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Fiscal Rules, Public Investment, and Growth

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Abstract

Solvency is an intertemporal concept, relating to the present value of revenues and expenditures, and encompassing both assets and liabilities. But the standard practice among policy makers, financial market participants and international financial institutions is to assess the strength of the fiscal accounts solely on the basis of the cash deficit. Short-term cash flows matter, but a preponderant focus on them can encourage governments to invest too little, especially during episodes of fiscal tightening. This has potentially adverse consequences for growth and, paradoxically, even for fiscal solvency itself. The paper offers an overview of the links between fiscal targets, public investment, and public sector solvency. After reviewing the international experience with public investment under fiscal adjustment, the paper lays out an analytical framework to illustrate the consequences of using the public deficit as a guide to solvency. The paper then discusses some alternatives to conventional cash deficit rules and their implications for investment and fiscal solvency.

This paper—a product of the Macroeconomics and Growth Team, Development Research Group—is part of a larger effort in the department to understand the macroeconomic impact of fiscal policy. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at lserven@worldbank.org.

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I. Introduction

Public sector solvency has to do with the government's assets and liabilities, its future revenues and expenditures. It possesses, by definition, an intertemporal dimension. In practice, however, financial markets and multilateral institutions routinely assess the strength of public finances on the basis of the cash deficit, that is, the rate of acquisition of liabilities by the public sector. Such practice amounts to ignoring public assets or, equivalently, the future income of the public sector and the intertemporal dimension of solvency.

Following this practice, fiscal adjustment programs, and their monitoring, typically focus on the time path of the government deficit. Because current and capital expenditure have identical effects on short-term government cash flows, and adjustment programs rarely set expenditure composition targets, the burden of fiscal adjustment tends to fall disproportionately on public investment and other productive expenditures of the public sector. Recent experiences of industrial and emerging countries attest to this conclusion.[1]

The use of public sector cash flow as sufficient statistic of fiscal discipline is especially problematic for those countries that face the task of building up their basic infrastructures, as is the case of most developing countries as well as newcomers to the European Union (EU). Such task demands a large investment effort that, under the action of conventional public deficit targets, would have to be financed through major increases in tax collection, entailing potentially large distortions and running counter to the objectives of tax smoothing and intergenerational equity.[2]

The alternative is to restrict the accumulation of productive assets to protect public sector cash flows. This, however, entails a cost in terms of future growth, and thereby an adverse impact on the *future* cash flows of the public sector, owing to the weakened growth of its revenue base. Thus, enhancing the government's *current* cash flows may not be an effective strategy to strengthen public solvency. This means that the conventional cash deficit is not a good guide to the strength of public finances, and hence other fiscal targets may do better at helping protect solvency without distorting the composition of spending and jeopardizing growth.

This paper offers an analytical review of the links between fiscal targets, public investment, and growth.[3] The rest of the paper is organized as follows. Section II reviews the international experience with public investment in the context of fiscal adjustment. Section III examines the arithmetic of solvency and its practical application. Section IV reviews alternatives to conventional cash deficit targets. Section V concludes.

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[1] For empirical evidence on the behavior of public investment and other government expenditure items in fiscal adjustment episodes, see Balassone and Franco (2000), Easterly and Servén (2003), Galí and Perotti (2003) and IMF (2003).
[2] This view is stressed by Buiter (2004) and Buiter and Grafe (2004).
[3] Key references in this literature are Blanchard and Giavazzi (2004), Buiter and Grafe (2004), and Mintz and Smart (2006). See also Easterly and Servén (2003).

II. Fiscal Adjustment and Public Investment

The macroeconomic literature has long acknowledged that fiscal adjustment episodes tend to include disproportionate public investment cuts. Such phenomenon has been amply documented in both developing and industrial countries.[4] Regarding the former, a recent independent evaluation of a large set of IMF-sponsored fiscal programs concluded that, in most cases, the restrictive fiscal measures led to a public investment contraction that proved excessive ex post (IMF 2003).

The experience of Latin America is particularly revealing in this sense. Over the last two decades, most of the countries in the region adopted fiscal adjustment measures that led to significant increases in the primary surplus. In most countries, the adjustment included a drastic contraction of public infrastructure investment. This is illustrated in the top panel of figure 1, which depicts the trajectories of the primary fiscal deficit and public infrastructure investment,[5] both as percent of GDP, for the average of eight Latin American countries. It is apparent from the graph that the decline in the primary deficit, from around 5 percent of GDP in the early1980s to about zero by 2000, was accompanied by a permanent fall in infrastructure investment, from an average of 3.5 percent of GDP in the early 1980s to 1.5 percent by the turn of the century.

The decline in public infrastructure investment affected virtually all countries (Calderón and Servén 2004a).[7] On average, it accounted for some 40 percent of the observed fiscal adjustment. This is remarkable because public infrastructure investment represents a small fraction of GDP, and a relatively small part of overall public expenditure. This is illustrated in the bottom panel of figure 1, which shows the average ratio of public infrastructure investment to the sum of public consumption plus public infrastructure investment -- a rough proxy for the overall primary expenditure of the public sector, for which information is not available. The graph shows that in the early 1980s infrastructure investment accounted for just under one-fourth of this expenditure aggregate. By the late 1990s, the proportion had declined to 10 percent. In other words, in the process of fiscal adjustment, investment fell much more abruptly than consumption. Indeed, in a majority of countries public consumption rose relative to GDP, while public infrastructure investment fell, implying that the public investment cuts partly financed an expansion of public consumption.

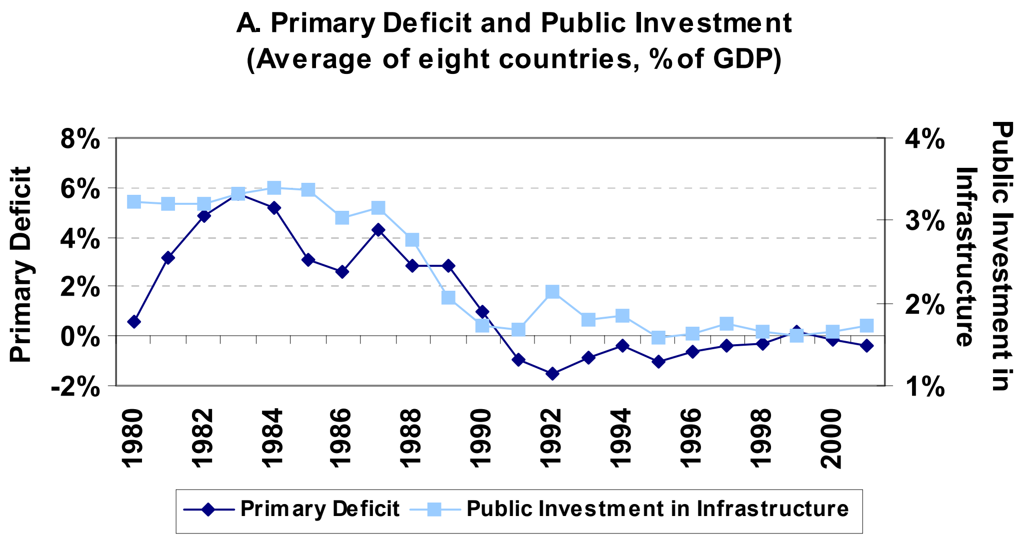
[4] Roubini and Sachs (1989) and de Haan, Sturn, and Sikken (1996) document the experience of industrial countries, and Hicks (1991) summarizes the facts on developing countries. Another reflection of the same empirical regularity is the fact that among all budget items public investment displays the highest volatility, a consequence of its strongly procyclical behavior. This is shown by Talvi and Végh (2000) using data from developing countries, and by Lane (2003) with data from industrial countries.

