicates overall progress toward achieving the MDGs. Our composite index is thus more general than the human development index developed by the United Nations Development Programme (and published in its *Human Development Report*), which is an unweighted arithmetic average of the (normalised) values of real GDP per capita, life expectancy and the educational attainment rate.¹⁴

3. APPLICATION TO NIGER: BASELINE PROJECTIONS

To illustrate the functioning of the framework described in the previous section, we apply it to Niger. With 63 per cent of the population living below the

¹¹ In general, one would expect infant mortality to be also determined by malnutrition prevalence. We did not, however, introduce this link because we could not find empirical support for it in our cross-country regressions.

¹² Another important effect of increasing public spending on health (as noted earlier) is that it raises the productivity of effective labour, and thus economic growth. Note that, due to lack of data, our regressions use 'flows' rather than 'stocks' of public expenditure.

¹³ One would also expect life expectancy to be affected by malnutrition prevalence, but our empirical findings did not support this link.

¹⁴ See Chakravarty (2003) for a discussion of the theoretical underpinnings of this index.

TABLE 1
Niger: MDG Indicators, 1990 and 2002

	<i>Niger</i>		<i>Sub-Saharan Africa</i>	
	<i>1990</i>	<i>2002</i>	<i>1990</i>	<i>2002</i>
Poverty rate <i>(Per cent of the population living below \$2 per day)</i>	63.0 (in 1993)	63.0 (in 2003)	44.7	55.5
Literacy rate <i>(Per cent of educated labour in total population)</i>	11.4	17.1	48.5	60.3
Infant mortality <i>(Infant mortality rate per 1,000 live births)</i>	191.0	155.0	104.2	96.3
Malnutrition <i>(Malnutrition prevalence, weight for age)</i>	42.6 (in 1992)	40.1 (in 2000)	27.8	26.3
Life expectancy <i>(Life expectancy at birth, years)</i>	42.1	46.2	50.6	48.2
Access to safe water <i>(Percentage of population with access to safe water)</i>	53.0	59.0 (in 2000)	59.1	60.5

Note:

Sub-Saharan countries exclude South Africa and oil-exporting countries.

poverty line, and 34 per cent considered as extremely poor, Niger is the second poorest country on earth.¹⁵ Despite recent improvements, social indicators remain abysmal, and among the weakest in the world (see Table 1). Child malnutrition is high and estimated at 40 per cent, compared with an average of 26 per cent in Sub-Saharan Africa. The infant mortality rate (deaths per 1,000 births) is currently 155, whereas it averages 96 for the continent as a whole. Less than 60 per cent of the population has access to potable water and only five per cent of the rural population has access to sanitation facilities. Life expectancy at birth is about 46 years, compared with an average of 48 years in Sub-Saharan Africa. At 17 per cent, the literacy rate is among the lowest in the world and far below the average for the region, estimated at 60 per cent.

We first established a baseline projection using the macro framework described earlier, based on assumptions that reflect recent trends regarding aid, prices of exports and imports, capital flows, and so on.¹⁶ In particular, the aid-to-GDP ratio is assumed to remain constant at 16.9 per cent until 2015, and foreign-currency

¹⁵ The United Nations Development Programme, using its Human Development Index, ranked Niger 176 out of 177 countries in 2004.

¹⁶ The complete set of simulation results, and details about the calibration process, are available upon request from the authors.

prices of exports and imports are assumed to grow at the same rate, so that we exclude net gains in the terms of trade. Domestic borrowing is kept at one per cent of GDP (the value observed in the base period) and tax rates that are exogenous are also kept constant.

Most importantly, we assume for the moment that the efficiency parameter of public investment in equation (1), α^h , is uniformly equal to 0.7, in the sense that public capital investment in all sectors increases the public capital stock less than one to one. As explained in Section 5, this value of α^h is higher than some estimated values in the literature. Thus, we assume that in the coming years Niger will continue to implement institutional reforms that will help to improve governance, strengthen management of public resources, reduce corruption and eliminate much of the waste that all too often characterised capital outlays in the past.

Baseline projections are shown in Table 2 for the period 2007–15. The results show that poverty drops throughout the simulation period. As shown in Table 2, the headcount index decreases in the ‘best’ case (a consumption growth elasticity of -1.5) by 24.3 percentage points, down to 38.7 per cent in 2015, from an estimated 63 per cent in 2003. However, in the Besley-Burgess case (a consumption growth elasticity of -0.5), over the same period the poverty rate drops by only nine percentage points. Thus, if current trends were to be maintained, the MDG of halving poverty would not be achieved by 2015. Indeed, in these circumstances, relative to 2003, it would take 16 years (or a target date of 2019) in the high elasticity case, or 42 years (or a target date of 2045) in the Besley-Burgess case, for Niger to reduce its poverty rate by half.

