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Linking Public Investment Programs and SPAHD Macro Models

Methodology and Application to Aid Requirements

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Abstract

This paper proposes a "bottom up" approach to link public investment programs with a class of macro models recently developed to quantify Strategy Papers for Human Development (SPAHD) in low-income countries. The methodology involves establishing constant-price projections of investment outlays (disaggregated into infrastructure, education, and health), spending on maintenance and other goods and services, salaries, and user charges. These estimates are incorporated in a SPAHD macro framework to calculate, under alternative scenarios, domestic financing, foreign borrowing, and aid requirements. The impact on growth and indicators associated with the Millennium Development Goals are also evaluated. Illustrative applications, based on a SPAHD model for Niger, are used to highlight the link between tax reform and aid requirements.

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I. Introduction

Promoting a large increase in public investment is increasingly recognized as a critical step to spur growth, reduce poverty, and improve the quality of human life of low-income countries. Indeed, a number of recent reports—such as those of the United Nations Millennium Project (2005), the Blair Commission (2005), and the World Bank (2005)—have called for a "Big Push" in public investment in education, health and infrastructure, financed by generous debt relief and a large increase in foreign aid, given the limited ability of the poorest countries to raise resources through domestic taxation or borrowing.[1]

More specifically, the declaration adopted at the UN World Summit of September 2005 called on all countries" to adopt, by 2006 and implement comprehensive development strategies to achieve the internationally agreed development goals and objectives, including the Millennium Development Goals (MDGs)." What it means, essentially, is that the logic of aid allocation should be aligned squarely on what countries need to achieve their development objectives. This "new view" of aid raises a host of political economy issues (involving, for instance, the role and nature of conditionality), which have not been fully resolved; as a result, it is too early to tell whether donors' behavior will be adjusted to respond to the new environment.

At a more technical level, however, a key issue raised by the "new view" of aid relates to the need to assess quantitatively requirements for foreign assistance, given a public investment program (PIP) and its impact on growth and the MDGs. Dwelling on some of our previous work, this paper proposes a "bottom up" approach to linking public investment programs with a class of macro models recently developed to quantify Strategy Papers for Human Development (SPAHD) in low-income countries. The methodology involves establishing

[1]Infrastructure plays a particularly important role in this context, in part because of its impact on health and education outcomes. See Agénor and Moreno-Dodson (2006) for a detailed discussion of the role of infrastructure in the growth process, and Agénor and Neanidis (2006) for a formal analysis in an endogenous growth framework.

constant-price projections of investment outlays (disaggregated into infrastructure, education, and health), spending on maintenance and other goods and services, salaries, and user charges. These estimates are then incorporated into an appropriate macro framework to calculate, under alternative scenarios regarding domestic financing and foreign borrowing, aid requirements.

The remainder of the paper is organized as follows. Section II provides a formal description of the methodology. Section III applies the methodology to Niger, using an illustrative PIP. This section also shows how calculations of aid requirements depend on the assumed path of tax policy. Section IV provides some final remarks. We emphasize the fact that to ensure that the PIP is realistic and based on reliable data, substantial improvements in project assessment capability within the public sector may be required in many countries.

II. Methodology

The methodology that we propose in this paper builds on the SPAHD macroeconomic framework developed by Agénor, Bayraktar and El Aynaoui (2006), and extended by Pinto Moreira and Bayraktar (2005), and Agénor, Bayraktar, Pinto Moreira, and El Aynaoui (2005). This class of models, which is now commonly referred to as SPAHD macro models, provides a unique and tractable framework for accounting for the links between aid, public investment, the supply side, and some key human development indicators—including the poverty rate, malnutrition, the infant mortality rate, percentage of population with access to safe drinking water, the literacy rate, and life expectancy.[2]

[2]See the Appendix for a more detailed presentation of SPAHD macro models. 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). See also Agénor (2005) for a broader perspective on the design of macro-economic models for poverty analysis.

We begin by describing formally the treatment of public investment and budget financing in a SPAHD framework in the case where aid is treated "above the line" and considered exogenous. We then explain how to re-arrange these equations to solve residually for aid needs, given a PIP built from micro data.