[5] As defined here, infrastructure includes land transportation, power, telecommunications, and water and sanitation.

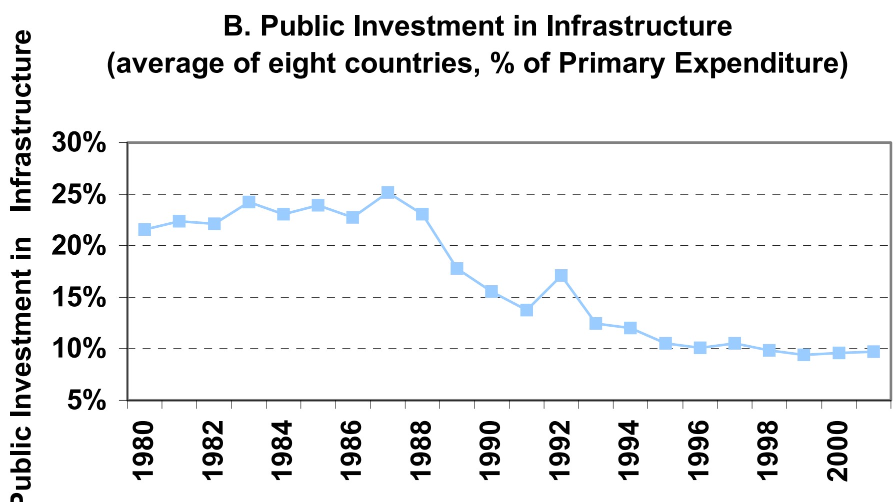
[7] Jonakin and Stephens (1999) also document the decrease in Latin America's public investment over this period.

Figure 1

Latin America: fiscal adjustment and public investment



Sources: Calderón and Servén (2004a); and Fitch database.

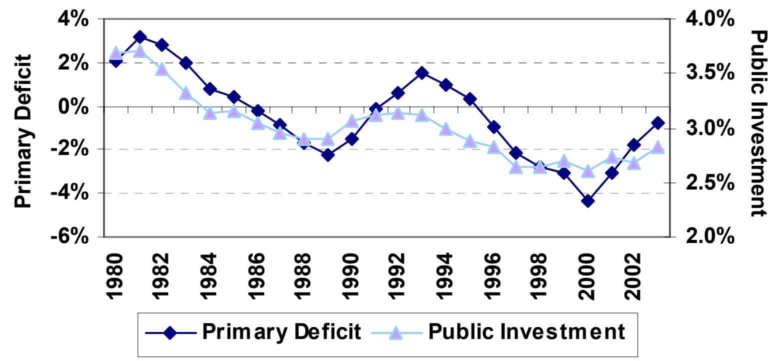


Sources: Calderón and Servén (2004a); and World Development Indicators.

Figure 2

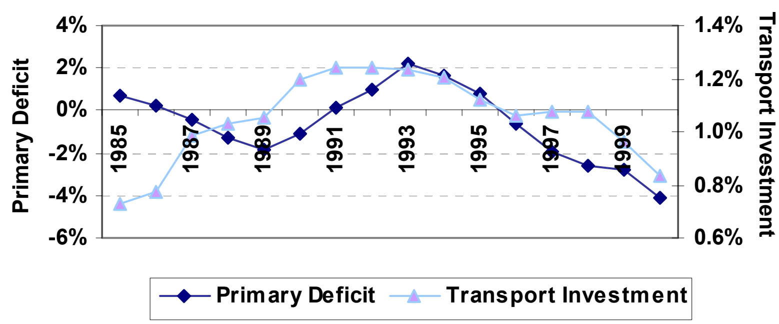
European Union: fiscal adjustment and public investment

A. Primary deficit and Public investment
(Average of 14 Maastricht countries, % of GDP)



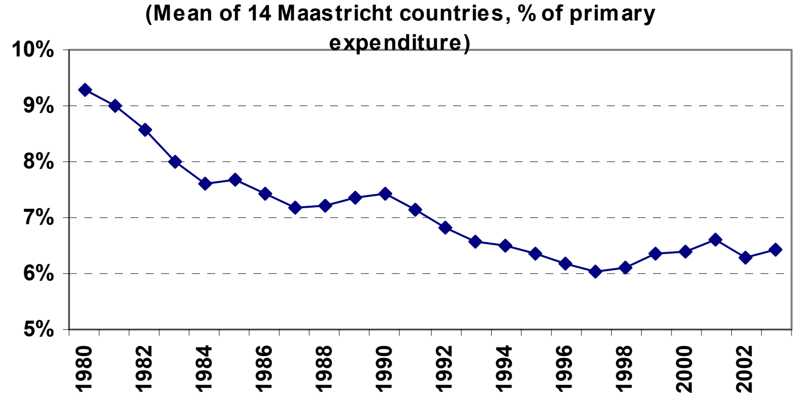
Source: OECD Economic Outlook database.

B. Primary deficit and transport investment
(average of 11 Maastricht countries, % of GDP)



Sources: World Development Indicators - World Bank; and provisional data from ECMT. Notes: (a) Total = Roads +Rails +Airports. (b) 11EU countries: Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Portugal, Spain, Sweden, and United Kingdom.

C. Public Investment
(Mean of 14 Maastricht countries, % of primary expenditure)



Source: OECD Economic Outlook database.

The experience of industrial countries is not much different. For example, an analysis of 32 episodes of fiscal adjustment in countries of the EU during the last two decades shows that in 25 of the 32 episodes public investment fell as percentage of GDP, and in 23 episodes investment fell more than other primary expenditure. Along the same lines, the evidence suggests that fulfillment of the Maastricht deficit targets sped up the decline of public investment in the EU countries: of the nine countries that exceeded the deficit target in 1992, eight met it in 1997; in all eight, public investment had fallen relative to GDP; and in seven, it had fallen relative to total primary expenditure as well. Conversely, three of the six countries that met the target in 1992 raised their public investment in the subsequent years (Balassone and Franco 2000).

Figure 2 illustrates the EU experience. Like in figure 1 above, the top panel shows the trajectories of public investment and the primary fiscal deficit, both as ratios to GDP. There is a clear comovement between the two series, with investment falling sharply during the fiscal adjustment of the 1980s as well as during the post-Maastricht period. Unlike in figure 1, public investment is not limited here to infrastructure; instead, it is inclusive of other categories. Nevertheless, the middle panel of figure 2 suggests that the situation was no different for infrastructure investment. The graph plots public investment in transport and communication along with the primary fiscal deficit. Again, we find a clear comovement between public investment and the primary deficit, with a steady contraction in both following the Maastricht agreement of 1992.