Regarding the other MDG indicators reported in Table 2, the literacy rate (defined as the ratio of educated labour to total population) increases from 17.1 per cent in 2003 to 26.8 per cent in 2015, as a result of an increase in public investment in education and infrastructure combined with an increasing number of teachers. Whereas infant mortality drops from 155 in 2002 to 115 in 2015, malnutrition prevalence drops only slightly from 40.1 per cent in 2000 to 35.2 per cent in 2015. These improvements result from a combination of factors – reduction in poverty, increased public investment in health, and higher GDP and private consumption per capita.¹⁷ For similar reasons, life expectancy also increases, from 46.2 in 2002 to 50.1 in 2015.

The last individual indicator, the percentage of population with access to safe water, rises from 59 per cent in 2000 to 61.4 per cent in 2015 as a result of increasing public investment in infrastructure, and higher GDP per capita and population density, all of which are estimated to have a positive effect on access to safe water. In sum, the MDG indicators improve quite sensibly in Niger; the

¹⁷ The elasticity used to link poverty and the MDGs corresponds to the ‘neutral’ case of unity. Adjusting this parameter is of course straightforward.

TABLE 2
Niger: MDG Indicators, Baseline Results for 2007–15

	<i>Projections</i>									
	1990	2007	2008	2009	2010	2011	2012	2013	2014	2015
Poverty rate (2003 = 63) <i>(Per cent of the population living below \$2 per day)</i>	63.0 ¹									
Consumption per capita growth elasticity of –0.5		65.0	63.5	61.9	60.4	58.9	57.5	56.3	55.1	54.0
Consumption per capita growth elasticity of –1.0		66.8	63.7	60.6	57.6	54.8	52.2	49.9	47.8	45.9
Consumption per capita growth elasticity of –1.5		68.4	63.7	59.0	54.6	50.6	47.0	43.9	41.2	38.7
Ravallion's (2004) adjusted elasticity (Gini = 50.5)		67.2	63.8	60.2	56.8	53.7	50.8	48.3	46.0	44.0
Literacy rate <i>(Per cent of educated labour in total population)</i>	11.4	20.5	21.3	22.1	22.9	23.7	24.5	25.2	26.0	26.8
Infant mortality (2002 = 155) <i>(Infant mortality rate per 1,000 live births)</i>	191	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Malnutrition (2000 = 40.1) <i>(Malnutrition prevalence, weight for age)</i>	42.6 ²	–37.1	–37.9	–38.7	–39.5	–40.3	–41.1	–41.8	–42.4	–43.0
Life expectancy (2002 = 46.2) <i>(Life expectancy at birth, years)</i>	42.1	1.4	1.4	1.4	1.5	1.5	1.5	1.5	1.5	1.5
Access to safe water (2000 = 59) <i>(Percentage of population with access to safe water)</i>	53.0	47.7	48.2	48.7	49.1	49.6	50.0	50.4	50.8	51.1
COMPOSITE MDG INDICATOR (2005 = 100) <i>(A rise denotes an improvement)</i>		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aid and external debt indicators										
Foreign aid (in per cent of GDP)		16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9	16.9
Aid (in per cent of total government revenue)		61.7	61.8	61.8	61.8	61.8	61.7	61.7	61.7	61.6
External debt (in per cent of GDP)		59.5	56.6	54.1	52.1	50.5	49.4	48.7	48.3	48.1
Interest payments on external public debt (in per cent of GDP)		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3
Interest payments on external public debt (in per cent of exports)		2.9	2.9	2.9	2.9	2.9	3.0	3.0	3.1	3.2

Notes:

The 'adjusted' elasticity formula proposed by Ravallion (2004) is $-9.3 * (1 - \text{Gini})^3 = -1.13$ where the Gini index is 50.5 for Niger.

Malnutrition prevalence is in per cent of children under five.

¹ The observation year is 1993.

² The observation year is 1992.

composite MDG index (with base 2005 = 100 for convenience) shows a significant overall improvement, rising by 27 percentage points over the period. But again, despite these improvements, Niger will not be able to achieve the MDG targets by 2015 based on recent trends. We therefore turn to examining the potential role of an increase in foreign aid.