1. Case of Exogenous Aid

In a standard SPAHD framework, aid (defined as grants only) is treated "above the line" and taken as exogenous, whereas all components of borrowing (concessional or not) are treated as financing items. In existing models, there is also an econometrically-estimated linking public investment in real terms, IG, with aid and domestic resources (taxes, for short):

$$IG = F(TAX,AID)/PQT, \quad (1)$$

where AID is foreign aid (measured in domestic currency), TAX total taxes, and PQT the equivalent of the after-tax consumer price index. This equation is generally specified in proportion of GDP, but we use a "level" specification to simplify the presentation. Note also that in some applications, nonlinearities in the AID variable are also introduced in this relationship to capture absorption constraints.[3]

Components of public investment consist of health, education, and infrastructure (ignoring, for simplicity, any residual category). Given the overall level of public investment determined from (1), these components are then calculated as fixed fractions:

$$IGh = \kappa h \cdot IG, \quad (2)$$

[3]See for instance the SPAHD model for Niger in Pinto Moreira and Bayraktar (2005).

where h = edu, hea, inf. In this expression, $\kappa h \in (0,1)$, and $\Sigma_h \kappa h = 1$. Thus, we have also $IG = \Sigma_h IGh$.

As discussed in Agénor, Bayraktar, Pinto Moreira and El Aynaoui (2005), we account for the possibility that a fraction of the resources invested in investment projects may not have a positive impact on public capital. Specifically, we follow the linear specification proposed by Arestoff and Hurlin (2005), which is based on a modified version of the perpetual inventory method:

$$KGh = \alpha h \cdot IGh_{-1} + (1 - \delta h) KGh_{-1}, \tag{3}$$

where $\alpha h \in (0,1)$ measures the degree of efficiency of investment category h, and $\delta h \in (0,1)$ the rate of depreciation of capital h. The case of "full efficiency" corresponds therefore to $\alpha h = 1$.

Total government spending at current prices is given by

$$GTOT = WG \cdot LE_G + PQT \cdot (CG + IG) + INT, \tag{4}$$

where $WG \cdot LE_G$ denotes the wage bill, CG total spending on goods and services, and INT interest payments on domestic and foreign debt.

Real spending on goods and services, CG, consists of maintenance expenditure, MAINT, and other spending:

$$CG = MAINT + CG_{oth}. \tag{5}$$

In turn, maintenance spending, measured at constant prices, is taken to be proportional to total depreciation of physical capital:

$$MAINT = \theta_M (\Sigma_h \delta h \cdot KGh_{-1}), \tag{6}$$

where $\theta_M > 0$.[4]

As noted earlier, the government budget balance treats aid (grants) above the line, and all borrowing (concessional or not) below the line:

$$GBAL = TAX + AID - GTOT. \quad (7)$$

Financing of the budget deficit is either from domestic borrowing, DB, or foreign borrowing, measured in domestic-currency terms, ER·FG:

$$- GBAL = DB + ER \cdot FG. \quad (8)$$

This equation is generally solved for the level of foreign borrowing (assumed to be at concessional terms).

Treating aid as exogenous in a typical exercise with a SPAHD macro model is warranted if the objective is, for instance, to assess whether large aid inflows (viewed as an exogenous impulse) can lead to an appreciation of the real exchange rate, given that demand- and supply-side effects tend to operate in opposite direction. However, to calculate aid requirements, the logic of the solution process described earlier must be amended.

2. Public Investment Programs and Aid Requirements

To alter the model structure outlined above and endogenize aid, the first step is to drop equation (1). We then treat IG as predetermined (taken from the PIP), and solve for aid as the budget equilibrating item. The starting point is thus

[4]Note that the coefficient θ_M may be greater than unity, if maintenance activities involve not only replacing the physical capital that is deteriorating but also other expenses associated with the delivery of these services (for instance, the cost of running a maintenance agency). See the discussion below.

the assumption that the PIP provides detailed multi-annual projections of capital outlays, maintenance costs, other spending on goods and services (such as, in the case of education, books, pencils, and uniforms), wages and salaries (such as teachers' pay, in the case of education), and the direct revenues (fees) derived from public investments, all at constant prices.