Finally, the bottom panel of figure 2 shows the trajectory of public investment relative to overall primary spending of the public sector. There is an apparent downward trend, which tends to accelerate at times of fiscal adjustment, indicating that public investment falls more than proportionately during fiscal crunches. Indeed, econometric estimations confirm that the public investment-to-total primary expenditure ratio shows a significantly positive association with the primary deficit, even after accounting for a time trend (which is itself negative and significant).[8]

To summarize, the recent drive toward fiscal discipline has been associated, more often than not, with a persistent infrastructure investment crunch.[9] This, of course, is not necessarily a cause for concern. The reduction in public investment might reflect efficiency enhancements, improved public procurement, or reduced corruption, allowing the same services to be provided at a lower investment cost. Also, if private and public capital are close substitutes, the public sector retrenchment may have been fully offset by private sector entry, without any adverse impact on service provision. Finally, public investment contraction might be a perfectly sensible strategy in a context in which the stock of public capital already has reached its target level, or following a shift in priorities toward other productive expenditures—such as education or health—not viewed as investment in the national accounts.

[8] Galí and Perotti (2003) stress the negative trend. The estimations mentioned in the text, reported in Servén (2004), employ a SUR procedure with fixed effects. A significant positive association is also found between the investment-to-GDP ratio and the primary deficit.
[9] Estache (2005) shows that this has been the case also in Sub-Saharan Africa.

There is a grain of truth in all these arguments. For example, in Latin America, the decline in public infrastructure investment was accompanied by the opening of most infrastructure sectors to private initiative. But the results were uneven: total investment (public plus private) fell in all infrastructure sectors except telecommunications (see Easterly and Servén 2003, chapter 2; Calderón and Servén 2004a). In fact, the countries that managed to attract higher private investment into such sectors were those that had maintained higher levels of public investment, which suggests that private and public investment may complement rather than substitute each other, contrary to the previous argument.

Moreover, the fall in total investment—reflecting the decline in public investment and the limited response of private investment—was in many cases so large that it is hard to explain in terms of efficiency gains and reductions in investment costs. In some Latin American countries, infrastructure investment has fallen to 1 to 2 percent of GDP, a level that can barely cover the depreciation of existing assets—and this in spite of the fact that in most cases infrastructure asset stocks remain wholly inadequate.[10] In some EU countries, public investment has likewise fallen to levels that, according to some estimates, probably imply asset decumulation.[11]

III. The Theory and Practice of Fiscal Solvency

The seeming anti-investment bias of fiscal discipline likely reflects several factors. Among them, political economy considerations are surely key: it is politically much harder to cut pensions or public sector wages at times of fiscal stringency than to cancel infrastructure projects. However, public deficit and debt rules also play a major role. Such rules aim to protect the solvency of the public sector, but they often do so at the cost of distorting the composition of public expenditures.

III.1 The Arithmetic of Public Sector Solvency

The concept of fiscal solvency follows from the intertemporal budget constraint of the public sector, which in essence prevents the government from running a Ponzi scheme in which interest payments on outstanding debt are financed by issuing more debt. Ultimately, interest payments must be financed, at least in part, through primary surpluses. The starting point for the arithmetic of solvency is the identity defining the trajectory of the public debt stock:

$$\dot{B}(t) = r(t)B(t) - \left[T(t) - C(t) - I(t)\right] \tag{1}$$

where B is the stock of public debt, r is the short-term real interest rate, T is public revenue, and C and I respectively represent the current and (gross) investment

[10] See World Bank (2005) for an assessment of infrastructure investment needs in Latin America.
[11] See Blanchard and Giavazzi (2004).

expenditures of the public sector.[12] It can be seen that the distinction between current and investment expenditure is of little consequence for the contemporaneous rate of debt accumulation (that is, the overall deficit). From this expression, we can compute the debt stock at instant *t+u* as follows:

$$B(t+u) = e^{\int_t^{t+u} r(v)dv} B(t) - \int_t^{t+u} e^{\int_s^{t+u} r(v)dv} \left[T(s) - C(s) - I(s)\right] ds \qquad (2)$$

As noted, the intertemporal budget constraint prevents the government from forever financing interest payments on its debt through additional debt issue. This amounts to saying that debt cannot indefinitely grow at a rate in excess of the real interest rate, that is, $\lim_{u\to\infty} e^{-\int_t^{t+u} r(v)dv} B(t+u) \leq 0$. Using equation (2), this is equivalent to the requirement

$$\int_t^{\infty} e^{-\int_t^{s} r(v)dv} \left[T(s) - C(s) - I(s)\right] \; ds - B(t) \geq 0 \qquad (3)$$

Thus, the present value of the stream of current and future primary surpluses must be no less than the initial public debt stock. In practice, the intertemporal budget constraint in equation (3) will always be met through appropriate adjustment of some residual fiscal variable—that is, taxes or public spending. Here we shall focus on the case in which the trajectories of these variables are given arbitrarily and the government has some initial debt *B*. Then the adjustment has to take the form of a suitable change in the initial debt stock that the government will honor. Formally, we can write analogously to (3):

$$\int_t^{\infty} e^{-\int_t^{s} r(v)dv} \left[T(s) - C(s) - I(s)\right] \; ds - D\,B(t) = 0$$

Here *D* is a "debt default discount factor," endogenously determined so that the expression holds with strict equality. A value of *D* smaller than one corresponds to the case in which the present value of future primary surpluses falls short of the outstanding debt stock, and hence implies a debt write-down; conversely, a value above unity reflects a "super-solvency premium" on public debt and implies a "debt write-up" (see Buiter 2002).[13]

For concreteness, we shall refer to the left-hand side of equation (3) as the public sector net worth (denoted *NW*), keeping in mind that the term is shorthand for the debt write-down (or up) required for the government's budget constraint to hold with equality when the time paths of taxes and primary expenditures are exogenously given. Hence, the government's net worth *NW* is positive (negative) if and only if *D* is greater (smaller) than one. Equivalently, *NW* can be viewed, after a sign change, as the present value of the

[12] For simplicity, we have abstracted from seigniorage and inflation. Their inclusion would be straightforward but would require some additional notation.

[13] Conceptually, the "write-up" provides the way for the government to dispose of any "excessive" primary surpluses it may collect.

fiscal correction necessary to ensure long-run balance of the government budget (Bruce and Turnovsky 1999).