4. APPLICATION TO NIGER: INCREASE IN FOREIGN AID

To fix ideas, we consider a permanent increase (from 2007 to 2015) in the ratio of foreign aid to GDP by five percentage points. To save space, we provide only a concise description of the transmission channels.¹⁸ We also focus our discussion on a comparison between 2007 and 2015, although a comparison between 1990 and 2015 would be more in line with a strict assessment of progress toward achieving the MDGs.

The immediate macroeconomic effect of an increase in aid is an expansion in aggregate demand. This, in turn, puts upward pressure on domestic prices. Given that the nominal exchange rate is fixed, the real exchange rate appreciates, which tends to dampen exports (and to raise sales of the domestically-produced good on the domestic market) and increase imports. The magnitude of these effects is somewhat muted by the fact that prices adjust only partially in the short run. As a result, the reallocation of output, as well as changes in the composition of private demand for domestic and imported goods, occur only gradually. Put differently, there is indeed a 'Dutch disease' effect, but its magnitude is not as large as one would obtain with full price flexibility and instantaneous adjustment in production and spending patterns.

Moreover, this effect is mitigated over time. The increase in foreign aid leads to a rise in public investment. Because the shares of each component of public capital outlays are fixed at baseline levels (and are thus constant throughout the simulation period), all components of public investment increase as well. This leads to a higher capital stock in education and infrastructure, and thus an increased supply of the 'public education input', which leads to higher production of educated labour. This increase, combined with the rise in the stock of public capital in health, leads to greater availability of 'effective' labour. These supply-side effects develop gradually, dampening over time the initial inflationary effect of the increase in aid. This effect is, in a sense, self-reinforcing: because tax revenues tend to increase over time (despite an adverse 'moral hazard' effect of aid on collection effort), there is an additional positive effect on public investment. Indeed, although the increase in aid tends to reduce incentives to collect

¹⁸ More details on this experiment can be found in Agénor, Bayraktar and El Aynaoui (2006) and Pinto Moreira and Bayraktar (2006).

taxes (thereby leading to lower 'effective' tax rates on both income and domestic sales), the tax base tends to expand, as a result of higher domestic income (which also raises spending on both categories of goods) and the increase in spending on imports induced by the real appreciation. The net effect is that overall tax revenues tend to increase, thereby raising capital outlays. An important implication of this result is that an aid-induced reduction in (indirect) taxation may be beneficial to the poor in the short term – to the extent that it mitigates upward pressure on prices of goods sold domestically – but in the longer term, it may hurt them, by reducing the capacity to finance public investment and mitigating supply-side effects.

The effects of this experiment on the MDGs are shown in Table 3. The head-count index based on a partial elasticity of -1.5 falls by 32.5 percentage points, from an estimated 67.6 per cent in 2007 to 35.1 per cent by 2015 (or, equivalently, a drop of 3.6 percentage points relative to baseline). However, with an elasticity of -0.5 , the drop is 12.4 percentage points, and poverty is estimated at 52.3 per cent in 2015 (corresponding to a drop of 1.7 percentage points relative to baseline). Thus in the high elasticity case of -1.5 , and relatively high efficiency of public investment, the simulation suggests that a five-percentage-point increase in aid leads to a reduction in poverty by almost half between 2007 and 2015. But the simulation also suggests that foreign aid may need to be increased by more than 13 percentage points of GDP in the Besley-Burgess case of a consumption growth elasticity of -0.5 even if public capital outlays are relatively efficient. Given the baseline assumptions, this would bring the aid-to-GDP ratio to almost 30 per cent. At that level, absorption constraints are almost certain to 'kick in' and become binding.

Because, as noted earlier, the increase in public capital in education and infrastructure leads to the production of a higher number of educated workers, the literacy rate increases by 7.2 percentage points, from an estimated 20.5 per cent in 2007 to 27.7 per cent by 2015 (or 0.9 percentage points relative to baseline). The incidence of child malnutrition also falls, both directly and indirectly. The increase in government resources associated with an increase in foreign aid raises public investment and capital in health, whereas the increase in real private consumption per capita tends to reduce poverty; both effects tend to reduce malnutrition. Given the estimated parameters, the net effect is a drop in this indicator, by 6.3 percentage points by 2015 (from 39.8 per cent in 2007 to 33.5 per cent, or a 1.7 percentage drop relative to baseline).