First, suppose that the PIP provides estimates of required public investment needs in education, health, and infrastructure. In terms of the previous notation, the public investment program implies that

$$IG^{PIP} = \Sigma_h IGh^{PIP}. \quad (9)$$

Using (3), the stock of public capital in category h is thus given by

$$KGh = (1 - \delta^h)KGh_{-1} + \alpha h \cdot IGh^{PIP}. \quad (10)$$

Second, suppose that the PIP provides data on "new" requirements for maintenance at constant prices, NR_MAINT^{PIP}. Using (6), total spending on maintenance is thus

$$TMAINT^{REV} = \theta_M \cdot (\Sigma_h \delta h \cdot KGh_{-1}) + NR_MAINT^{PIP}, \quad (11)$$

with KGh determined from (10).

Third, suppose that the PIP provides estimates of spending on goods and services other than maintenance at constant prices, $NR_CG_{oth}^{PIP}$. Using (5) and (11), total spending on goods and services at constant prices is now

$$CG^{REV} = TMAINT^{REV} + CG_{oth} + NR_CG_{oth}^{PIP}. \quad (12)$$

Fourth, suppose that the PIP provides estimates of wages and salaries that will recur as a result of the new investment at constant prices, N_SAL^{PIP}. Total wage payments at current prices is thus

$$SAL^{REV} = WG \cdot LE_G + PQT \cdot N_SAL^{PIP}. \quad (13)$$

Fifth, suppose that the PIP provides estimates of user charges at constant prices that accrue directly to the budget (possibly through transfers from public enterprises), denoted by $USER^{PIP}$.[5] Total government resources at current prices excluding aid, GOVR, are thus

$$GOVR^{REV} = TAX + PQT \cdot USER^{PIP}. \quad (14)$$

Substituting (9), (12) and (13) in (4) implies that total government spending implied by the PIP is

$$GTOT^{REV} = SAL^{REV} + INT + PQT \cdot CG^{REV} + PQT \cdot IG^{PIP}. \quad (15)$$

For a given path of domestic and foreign borrowing (DB and ER·FG, respectively) aid requirements associated with the PIP can thus be calculated residually from equations (7), (8), (14), and (15):

$$AID^{PIP} = - (DB + ER \cdot FG) - GOVR^{REV} + GTOT^{REV}. \quad (16)$$

The foregoing discussion shows that the degree of efficiency of investment has only indirect effects on aid requirements. In particular, the lower is the efficiency parameter α in equation (10), the lower will total maintenance spending be in equation (11). From (12), (15) and (16), aid requirements will be

[5]User charges may be higher for some components of infrastructure (such as telecommunications or, to a lower extent, toll roads) than others (such as health services, for instance). It should also be kept in mind that even a small bill on public utilities may represent a substantial burden for poor households. In establishing projections in that area, it is therefore better to err on the side of caution.

lower than otherwise. However, to the extent that lower efficiency of public investment translates into lower growth and revenues, aid requirements will increase. Thus, the net effect of an increase in efficiency on foreign assistance is in general ambiguous.

In the foregoing presentation, we have assumed that the PIP incorporates estimates of projected spending on *total* wage payments at constant prices, N_SAL^{PIP}. In principle, these estimates should be derived from the projected path of an "effective" average wage (at constant prices) on new hires, N_RWG^{PIP}, multiplied by the increase in public sector employees, $N_\Delta LE_G^{PIP}$. Thus, instead of (13), total wage payments at current prices would be given by

$$SAL^{REV} = WG \cdot LE_G + PQT \cdot N_RWG^{PIP} \cdot N_\Delta LE_G^{PIP}. \qquad (13')$$

From the point of view of fiscal accounting, decomposing the projected wage bill of the public sector into movements in an effective wage and changes in employment may not matter too much, given that both variables are treated as predetermined in our approach. However, from the perspective of the labor market, this decomposition could be quite important. The reason is that hiring by the public sector affects the composition of labor supply in the economy, and could therefore have significant implications for the private sector. A sharp increase in the demand for educated labor by the government, for instance, could drive wages up in the private sector. In turn, this may translate into higher prices and lower output. Similarly, higher wages on new hires in the public sector could have an adverse "signaling effect" on wages in the private sector. Thus, higher public investment could generate negative externalities, which could mitigate the positive supply-side effects accounted for in SPAHD macro models.

