Building Sector Concerns into Macroeconomic Financial Programming: Lessons from Senegal and Uganda

Antonio Estache and Rafael Muñoz

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About AICD

This study is a product of the Africa Infrastructure Country Diagnostic (AICD), a project designed to expand the world’s knowledge of physical infrastructure in Africa. AICD will provide a baseline against which future improvements in infrastructure services can be measured, making it possible to monitor the results achieved from donor support. It should also provide a better empirical foundation for prioritizing investments and designing policy reforms in Africa’s infrastructure sectors.

AICD is based on an unprecedented effort to collect detailed economic and technical data on African infrastructure. The project has produced a series of reports (such as this one) on public expenditure, spending needs, and sector performance in each of the main infrastructure sectors—energy, information and communication technologies, irrigation, transport, and water and sanitation. *Africa’s Infrastructure—A Time for Transformation*, published by the World Bank in November 2009, synthesizes the most significant findings of those reports.

AICD was commissioned by the Infrastructure Consortium for Africa after the 2005 G-8 summit at Gleneagles, which recognized the importance of scaling up donor finance for infrastructure in support of Africa’s development.

The first phase of AICD focused on 24 countries that together account for 85 percent of the gross domestic product, population, and infrastructure aid flows of Sub-Saharan Africa. The countries are: Benin, Burkina Faso, Cape Verde, Cameroon, Chad, Côte d’Ivoire, the Democratic Republic of Congo, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, South Africa, Sudan, Tanzania, Uganda, and Zambia. Under a second phase of the project, coverage is expanding to include as many other African countries as possible.

Consistent with the genesis of the project, the main focus is on the 48 countries south of the Sahara that face the most severe infrastructure challenges. Some components of the study also cover North African countries so as to provide a broader point of reference. Unless otherwise stated,
therefore, the term “Africa” will be used throughout this report as a shorthand for “Sub-Saharan Africa.”

The World Bank is implementing AICD with the guidance of a steering committee that represents the African Union, the New Partnership for Africa’s Development (NEPAD), Africa’s regional economic communities, the African Development Bank, the Development Bank of Southern Africa, and major infrastructure donors.

Financing for AICD is provided by a multidonor trust fund to which the main contributors are the U.K.’s Department for International Development, the Public Private Infrastructure Advisory Facility, Agence Française de Développement, the European Commission, and Germany’s KfW Entwicklungsbank. The Sub-Saharan Africa Transport Policy Program and the Water and Sanitation Program provided technical support on data collection and analysis pertaining to their respective sectors. A group of distinguished peer reviewers from policy-making and academic circles in Africa and beyond reviewed all of the major outputs of the study to ensure the technical quality of the work.

The data underlying AICD’s reports, as well as the reports themselves, are available to the public through an interactive Web site, www.infrastructureafrica.org, that allows users to download customized data reports and perform various simulations. Inquiries concerning the availability of data sets should be directed to the editors at the World Bank in Washington, DC.
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About the authors

Antonio Estache is a member of the faculty of the European Centre for Advanced Research in Economics and Statistics at the Université Libre de Bruxelles (Belgium). Rafael Muñoz is an economist at the World Bank.
Abstract

Underinvestment in infrastructure, health, and education during much of the 1990s has ignited a lively debate on whether some countries could tolerate a larger public deficit if the additional resources were invested in growth-enhancing sectors. The financial programming model used by the International Monetary Fund in its macroeconomic analyses does not explicitly recognize a link between public investment and growth—only the short-term costs of investments are taken into account, not their effect on growth. Yet many economists maintain that the growth-inducing effects of sectoral investment decisions should not be ignored. By running a short-term deficit now, they argue, investments can be made that will produce growth and make it easier to balance the budget later.

Our model is a first attempt to use the IMF’s financial programming tool to incorporate microeconomic sector information relevant to growth into macroeconomic analysis and planning. We do this by supplementing the financial programming tool with details pertinent to the sectors of infrastructure, health, and education. Particularly important are the effects of operations and maintenance (O&M) expenditures in infrastructure and current expenditures in the social sectors, as well as the quality of capital stock, as proxied by O&M expenditures. Stock quality, often ignored at the macro level, has a large impact on the productivity of capital.

We use our model to compare the impact of additional investment in each sector on output growth and debt sustainability in Uganda and Senegal. Implicit in that approach is our belief that the true macroeconomic impact of public investment depends on its sector composition and on its distribution between new investment and spending for O&M. Our principal aim is to assess the extent to which a set of sector-specific public investments may be at least partially self-financing and how those investments may improve the debt-to-output ratio by stimulating growth in the medium term—that is, beyond the horizon typically considered by financial programming exercises.

Application of the model to Uganda and Senegal demonstrates that country specificity remains essential when evaluating output growth and debt. In Uganda, investment in infrastructure enhances output, but also, because of its relatively low productivity, worsens the debt ratio. The model suggests that a better way to finance infrastructure may be to improve existing capital stock by allocating expenditures to O&M rather than to new investment. The model also shows that spending on health and education raises output but is less efficient than infrastructure investment.

In Senegal, by contrast, investment in infrastructure does not seem to be effective in improving output growth. An alternative solution would be to spend a great deal more on O&M, where the current level of spending is very low, or on health and education—all of which have greater power than new infrastructure investment to stimulate growth in output. No matter how spending is allocated, however, it worsens the ratio of debt to GDP, reflecting the poor productivity of public spending.

Several elements relevant in macroeconomic analysis are not factored into the model. Chief among these are complementarities between investment types, monetary issues, exchange rates, and interest rates. Furthermore, the model shows the need for further research on how health and education affect output growth and how best to include sectoral data in the financial programming framework.
Underinvestment in infrastructure, health, and education during much of the 1990s has ignited a lively debate on “fiscal space”—that is, whether some countries could tolerate a larger public deficit if the additional resources were invested in growth-enhancing sectors. The two extremes of the debate may be caricatured as follows.

On one side is standard financial programming as it has been used by many economists in international financial institutions such as the International Monetary Fund (IMF). The financial programming model does not explicitly recognize a link between public investment and growth—only the short-term costs of investments is taken into account, not their effect on growth. The main policy implication of that position is best summarized in Heller (2005) and IMF (2005). The main message is that the only way to create fiscal space is to raise revenue, improve efficiency, or reallocate resources.

At the other pole of the debate, one finds many ministers of public works, infrastructure, education, and health arguing for the need to support the growth agenda of their countries. They would like to get the IMF to adopt a different set of rules under which to assess the fiscal viability of resource-allocation decisions. In the context of a series of evaluations of the extent of infrastructure rationing, Ferreira and Gonçalves (2005), Glomm and Rioja (2004), and Suescun (2005), among others, have proposed an alternative set of fiscal principles designed to increase the gross domestic product (GDP) through the asset-building power of public spending on infrastructure in developing countries. Investments in infrastructure, they argue, create assets in the public sector that yield increasing gains over time and thus must not be judged by their short-term financing cost alone. The three papers propose alternative ways of measuring the sustainability and productive impact of debt-funded investment in economic growth.

In this paper, we try to accommodate these two extreme positions, incorporating into traditional macroeconomic financial programming some of the sector reallocation, earmarking, and prioritization with which governments are generally concerned. To this end, we try to show how a simple extension of the standard macroeconomic financial programming model could explicitly link public spending for infrastructure, health, and education to economic growth while maintaining the useful simplicity of this standard tool. This simple model can then be used to evaluate the effect of different levels and modes of investment on GDP and public debt sustainability.

While pursuing that point, we touch on other issues as well—among them the relationship between capital investment and spending for operations and maintenance (O&M); short-term financing needs during periods of capital investment; the productivity of different forms of investment; and alternative financing sources.

We apply our model to two countries in Africa—Uganda and Senegal. The exercise is intended to be illustrative only, as deeper knowledge of the sectors and constraints of both economies would be required to produce ready-to-use policy advice. However, in spite of its simplicity, the approach provides analytical support for future efforts to reconcile the two poles of the debate described above.

The paper is organized as follows. The first section illustrates some of the main issues raised by the debate over fiscal space in the context of infrastructure. The next section offers general notes on the

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1 Similar proposals have emerged in Europe in the context of the debate on fiscal convergence. See, for instance, Blanchard and Giavazzi (2004), Buiter (2003) and Buiter and Grafe (2004).
potential value of an alternative approach to financial programming. There follows a formal presentation of the revised financial programming model, including some of the crucial assumptions that need to be made to document the fiscal space debate. We then present case studies of Uganda and Senegal before concluding.