The reduction in poverty and the rise in public capital in health are associated with a reduction in infant mortality, which falls from an estimated 150 per 1,000 live births in 2007 to 109 in 2015 (or a drop of seven percentage points relative to baseline). Thus, the simulation results suggest that reducing the under-five mortality rate by two-thirds could be achieved in Niger through the increase in aid considered here. Life expectancy also improves, from an estimated 47.5 years in 2007 to 51.1 years in 2015. Increasing real income per capita, as well as public capital in infrastructure, leads to a relatively small increase in access to safe

TABLE 3
Niger: Five Percentage Point Increase in Aid-to-GDP Ratio, Simulation Results for 2007–15
(Absolute deviations from baseline)

	<i>Projections</i>								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Poverty rate (2003 = 63)									
<i>(Per cent of the population living below \$2 per day)</i>									
Consumption per capita growth elasticity of -0.5	-0.2	-0.4	-0.6	-0.7	-0.9	-1.1	-1.3	-1.5	-1.7
Consumption per capita growth elasticity of -1.0	-0.5	-0.8	-1.1	-1.4	-1.8	-2.1	-2.4	-2.6	-2.9
Consumption per capita growth elasticity of -1.5	-0.7	-1.2	-1.7	-2.1	-2.5	-2.8	-3.1	-3.4	-3.6
Ravallion's (2004) adjusted elasticity (Gini = 50.5)	-0.5	-0.9	-1.3	-1.6	-2.0	-2.3	-2.6	-2.9	-3.1
Literacy rate	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.7	0.9
<i>(Per cent of educated labour in total population)</i>									
Infant mortality (2002 = 155)	-5.0	-5.0	-5.0	-5.0	-6.0	-6.0	-6.0	-7.0	-7.0
<i>(Infant mortality rate per 1,000 live births)</i>									
Malnutrition (2000 = 40.1)	-1.3	-1.2	-1.3	-1.3	-1.4	-1.5	-1.6	-1.6	-1.7
<i>(Malnutrition prevalence, weight for age)</i>									
Life expectancy (2002 = 46.2)	0.7	0.7	0.7	0.7	0.8	0.8	0.9	0.9	1.0
<i>(Life expectancy at birth, years)</i>									
Access to safe water (2000 = 59)	0.2	0.2	0.2	0.2	0.3	0.3	0.4	0.4	0.5
<i>(Percentage of population with access to safe water)</i>									
COMPOSITE MDG INDICATOR	1.6	1.7	2.0	2.4	2.9	3.4	3.9	4.5	5.1
<i>(A rise denotes an improvement)</i>									
Aid and external debt indicators									
Foreign aid (in per cent of GDP)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Aid (in per cent of total government revenue)	6.6	6.8	6.9	7.1	7.1	7.2	7.3	7.3	7.3
External debt (in per cent of GDP)	-5.5	-8.8	-11.8	-14.2	-16.4	-18.3	-20.0	-21.5	-22.9
Interest payments on external public debt (in per cent of GDP)	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2
Interest payments on external public debt (in per cent of exports)	0.0	-0.2	-0.4	-0.5	-0.7	-0.9	-1.0	-1.2	-1.3

water, from 58.2 per cent in 2007 to 61.9 per cent in 2015 (or 0.5 relative to baseline). Overall, by 2015 the composite MDG index improves by about 5.1 percentage points relative to the baseline scenario.

5. LOWER EFFICIENCY OF PUBLIC INVESTMENT

The foregoing analysis assumed that the efficiency parameter of public investment is 0.7. We now consider the case where inefficiency persists, or that reforms aimed at improving governance and eliminating mismanagement of public resources are not deep enough to bring lasting results. Because we do not have specific estimates of the parameter α^h in equation (1) for Niger, we chose a value of 0.5 for all categories of public capital. This is consistent with Pritchett's (1996) estimate that half of all capital outlays are wasted in developing countries. It also corresponds to the mid-point of the range of values – between 0.4 and 0.6 – estimated by Arestoff and Hurlin (2005).

The results in Table 4 present the effects of a five-percentage-point increase in the aid-to-GDP ratio in the case of lower efficiency of public investment. The results show clearly that, in the absence of reforms aimed at improving the management of capital outlays, progress toward all the MDG indicators will be hampered – despite increasing foreign aid. In particular, the composite indicator *drops* by 1.4 percentage points between 2005 and 2015 (compared to a 5.1 per cent improvement in the high-efficiency case). Whatever the elasticity chosen, poverty deteriorates relative to the baseline results presented in Table 2. Thus, even in the best possible scenario, a five-percentage-point increase in the foreign aid to GDP ratio would not be enough to halve the poverty rate without an improvement in governance. In fact, to achieve the poverty MDG by 2015, the aid-to-GDP ratio would need to increase by as much as 37 per cent in the Besley-Burgess case – therefore exacerbating the potential problems of absorption capacity that were discussed earlier.