Finally, it should also be noted that our methodology may involve some element of "double counting" when it comes to evaluating maintenance spending. Indeed, SPAHD models calculate maintenance requirements endogenously, by

relating them to depreciation of physical capital (see equation (6)). Thus, any new investment, whether in infrastructure, health, or education, to the extent that it translates into an increase in the corresponding capital stock, will automatically generate an estimate of maintenance outlays. A legitimate question, therefore, is whether a PIP estimate of maintenance outlays is at all needed. However, it is important to keep in mind that the estimate produced by the SPAHD model can be viewed as corresponding strictly to the expenditure needed to avoid physical depreciation of public assets. Assuming that the (average) depreciation rates included in the SPAHD framework are accurate estimates, this would require setting $\theta_M = 1$ in equation (6). The maintenance expenditure accounted for in the PIP could therefore be viewed as corresponding mostly to the other outlays associated with the delivery of maintenance activities, such as the cost of running a maintenance agency (excluding salaries and other compensation). In practice, these expenses could be very difficult to separate from the category "other spending on goods and services" identified in the PIP, so that some "double counting" may be inevitable.

3. Link with a Medium-Term Budget

It is apparent from the foregoing discussion that implementing the above methodology can produce a complete set of fiscal accounts, including a Medium term Budget Framework (MTBF) as long as PIP estimates are available for several years. This is important, given that several observers (including donors) have emphasized that elaborating more advanced Medium-term *expenditure* frameworks is a key priority for strengthening the PRSP process (see, for instance, German Development Cooperation (2005)). The foregoing approach goes a step further by providing a complete medium-term budget, with simultaneous determination of aid requirements.

In summary, the methodology proposed in this paper for linking PIPs and SPAHD macro models can be summarized as follows:

Step 1. Establish the public investment program from the "bottom up", and provide estimates at constant prices (that is, at prices of the base period t = 1) of *a*) investment in health, education and infrastructure; *b*) maintenance needs associated with these new investments; *c*) other spending on goods and services; *d*) wages and salaries; and e) estimate user charges that would accrue directly to the budget, for periods t = 1,…, T.

Step 2. Incorporate estimates of investment, maintenance and user charges in the model; given assumptions for the path of domestic and foreign borrowing, solve the model for aid requirements for periods t = 1,…, T.

Step 3. If aid requirements are deemed feasible (in the sense of representing a realistic basis for discussion with donors), go to the next step. If not, go back to step 1 and revise (downward) spending estimates contained in the public investment program.

Step 4. Calculate the medium-term budget for t = 1,…, T, with aid requirements shown as residual. Repeat steps 1 to 3, If necessary, with alternative assumptions about domestic and external financing.

III. Applications

To illustrate the functioning of the framework described in the previous section, we apply it to Niger, using the SPAHD framework developed by Pinto Moreira and Bayraktar (2005). With 63 percent of the population living below the poverty line, and 34 percent considered as extremely poor, Niger is the second poorest country on earth. Despite recent improvements, social indicators remain abysmal, and among the weakest in the world. Infrastructure indicators are also poor, as in the rest of Sub-Saharan Africa. Various observers have taken the

view that to stimulate growth and improve human indicators, a large increase in public investment is needed.

We begin by describing an illustrative PIP for Niger. We then determined the implied aid requirements. We conclude with an examination of the impact of alternative assumptions of tax effort on these requirements.

1. An Illustrative Public Investment Program, 2006-15

Table 1 shows an illustrative PIP for Niger, with all flows measured at constant 2004 prices. In the table, public investment includes not only the three categories identified earlier (education, health, and infrastructure) but also a category "other", which represents a relatively small share of total capital outlays. In a typical SPAHD application, this component is generally treated as a flow only, with no impact on the stock of public assets.