In a growing economy, it is often more convenient to restate the solvency condition in terms of the debt-to-GDP ratio b.[14] Letting g denote the growth rate of real GDP, the trajectory of b is given by

$$\dot{b}(t) = \left[r(t) - g(t)\right]b(t) - \left[\tau(t) - c(t) - i(t)\right]$$

where the lowercase letters in the second square brackets denote the ratios to GDP of the corresponding uppercase variables. In this notation, the solvency condition prevents debt as a percentage of GDP from indefinitely growing at a rate exceeding the difference between the real interest rate and the GDP growth rate, so that

$$\lim_{u\to\infty} e^{-\int_t^{t+u}[r(v)-g(v)]dv}\, b(t+u) \leq 0\,.$$[15]

Hence, the counterpart to equation (3) is

$$\int_t^{\infty} e^{-\int_t^{s}[r(v)-g(v)]dv} \left[\tau(s) - c(s) - i(s)\right] \; ds - b(t) \geq 0 \qquad \text{(3a)}$$

As before, we let $nw(t)$ denote the left-hand side of equation (3a). To highlight the role of public investment and public capital (or, more broadly, of public expenditure that generates future revenue), it is convenient to break up total revenues into two components: one that captures the direct financial return on the public capital stock, and another that includes all other income. Therefore, $T = \widetilde{T} + \theta K$, where K is the public capital stock, θ is the gross financial rate of return captured by the government on each unit of public capital—for example, public service user fees minus operating costs—and $\widetilde{T}$ includes all other public revenues. Then we can rewrite (3a) as follows:

$$nw(t) = \int_t^{\infty} e^{\int_t^{s}[r(v)-g(v)]dv} \left[\widetilde{\tau}(s) + \theta k(s) - c(s) - i(s)\right]ds - b(t) \qquad \text{(4)}$$

Here, k denotes the public capital-to-GDP ratio, whose time path is given by

$$\dot{k}(s) = \frac{i\,(s)}{p} - \left[g(s) + \delta\right]k(s) \qquad \text{(5)}$$

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[14] The use of GDP as a scale variable is based on the implicit assumption that it is the main determinant of tax collection. If such a role corresponds instead to another macromagnitude—for example, aggregate consumption, as in the case of the value added tax—the latter would become the relevant scale variable.

[15] Here we need to assume $\lim_{u\to\infty} \int_t^{t+u} [r(v)-g(v)]dv \geq 0$. Otherwise, the government would be able to grow its way out of any debt stock no matter how large.

where δ is the depreciation rate of public capital and p denotes its replacement cost. In general, p will reflect not only the market price of investment goods, but also other factors such as the efficiency of public procurement or the effects of corruption on the actual cost of new public capital (Keefer and Knack 2006; Pritchett 2000). Inefficient procurement, bribes and kickbacks will result, other things equal, in higher values of p.

It is easy to illustrate the effect of public investment on government net worth. Assume for the moment that the real interest rate and the growth rate are exogenously given (with $r > g$); we shall return to this assumption later. Assume further that the current expenditure, investment, and tax revenue ratios are also constant. Solving equation (5) for $k(s)$ and replacing the result in equation (4), net worth at time 0 is given by:

$$nw = \left[\frac{\theta}{r+\delta}k_0 - b_0\right] - \frac{1}{r-g}\left[\tilde{\tau} - c + i\left(\frac{\theta}{p(r+\delta)} - 1\right)\right] \qquad (4a)$$

where the zero subscript denotes the initial values of debt and public capital. The first term of this expression captures the government's initial net assets. Their replacement cost is ($pk_0 - b_0$), but that of the capital stock pk_0 needs to be adjusted multiplying by the return on capital relative to its user cost $\theta / p(r+\delta)$. In turn, the second term of the expression captures the contribution to net worth of income and expenditure flows. Public investment appears multiplied by the ratio of the direct financial yield on public capital θ to the user cost of capital $p(r+\delta)$. From this expression, the impact of a permanent, deficit-financed change in the public investment ratio i is just:[16]

$$\left.\frac{d\ nw}{d\ i}\right|_g = \frac{1}{r-g}\left[\frac{\theta}{p(r+\delta)} - 1\right] \qquad (6)$$

Thus, an increase in public investment raises or reduces the government's net worth depending on whether the financial rate of return on public capital θ is greater or smaller than the user cost of capital $(r+\delta)p$.

An equivalent way to illustrate the same point is to express the net worth of the government in terms of its net liabilities, $b - pk$. The expression equivalent to equation (4), for the case of constant r and g, is as follows:[17]

$$nw(t) = \int_t^{\infty} e^{-(r-g)(s-t)}\left\{\tilde{\tau}(s) + \left[\theta - (r+\delta)p\right]k(s) - c(s)\right\}\ ds - \left[b(t) - pk(t)\right] \qquad (4b)$$

[16] If the change were temporary, the present-value term $(r\text{-}g)^{-1}$ would from not appear in (6).

[17] To derive equation (4b), we just replace equation (5) into equation (4) and integrate the resulting expression.

In this formulation, solvency requires the present value of the government's primary surplus on current account, net of the user cost of public capital, to be no less than the face value of net public liabilities—that is, debt minus capital. From equation (4b), it is clear that an increase in the public capital stock matched by an equal increase in public debt at time t (so that net liabilities $b - pk$ remain unchanged) raises or lowers the net worth of the public sector depending on the sign of the return differential $\theta - (r+\delta)p$.[18]

Irrespective of the net worth effect of an investment increase, its impact on the primary surplus must be negative in the short run, while that on the debt-to-GDP ratio must be positive. Over time, as the extra capital is put in place and returns accrue at the rate θ, the primary surplus will rise and—provided that $\theta > (r+\delta)p$—the debt-to-GDP ratio will decline below its initial level.[19] This contrast between the short- and long-run effects on the primary surplus and debt is a reminder that cash flow can be a poor guide to solvency.

These expressions illustrate the net worth effects of a debt-financed investment change. The effects of an investment expansion financed instead by cutting public consumption are much more straightforward: short-run cash flow is unchanged, but government net worth must rise if the net financial rate of return on public capital θ is greater than zero.[20] Obviously, the composition of spending matters for net worth as long as financial rates of return differ across expenditure types—as is the case in this framework, which assumes that public consumption yields zero return.

III.2 Public Investment, Growth, and Solvency

The above discussion shows that the effects on net worth of a public investment expansion depend on the direct financial return on public capital θ. However, the value of θ is likely to vary greatly across investment types. User fees may cover the user cost of capital of government-owned utilities, but not that of untolled roads or sanitation projects, which often yield no direct financial return (that is, $\theta \le 0$). Nevertheless, public

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[18] A fall in pk matched by an equal reduction in b could be interpreted as a privatization whose proceeds are used to retire public debt. Such transaction strengthens public finances only if $\theta > p(r+\delta)$. This amounts to requiring that the government sell the capital assets at a price greater than the present value of the future financial returns that would have accrued from holding them. This might occur if the government smartly manages to overbill the private purchaser or, more realistically, if the returns that the purchaser can accrue (and hence the purchase price s/he is willing to pay) exceed those that the government would have obtained if it had retained the asset.

[19] Specifically, the primary surplus will decline (relative to GDP) up to time $\hat{t} = \dfrac{\ln\left[1 - \dfrac{p(g+\delta)}{\theta}\right]}{g+\delta}$, and the debt ratio will be rising up to a later time $\tilde{t} = \dfrac{\ln\left[1 - \dfrac{p(r+\delta)}{\theta}\right]}{r+\delta} > \hat{t}$ as $r > g$.