1 Investment matters for growth: the case of infrastructure

Investment in public infrastructure has been recognized as an important source of improved competitiveness and production gains for firms (Prud’homme 2004), with very positive effects on private capital accumulation, poverty reduction, and outcomes in education and health (Estache 2006). The public sector has traditionally been the main source of infrastructure finance, which today ranges between 2 percent of GDP in middle-income countries to 4 percent of GDP in low-income countries. However as Briceño, Estache, and Shafik (2004) point out, these figures are around 3 percent lower than the average estimated investment needs for developing countries. The shortfall hinders growth and slows welfare improvements in developing countries.

Public investment in infrastructure declined for most of the 1990s in most developing countries. Calderón and Servén (2004) show that in eight Latin American countries, public sector investment during the 1990s fell from 3 percent of GDP to 0.8 percent. Similar trends are seen in other regions. Even the World Bank reduced its lending for infrastructure—from 40 percent of total lending during the period 1987–97 to around 30 percent during 1998–2002 (World Bank 2006). Other bilateral and multilateral institutions followed similar patterns.

It was expected that the private sector would compensate for this decrease in investment, but the reality was quite different. Private sector commitments for infrastructure in developing countries during the 1990s were approximately $807 billion—no more than 22 percent of the total investment and 10–15 percent of the amount needed. Furthermore most of the investment was highly concentrated in a few countries and sectors. The private sector has not been able to make up for the reduction of public investment, chiefly because policies and regulatory frameworks in developing countries remain inadequate or incomplete.

Another reason for the reduction in public investment in infrastructure was the severe fiscal adjustment that developing countries went through in the 1990s. Many countries had extremely high debts, deriving for the most part from the public sector, which led the IMF to promote adjustment programs to curb deficits. Given the stickiness of public consumption and political resistance to reducing current expenditures, most adjustments were made at the expense of public investment. Easterly and Servén (2003) found that decreases in public infrastructure investment explained 31.5 percent of Mexico’s fiscal adjustment in Mexico and 174.3 percent of Brazil’s.

The decline in investment in infrastructure provoked some subtle fiscal debates. For instance, when countries began to privatize public enterprises, mainly utilities, as part of their adjustment programs, their actions raised concerns about fiscal risks in many countries. Countries with poor regulatory controls
experienced a large increase in hidden subsidies and price-setting distortions. These have become contingent, and sometimes actual, liabilities for governments. The problem motivated the IMF, in its 2001 *Government Finance Statistics Manual*, to widen the definition of the general government sector to include government financial and nonfinancial corporations so as to better detect and analyze the extent of the government’s true fiscal risk. This issue remains at the center of the fiscal space debate in any sector where private participation may leave a residual financial liability for the government.

The bottom line, however, is that, in the minds of many development experts, the poorest countries have underallocated resources to infrastructure. Many observers are particularly concerned that the consequences of underallocation have been underestimated by the standard tools used by macroeconomists in their evaluations of fiscal performance, in particular the financial programming models used by the IMF and others to assess the fiscal sustainability of policies in the short to medium term.

The observations just made about infrastructure also apply to investment in health and education. The financial programming tools not only fail to detect overall levels of underinvestment; they also produce no insight into the optimal sectoral composition of resource allocations. A recurring theme in the fiscal space debates, the efficiency of public expenditures has been the subject of many estimates that have proven quite controversial (Estache, Gonzalez, and Trujillo 2006). The issue of allocational efficiency is implicit in the split between new investment and expenditures for O&M. Most donors will finance only new investment in infrastructure, which may improve coverage but often at the cost of underinvestment in O&M. Inadequate attention to O&M can quickly render infrastructure obsolete or useless.

**2 Toward a better financial programming model**

The IMF uses macroeconomic financial programming to ensure that nations’ macroeconomic, fiscal, and balance-of-payments positions are consistent in the medium term. It is essentially a top-down approach, in which assumptions about GDP growth are fed into fiscal, monetary, and balance-of-payments equations. The model does not optimize economic behavior, and so it cannot be used to determine the potential costs and benefits of alternative public choices. Under the model, an increase in sector-specific public investments can only drain the fiscal balance. In its present form, the model cannot incorporate feedback from investments into other macroeconomic or fiscal variables. With respect to investments in infrastructure, health, or education, the model as it presently stands cannot estimate their net fiscal cost over time for the simple reason that it ignores the benefits of the investments.

In this paper, while maintaining the simplicity and the relatively low data requirements of the IMF’s current financial programming tool, we that tool on its head by making growth and key fiscal variables a function of the government’s spending for infrastructure, health, and education. We then adapt it to incorporate both first-order effects (the direct and immediate fiscal impact of the expenditure) and second-order effects (the feedback of those expenditures on economic activity and key fiscal variables, as well as on related O&M spending). Our principal aim is to assess the extent to which a set of sector-specific public investments may be at least partially self-financing and how these investments may
improve the debt-to-output ratio by stimulating growth in the medium term—that is, beyond the horizon typically considered by financial programming exercises.

Our revision of the financial programming tool makes it possible to:

- Explicitly identify public expenditures in the fiscal framework
- Track the effect of those expenditures on growth and fiscal outcomes.

In standard financial programming an economy is identified by four related blocks representing real variables, the fiscal and monetary accounts, and the balance of payments. Our revision requires us to estimate the impact of public infrastructure on the growth and fiscal variables. The first-order effects of public investment fall on the monetary accounts and/or the balance of payments. Their second-order effects are to benefit households by improving welfare and stimulating growth through lower production costs and larger markets for firms. In the medium term, growth also may increase tax revenue.

The idea is not to endogenize growth but rather to evaluate the self-financing capacity of investments in some sectors of the economy, such as infrastructure or education, and to gauge their effect on the ratio of public debt to GDP. As a first approximation of this assessment of the ability of sectors to self-finance over time, we relate the impact of any sectoral expenditure on value added, developing an incremental capital–output ratio (ICOR) to represent the economic effect of investing in that sector, whether it is infrastructure, health, or education. Of particular interest is the ability of assessing the interactions between sectors, including the trade-offs that may arise when budget constraints are binding.

The upgraded financial programming tool also allows assessments of alternative sources of investment funds (tax revenues, loans, grants), with the aim of identifying optimal choices from a fiscal viewpoint. In making this assessment, we assume that the implementation time of investment projects typically ranges between 12 and 24 months, with more time required for education. During this period only the financing requirements, and not their payoff, are relevant.

Ultimately, the most relevant feature of the model is its consistency with the IMF’s financial programming tool. This allows us to show, quantitatively, the impact of an explicit modeling of public investment choices by comparing the results of the model with and without the upgrade. It also enables us to use without modification readily available data on the tax rate, internal and external debt ratios, and other external information (such as the share of exports and imports in GDP). Wherever possible, we simplify variables not pertinent to the main analysis (principally those in the monetary accounts or the balance of payments). This enables us to develop a theoretical model that is simple enough to be replicated using the financial programming tool but with few computational or data needs.

Our model, like the standard financial programming model on which it is based, is far from best practice for modeling an economy. Its main advantage is that it is consistent with the type and quantity of data available for many of the poorest countries of the world where the rationing of growth can have dramatic consequences.

In the rest of this section, we first provide a brief presentation of the core model. We then show how we include the ICOR to ensure an explicit linkage between a country’s investment program and its growth rate. We end with a discussion of the additional assumptions we had to make to keep the model manageable.
The core model

This section presents a technical discussion of our upgrade of the standard financial programming model used by the IMF.

We adopt the description of the economy proposed by Kahn and others (1988). Output (Y) and imports (Z) can be consumed by the private sector (Cp) or the public sector (Cg), exported (X), or invested either by the private sector (Ip) or the public sector (Ig) in various forms of infrastructure (electricity, roads, rails, fixed-line or cellular telephones, water and sanitation) or in health or education. In addition to net investment we also consider the cost of operating and maintaining these capital stocks (O&M):

\[ Y - C_p - C_g - I_p - I_g - O&M - X + Z = 0 \]

aggregate economy

From the supply side, output is the sum of value added in agriculture (VAag), industry (VAind), and services (VAser).