The 2005 values of the capital expenditure series are taken from the baseline table estimated by Pinto Moreira and Bayraktar (2005). The growth rate of public investment in infrastructure is assumed to increase gradually from 3 percent in 2006 to 6 percent in 2009, and to remain at that level up to 2015. Regarding maintenance expenditures in infrastructure, user charges, and wages and salaries, we assume that they represent 5 percent of investment in infrastructure. Other spending on goods and services is assumed to account for one percent of capital outlays in infrastructure.

The growth rate of public investment in education is assumed to grow at the lower rate of 2 percent in 2006, 3 percent in 2007, and 4 percent from 2008 to 2015. While maintenance expenditures in education, user fees, and other spending on goods and services are equal to 1 percent of capital expenditures in education, wages and salaries are taken as 5 percent of this component of investment.

The growth rate of public investment in health is taken to be equal to the growth rate of investment in infrastructure. Similarly, the shares of maintenance expenditures in health, user fees, other spending on goods and services, and wages and salaries are assumed to be equal to the corresponding shares in investment in education. Finally, the growth rate of other public investment is assumed to be equal to a constant value of 1 percent throughout the simulation period. For this component, whereas the shares of maintenance expenditures and user fees is taken to be zero, the shares of other spending on goods and services, and wages and salaries are set at 1 percent of investment.

Total public capital expenditure data are obtained by adding up the components of capital expenditures. As shown in Table 1, investment in infrastructure represent about two-thirds of total investment, investment in education about 10 percent of that total, and investment in health about 18 percent. In proportion of GDP (as shown in the bottom part of Table 2), public investment represents about 5 percent in the base period.

2. Aid Requirements and the Medium-Term Budget Framework

We now turn to a calculation of aid requirements using the methodology described earlier and the SPAHD framework for Niger described by Pinto Moreira and Bayraktar (2005).[6] To project exogenous variables, we follow the assumptions underlying the experiments in that paper. These involve, for instance, setting the rate of growth of export and import prices to the same value, imposing an effective interest on foreign borrowing of 0.5 percent per annum. Domestic borrowing is kept at 1 percent of GDP (the value observed in the base period) and foreign (concessional borrowing is limited to 2 percent of GDP). Tax rates that are exogenous are also kept constant initially.

[6]The paper also provides details about parameter estimates and the calibration process.

We also assume that public investment is only partially efficient, in the sense that capital outlays in education, infrastructure, and health do not serve to increase one to one the public capital stock. Specifically, we assume that only half of investment flows turn into increases in public capital and impose $\alpha h = 0.5$ for all h in equation (10). 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 estimated by Arestoff and Hurlin (2005). Although this choice has no effect on the calculations of aid requirements (which are based on the *flow* data provided by the PIP), they do affect macroeconomic outcomes, namely, the economy's growth rate and the MDGs.[7]

Table 2 shows the aid requirements calculated by the model and the associated medium-term budget framework for the period 2006-15. The results show that with (domestic and foreign) borrowing constant as a share of GDP, and a more or less constant tax effort (of about 10 percent of GDP), expenditure of about 25 percent of GDP, aid requirements drop slightly over time from 12.5 percent in 2006 to 11.4 in 2015. In proportion of tax revenues, aid falls from 125 percent in 2006 to 109 in 2015, but in proportion of total public investment, aid rises from about 241 to 250 percent during the same period.

The impact of the PIP-cum-aid package on the MDGs is shown in Table 3. The headcount index decreases in the "best" case (a consumption growth elasticity of -1.5) from about 63 percent in 2006 to 38.5 percent in 2015. However, with a consumption growth elasticity of -0.5, the poverty rate drops by less than 10 percentage points over the same period. The literacy rate (defined as the ratio of educated labor to total population) increases from 20.3 percent in 2006 to 27 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 150 in 2006 to 118 in 2015, malnutrition prevalence

[7]Of course, experiments involving a higher efficiency assumption parameter (perhaps as a result of reforms aimed at improving governance) could also be performed.

drops from 40.6 to 36 percent during the same period. In the model, these improvements are a result of a combination of factors—reduction in poverty, increased public investment in health, and higher GDP and private consumption per capita.[8] For similar reasons, life expectancy also increases (albeit slightly), from 46.9 in 2006 to 49.5 in 2015. The percentage of population with access to safe water rises from 58.1 percent in 2006 to 61.4 percent in 2015 as a result of increasing public investment in infrastructure.