[20] Of course, this need not always be the case. For example, if user fees charged for public services fall short of the direct costs of providing them, we would have $\theta < 0$.

investment projects may generate indirect financial returns to the government, to the extent that they affect aggregate income growth and hence the expansion of tax bases and public income.[21]

The impact of public investment, and particularly infrastructure investment, on aggregate growth has attracted considerable attention in recent years.[22] An abundant body of empirical literature, beginning with Aschauer (1989), has sought to quantify the contribution of public capital to growth; see Calderón and Servén (2007) and Romp and de Haan (2005) for recent overviews. These studies typically are based on the estimation of aggregate production functions augmented with infrastructure stocks (for example, Calderón and Servén 2003, 2007; Canning 1999; Demetriades and Mamuneas 2000; Röller and Waverman 2001), or on empirical growth equations, including measures of public infrastructure or public investment among the explanatory variables (Aschauer 1998; Calderón and Servén 2004b; Easterly and Rebelo 1993; Esfahani and Ramirez 2003). While far from unanimous, a majority of studies – especially those using physical asset stocks to measure infrastructure – find significantly positive effects of public capital on aggregate output and its growth rate, although the findings are less robust among those studies that use public investment flows (or their cumulative value) as regressors.[23]

One important implication of this literature is that evaluation of alternative fiscal strategies has to take into account their respective growth consequences, not just to gauge the economy's future aggregate performance, but also to assess the full effects of the different fiscal policy paths on public finances themselves. Analytically, a simple illustration can be provided as follows. Assume that the economy's aggregate production technology is of the form

$$Y(s) = A\,K(s)^{\alpha}\left[L(s)\,e^{\gamma s}\right]^{1-\alpha} \tag{7}$$

where L is labor, $1 > \alpha > 0$, and $\gamma \geq 0$ denotes the rate of exogenous labor-augmenting technical progress (the appendix briefly reviews the case $\alpha = 1$ in which the marginal product of capital is constant). For simplicity, we ignore private capital and assume continuous full employment of the given labor supply $\overline{L}$, which for convenience will be

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[21] This is well known to budgetary authorities in many countries, who often turn to overoptimistic growth projections as a last resort to balance public finances, even if only on paper.

[22] Analytically, numerous articles have explored the role of public investment in the growth process. Early on, the focus was on the flow of productive public services (Barro 1990; Turnovsky and Fisher 1995), but more recently, it has shifted to the accumulation of public infrastructure and/or human capital assets, whose services are viewed either as pure public goods (Futagami, Morita, and Shibata 1993; Ghosh and Roy 2004; Kalyvitis 2002) or public goods subject to congestion (Agénor 2004; Glomm and Ravikumar 1997; Turnovsky 1997). Zagler and Durnecker (2003) survey this literature. In these models, the impact of public investment on long-run growth is typically positive, but may change sign if public investment rises beyond a certain level. Furthermore, the growth-maximizing level of public investment may differ (most commonly, exceed) its welfare-maximizing level (for example, Turnovsky 1997).

[23] The likely reason is that investment spending may be a poor proxy for the accumulation of productive assets; see Pritchett (2000) and Keefer and Knack (2006).

set equal to one and ignored in what follows.[24] Hence, $\gamma(1-\alpha)$ captures the growth of output due to exogenous factors affecting the productivity of public capital. Note that the marginal product of public capital is just $\partial Y/\partial K = \alpha / k$. In this framework, the growth impact of a given change in the public investment ratio is smaller the higher the prevailing public capital-to-output ratio *k*. Furthermore, investment only affects the economy's transitional dynamics; with a constant investment-to-output ratio, the growth rate of the economy converges to γ in the long run.

Assuming a constant real interest rate *r* (with $r > \gamma$), as well as constant public consumption, investment, and tax ratios to GDP, the appendix shows that net worth is given by

$$nw = \left[\frac{\theta}{r+\delta}k_0 - b_0\right] + \frac{1}{r-\gamma}\left[\tilde{\tau} - c + i\left(\frac{\theta}{p(r+\delta)} - 1\right)\right] H\left(\frac{i}{pk_0(\gamma+\delta)}\right) \quad (8)$$

The two terms in square brackets are identical to equation (4a) above, with the long-run growth rate γ replacing *g*. But here the second term is multiplied by a factor *H*(.) that captures the effect of net investment on output growth. It is straightforward to verify[25] that *H* is monotonically increasing in its argument, with $H(0) = \dfrac{r-\gamma}{r-\gamma+\alpha(\gamma+\delta)} < 1$ and $H(1) = 1$. Hence when investment is just sufficient to keep the public capital-output ratio constant, the growth rate is equal to γ, and net worth (8) reduces to the simpler version (4a).[26] Aside from that particular situation, $H(.) > 1$ if $i > pk_0(\gamma+\delta)$, so that the capital-output ratio is rising, and $H(.) < 1$ in the opposite case.

Using equation (8), it is straightforward to compute the change in net worth arising from a change in the public investment ratio. To simplify the algebra, it will be convenient to assume that we start from a situation with $i = pk_0(\gamma+\delta)$, so that initially the capital-to-output ratio is not changing. Holding the public consumption and tax collection ratios constant, we get:

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[24] It would be straightforward to add a labor supply decision in the model, derived from consumer optimization. In contrast, allowing for endogenously determined private capital accumulation would add considerable complication to the analysis, and we shall not pursue that extension here.

[25] Here we have defined $H\left(\frac{i}{pk_0(\gamma+\delta)}\right) \equiv {}_2F_1\left(1, \frac{\alpha}{\alpha-1}, 1+\frac{r-\gamma}{(1-\alpha)(\gamma+\delta)}, 1-\frac{i}{pk_0(\gamma+\delta)}\right)$, where ${}_2F_1(.)$ is Gauss' hypergeometric function, which can be expressed in integral form as ${}_2F_1(a,b,c,z) = \frac{\Gamma(c)}{\Gamma(b)\Gamma(c-b)}\int_0^1 t^{b-1}(1-t)^{c-b-1}(1-tz)^{-a}\,dt$, with $c>b>0$.

[26] The same happens if $\alpha = 0$, so that output is unaffected by the public capital stock. In such case, $H(.) = 1$ regardless of the value of *i*.

$$\left.\frac{d\ nw}{d\ i}\right|_{\dot{k}=0} = \frac{1}{p\left(r+\delta(1-\alpha)-\alpha\gamma\right)\left(r-\gamma\right)}\left\{(\tilde{\tau}-c)\left(\frac{\partial Y}{\partial K}\right)_0 + \theta - p\left(r+\delta\right)\right\} \qquad (9)$$

Where $\left(\partial Y/\partial K\right)_0 = \alpha / k_0$. If $r > \gamma$, as assumed, the denominator of this expression is positive. The expression boils down to equation (6) when $\alpha = 0$, in which case the marginal product of public capital is also zero: the net worth effect of investment changes depends only on the (direct) rate of return on capital relative to its user cost. When $\alpha \neq 0$, capital accumulation generates additional output and net government revenue, provided the *net* tax collection ratio $(\tilde{\tau} - c)$ is positive. Hence, in this case, a rise in the public investment ratio increases net worth if the *total* financial return on the additional public capital—given by the sum of user fees plus the indirect tax revenue effect, the first two terms inside the curly brackets in equation (9)—exceeds its user cost. This is more likely to be the case the higher the marginal product of public capital and the net tax ratio, and the lower the user cost of capital. Furthermore, under the plausible assumption that the total financial return captured by the government on public capital cannot exceed its marginal product, equation (9) implies that a necessary condition for net worth to rise with an increase in the public investment ratio is that public capital be initially underprovided—that is, $(\partial Y/\partial K)_0 > p(r+\delta)$.