We seek to analyze the behavior of the public and private sectors, and especially to account for the savings of each sector and how deficits are financed. We assume that the private sector holds all output (Y), which it uses to pay taxes (T), consume (Cp), and invest (Ip). The net accumulation of financial assets by the private sector consists of money (ΔM) and foreign assets (ΔFp), less domestic borrowing from the banking system (ΔDp).

\[ Y - T - C_p - I_p = \Delta M + \Delta F_p - \Delta D_p \]

private sector

The public sector receives taxes from the private sector (T), which it uses to consume (Cg), finance O&M of capital stocks, and invest in new infrastructure, health, and education (Ig). Any surplus is accumulated in the form of net foreign assets (ΔFg), less net borrowing from the banking system (ΔDg).

\[ T - C_g - I_g - O&M = \Delta F_g - \Delta D_g \]

public sector

The balance of payments is a representation of the foreign sector. Revenues flow in from the sale of exports (X), and expenditures are made for imports (Z). Any excess of revenues over expenditures—that is, a current account surplus—places the economy in a credit position with respect to the rest of the world. That credit can take the form of foreign assets held either by the private sector (ΔFp) or the public sector (ΔFg) or an increase in international reserves (ΔR).

\[ X - Z = \Delta F_p + \Delta F_g + \Delta R \]

balance of payments

The banking system, represented by the central bank, holds assets in the form of international reserves (ΔR) and loans to the private sector (ΔDp) and public sector (ΔDg). These assets, combined, mirror the money supply (ΔM), a liability.

\[ \Delta M = \Delta R + \Delta D_p + \Delta D_g \]

banking system

Annex 1 presents in graphic form the main macroeconomic relationships among accounts in the standard IMF financial programming and the revised model proposed here.
Introducing feedback effects: the ICOR solution

The idea of introducing feedback effects in the tools used to assess the fiscal viability of public investment programs is not new. The model used by many at the World Bank to provide quantitative support to the macro policy dialogue with many of the poorest countries (the Revised Minimum Standard Model, or RMSM) is based on the historical Harrod-Domar model but has been adapted to include all the monetary accounts of the IMF standard financial programming model. In this upgraded Harrod-Domar model, the feedback effect is supplied by the active use of an incremental capital–output ratio (ICOR), which translates investment into output at a constant rate and is used as a measure of the efficiency of investment. That model also addresses explicitly the financing gap between national savings and the investment needed to achieve a given growth target, another feature of interest in the context of the debate on how much public investment to tolerate when fiscal constraints prevail. The financing gap is a measure of the country’s need for external capital or international aid.

When applying the model, economists typically pin down the target output and the ICOR, extrapolating from the previous relationship between output growth and investment. The ICOR varies by country, but the most common values range between four and seven. Domestic savings are then computed, yielding the balance-of-payments deficit and the financing gap.

The RMSM makes several important assumptions of relevance to the analysis we are conducting here. First, it assumes that investment spending is the only determinant of growth, with no attention to labor scarcity or technological growth. Second, it does not consider allocation of investment between sectors, assuming instead that all sectors represent equally efficient investment opportunities. Third, it stipulates a fixed relationship between investment and growth, disregarding the longer maturities of certain types of investment.

Some of the consequences of the model are analyzed by Easterly (1999). Economic theory rejects the assumption of constant returns from output to investment. As capital productivity decreases, growth can occur only if the productivity of labor or technology rises. Furthermore, neither neoclassical nor endogenous growth theory supports the use of ICOR as a measure of investment quality. Based on cross-country data for developing countries, Easterly also rejects the assumption that all aid is actually invested, as well as the short-run link between investment and growth.

Although Easterly’s critiques are correct, the ICOR assumption provides a simple and appealing growth model, which IMF’s financial programming lacks. In a way, ICOR is used to estimate the short-run efficiency of investments in growth, with labor and technology held fixed, based on the previous relationship between investment and growth. A practical risk arises from the fact that in many developing countries a great deal of current public expenditure is lumped in with investment to raise the amounts subject to financing through external aid. We deal with this risk by estimating ICOR by sectors, which also serves to improve the model’s sensitivity to allocation efficiency. If the dataset allows, one can incorporate into the model alternative time lags between investment and growth. The time lag between investment in infrastructure and growth is based on the highest annual cross-correlation: two periods for

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2 Khan (1990) extended RMSM to include monetary accounts.
3 Easterly (1999) considers a standard ICOR to be around three, normally ranging between two and five.
electricity, roads, rail lines, water, and sanitation, and one period for the rest of investments. The time lag between education and growth is assumed to four periods (the time required to complete basic education), whereas the lag for health is assumed to be one period.

Khan, Montiel, and Haque (1988) use a simplified ICOR (ρ) of the form ΔY* = 1/ρ ΔK, which yields ρ = ΔK/ΔY*.

We prefer to express ICOR as follows:

ΔVA(i)/ VA(i) = 1/ρ(i,j) ΔK(j)/ VA(i),

where i=1,..n is a sector of the economy (n=agriculture, industry, or services) and where j=1,..m is a type of investment (m=electricity, roads, rail, fixed-line telephone, mobile telephone, water and sanitation, education, health, and private investment), so that the ICOR per sector is

ρ(i) = ΔK / ΔVA(i)

In this case, 1/ρ(i) = ΔVA(i)/ΔK can be seen as a measure of the productivity of capital accumulation. For any sector, the sum of the ICOR for each type of investment is the ICOR of the total investment. 4

ρ(i) = ∑ρ(i,j) for i=1,...n and j=i,...m

Taking into account longer lag periods, so that value added per sector is affected by investment after a lag of t–s, we get, 5

ΔVA(i,t)/ VA(i,t) = 1/ρ(i,j,t) [ΔK(j,t-s)/ΔK(t-s)] [ΔK(j,t-s)/VA(i,t)]

The increase in value added can be explained by a weighted average of the productivity multiplied by the increase in the different type of investment.

Actual capital follows:

K*(t) = I(t-1) + (1 – δ) K* (t-1)

We use a measure of capital that incorporates quality as approximated by expenditures on O&M:

K* = K + O&M(t–1)

The public sector may invest in alternative types of infrastructure, each of which has a different effect in each sector (agriculture, industry, or services) and at a different pace (depending on the time required for the investment to become productive). Expenditures on O&M are assumed to be a proportion of

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4 Proof. Assuming ρ(i) = ΔK / ΔVA(i), decompose capital accumulation in the different types of investment as ΔK= ∑ΔK(j). To get ρ(i) = ΔK / ΔVA(i) = ∑ΔK(j)/ ΔVA(i) = ∑ρ(i,j) ΔK(energy) / ΔVA(i) + ΔK(roads) / ΔVA(i) + ...+ ΔK(private) / ΔVA(i) = ρ(i, energy) + ρ(i, roads) + ...+ ρ(i, private)

5 Proof. For notational simplicity we do not consider time lags in the proof.

ΔVA(i)/ VA(i) = 1/ρ(i,j) ΔK(j)/ VA(i) = 1/ρ(i) ∑ΔK(j)/ VA(i) = ∑1/ρ(i,j) ΔK(j)/ VA(i) =

= ∑[ΔVA(i)/ ΔK] [ΔK(j)/ VA(i)] [ΔK(j)/ ΔK(j)].

Rearranging the terms, ∑[ΔVA(i)/ΔK(j)] [ΔK(j)/ΔK] [ΔK(j)/VA(i)] = ∑1/ρ(i,j) [ΔK(j)/ΔK] [ΔK(j)/VA(i)]
investment and to improve capital quality with a lag of one year. Thus, for each sector, effective capital evolves as follows:

\[ K^*(t) = I(t-s) + (1 - \delta) K^*(-1) \]

We do not directly observe the capital stock for education and health. Instead, we assume that both sectors have a positive impact on growth in the form of human capital. We further assume that both current expenditure and investment in health and education are equally relevant in promoting growth. We also consider a minimum expenditure threshold for health and education, below which spending is insufficient and not able to boost GDP. In the case of the countries we analyze, these thresholds are, for health and education respectively, 4.6 and 2.9 percent of GDP, based on orders of magnitude available from a review of the experience and a calibration of the model. Other specifications of the social sectors will be also explored later on.

Effective health = \( I(t-1) + O&M(t-1) - 4.6 \text{ percent of GDP} \)

Effective education = \( I(t-1) + O&M(t-1) - 2.9 \text{ percent of GDP} \)

Value added per sector can be expressed as a function of investment:

\[ VA(i) = VA(i,t-1) \left[ 1 + \sum l/p(i,j,t) \left[ \Delta K(j,t-s)/\Delta K(t-s) \right] \left[ \Delta K(j,t-s)/VA(i,t) \right] \right] \]

where \( j=1,..,m \) represents the ten different investment options (seven infrastructure types, plus education, health, and private investment) and \( i \), the three sectors of the economy (agriculture, industry, and services).

Finally, aggregate output is the sum of value added in the three sectors:

\[ Y = VA_{ag} + VA_{ind} + VA_{ser} \]

**Other assumptions**

We assume that the government levies taxes as a fixed proportion of GDP: \( T = \alpha Y \)

We also consider alternative financing sources as non-tax revenues and foreign grants. Private consumption is the variable that preserves balance in the national account:

\[ C_p = Y - C_g - I_p - I_g - O&M - X + Z \]

At this stage we make some assumptions about several variables to simplify our model:

- **Prices.** Inflation is not considered.
- **Capital.** No complementarity between private and public capital is considered.