In sum, the projections show that MDG indicators improve quite sensibly in Niger; the composite MDG index (which is defined as a geometric average with base 2005 = 100 for convenience) shows a significant overall improvement, increasing by 20.1 percentage points. But despite these improvements, and given the illustrative PIP considered here and other assumptions about the environment that Niger is likely to face in the coming years, the MDG of halving poverty and malnutrition would not be achieved by 2015. Everything else equal, a more ambitious program of public investment would be required—possibly leading to absorption problems.

3. Tax Reform and Aid Requirements

The foregoing analysis was based on the assumption that the exogenous effective direct tax rate (which is assumed to be under the control of the authorities) in the SPAHD model was kept constant at its base period value.[9] Thus, tax effort, as measured by the ratio of the associated revenues to GDP was taken to be constant.

To highlight the link between the calculation of aid requirements and tax policy, we consider an alternative scenario. Specifically, we assume that the direct "effective" tax rate, which amounted to 1.9 percent of GDP in 2004, is

[8]The elasticity used to link poverty and the MDGs corresponds to the "neutral" case of unity. Adjusting this parameter is of course straightforward.

[9]The effective indirect tax rate was assumed to be endogenously determined, as in the original model (see Pinto Moreira and Bayraktar (2005)).

gradually increased, by one percentage point per annum beginning in 2007 for 5 years. Thus, the direct tax rate rises gradually to 6.9 percent of GDP in 2011. While this exercise is, again, for purely illustrative in nature, it is a sensible policy to consider in the case of Niger, where tax revenue ratios are relatively low compared to other countries at a similar level of per capita income.

The results of this experiment are illustrated in Tables 4 and 5. As shown in Table 4, the revenue-to-GDP ratio rises gradually over time, from about 10 percent to about 16 percent now. With the expenditure and borrowing ratios remaining practically the same, the implication is a significant drop over time in aid requirements, from 12.5 percent in 2006 to 7.9 percent in 2010 and 6.6 percent in 2015. As a proportion of tax revenues, aid requirements drop considerably, from 124.8 percent in 2006 to 41.6 percent in 2015 (compared to a drop to 109 percent with a constant direct tax rate). As a proportion of total public investment, they also drop quite dramatically, from 241 to 137 percent during the same period (compared to an increase to 250 percent in the previous scenario). However, in terms of the MDGs, the impact is much less significant; poverty, in the neutral elasticity case drops now from 63 percent to 50.3 percent (compared to 45.5 percent in the previous case) between 2006 and 2015, whereas the composite indicator improves from 102 in 2006 to 118 in 2006 (compared to 122 previously). The reason, of course, is that the increase in the direct tax rate lowers disposable income, which in turn slows the growth rate of private consumption. As a result, the fall in poverty is less significant, and other human indicators improve by less as well. Put differently, reducing aid dependency over time through domestic tax reform entails a cost, in terms of the speed at which the MDGs can be achieved—even though a significant portion of the increase in domestic resources is used to finance productive spending.

Of course, this apparent trade-off between increasing the share of government spending financed through domestic resources and poverty results from the fact that, because there is only one category of households in the

model, the increase in the tax rate is implicitly assumed to affect equally all households in the economy. In practice, low-income households would be largely exempt from direct taxation; their consumption pattern would not be affected, implying that the overall effect of higher taxes may well be a lower poverty rate (relative to the case considered here).

At the same time, however, upper-income households may be more inclined (or capable) to evade tax payments following an increase in the direct tax rate, thereby reducing (marginal) revenues from the tax. As a result, public investment may be lower than otherwise, which may dampen growth as well as the increase in disposable income and consumption expenditure. The net effect on poverty may therefore be ambiguous. These considerations are worth bearing in mind when designing “scaling down” scenarios, following a period of sustained increases in foreign assistance.