To the extent that a coefficient of $\alpha^h = 0.5$ is an adequate estimate for Niger in the coming years, the lesson from this experiment is clear – without reforms to strengthen the management of public resources and eliminate waste, the benefits that an increase in aid could bring in terms of achieving progress toward the MDGs would be significantly hampered. In that sense, our results accord well with the view adopted by some that governance (broadly defined to include the efficient management of public funds) must improve to make aid effective. This is in line with the conclusions of a detailed overview by Doucouliagos and Paldam (2005). Using meta-analysis of a large set of regression results, they found that the impact of aid on domestic investment and growth has been either relatively insignificant, or even when positive and significant, the effect has been small. In our framework, this can be interpreted as the consequence of poor governance.

TABLE 4
Niger: Five Percentage Point Increase in Aid-to-GDP Ratio, Simulation Results for 2007–15, Lower Efficiency of Public Investment
(Absolute deviations from baseline)

	<i>Projections</i>								
	2007	2008	2009	2010	2011	2012	2013	2014	2015
Poverty rate (2003 = 63)									
<i>(Per cent of the population living below \$2 per day)</i>									
Consumption per capita growth elasticity of -0.5	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Consumption per capita growth elasticity of -1.0	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.3	1.4
Consumption per capita growth elasticity of -1.5	0.1	0.3	0.6	0.9	1.2	1.4	1.6	1.7	1.9
Ravallion's (2004) adjusted elasticity (Gini = 50.5)	0.0	0.2	0.4	0.7	0.9	1.1	1.3	1.4	1.6
Literacy rate	-0.2	-0.3	-0.5	-0.6	-0.8	-0.9	-1.0	-1.2	-1.3
<i>(Per cent of educated labour in total population)</i>									
Infant mortality (2002 = 155)	-4.0	-3.0	-2.0	-2.0	-1.0	-1.0	0.0	0.0	0.0
<i>(Infant mortality rate per 1,000 live births)</i>									
Malnutrition (2000 = 40.1)	-1.2	-1.0	-0.9	-0.8	-0.8	-0.7	-0.6	-0.5	-0.5
<i>(Malnutrition prevalence, weight for age)</i>									
Life expectancy (2002 = 46.2)	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2
<i>(Life expectancy at birth, years)</i>									
Access to safe water (2000 = 59)	0.1	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2
<i>(Percentage of population with access to safe water)</i>									
COMPOSITE MDG INDICATOR	1.1	0.7	0.4	0.1	-0.2	-0.6	-0.9	-1.1	-1.4
<i>(A rise denotes an improvement)</i>									
Aid and external debt indicators									
Foreign aid (in per cent of GDP)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Aid (in per cent of total government revenue)	6.5	6.6	6.7	6.8	6.9	6.9	7.0	7.0	7.0
External debt (in per cent of GDP)	-4.7	-7.7	-10.3	-12.5	-14.6	-16.4	-18.1	-19.7	-21.2
Interest payments on external public debt (in per cent of GDP)	0.0	0.0	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.2
Interest payments on external public debt (in per cent of exports)	0.0	-0.1	-0.3	-0.5	-0.6	-0.8	-1.0	-1.1	-1.3

6. CONCLUSIONS

The purpose of this paper has been to present an integrated macroeconomic approach to monitoring progress toward achieving the Millennium Development Goals (MDGs) in Sub-Saharan Africa. At the heart of our approach is the macro model developed by Agénor, Bayraktar and El Aynaoui (2006) and extended by Pinto Moreira and Bayraktar (2006). A detailed presentation was provided in the first part of the paper. A key feature of the model is a production function that accounts explicitly for the effect of public capital (in health and infrastructure) on output and the marginal productivity of private production inputs. Public capital in education also plays a role in the production process, because 'raw' labour must be turned into educated labour to become productive. The domestic good is treated as an imperfect substitutable to the foreign good. By accounting for changes in relative prices, potential Dutch disease effects associated with aid flows can therefore be analysed. In addition, the model captures explicitly the link between aid and public investment, and the possible adverse effects of large inflows of foreign aid on fiscal accounts (most notably incentives to collect taxes). Finally, the impact of policy shocks on poverty can be assessed either by linking the model to a household survey or by using partial elasticities relating consumption growth to poverty, using a range of available estimates for low-income countries.