If the initial situation is such that net worth equals zero, equation (9) becomes

$$\left.\frac{d\ nw}{d\ i}\right|_{\dot{k}=0,\ nw=0} = \frac{1}{r+\delta(1-\alpha)-\alpha\gamma}\left\{\left(\frac{1-\alpha}{r-\gamma}\right)\left[\frac{\theta}{p}-\left(r+\delta\right)\right]+\alpha\left(\frac{b_0}{pk_0}-1\right)\right\} \qquad (9a)$$

Thus, a deficit-financed investment expansion is more likely to raise government net worth the higher the initial ratio of public debt to public capital. Indeed, if the direct financial return on public capital fails to cover its user cost (that is, when $\theta < (r+\delta)p$), a necessary condition for net worth to rise with public investment is $b_0 > pk_0$, so that the government's initial debt exceeds its capital stock.[27] The intuitive reason for this is that under such condition the additional growth associated with capital accumulation contributes to erode the government's net liabilities, thereby enhancing its patrimonial position; this has been stressed by Easterly (1999) and Easterly and Servén (2003). As before, in the short run the public debt-to-output ratio is likely to rise following a deficit-financed public investment expansion,[28] but if expressions (9) or (9a) are positive, the initial rise will be followed by a decline in the public debt ratio, which will eventually fall below its initial level.

[27] This is also the case if the government's net worth is initially positive.

[28] Starting from a position of zero net worth, the debt ratio will rise initially provided $(\partial Y/\partial K)_0 \leq 1/b_0$, which is likely to hold unless indebtedness is very high or the public capital stock is very low.

So far we have assumed that the investment expansion is deficit-financed and the net tax collection ratio $(\tilde{\tau}-c)$ remains constant relative to GDP. This amounts to assuming that the tax system is sufficiently elastic so that tax revenue rises in proportion with aggregate output.[29] What if the investment expansion were financed instead by an offsetting change in net tax collection? In such scenario di = $\mathrm{d}(\tilde{\tau}-c)$, so that for given k the primary surplus ratio remains constant. In this simple framework, which abstracts from the distorting effects of taxation, net worth must unambiguously rise.[30]

3.3 Operations and Maintenance

The preceding discussion equates public investment with productive expenditure and public consumption with unproductive expenditure. In reality, things are more complicated: not all capital expenditure is productive – in the sense of increasing current and/or future output supply -- and not all current expenditure is pure waste. One important example of productive current public expenditure is that of operations and maintenance (O&M). While public investment in new roads or transport facilities usually attracts much more attention than O&M, the latter is essential for public capital to yield productive services. Information on these expenditures is generally hard to obtain, but anecdotal evidence suggests that they tend to be compressed even more sharply than investment at times of fiscal retrenchment. This should be a cause of concern, because inadequate maintenance reduces the productive contribution of capital assets and shortens their useful life. The key role of O&M has been duly recognized in recent analytical literature. For example, Rioja (2003a, 2003b) shows that if maintenance expenditures are too low, new investment in infrastructure can be growth- and welfare-reducing—while additional O&M spending has the opposite effect.

We can easily expand the present analytical framework to accommodate O&M spending, as follows. Let z denote O&M expenditure per unit of public capital, and let $\theta=\theta_0-z$; hence θ_0 denotes the direct return on public capital gross of O&M charges. Likewise, let $\delta=\delta(z/p)$ with $\delta'<0$. Thus, an increase in maintenance spending has a dual effect: on the one hand, it reduces the instantaneous rate of return on existing public capital; on the other, it extends its useful life, so that the lower return accrues over a longer horizon. Depending on the relative magnitude of these two effects, raising z may raise or lower the present value of future primary surpluses.

Formally, the impact on net worth of a deficit-financed change in O&M spending per unit of public capital z can be computed replacing θ and δ into, equation (8), and

[29] Public capital operating costs and maintenance spending may rise along with investment, but they are already included in θ. Regarding other current spending c, as well as revenue collection $\tilde{\tau}$, rather than assuming them fixed, we could let them vary with the long-run growth rate g. Empirically, however, the evidence seems consistent with the constancy assumption; see Calderón, Easterly, and Servén (2003).

[30] For example, equation (9a) would become

$$\left.\frac{d\ nw}{d\ i}\right|_{\dot{k}=0,\ nw=0, di=-dc}=\frac{1}{r+\delta(1-\alpha)-\alpha\gamma}\left\{\left(\frac{1-\alpha}{r-\gamma}\right)\frac{\theta}{p}+\alpha\frac{b_0}{pk_0}\right\}\geq 0.$$

for simplicity starting again from zero net worth and a constant capital-output ratio. Differentiating equation (8) we get:

$$\left.\frac{d\ \ nw}{d\ \ z}\right|_{\dot{k}=0,\ nw=0} = \frac{-k_0}{r+\delta(z/p)(1-\alpha)-\alpha\gamma}\left\{\left(\frac{1-\alpha}{r-\gamma}\right)\left[\theta\delta' + \left(r+\delta(z/p)\right)\right] + \alpha\left(\delta'\frac{b_0}{k_0}+1\right)\right\} \quad (10)$$

If the capital-creating effect of O&M expenditures, via reduced depreciation, exceeds the return-reducing effect of higher O&M costs, so that $\delta'+1<0$, this expression is more likely to be positive than equation (9a) or, in other words, increased O&M has a more favorable effect on net worth than increased investment—and conversely if $\delta'+1>0$. We can define a critical level of O&M spending per unit of capital z^*, such that $\delta'(z^*)=-1$; monotonicity of δ ensures that z^* is unique. As long as $z \neq z^*$, a reallocation of expenditure between investment and O&M–keeping total primary spending constant—will yield higher growth and net worth. For $z < z^*$, this can be achieved by reducing investment expenditure and raising O&M, and conversely if $z > z^*$.[31]

3.4 Reality Checks

So far we have assumed a constant real interest rate. This amounts to assuming that the government faces given borrowing terms in financial markets. In practice, interest rates may vary reflecting changing default premia, which are typically assumed to depend on the outstanding debt stock (as a ratio to GDP, say). In such case, the discount rate relevant for judging the solvency effects of public expenditure changes is the marginal cost of public debt, which in general will exceed its average cost, given by the prevailing interest rate. The reason is that a deficit-financed increase in investment (or in O&M spending) reduces the primary surplus and raises the debt stock in the short term—even if it may have the opposite effect in the long term—and thereby the default premium and the real interest rate.