IV. Conclusions

The purpose of this paper was to develop a "bottom up" approach to linking public investment programs with a class of macro models recently developed to quantify Strategy Papers for Human Development (SPAHD) in low-income countries. This class of models, developed by Agénor, Bayraktar and El Aynaoui (2006) and extended by Pinto Moreira and Bayraktar (2005) and Agénor, Bayraktar, Pinto Moreira, and El Aynaoui (2005), provides a tractable framework for accounting for the links between aid, public capital (diaggregated between education, health, and infrastructure), and the supply side. By linking the model through cross-country regressions to indicators of poverty, malnutrition, infant mortality, life expectancy, and access to safe water, we obtain a consistent framework for evaluating the impact of policy decisions on the Millennium Development Goals.

The methodology proposed in the paper involves establishing constant-price projections of investment outlays (disaggregated into infrastructure, education, and health), spending on maintenance and other goods and services, salaries, and user charges. These estimates are then incorporated in the SPAHD macro framework to calculate, under alternative scenarios regarding domestic financing and foreign borrowing, aid requirements. The impact on growth and indicators associated with the Millennium Development Goals were also calculated. Illustrative applications, based on a SPAHD model for Niger, were used to highlight the impact of tax reform on aid requirements.

The "bottom up" approach proposed in this paper needs assurance about the quality and productivity of public investment. This would require building up the institutions and capacity to conduct objective cost-benefit analyses of proposed investment projects, to structure contracts and evaluate bids, and to monitor the implementation of public investment projects. This may also involve

the compilation and reporting of improved data, including estimates of the public capital stock and its depreciation rate.

An issue that needs to be further explored in the context of our proposed approach is the treatment of contingent liabilities, which may be sizable if some investments involve private participation. Although this may be an issue of limited importance for the low-income countries that we have in mind, in general excessive commitments can create problems. In principle, actual and potential costs for the government implied by a private-public partnership (PPP) contract should be taken into account when calculating aid requirements. Indeed the net present value of scheduled government payments under PPP contracts, less any contractual receipts such as concession fees—both discounted using a risk-free interest rate—should be counted as a liability and added to the initial stock of government debt.[10] Our methodology implies that, through their effect on debt servicing, these commitments would affect the calculation of aid requirements.[11] At the same time, however, it should be borne in mind that adequate estimates of contingent liabilities are difficult to establish.

[10] More precisely, it is the *expected* liability— that is, the stock of guarantees weighted by the probability that they will materialize—that should be added to the public debt.

[11] Alternatively, they would require the generation of larger future primary surpluses (or smaller primary deficits to ensure debt sustainability.

Appendix
SPAHD Macro Models: Structure and Link with the MDGs

The simulations presented in this paper are based on a macroeconomic model for Niger described in Pinto Moreira and Bayraktar (2005). The model is part of the SPAHD class of macro models first discussed by Agénor, Bayraktar and El Aynaoui (2006).[12]

SPAHD models are designed to capture the links between foreign aid, the level and composition of public investment, the supply-side effects of public capital, growth, and poverty, in the context of a "typical" low-income country. They focus on the fiscal and supply-side effects of aid, as well as the stock and flow effects of public investment---which is disaggregated into education, infrastructure (roads, electricity, telecommunications, and so on), and health---while accounting at the same time for potential congestion effects associated with the use of public services. They are designed, in particular, 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 SPAHD models contain only one category of households, they are silent on distributional issues. However, this is very much by design; the fundamental premise of SPAHD models is that the ability to engage in substantial income or asset redistribution in low-income countries (in Sub-Saharan Africa and elsewhere) is limited for a variety of reasons (including the low level of income to begin with), and that the key to achieving the Millennium Development Goals (MDGs) is a sustained increase in growth rates.

The first part of this Appendix describes the macro component of the SPAHD model for Niger 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.

On the production side, the economy produces one composite good, which is imperfectly substitutable to an imported good. Domestic production requires effective labor, private capital, and public capital in infrastructure and health. The stock of private capital is calculated by applying the standard perpetual inventory method (see OECD (2001, Chapter 5)).[13] In the case of public investment, however, the model accounts for the possibility that a fraction of the resources invested may not translate into an increase in the public capital stock—a point emphasized by Prichett (1996) in the context of developing

[12]The acronym SPAHD stands for Strategy Papers for Human Development, a term proposed by Agénor, Bayraktar, Pinto Moreira, and El Aynaoui (2005) as more encompassing than the current "PRSP" concept.