By linking the model through cross-country regressions to indicators of malnutrition, infant mortality, life expectancy and access to safe water, and by accounting for interactions between these variables among themselves and with poverty, we provided a consistent framework for evaluating the impact of policy decisions on the MDGs. The functioning of our framework was illustrated by simulating the impact of a five-percentage-point increase in the share of foreign aid in GDP for Niger for the period 2007–15. We conducted this experiment under two alternative assumptions regarding the degree of efficiency of public investment: high efficiency, in which 70 per cent of all investment outlays serve to increase the capital stock, and lower efficiency, where only half of every currency unit spent helps to raise the stock of public capital. Overall, our results showed that an increase in aid is essential to allow a low-income country like Niger to reach the MDGs at the horizon 2015. At the same time, however, the magnitude of the required increase, if the elasticity of poverty with respect to consumption growth is relatively low, and if public investment is relatively inefficient, may well be unfeasible due to absorption constraints. In such conditions, a gradual and sustained increase in foreign assistance may be preferable.

The analysis presented in this paper can be extended in various directions. It would be important, for instance, to account for the impact of health on educational attainment – and thus indirectly on growth, poverty and other social indicators. A large body of evidence – aptly documented by Wagstaff and Claeson (2004) and Bundy and others (2005), and further discussed by Agénor and

Moreno-Dodson (2006) – has shown that health is an important factor in determining both the quantity and quality of human capital. Healthier children tend to do better in school, just like healthier workers perform their tasks better (as captured in our macro model). This, in turn, stimulates growth (see Agénor and Neanidis, 2006). Accounting for these effects in an operational context may be quite challenging, due to the difficulty of estimating reliable parameters with limited data, but would be well worth the effort.

Another issue worth investigating is the possibility of ‘reverse linkages’ between the MDGs and the macro model. At the moment, the only feedback effect is from the literacy rate to the supply side. But several other channels could be envisioned. For instance, as indicated by a dotted line in Figure 4, a high poverty rate could lower the propensity to save and invest, along the lines of the ‘vicious circle’ described by Nurkse (1953). We are currently pursuing this line of research. Alternatively, malnutrition could be modelled as having an adverse effect on labour productivity – a well-documented fact in micro studies (see Broca and Stamoulis, 2003). Estimating these relationships could be difficult at the country level, but using cross-country regressions (as was done here) could help to alleviate problems of degrees of freedom.

Our contention, however, is that even in its present form the approach proposed in this paper does provide policymakers in Sub-Saharan Africa with a unique operational framework to quantify the impact of some key policy choices on their ability to achieve the MDGs. Many observers agree that a fundamental policy issue for many low-income countries is the allocation of public investment – an issue that lies at the heart of our approach.

Moreover, our approach has considerable practical appeal. We know quite well how to build more complicated models, with multiple sectors and households, while at the same time capturing also the dynamics of public investment, segmented labour markets, credit market imperfections, and many other important features that matter for growth and employment. A prominent class of models in that category is IMMPA, which has been applied to a number of middle-income countries, including Bolivia, Brazil, Colombia, Morocco, Tunisia and Turkey (see Agénor, Izquierdo and Jensen, 2006). However, in a low-income environment where data are limited and human capital scarce, building complex models may simply not be feasible. The macro model that lies at the core of our approach was built in about six to eight months for two countries (Ethiopia and Niger) for which data are comparable in quality and availability to other LICs in Sub-Saharan Africa. Using the cross-country regressions presented in this paper, our approach should be therefore relatively easy to replicate for a number of other countries in the region. Doing so would enable these countries to strengthen the analytical basis for designing their PRSP and improve the quality of the policy debate – particularly regarding the likely effects of increased aid and the level of assistance needed to meet the MDGs.

Our approach also brings to the fore the limitations of the current concept of 'Poverty Reduction' Strategy Papers. The implicit focus on poverty in this approach is too narrow, and does not account for the fact that other social indicators may be equally important in assessing the implications of a particular development strategy. The fact that such indicators may be correlated with poverty does not imply that reducing the incidence of poverty will necessarily lead to improvements in those dimensions as well; targeted policy measures may be essential. A more encompassing term than PRSP, emphasising the different dimensions of human development, would redress any sense of imbalance in policy objectives and strategies to attain them. Our proposed term is Strategy Papers for Human Development, or SPAHD. This is more, in our view, than simply a matter of semantics. It would help to provide a constant reminder to all parties involved that although it is increasingly clear that many low-income countries are unlikely to attain the MDGs by the target date of 2015, the objectives set forth in the Millennium Declaration should remain a focal point of the development agenda for years to come.