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6 We consider a fixed time effect of investment on capital. It would be more accurate to consider a form like \( K^*(t) = \sum s I(t-s) + (1 - \delta) K^*(-1) \), where \( s \) represents the years needed for an investment to become effective. Unfortunately, we are not able to compute these results and thus use the single-impact effect of investment on capital.

7 An expenditure of 4.6 percent of GDP on health in Uganda represents around US$12 per person per year, the cost of a package of minimum health services proposed by the *World Bank Development Report 1993: Investing in Health*. There is no analogous estimate for a minimum education package. We have assumed 2.9 percent of GDP, in line with previous years’ education expenditure.
• **Interest rates.** Interest rates are not specified.

• **Exchange rate.** No exchange rate is assumed. Exports and imports are determined exogenously.

• We assume no money growth (ΔM) or increase in reserves (ΔR).

A full specification of the model is presented in annex 2.

3 **Calibrating the model for Uganda**

We calibrate the model for Uganda using data from IMF’s financial programming at constant 1997 prices. Parameters are set to their estimated value for the period considered.

**The main macro assumptions**

The yearly tax collection rate, \( \alpha \), is chosen from the financial programming for the corresponding year, a value that fluctuates around 16 percent of total GDP.

Absolute values for output (Y), public consumption (Cg), public investment (Ig), exports (X) and imports (Z), taxes (T), nontax revenue (Tn), and grants and private investment (Ip) are taken from financial programming for 2004 and beyond. The IMF’s financial programming for Uganda forecasts variables up to 2010; we make assumptions about their growth thereafter. We assume that public investment grows 10 percent per year after 2010 and public consumption at the average growth rate of the last five years. The remaining exogenous variables follow the previous year’s growth rate. Private consumption (Cp) keeps the national account in balance.

Forecasts of exports (X) and imports (Z) are included as the proportion of actual GDP as considered in the IMF’s financial programming. Grants are taken in absolute terms from the financial programming for Uganda.

Depreciation data are taken from Fay and Yepes (2002). The ratio of O&M expenditures to investment expenditures is computed from the Uganda database on investment expenditure in infrastructure for 2004.

**Estimating initial infrastructure stock for Uganda**

Because data on the various types of investments in infrastructure are not available, we derive them from differences in capital stock. To obtain the stock of infrastructure for Uganda in 2000, we use data
from Fay and Yepes (2002). Their dataset includes the number of telephone mainlines, number of mobile telephones, electric generation capacity in megawatts, kilometers of paved roads and rail lines, and as well as the percentage of the population with access to safe drinking water and improved sanitation. Together with these data on capital stock, the authors provide unit costs, deflated at 1997 prices for homogeneity with the rest of the economic variables.

We compute the U.S.-dollar value of Uganda’s infrastructure stock for 1990, 1995, and 2000 and convert prices to Uganda shillings (USh) at the average exchange rate for the year. We then annualize the infrastructure stock to get a full annual data series for the period 1990 to 2004 (figure 1). Table 2 compares the stock of infrastructure capital in Uganda with the average in low-income countries, taken from Fay and Yepes (2002).

### Table 2 Infrastructure stock in Uganda in 2000

<table>
<thead>
<tr>
<th>Stock</th>
<th>Unit cost (US$, 1997 constant prices)</th>
<th>Value of stock (in US$ thousands)</th>
<th>Share of each infrastructure type in total public infrastructure stock (percent)</th>
<th>Average share of each infrastructure type in total public stock in low-income countries (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical generating capacity</td>
<td>1,663 per Kw</td>
<td>465,582</td>
<td>8.8</td>
<td>25.6</td>
</tr>
<tr>
<td>Roads</td>
<td>358,883 per Km</td>
<td>649,094</td>
<td>12.3</td>
<td>50.9</td>
</tr>
<tr>
<td>Rail lines</td>
<td>787,639 per Km</td>
<td>984,549</td>
<td>18.7</td>
<td>7.2</td>
</tr>
<tr>
<td>Water (2001)</td>
<td>350 per household connection</td>
<td>831,341</td>
<td>15.8</td>
<td>14.5</td>
</tr>
<tr>
<td>Sanitation (1999)</td>
<td>613 per household connection</td>
<td>2,210,248</td>
<td>41.9</td>
<td>14.5</td>
</tr>
<tr>
<td>Fixed-line telephones</td>
<td>350 per line</td>
<td>23,044</td>
<td>0.4</td>
<td>1.3</td>
</tr>
<tr>
<td>Mobile telephone subscribers</td>
<td>613 per subscriber</td>
<td>113,270</td>
<td>2.1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*Note: Last two columns present the relative weight of each type of infrastructure in Uganda and the average low-income country.*

We also compute the value of capital stock from 2000 to 2004, following different alternatives for each kind of stock (figure 1). Data on fixed-line and mobile telephones are taken from Estache and Goicoechea (2005). We determine the value of electrical generating capacity for 2003 and extrapolate values for 2001, 2002, and 2004.

We use the growth of roads and rail lines in value terms used in IMF’s financial programming. We take investment in water and sanitation for 2003 and 2004 (the only years available) from Uganda’s National Water and Sewerage Corporation (NWSC), figuring a 3 percent depreciation of existing capital per year. We deem that investment is equally divided between water and sanitation, because we cannot determine the sector in which spending actually occurred.

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8 Total number of households is obtained from UN Habitat. We assume that the percentage of households connected to water and sanitation is the same as the percentage the population connected to water and sanitation.

9 Data series are very short for water and sanitation and for mobile telephones.
Capital stock is expressed relative to GDP for 2004, our calibration year (table 3). The total capital-output ratio is taken from the economc.dta dataset available from the Harvard University website, which provides data on the capital-output ratio for Uganda in 1990. 10 From that year onward, investment and output are taken from national accounts, and capital is computed using a perpetual inventory method:

\[ K = I + (1 – \delta) K(-1) \]

Following Klenow and Rodriguez Clare (1997) the depreciation rate of capital, \( \delta \), is set at 3 percent. Data on public spending for health and education and value added per sector (agriculture, industry, and services) are taken from financial programming.

**Estimating the ICOR for Uganda**

The measurement of productivity,11 while a key element of the model, is compromised by data gaps. Unfortunately, we know very little about the true levels of public investment in infrastructure, the amounts actually devoted to O&M, the subsidies provided to state-owned enterprises, and the sums spent by those enterprises. The importance of each of these quantities is acknowledged by economists, and the World Bank is making an effort to collect and process these data as part of its new focus on Africa’s infrastructure.

Although ICORs are a controversial measure of the sector-output growth link we use them as a simple and standard measure to link sector investment to output growth, knowing (i) that ICORs do not

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10 http://africa.gov.harvard.edu/data/economc.htm#top
11 We measure productivity as the inverse of ICOR, that is, as the impact of investment on economic growth.
incorporate future structural changes (for example, privatizations) and (ii) that data series are very short, weakening the ICOR estimation. Although we assume that the rate of growth of private investment is the same as that of public investment, we consider that deviations from the growth rate of public investment (either infrastructure or social sectors) will not affect the growth rate of private investment but rather will diminish private consumption. We therefore assume that public investment has only a direct impact on growth, without considering its “second-round” effects, which would further improve the productivity of private investment. While the complementarity between social expenditures, infrastructure, and private capital is obvious, we lack specific knowledge of their relationship and of the binding constraint on growth in each country. Hence, we have chosen not to include this link in the model.

Productivity is even more difficult to calculate in social sectors, where the effectiveness of current expenditures rather than capital stock is the key variable. To reflect this difference, we test specifications of the model that differentiate between investment spending and current spending and others that build in no minimum required expenditures. The model’s results vary greatly depending on the specification. That variance is not a reason to disregard the results, but it does suggest that further research will be needed to find a specification and a productivity measure that can be widely accepted.

The ICOR for Uganda is computed for 2000–04 as

\[ \Delta VA(i)/ VA(i,–1) = 1/\rho \Delta K(j,s)/ K(s–1) \]

where i refers to agriculture, industry, or services, and j refers to infrastructure (electricity, roads, rail lines, water, sanitation, telephones). We measure the ICOR of investment in any type of infrastructure using the same lags we applied to the effect of investment on overall growth in output.