Consider, for example, the analytically convenient real interest rate specification $r(t)=\bar{r}+\eta(1-\bar{b}/b(t))$, where $\eta \geq 0$, and $\bar{r},\bar{b}>0$ are given constants. If $\eta > 0$, the interest rate rises with the public debt-to-GDP ratio. By choosing $\bar{b}=b(0)=b_0$ for simplicity (which implies that $r(0)=\bar{r}$), it can be verified that the solvency impact of a change in public investment continues to be given by expressions (9) and (9a), but with r replaced by the marginal cost of public debt $\bar{r}+\eta$—which is higher than the interest rate prevailing at time 0. Thus, the steeper the slope of the lending supply schedule—as

[31] In general, the optimal choice between new investment and O&M spending depends on other factors in addition to their net worth impact; see Kalaitzidakis and Kalyvitis (2004).

reflected by a larger η—the less favorable (or more adverse) the impact on net worth of a deficit-financed public investment increase.[32]

A second caveat concerns the issue of uncertainty, which has been ignored so far. Yet the net worth calculations above involve estimates of future output, tax revenues, and user fees, all of which are intrinsically uncertain. In this framework, a simple way to take uncertainty into account would be to employ risk-adjusted discount rates to bring future cash flows to present value terms. This would amount to adding a risk premium to the real interest rate, with consequences similar to those described in the previous paragraph.[33]

The third caveat is the partial equilibrium setting used here, which neglects feedback effects on the productivity of public capital arising from endogenous changes in the supply of other inputs—labor or, most important, private capital—ignored in equation (7). In reality, changes in public investment will likely affect both the marginal productivity and the user cost of private capital and thus its rate of accumulation. If public and private capital are complements (as much of the empirical literature suggests), then increased public capital accumulation raises the marginal product of private capital and hence encourages private investment. In such case, the growth impact of public investment would be understated in the above analysis, as would be its contribution to government net worth. If public and private capital are complements instead, the conclusion would be reversed. On the other hand, if real interest rates are endogenous, a debt-financed public investment expansion may raise the user cost of private capital and crowd out private investment, and then the above results would overstate the growth and solvency contribution of public capital. Proper account of these general equilibrium effects requires a fully specified macroeconomic model, which is beyond the scope of this paper.

3.5 Discussion

The main point to be stressed is the key distinction between productive and unproductive expenditures that arises from the government's intertemporal budget constraint: their respective implications for solvency are different because the former finance the acquisition of assets accruing (directly or indirectly) future financial returns, while the latter do not.

This, however, is rarely recognized in practice, because conventional fiscal targets are typically set in terms of cash deficit, paying scant attention to the composition of expenditure and the intertemporal budget constraint. This amounts to using short-term cash flow as the yardstick for solvency, which tends to discourage the adoption of *any* projects with negative short-term cash flows. Such category includes virtually all public

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[32] In other words, (9) and (9a) are more likely to be negative—except, in the case of the latter, when $(\partial Y/\partial K)_0 > 1/b_0$, so that the debt ratio falls initially instead of rising, in which case the marginal cost of debt falls as well.

[33] Another alternative would be to introduce uncertainty explicitly and then examine the impact of public investment on the entire probability distribution of net worth.

infrastructure projects, even if their future returns exceed the user cost of capital—in which case such projects strengthen solvency and are consistent with good public economics. Only projects whose investment cost is fully financed by taxes would be exempted from these constraints—even though raising taxes today to fund the acquisition of long-lasting assets may represent bad public economics, as it may run counter to the objectives of tax smoothing and intergenerational equity.

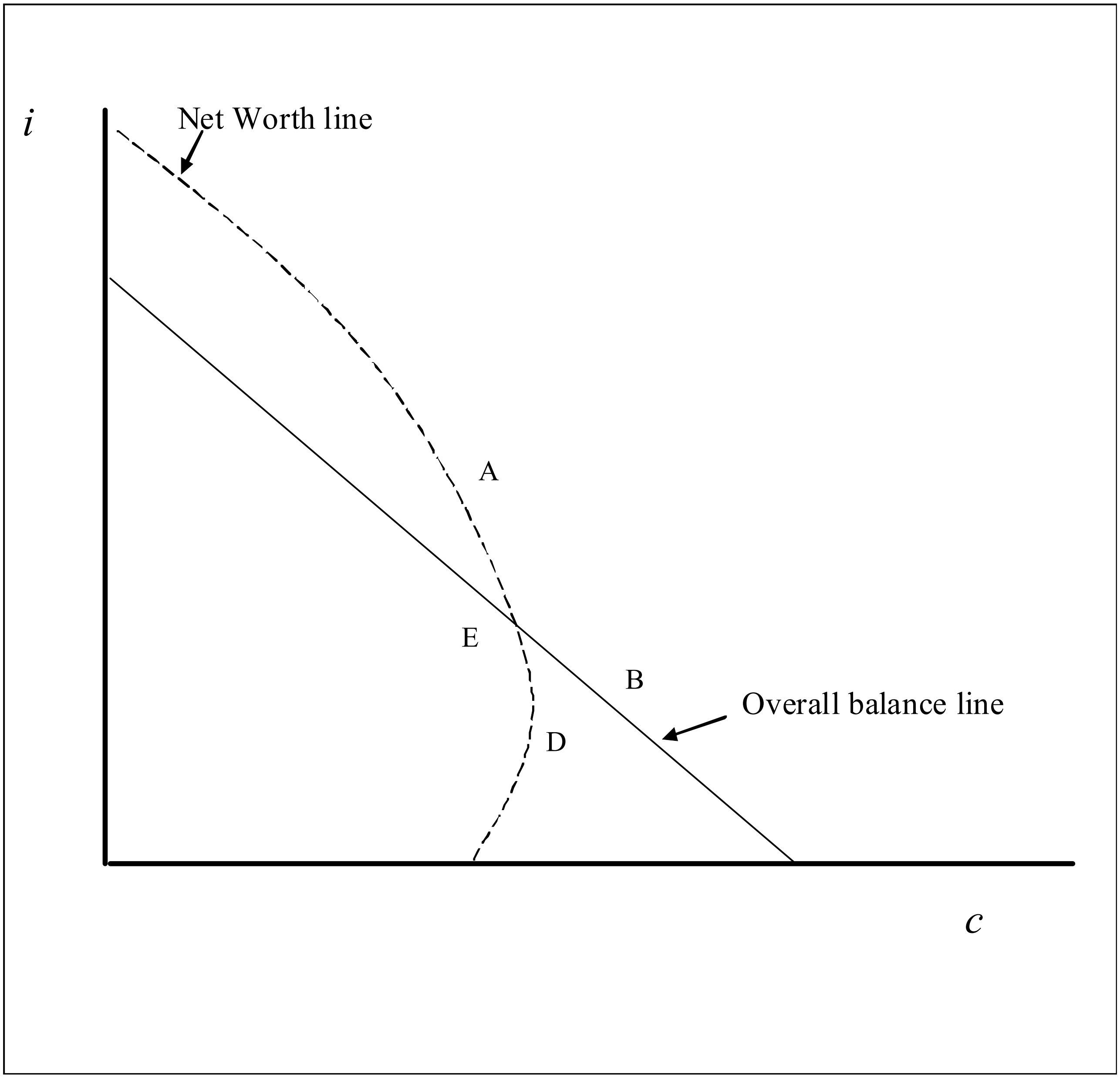
Figure 3 illustrates the effects of net worth and cash-flow targets on the composition of public expenditure. Along the overall balance (solid) line in the graph, total primary expenditure $c+i$ is constant relative to output; hence, for given tax rates and debt, so is the government's overall balance. The slope of the line equals -1. In turn, along the dashed curve, which describes the contour set of equation (8), net worth is constant. The curve must be steeper than the overall balance line if public capital yields *some* financial return, whether through user fees or taxes. Furthermore, the slope of the curve is not constant. At low levels of investment, the public capital stock remains low and its return high, and hence the curve is very steep—it may even slope upward over an initial region, if the marginal unit of investment yields a financial return in excess of the cost of borrowing. In the graph, this happens in the segment of the curve between point D and the horizontal axis. As public investment rises, so does the public capital stock, its marginal financial return declines toward zero, and the net worth curve eventually becomes parallel to the overall balance line. Toward the northeast quadrant of the graph, both the overall balance and net worth deteriorate; toward the southwest, they improve.