[13]We thus assume that it is the flow of services associated with a given capital stock that affects production, and that this flow is proportional to the prevailing stock. See OECD (2001) for a discussion of alternative methods for calculating a volume index of capital services.

countries in general. As discussed in the text, we follow the linear specification proposed by Arestoff and Hurlin (2005).

In addition to public capital in infrastructure improving the productivity of all private factors used in production, public capital in health improves the quality of labor employed in production. Effective labor is a composite input produced by the actual stock of educated labor 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 in domestic production, lagged output is used as an indicator of the intensity of use of public infrastructure. Domestic output is allocated between exports and domestic sales, based on relative prices.

Population and "raw" labor grow at the same constant exogenous rate. The transformation of raw labor into educated labor takes place through the education system, which provides schooling services free of charge. A key input in this process is a composite public education input, which is a function of the number of teachers and the stock of public capital in education. But production of educated labor requires not only teachers and public capital in education but also access to infrastructure capital.[14] A congestion effect is introduced by dividing the stock of public capital in education by the quantity of raw labor. Educated labor is employed either in the production of goods, or as government employees.

Income from production is entirely allocated to a single household. This household holds the totality of 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 subtracting direct taxes from total income. Total private consumption is a constant fraction of disposable income.

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.

Total demand for goods sold on the domestic market is the sum of private and public spending on final consumption and investment. Goods bought and sold on the domestic market are the combination of imported goods and domestically-produced goods, in standard Armington fashion. The domestic good is imperfectly substitutable with the foreign good, and its relative price is endogenous. As a result, the model allows the user to analyze potential Dutch disease effects that may be associated with large aid flows in a fixed-exchange rate economy such as Niger, through increases in domestic prices.

Aid, defined only as grants, is linked to the government budget through various channels. The government collects taxes and spends on salaries, goods and services, interest payments, and accumulates public capital. Aid is

[14]As discussed 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, possibly through an indirect improvement in health indicators.

accounted for “above the line.” 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. This specification captures therefore an adverse (moral hazard) effect of foreign assistance on fiscal effort. The effective indirect tax rate is also negatively related to aid. 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.

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 flow 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. In the Niger SPAHD model, the price of the domestic good on the domestic market is assumed to adjust only gradually to its equilibrium value. Finally, the domestic-currency price of exports is equal to the exchange rate times the world price of exports.

Six of the MDG indicators are integrated: the poverty rate, the literacy rate, infant mortality, malnutrition, life expectancy, and access to safe water. These MDG indicators also interact with each other, in a way that is made precise through a series of cross-country regressions.

The poverty rate is linked directly to the macroeconomic model either through partial growth elasticities relating a poverty indicator to consumption, or a household survey. The first method consists of relating the poverty rate (as measured by the headcount index) to the growth rate of real private consumption per capita, as derived from the aggregate component of the model. In the absence of more precise estimates for Niger, we use three partial elasticity values in the simulations reported in the text: a “neutral” or central value of -1, a “low” value of -0.5, and a “high” value of -1.5.

The literacy rate, which is defined as the ratio of educated labor to total population, is also a direct output of the model. It is only an approximation to the conventional definition, which relates to the proportion of the population aged 15 years and over which 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 Agénor, Bayraktar, Pinto Moreira, and El Aynaoui (2005).

Malnutrition prevalence is linked to the model through real consumption per capita and the poverty rate. While increasing consumption per capita reduces the incidence of malnutrition, an increase in the poverty rate raises it. Infant mortality is inversely related to poverty, and positively related to real income per capita and public spending on health. Thus, declining poverty may not be sufficient to decrease infant mortality if public investment in health is not increasing sufficiently.

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 infant mortality rates and higher real income per capita also tend to increase life expectancy.

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. Public investment in infrastructure raises access to safe water—both directly and possibly indirectly as well, through its impact on real income per capita.

To provide a synthetic view on progress toward achieving the MDGs, the Niger SPAHD model also calculates a composite 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.

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