Following the previous specification, we estimate the impact of each type of capital on each sector’s value added (1/ICOR) —30 different ICORs (table 4).

| Table 4  | Impact of various types of capital on value added (1/ICOR) in economic sectors in Uganda |
|---------------------------------|--------------------------|--------------------------|--------------------------|
| Value added                     | Agriculture              | Industry                 | Services                 |
| Electrical generating capacity  | 2.52                     | 2.56                     | 5.36                     |
| Fixed-line telephones           | 15.57                    | 26.60                    | 46.02                    |
| Roads                           | 0.62                     | 0.51                     | 1.32                     |
| Rail lines                      | 1.20                     | 2.15                     | 3.64                     |
| Water                           | 1.23                     | 1.04                     | 2.36                     |
| Sanitation                       | 7.20                     | 17.57                    | 27.12                    |
| Mobile telephones               | 0.76                     | 0.78                     | 1.51                     |
| Health                          | 3.11                     | 2.71                     | 5.28                     |
| Education                       | 1.00                     | 1.16                     | 2.07                     |
| Private capital                 | 0.07                     | 0.08                     | 0.14                     |

*Note:* Numbers in bold show the estimated 1/ICOR after one of the estimations was discarded because of data inconsistency. The increase in value added is weighted by the share of each sector’s capital.
This procedure departs from the standard literature in several aspects:

- The standard ICOR takes into account a single type of investment. We consider 10 alternative investments, chiefly public sector infrastructure investments, but also public investments in health and education, as well as private sector investments.

- The standard ICOR considers only new investment in each period. We incorporate a measure of the quality of capital stock, as proxied by O&M spending. The failure to properly maintain infrastructure in many African countries helps to explain why, after a few years, new investment no longer produces payoffs.

- We used a dataset collected by the African infrastructure network on public investment for 2003 and 2004. The dataset presents public investment by type of infrastructure, differentiating between net investment and O&M expenditures. The dataset is complemented by data on investments made by public firms responsible for utility services, a main source of off-budget investment.\(^\text{12}\)

**Model specifications**

We test five nested specifications of the model (table 5). The first assumes no depreciation of capital, no spending on state-owned enterprises (SOEs), no spending on O&M, and no lag between investment and growth. These conditions are successively reversed to build into the model capital depreciation, SOE expenditures (not very relevant in Uganda), O&M expenditures, and a time lag between investment and growth (two periods for electricity, roads, rail lines, water, and sanitation; four periods for education; and one period for other investments, including health). We then compare the results of the models to variables forecasted from the actual IMF-financial programming, assuming a constant growth rate after 2008 equal to the average in the 2004–08 period and a decay in the debt-to-GDP ratio of 0.02 per year, similar to the average for 2004–08.

\(^{12}\) Given the lack of time series data we cannot be sure that the relationship between investment and growth is not restricted to one period. Therefore we cannot incorporate external information on the timing lag of investment impact, which we deem to be one period for fixed-line telephones, mobile phones, and private investment; two periods for water, sanitation, roads, railroads, electricity, and health; and four periods for education.
We analyze how the model replicates some of the main features of the IMF’s financial programming, notably its ability to forecast output growth and the ratio of debt to GDP. The interest rate used in the model is inferred from the interest paid on debt in the actual financial programming.

**How well do the alternative forms of the model forecast growth and GDP?**

We compare the growth forecasts and debt-to-GDP ratio of each of the specifications to the baseline IMF financial programming (figure 2). The model that includes none of the four parameters (model 1 in table 5) generates the highest output growth (figure 4). When depreciation is added (model 2), it has a large negative effect because of the minimum expenditure required in health and education. The parameters related to spending on SOEs and O&M further increase output, whereas the lag parameter decreases it, bringing the forecast close to the values generated by the baseline model of the IMF.

Figure 2  Uganda’s output as forecast using model specifications that include minimum spending on health and education, 2004–15

With investment and current expenditures assumed to be equally productive

![Uganda: Output](image)

Figure 3 shows the debt-to-output ratio under the different models. Model 1 (without depreciation) is the only one that reduces the debt-to-output ratio, reflecting higher productivity or nondepreciating capital. However, when public expenditure must reach a minimum threshold to compensate for infrastructure depreciation and the minimum expenditure requirements in health and education, GDP growth is reduced, and the ratio of debt to GDP is no longer sustainable. This implies that in order to bring the debt-to-GDP ratio to the baseline level, public spending would have to be reduced or public sector efficiency boosted by an unlikely 350 percent. However, we must keep in mind that the model results may be quite dependent on alternative specifications, particularly for health and education expenditures. The following sections elaborate on alternative specifications of the model to analyze the robustness of the results.
What happens when alternative education and health specifications are considered in the model?

To analyze the robustness of the results we compare in this section alternative specifications of health and education investment. We test two social-spending configurations. First, we assume that education and health do not depreciate or become obsolete; accordingly, any investment in the social sectors can boost GDP, with no minimum expenditure required. Second, we assume that a minimum expenditure of 4.6 percent of GDP on health and 2.9 percent of GDP on education is required to boost GDP growth. Furthermore, with respect to education, we differentiate between current expenditures, assumed to be productive after a lag of one period, and investment, which we assume takes a lag of four periods to raise the productivity of human capital and thus stimulate output growth.

Thus, our two health and education model alternatives are:

- No minimum expenditure in health and education required
  - Effective health spending = I(t–1) + O&M(t–1)
  - Effective education spending = I(t–1) + O&M(t–1)
- Differentially productive investment and current expenditures (O&M)
  - Effective health spending = I(t–1) + O&M(t–1) – 4.6 percent of GDP
  - Effective education spending = I(t–s) + O&M(t–1) – 2.9 percent of GDP, s=4

If no minimum expenditure in health and education is required

All forms of the model, including the baseline, show accelerating growth owing to increasing capital stock accumulation and improvement in the quality of capital stock (figure 4). Depreciation does not have
a significant negative effect because we assume that education and health are counted as current expenditure and therefore do not depreciate. Note, for example, that GDP doubles in the baseline forecast.

The forecasts of the different forms of the model do not differ greatly, except for the last one. When the time lag between investment and growth is added to the model, the growth curve reflects the lower capital accumulation that results when the time needed to build is incorporated into the investment process.

Figure 4  Uganda’s output as forecast using various model specifications, 2004–15

All forms of the model show a steady drop in the debt-to-GDP ratio (figure 5), which is largely explained by output growth. Spending on O&M increases output growth more than any other factor but produces a higher debt-to-GDP ratio. Additional public spending on O&M, while positive in terms of growth, is not justified, because the elasticity of the debt-to-GDP ratio to public expenditure is larger than one, reflecting the low productivity of public expenditure. This effect is offset by spending on health and education, which, because it is not subject to depreciation, has the effect of driving down the debt-to-GDP ratio. These results imply that some portion of spending on O&M would be more productive if shifted to education and health.

If investment and current expenditures are differentially productive

In the next specification, social expenditures are split between new investment and current expenditures (figure 6). When depreciation is factored into the model, output actually decreases, because the new investment amounts to less than the minimum requirements for health and education. Only later on, as the minimum requirement falls in response to the decline in GDP, does output rise again, although it remains lower than in the baseline IMF model. When O&M expenditures are incorporated, the model is able to increase growth, but by an amount not much larger than the baseline IMF model. Inclusion of the time lag for investment in health and education reduces output growth, although not in a significant way.

The ratio of debt to GDP in this specification follows the same pattern as when all spending for health and education was assumed to be equally productive (figure 7).
Figure 5  Uganda’s debt-to-GDP ratio as forecast using various model specifications, 2004–15

Figure 6  Uganda’s output as forecast using model specifications that include minimum spending on health and education, 2004–15

With investment and current expenditures assumed to be differentially productive
Figure 7  Uganda’s debt-to-GDP ratio as forecast using model specifications that include minimum spending on health and education, 2004–15

With investment and current expenditures assumed to be differentially productive

**Uganda: Debt to GDP Ratio**

<table>
<thead>
<tr>
<th>Year</th>
<th>Debt/GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>0.50</td>
</tr>
<tr>
<td>2005</td>
<td>1.00</td>
</tr>
<tr>
<td>2006</td>
<td>1.50</td>
</tr>
<tr>
<td>2007</td>
<td>2.00</td>
</tr>
<tr>
<td>2008</td>
<td>2.50</td>
</tr>
<tr>
<td>2009</td>
<td>3.00</td>
</tr>
<tr>
<td>2010</td>
<td>3.50</td>
</tr>
<tr>
<td>2011</td>
<td>4.00</td>
</tr>
<tr>
<td>2012</td>
<td>4.50</td>
</tr>
<tr>
<td>2013</td>
<td>5.00</td>
</tr>
<tr>
<td>2014</td>
<td>5.50</td>
</tr>
<tr>
<td>2015</td>
<td>6.00</td>
</tr>
</tbody>
</table>

**Should Uganda invest more in infrastructure and the social sectors?**

Returning to the specification of the model in which a minimum expenditure on health and education is required, and applying all four parameters specified in table 5 (depreciation, spending on SOEs, spending on O&M, and a time lag for investment to become productive), we analyze alternative spending configurations. Our results must be viewed with caution, because sector productivity is derived from the ICOR, which provides only a rough approximation of the effectiveness of investment. Furthermore, previous sections show that results are admittedly sensitive to changes in social spending specifications.