APPENDIX

Data and Cross-section Regressions

As described in the text, the focus of our macroeconomic approach is on six of the MDG indicators. Because the model can directly calculate values for the poverty and the literacy rates, we only ran regressions to estimate the equations for infant mortality, malnutrition, life expectancy and access to safe water. The estimation method is ordinary least squares. We use cross-section data, obtained by taking average values of variables for each country for the period 1965–2003, depending on the availability of data series. Our sample consists of Sub-Saharan countries. This appendix provides more detail about the data and the regressions.

The main data source of the regressions is World Development Indicators and World Bank African Database (unless otherwise specified). The following Sub-Saharan African countries are included in the sample:¹⁹ Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Côte d'Ivoire, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, São Tomé and Príncipe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania,

¹⁹ The number of countries included in each regression changes, depending on data availability.

Togo, Uganda, Zambia and Zimbabwe.²⁰ The time period is 1965 and 2003, depending on data availability.

Due to insufficient number of data points for Sub-Saharan countries, all developing countries are included in the improved water source regressions, depending on data availability. The list of countries included in the 'improved' water source regressions is: Argentina, Bolivia, Brazil, Bulgaria, Burkina Faso, Cameroon, Colombia, Côte d'Ivoire, Dominican Republic, Egypt, Ethiopia, Hungary, India, Indonesia, Iran, Madagascar, Maldives, Mauritius, Mexico, Morocco, Myanmar, Nepal, Nicaragua, Paraguay, Sri Lanka, Syria, Thailand, Tonga, Tunisia, Turkey, Vanuatu and Yemen.

The list of variables and their definitions are as follows:

Malnutrition prevalence, weight for age (per cent of children under five):

Prevalence of child malnutrition (weight for age) is the percentage of children under five whose weight for age is more than two standard deviations below the median reference standard for their age as established by the World Health Organisation, the US Centres for Disease Control and Prevention, and the US National Centre for Health Statistics. Figures are based on children under age three, four and five years of age, depending on the country.

Mortality rate, infant (per 1,000 live births): Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.

Life expectancy at birth, total (years): Life expectancy at birth indicates the number of years a newborn infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.

Improved water source (per cent of population with access): Access to an improved water source refers to the percentage of the population with reasonable access to an adequate amount of water from an improved source, such as a household connection, public standpipe, borehole, protected well or spring, and rainwater collection. Unimproved sources include vendors, tanker trucks, and unprotected wells and springs. Reasonable access is defined as the availability of at least 20 litres a person a day from a source within one kilometre of the dwelling.

Public health expenditure in per cent of GDP: Public health expenditure consists of recurrent and capital spending from government (central and local)

²⁰ The regression results are robust to excluding oil-exporting countries and South Africa. The results obtained using this smaller dataset are presented in Table A2.

budgets, external borrowings and grants (including donations from international agencies and non-governmental organisations), and social (or compulsory) health insurance funds.

Public infrastructure expenditure in per cent of GDP: Public infrastructure expenditure consists of energy, transportation and communication. The data source is Government Financial Statistics.

Final private consumption expenditure in per capita terms (in constant 2003 US dollars): Household final consumption expenditure (private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licences. Here, household consumption expenditure includes the expenditures of non-profit institutions serving households, even when reported separately by the country.

GDP in per capita terms (in constant 2003 US dollars): GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources.

Population density (people per sq. km): Population density is mid-year population divided by land area in square kilometres. Population is based on the *de facto* definition of population, which counts all residents regardless of legal status or citizenship – except for refugees not permanently settled in the country of asylum, who are generally considered part of the population of their country of origin. Land area is a country's total area, excluding area under inland water bodies, national claims to continental shelf and exclusive economic zones. In most cases the definition of inland water bodies includes major rivers and lakes.

Poverty headcount ratio at national poverty line (per cent of population): National poverty rate is the percentage of the population living below the national poverty line. National estimates are based on population-weighted sub-group estimates from household surveys.

Estimation results are shown in Tables A1 to A2.