We find that an annual increase of 1 percent point in the rate of growth of public investment in both infrastructure and the social sectors would raise output in 2015 by 3.5 percent compared with its level without extra investment. However, it would also cause the ratio of debt to GDP to deteriorate from 2.09 to 2.26. In other words, public expenditure would enhance output but worsen the debt situation. The problem lies in the poor performance of public investment. To hold the debt ratio steady while increasing the rate of investment by 1 percent point each year, one of the following conditions would have to obtain: (1) the productivity of public expenditure, as measured by improvement of the ICOR, would have to rise 16 percent; (2) the entire economy (private and public sectors) would have to become 7.5 percent more efficient; (3) the social sectors would have to become 38 percent more productive (holding infrastructure’s performance steady); or the productivity of infrastructure would have to increase by 27 percent (holding social sector productivity unchanged). Our results suggest that unless there is reason to believe that the productivity of the social sectors will improve sharply (by at least 38 percent), investment
allocations should be redirected to infrastructure, although even here 27 percent more productivity would be required to keep the debt-to-GDP ratio unchanged.\textsuperscript{13}

An annual increase of 1 percentage point in the rate of growth of public investment in infrastructure alone (without modifying the composition of that investment) would increase output in 2015 by 1.5 percent, while driving the debt-to-GDP ratio from 2.09 to 2.16. To keep the debt ratio unchanged, infrastructure would have to become 10 percent more productive, which would, in turn, increase output an extra 2.8 percent.

An annual increase of 1 percentage point in the rate of growth of public expenditure in the social sectors (education and health) would raise output in 2015 by 2.2 percent while pushing the debt-to-GDP ratio upward from 2.09 to 2.19. To maintain the same debt ratio, the social sectors would have to become 22 percent more efficient, which, in turn, would increase output an extra 4.7 percent. Table 6 present a summary of these results.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Infrastructure</th>
<th>Social</th>
<th>Public (infrastructure + social)</th>
<th>Economy (public + private investment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase the annual rate of public investment by 1 percentage point</td>
<td>27</td>
<td>38</td>
<td>16</td>
<td>7.5</td>
</tr>
<tr>
<td>Increase the annual rate of infrastructure investment by 1 percentage point</td>
<td>10</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Increase the annual rate of social investment by 1 percentage point</td>
<td>n.a.</td>
<td>22</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

To extend the analysis of the allocation efficiency of public expenditure, we consider the effect of reallocating to O&M the entire increase previously devoted to new infrastructure investment.\textsuperscript{14} Making this shift would increase O&M expenditure in 2015 by 23 percent over its level in the case where spending was entirely devoted to new investment. GDP improves by 2.14 percent when all the expenditure is allocated to O&M, compared with 1.46 percent when it is allocated to new investment in infrastructure. Although the debt-to-GDP ratio increases in both cases, the increase is lower for investment in O&M (2.12) than for investment in new infrastructure (2.16). This suggests that when planning infrastructure investments the government should consider budgeting larger amounts for O&M, rather than spending too much of their available funds on new investment.

Increasing the ratio of O&M to investment by 10 percent would improve output growth in 2015 by 1 percent while leaving the debt-to-GDP ratio unchanged. Because spending for O&M improves the productivity of capital already in place with immediate effect (no build-up period), the Ugandan

\textsuperscript{13} The comparison is done in terms of output growth and debt sustainability. Recall that neither impact on poverty nor complementarities between sectors are considered.

\textsuperscript{14} Keep in mind that when new investments are approved the government budgets an increase for O&M. In our example, a 1% annual increase in new investment translates into a 10 percent increase O&M expenditure by 2015.
government should consider redirecting part of its investment in new infrastructure stock and the social sectors toward O&M for existing capital stock.

4  **Calibrating the model for Senegal**

We calibrate our model for Senegal using data from IMF financial programming and World Bank data at constant 2000 prices. Parameters are set to their estimated value for the period considered.

The yearly tax collection rate, $\alpha$, is chosen from IMF financial programming for the corresponding year. That rate is about 20 percent of total GDP.

Absolute values for output ($Y$), public consumption ($C_g$), public investment ($I_g$), exports ($X$) and imports ($Z$), taxes ($T$), nontax revenue ($T_n$), grants ($G$) and private investment ($I_p$) are taken from financial programming for the years 2004 onward. Private consumption ($C_p$) keeps the national account in balance.

Forecasts of exports ($X$) and imports ($Z$) are included as shares of actual GDP, as in IMF’s financial programming. Grants are taken from the IMF-financial programming for Senegal as a share of GDP. Depreciation data are taken from Fay and Yepes (2002). The ratio of O&M expenditures to investment expenditures is computed from the World Bank’s 2005 public expenditure review for Senegal. Senegal spends less than Uganda on O&M, especially in the areas of electricity, roads, water, and sanitation (table 7). In the social sector, recurrent expenditures on health are particularly low.

**Estimating the initial infrastructure stock for Senegal**

We follow the same methodology as previously described for Uganda. Data from Fay and Yepes (2002) are used to obtain Senegal’s stock of infrastructure in 2000 (table 8). That stock is then annualized to yield a full data series for the years between 1990 and 2004.15

We also compute the value of capital stock from 2000 to 2004, following different alternatives for each kind of stock (figure 8). Data on fixed-line and mobile telephones are taken from Estache and Goicoechea (2005). We determine the value of electrical generating capacity for 2001–03 and extrapolate the value for 2004. No new investment has been made in Senegal’s rail lines, and nothing has been spent on maintenance, but we compute the value of the system, net of depreciation, for 2001–04. Water and sanitation values are updated in light of the government’s investment figures, net of depreciation.

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**Table 7 Model parameters for Senegal**

<table>
<thead>
<tr>
<th></th>
<th>Depreciation ($\delta$)</th>
<th>O&amp;M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical generating capacity</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>Fixed-line telephones</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Roads</td>
<td>0.02</td>
<td>0.01</td>
</tr>
<tr>
<td>Rail lines</td>
<td>0.02</td>
<td>0.00</td>
</tr>
<tr>
<td>Water</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Sanitation</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td>Mobile telephones</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>Health</td>
<td>0.02</td>
<td>0.79</td>
</tr>
<tr>
<td>Education</td>
<td>0.03</td>
<td>4.36</td>
</tr>
<tr>
<td>Private capital</td>
<td>0.03</td>
<td>0.00</td>
</tr>
</tbody>
</table>

15 As for Uganda, data series are very short for water, sanitation, and mobile telephones.
Table 8 Infrastructure stock in Senegal in 2000

<table>
<thead>
<tr>
<th>Stock</th>
<th>Unit cost (US$)</th>
<th>Value of stock (US$ thousands)</th>
<th>Share of total (percent)</th>
<th>Average share for all low-income countries (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical generating capacity</td>
<td>235 Mw</td>
<td>1,900 per Kw</td>
<td>446,500</td>
<td>10.4</td>
</tr>
<tr>
<td>Roads</td>
<td>4,271 Km</td>
<td>410,000 per Km</td>
<td>1,751,016</td>
<td>40.7</td>
</tr>
<tr>
<td>Rail lines</td>
<td>906 Km</td>
<td>900,000 per Km</td>
<td>815,400</td>
<td>19.0</td>
</tr>
<tr>
<td>Water</td>
<td>78 percent of population</td>
<td>400 per household connection</td>
<td>400,608</td>
<td>9.3</td>
</tr>
<tr>
<td>Sanitation</td>
<td>70 percent of population</td>
<td>700 per household connection</td>
<td>629,160</td>
<td>14.6</td>
</tr>
<tr>
<td>Fixed-line telephones</td>
<td>207,724 lines</td>
<td>400 per line</td>
<td>83,090</td>
<td>1.9</td>
</tr>
<tr>
<td>Mobile telephone subscribers</td>
<td>26.3 per 1000 habitants</td>
<td>700 per subscriber</td>
<td>174,385</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Figure 8 Annual percentage change in value of capital stock in Senegal, 1990–2003

CFA francs

The capital-output ratio is taken from the economc.dta dataset, which provides data on the capital output ratio for Senegal in 1990. From that year onward, investment and output are taken from national accounts, and capital is computed using a perpetual inventory method:

\[ K = I + (1 - \delta) K(-1) \]

Following Klenow and Rodriguez Clare (1997) the depreciation rate of capital, \( \delta \), is set at 3 percent. All capital stock is expressed relative to GDP (table 9).

16 http://africa.gov.harvard.edu/data/economc.htm#top
Data on public spending for health and education from 2001 to 2004 are taken from the IMF’s financial programming. Values for 2000 are obtained from the World Bank.\footnote{World Bank Development Data Platform: http://ddp.worldbank.org/ddp/home.do} Data on value added by sector (agriculture, industry, and services) for the same period are obtained from the World Bank, expressed in billions of CFA francs.

As for Uganda, we assume that a minimum level of health and education is required in order to stimulate GDP growth. Following the same methodology we calculate a minimum effective expenditure of 1.7 percent of GDP for health and 2.9 percent of GDP for education.

- Effective health = I(t–1) + O&M(t–1) – 1.7 percent GDP
- Effective education = I(t–1) + O&M(t–1) – 2.9 percent GDP

Table 10  Impact of various types of capital on value added (1/ICOR) in economic sectors in Senegal

<table>
<thead>
<tr>
<th>Value added</th>
<th>Agriculture</th>
<th>Industry</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical generating capacity</td>
<td>–0.64</td>
<td>2.40</td>
<td>2.94</td>
</tr>
<tr>
<td>Fixed-line telephones</td>
<td>2.16</td>
<td>–1.51</td>
<td>–1.10</td>
</tr>
<tr>
<td>Roads</td>
<td>0.36</td>
<td>–0.09</td>
<td>0.07</td>
</tr>
<tr>
<td>Rail lines</td>
<td>0.80</td>
<td>0.36</td>
<td>1.82</td>
</tr>
<tr>
<td>Water</td>
<td>1.62</td>
<td>0.13</td>
<td>1.52</td>
</tr>
<tr>
<td>Sanitation</td>
<td>2.73</td>
<td>1.53</td>
<td>4.42</td>
</tr>
<tr>
<td>Mobile telephones</td>
<td>–0.04</td>
<td>0.43</td>
<td>1.08</td>
</tr>
<tr>
<td>Health</td>
<td>0.74</td>
<td>0.70</td>
<td>1.49</td>
</tr>
<tr>
<td>Education</td>
<td>0.34</td>
<td>0.31</td>
<td>0.66</td>
</tr>
<tr>
<td>Private capital</td>
<td>0.13</td>
<td>0.12</td>
<td>0.26</td>
</tr>
</tbody>
</table>

\textit{Note:} Numbers in bold show the estimated 1/ICOR after one of the estimations was discarded for data inconsistency. The increase in value added is weighted by the share of each sector’s capital.

Estimating the ICOR and specifying the model for Senegal

We estimate the productivity of investment on sector value added (1/ICOR) for Senegal as we did for Uganda (table 10).

We test four nested specifications of the model, instead of the five done for Uganda (table 11), because we are not able to obtain data on state-owned enterprises. The first specification assumes no depreciation of capital, no spending on O&M, and no lag between investment and growth. These conditions are successively reversed to build into the model capital depreciation, O&M expenditures, and a time lag between investment and growth (two periods for electricity, roads, rail lines, water, and
sanitation; four periods for education; and one period for the remaining forms of investment, including health).

Table 11 Specification of four forms of financial programming model (and baseline IMF model)

<table>
<thead>
<tr>
<th>Model</th>
<th>Depreciation</th>
<th>O&amp;M expenditures</th>
<th>Time lag in investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline IMF financial programming</td>
<td>δ ≠ 0</td>
<td>O&amp;M ≠ 0</td>
<td>s ≠ 0 in I(t-s)</td>
</tr>
<tr>
<td>Model 1: δ = O&amp;M = s = 0</td>
<td>δ ≠ 0</td>
<td>O&amp;M ≠ 0</td>
<td>s ≠ 0 in I(t-s)</td>
</tr>
<tr>
<td>Model 2: Depreciation</td>
<td>δ ≠ 0</td>
<td>O&amp;M ≠ 0</td>
<td>s ≠ 0 in I(t-s)</td>
</tr>
<tr>
<td>Model 3: Depreciation + O&amp;M spending</td>
<td>δ ≠ 0</td>
<td>O&amp;M ≠ 0</td>
<td>s ≠ 0 in I(t-s)</td>
</tr>
<tr>
<td>Model 4: Model 3 + Time lag in investment</td>
<td>δ ≠ 0</td>
<td>O&amp;M ≠ 0</td>
<td>s ≠ 0 in I(t-s)</td>
</tr>
</tbody>
</table>

Note: X signifies the model takes a parameter different from zero

We then investigate how the model replicates some of the main features of the IMF’s financial programming, notably its ability to forecast output growth and the ratio of debt to GDP. The interest rate used in the model is inferred from the interest paid on debt in the actual financial programming.

**How well do the models forecast growth and GDP in Senegal?**

We compared the growth forecasts and debt-to-GDP ratio of each of the specifications to the baseline IMF financial programming (figure 9).

Only the model that includes none of the four parameters (model 1 in table 11) generates greater output growth than the IMF baseline model (figure 11). When depreciation is added (model 2), it has a large negative effect on growth, due to the depreciation of infrastructure capital and the minimum expenditure required in the social sectors. O&M spending does not greatly affect output, because the amounts involved are very small.

All of our model specifications produce a larger debt-to-GDP ratio than the baseline IMF model (figure 10). Note that in the first years, the ratio of debt to GDP falls but then rises as the new investment is not able to compensate for the increase in health and education spending linked to the growing GDP.
Figure 9  Senegal’s output as forecast using model specifications that include minimum spending on health and education, 2004–15

With investment and current expenditures assumed to be equally productive

![Senegal: Output](image)

Figure 10  Senegal’s debt-to-GDP ratio as forecast using model specifications that include minimum spending on health and education, 2004–15

With investment and current expenditures assumed to be equally productive

![Senegal: Debt to GDP Ratio](image)
What happens when alternative education and health specifications are considered in the model?

As for Uganda, we test two different configurations of social expenditures. In the first one, we assume no depreciation or obsolescence of health and education. In the second, we assume that investment in education requires four periods to become effective:

- No minimum amount required of health and education expenditures
  - Effective health = I(t–1) + O&M(t–1)
  - Effective education = I(t–1) + O&M(t–1)
- Differentially productive investment and current expenditures (O&M)
  - Effective health = I(t–1) + O&M(t–1) – 4.6 percent of GDP
  - Effective education = I(t–s) + O&M(t–1) – 2.9 percent of GDP, s=4

If no minimum amount of education and health spending is required

Only model 1 (as described in table 11) generates a rate of growth higher than the IMF baseline model. The other models fall slightly below the baseline case. Capital stock accumulation and quality of capital stock are the main drivers of growth.

Figure 11 Senegal’s output as forecast using various model specifications, 2004–15

All the models show an increase in the debt-to-GDP ratio (figure 12). Because of the low productivity of investment and O&M, spending for these purposes does not increase output as fast as it increases debt.
If investment and current expenditures are differentially productive

In the next specification, social expenditures are split between new investment and current expenditures (figure 13). With depreciation at zero (model 1, table 11) output tracks the baseline IMF forecast. However, when depreciation is incorporated into the model, output sags 18 percent below the baseline. Including O&M improves output growth, whereas the time lag for investment does not significantly affect output.

The ratio of debt to GDP in this specification improves compared with the baseline both with and without depreciation (figure 14). It worsens when O&M spending is incorporated. Introducing the time lag produces no significant change from the baseline.
Should Senegal invest more in infrastructure and social sectors?

Returning to the initial specification of the model, when a minimum expenditure on health and education is required, and applying all of the parameters specified in table 11 (depreciation, spending on O&M, and a time lag for investment to become productive), we analyze alternative spending configurations in terms of the productivity of investment, sector allocations, and the relative importance of investment and O&M expenditures.

We find that an annual increase of 1 percentage point in the rate of growth of public investment in both infrastructure and the social sectors raises output in 2015 by just 0.1 percent compared with its level without extra investment. It also causes the ratio of debt to GDP to rise from 0.86 to 0.92.

To hold the debt ratio steady while increasing the rate of investment by 1 percentage point each year, one of the following conditions would have to obtain: (1) the productivity of public expenditure, as measured by improvement in the ICOR, would have to rise 125 percent; (2) the entire economy (private and public sectors) would have to become 20 percent more efficient; (3) the social sectors would have to become 200 percent more productive (holding infrastructure’s performance steady); or the productivity of infrastructure would have to improve by 350 percent (holding social sector productivity unchanged). Although the model is admittedly sensitive to changes in social spending, our results suggest that public productivity is extremely low when compared to private investment. Nonetheless, investing in social sectors seems to be more efficient than infrastructure investments; therefore, public allocations should be redirected to the social sectors.18

An annual increase of 1 percentage point in the rate of growth of public investment in infrastructure alone (without modifying the composition of that investment) would reduce output in 2015 by 0.06 percent, while causing the debt-to-GDP ratio to slip from 0.86 to 0.88. This effect is explained by the low

18 The comparison is done in terms of output growth and debt sustainability. Recall that neither impact on poverty nor complementarities between sectors are considered.
initial investment level—even the 1 percent increase does not compensate for depreciation. To keep the debt ratio unchanged, infrastructure would have to become 130 percent more productive, which, in turn, would increase output an extra 2.5 percent.