We explain the malnutrition prevalence rate by public health expenditure in per cent of GDP, real private consumption per capita and poverty. The estimated

TABLE A1
Cross-section Regression Results
(All Sub-Saharan countries are included unless otherwise indicated)

	<i>Dependent Variables</i>			
	<i>MALNUTRITION</i>	<i>ln(MORTALITY)</i>	<i>ln(LIFE_EXP)</i>	<i>WATER</i> ²
Constant term	75.415 (6.055)	5.485 (10.761)	3.428 (27.187)	6.711 (0.299)
HEA_P_GDP ¹	-4.790 (-3.961)	-0.091 (-1.949)	0.048 (2.802)	...
ln(CPPC2003\$)	-7.951 (-4.126)	...	...	...
POVERTY	0.144 (1.635)	0.011 (3.247)	-0.002 (-2.771)	...
ln(GDPPC2003\$)	...	-0.191 (-2.820)	0.078 (4.189)	6.921 (2.458)
INF_GDP	...	...	...	1.702 (1.718)
ln(POP_DENSITY)	...	...	...	4.076 (1.551)
Number of observations	28	31	20	31
Adjusted <i>R</i> ²	0.552	0.479	0.739	0.292

Notes:

The estimation technique is OLS. Data points of independent variables in each country correspond exactly to the years in which dependent variables are available. First, averages at the country level are calculated, then the regression equations are run using these cross-sectional data. *t*-Statistics are reported in parentheses. MALNUTRITION is malnutrition prevalence, weight for age (per cent of children under five); HEA_P_GDP is public health expenditure in per cent of GDP; CPPC2003\$ is private consumption per capita (in constant 2003 dollars); POVERTY is the per cent of population living under \$2 per day; MORTALITY is infant mortality rate (per 1,000 live births); GDPPC2003\$ is GDP per capita (in constant 2003 dollars); LIFE_EXP is life expectancy at birth, total years; INF_GDP is public infrastructure expenditure in per cent of GDP; WATER is percentage of population with access to safe water; POP_DENSITY is population density (people per sq. km).

¹ While the data source of public health expenditure is Government Financial Statistics in the life-expectancy regression, the data source of public health expenditure is World Bank African Database in other regressions.

² Due to an insufficient number of data points for Sub-Saharan African countries, all developing countries are included depending on data availability.

coefficients of the first two variables have a negative sign and are statistically significant. This indicates that both public health expenditure and private consumption reduce the malnutrition prevalence rate. The coefficient of poverty is positive, which indicates that as poverty decreases, malnutrition prevalence falls as well.

Infant mortality is explained by public health expenditure, GDP per capita and poverty. The estimated coefficients of public health expenditure and GDP per capita have a negative sign, which indicates that, as they increase, infant mortality drops. The coefficient of poverty is positive and statistically significant. This indicates that, as poverty drops, infant mortality decreases as well.

TABLE A2
Cross-section Regression Results
(Oil-exporting countries and South Africa are excluded)

	<i>Dependent Variables</i>		
	<i>MALNUTRITION</i>	<i>ln(MORTALITY)</i>	<i>ln(LIFE_EXP)</i>
Constant term	74.122 (6.138)	5.486 (10.121)	3.440 (26.203)
HEA_P_GDP¹	-5.961 (-4.542)	-0.093 (-1.733)	0.050 (2.783)
ln(CPPC2003\$)	-7.078 (-3.789)	...	...
POVERTY	0.140 (1.673)	0.011 (3.111)	-0.002 (-2.714)
ln(GDPPC2003\$)	...	-0.191 (-2.662)	0.075 (3.792)
Number of observations	26	29	19
Adjusted <i>R</i> ²	0.605	0.474	0.736

Notes:

The estimation technique is OLS. Data points of independent variables in each country correspond exactly to the years in which dependent variables are available. First, averages at the country level are calculated, then the regression equations are run using these cross-sectional data. *t*-Statistics are reported in parentheses. MALNUTRITION is malnutrition prevalence, weight for age (per cent of children under five); HEA_P_GDP is public health expenditure in per cent of GDP; CPPC2003\$ is private consumption per capita (in constant 2003 dollars); POVERTY is the per cent of population living under \$2 per day; MORTALITY is infant mortality rate (per 1,000 live births); GDPPC2003\$ is GDP per capita (in constant 2003 dollars); LIFE_EXP is life expectancy at birth, total years.

¹ While the data source of public health expenditure is Government Financial Statistics in the life-expectancy regression, the data source of public health expenditure is World Bank African Database in other regressions.

Life expectancy is explained by public health expenditure, GDP per capita and poverty. The results indicate that both health expenditure and GDP per capita increase life expectancy. On the other hand, the coefficient of poverty is highly significant and negative, as expected. As poverty drops, life expectancy at birth increases.

The share of population with access to safe water is taken to be a function of population density, GDP per capita and public infrastructure expenditure per capita. The sign of population density is positive as expected since the average cost of building infrastructure capital may drop with higher density; thus, the share of population with access to safe water increases. The coefficient of GDP per capita is positive as well. An increase in public infrastructure expenditure per capita leads to a rise in the share of population with access to safe water increases.

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