An annual increase of 1 percentage point in the rate of growth of public expenditure in the social sectors (education and health) would raise output in 2015 by 0.1 percent while pushing the debt-to-GDP ratio from 0.86 to 0.90. To maintain the same debt ratio, the social sectors would have to become 120 percent more efficient, which, in turn, would increase output an extra 4.5 percent. Results for these analyses are presented in table 12.

Table 12 Productivity increase required to hold the debt ratio steady under various conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Infrastructure</th>
<th>Social</th>
<th>Public (infrastructure + social)</th>
<th>Economy (public + private investment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase the annual rate of public investment by 1 percentage point</td>
<td>350</td>
<td>200</td>
<td>125</td>
<td>20</td>
</tr>
<tr>
<td>Increase the annual rate of infrastructure investment by 1 percentage point</td>
<td>130</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
<tr>
<td>Increase the annual rate of social investment by 1 percentage point</td>
<td>n.a.</td>
<td>120</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

To extend the analysis of the allocational efficiency of public expenditure, we consider the effect of reallocating to O&M the entire increase previously devoted to new infrastructure investment.19 Making this shift (1) increases O&M expenditure in 2015 by 190 percent over its level in the case where spending was entirely devoted to new investment, and (2) increases GDP by 0.15 percent, though at the cost of pushing the debt-to-GDP ratio to 0.88, the same situation that obtained when all available funds were devoted to new investment. This suggests that when planning infrastructure investments the government should consider budgeting larger amounts for O&M rather than spending too much of their available funds on new investment. It should be noted that O&M expenditures in Senegal are presently very low, at around 1 percent of total investment.

Increasing the ratio of O&M to investment expenditure by 10 percent would not alter either output growth or the debt-to-GDP ratio. This result reflects the fact that the initial level of O&M is so low that it is not much affected by a mere 10 percent increase.

5 Conclusion

We have presented a model that refines the IMF’s financial programming tool, supplementing it with details pertinent to the sectors of infrastructure, health, and education. Although highly relevant to sector specialists, these details typically are not taken into account in macroeconomic analysis. Particularly

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19 We must keep in mind that when new investments are approved the government budgets an increase for O&M. In our example, a 1 percent annual increase in new investment translates into a 10 percent increase in O&M expenditure by 2015.
important are the effects of O&M expenditures in infrastructure and current expenditures in the social
sectors, as well as the quality of capital stock, as proxied by O&M expenditures. Stock quality, often
ignored at the macro level, has a large impact on the productivity of capital.

We use our model to compare the impact of additional investment in various economic sectors on
output growth and debt sustainability in Uganda and Senegal. Implicit in that approach is our belief that
the true macroeconomic impact of public investment depends on its sector composition and on its
distribution between new investment and spending for O&M.

Application of the model to Uganda and Senegal demonstrated that country specificity remains
essential when evaluating output growth and debt. In Uganda, investment in infrastructure enhances
output, but also, because of its relatively low productivity, worsens the debt ratio. The model suggests
that a better way to finance infrastructure may be to improve existing capital stock by allocating
expenditures to O&M rather than to new investment. The model also shows that spending on health and
education raises output but is less efficient than infrastructure investment.

In Senegal, by contrast, investment in infrastructure does not seem to be effective in improving output
growth. An alternative solution would be to spend a great deal more on O&M, where the current level of
spending is very low, or on health and education—all of which have greater power than new
infrastructure investment to stimulate growth in output. No matter how spending is allocated, however, it
worsens the ratio of debt to GDP, reflecting the poor productivity of public spending in general.

The World Bank’s deep knowledge of the sectors of its members’ economies, from education to
energy, is often inadequately reflected in macroeconomic indicators. As a result, the IMF often considers
the immediate cost of an increase in investment but not its pay-off in terms of medium- and long-term
growth in output. Conversely, apparently reasonable requests for additional investment from individual
sectors are often compiled without considering their aggregate impact or optimal distribution. Our model
is a first attempt to use the IMF financial programming tool to incorporate microeconomic sector
information relevant to growth into macroeconomic analysis and planning in a constrained environment.

Several elements relevant in macroeconomic analysis are not factored into the model. Chief among
these are complementarities between investment types, monetary issues, exchange rates, and interest
rates. Furthermore, the model shows the need for further research onto how health and education affect
output growth and how best to include spending for these purposes in the financial programming
framework.
References


Annex 1   Relations of macroeconomic accounts according to the International Monetary Fund

National accounts
Output =
Private consumption +
Public consumption +
Public investment +
Private investment +
Exports −
Imports

External sector
Exports −
Imports +
Net income +
Net capital transfers +
Net direct investment +
Net long-term capital +
Private sector
Government
Net short-term capital
Private sector
Government
= Reserves

Monetary sector
Monetary authorities
Net foreign assets +
Net domestic assets +
Net credit to government
Credit to banks
Other items (net)
= Reserve money
Currency
Bank reserves

Deposit money, banks
Net foreign assets +
Banks reserves +
Net domestic assets
Net credit to government
Credit to nongovernment
Other items (net)
= Liabilities to monetary authorities
+ Private sector deposits
BUILDING SECTOR CONCERNS INTO MACROECONOMIC FINANCIAL PROGRAMMING:
LESSONS FROM SENEGAL AND UGANDA

**National Accounts**
- Output = Private consumption + Public consumption + Public investment + Private investment + Exports – Imports

**Fiscal Accounts**
- Revenues + Grants – Public consumption – Public investment
- Overall balance = Domestic financing + External financing

**External Sector**
- Exports – Imports + Net income – Net capital transfers – Net foreign capital = Reserves

**Monetary Sector**
- Net foreign assets + Net domestic assets
- Net credit to government + Net credit to nongovernment = Reserve money
Annex 2  The model

We solve the system of equations corresponding to the relations in annex 1 so as to analyze the main implications of increases in public capital. We assume a single private sector (Yp), seven types of infrastructure, and a social sector consisting of health and education. Each of these requires a different lag before investments become productive. Each has a different ICOR:

\[ Y = VA_{ag} + VA_{ind} + VA_{ser} \quad \text{Output} \]

For \( i = 1, \ldots, 3 \) Value added agriculture, industry and services

\[ Y - C_p - C_g - I_p - I_g - O&M - X + Z \text{equal 0} \quad \text{Aggregate economy} \]

\[ Y - T - C_p - I_p = \Delta M + \Delta F_p - \Delta D_p \quad \text{Private sector} \]

\[ T - C_g - I_g - M = \Delta F_g - \Delta D_g \quad \text{Public sector} \]

\[ X - Z = \Delta F_p + \Delta F_g + \Delta R \quad \text{Balance of payments} \]

\[ \Delta M = \Delta R + \Delta D_p + \Delta D_g \quad \text{Banking sector} \]

\[ C_p = (1 - s) (Y - T) \quad \text{Private consumption} \]

\[ \Delta F = \Delta F_p + \Delta F_g \quad \text{Foreign assets} \]

\[ \Delta D = \Delta D_p + \Delta D_g \quad \text{Domestic borrowing} \]

\[ T = \alpha Y \quad \text{Taxes} \]

\[ K^*_j = I_j(-1) + (1 - \delta j) K^*_j (-1) \quad \text{Actual capital, } j = 1, \ldots, m \]

\[ K^*_j = K_j + O&M_j \quad \text{Quality capital} \]

\[ K^*_{i,j}(t) = I_{i,j}(t-a) + (1 - \delta j) K^*_{i,j}(-1) \quad \text{Effective capital, } i = 1, \ldots, n, j = 1, \ldots, m \]

Based on the system of equations described above and, giving values to parameters, \( \alpha, \delta j \), and \( \rho(i,j,t) \), and with sectors \( i = 1, \ldots, n \) (\( n = 3 \)) and investment types \( j = 1, \ldots, m \) (\( m = 10 \))

Exogenous values, \( C_g, X, Z, \Delta M, \Delta R, \)

Initial variables, \( Y(0), Y_{agr}(0), Y_{ind}(0), Y_{serv}(0), K_j(0), j = 1, \ldots, m \)

And control variables, \( I_j, O&M_j, j = 1, \ldots, m \)

We get the following endogenous variables, for each period \( t \):

\( Y_{agr}, Y_{ind}, Y_{serv} (=Y), K_j, T_p, C_p, I_p; \Delta F; \Delta D; \text{Sp–} I_p; \text{Sg–} I_g; \text{public deficit } (T - C_g - I_g - M) \) and debt/GDP.

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