The figure also illustrates the link between expenditure composition and fiscal performance indicators. Consider point E, where the two lines intersect. Movements along the overall balance line to the southeast of E—to a point such as B, say—leave the overall balance unchanged but reduce net worth. The reason is that zero-return current expenditure is being substituted for public investment. Conversely, as we move toward the northwest of E along the net worth curve—to a point such as A, say—the overall balance deteriorates but net worth is unchanged, precisely for the opposite reason.

We could think of the government determining its spending composition in textbook fashion—at the tangency between (a) some indifference curve (not drawn) characterizing the government's preferences between public consumption and investment and (b) the relevant constraint. Because the net worth line is steeper than the overall balance line, the government spending mix will generally be more biased toward consumption under binding cash-flow constraints than under net worth constraints. Thus, other things equal, governments facing binding cash-flow targets today may devote too few resources to expenditures that yield returns tomorrow. This is a simple consequence of the different trade-off between consumption and investment posed by net worth targets and cash-flow targets.

Figure 3

Cash-flow targets, net worth targets, and spending composition



Related to these effects on the composition of expenditure, the use of the conventional public deficit to gauge the soundness of public finances also creates incentives for governments to adopt policy measures that ostensibly aim at "fiscal adjustment" but often are little more than accounting gimmicks. In light of the intertemporal budget constraint, such measures are of no consequence for fiscal solvency, and in some cases, they may even weaken public finances. The international experience highlights a wide variety of illusory adjustment measures, ranging from changes in the time profile of public revenues or expenditures without any change in their present value, to reductions in the rate of public debt issuance achieved through matching reductions in the rate of accumulation of public assets—a strategy that by itself has no effect on public sector net worth.[34] In terms of figure 3, a movement from A to E, for example, improves the overall balance but has no effect on solvency.

Paradoxically, some governments have also resorted to creative tricks to shelter investment from the pressure of deficit limits. For example, many countries have made use of extra-budgetary financing of public investment, effectively hiding the latter from public view. Another popular option has been the issuance of contingent liabilities—such as credit or rate-of-return guarantees—to private investors, under partnership agreements between the public and private sectors. These arrangements can, and sometimes do, have efficiency-increasing effects, but they often leave the public sector bearing most or all of the investment risk, in which case they amount to little more than accounting gimmicks. Furthermore, the lack of clear standards for the budgetary accounting of such operations tends to weaken fiscal transparency, and in some countries, has allowed the accumulation of large hidden liabilities that surfaced unexpectedly—and with large fiscal consequences—when the government guarantees have been called on.[35]

The preceding discussion illustrates the fact that cuts in the public sector's productive expenditures undertaken in the name of fiscal discipline may represent another form of fictitious adjustment. Their direct effect is to reduce the conventional public deficit and the rate of debt accumulation, but they may do so at the cost of a slowdown in growth and future fiscal revenue, which indirectly results in reduced future primary surpluses and undermines the fiscal adjustment itself. In terms of figure 3, a movement from A to B, for example, improves the overall balance but weakens solvency.[36]

How important, in practice, is this indirect effect? From the preceding discussion, there are two key ingredients. The first is the growth impact of public investment, given by the marginal productivity of public capital as well as its acquisition cost. Other things equal, the marginal productivity is likely to be higher when the government has strong project selection capabilities, so that its investment involves top-quality projects, and when the initial endowment of public capital is low. It should also depend on the

[34] Easterly (1999) and Easterly and Servén (2003, chapter 1) offer numerous examples.
[35] These issues are discussed at length by Irwin, Klein, Perry, and Thobani (1997) and Engel, Fischer, and Galetovic (2003).
[36] Buiter (1990, chapter 13) offers a rigorous illustration of the scenario in which such kind of fiscal adjustment leads to a weakening of public finances.

composition of public investment. Some public investment projects (for example, in areas such as environmental conservation) unquestionably enhance welfare but have little effect on future output, while others (for example, major roads) may have a significant growth impact. Finally, if the purchase of public capital involves significant waste (i.e., p is high), changes in public investment may have only a minimal impact on asset accumulation and growth.

The second ingredient is the government's ability to capture at least part of the marginal return, via user fees or taxes—which, in the latter case, depends on the tax system and its administration. If these are deficient, and thus the output elasticity of fiscal revenue is low, then even projects with high growth impact may weaken public finances.

These two ingredients reflect a multiplicity of country-specific factors, which are hard to quantify in general. Empirical studies have focused mainly on public infrastructure capital. Some recent estimates, using an aggregate production function approach in a large cross-country sample, find considerable international variation in the marginal productivity of infrastructure assets, with lower-income countries generally exhibiting higher marginal products because of their smaller public capital endowments. In the vast majority of countries, the marginal productivity of infrastructure assets exceeds that of other capital. [37]

These estimates suggest that in many countries—especially poorer ones—the productivity of infrastructure capital likely exceeds its user cost. Still, from the solvency perspective, the question is how much of the return is actually captured by the government. For example, absent user fees, equation (9) implies that if the user cost of public capital is about 0.10 (say $r = .06$, $\delta = .04$, $p = 1$), then the marginal (net) tax rate should be at least 0.20 if the government is to break even (in net worth terms) on a project yielding a marginal product equal to 0.50, in line with the estimates obtained for poor countries. This may seem like a modest requirement, but in effect it likely exceeds the revenue-raising abilities of many poor countries.

The self-financing ability of public investment has attracted some empirical attention. Perotti (2004) assesses whether public investment can "pay for itself" using data from five rich countries—the United States, Germany, the United Kingdom, Canada, and Australia—and focusing on total public investment. He evaluates a condition similar to equation (9) with $\theta = 0$, so that public capital accrues no direct financial return. In such case, whether public capital is self-financing depends on the sign of $1-(\tilde{\tau}-c)(\partial Y/\partial K)_0/[p(r+\delta)]$. This expression equals one if public investment yields no future income, and becomes negative if investment "pays for itself." Using a VAR approach, Perotti finds that the empirical counterpart of this expression varies greatly across countries, ranging from above unity in Canada and the United Kingdom (which suggests a negative growth contribution of public capital at the margin), to 20 to 30 percent in Australia and the United States, to zero or even negative values in Germany.

[37] See Calderón and Servén (2007).

Perotti's sample is made up of countries whose public capital stocks per capita are probably among the highest in the world. What about countries with lower endowments -- and possibly higher marginal productivities too? Pereira and Pinho (2006) report calculations analogous to Perotti's for 12 EU countries. In most of these countries, public investment is found to have large output growth effects. Their estimates suggest that investment is roughly self-financing in Ireland, France, and Greece, and more than self-financing in Italy and Germany. In turn, Ferreira and Araujo (2005) perform a similar exercise using Brazilian data. The main methodological difference is that they use a vector error-correction model rather than a VAR. They find that public investment is generally self-financing in Brazil, although in most experiments it takes at least 10 years for the government to collect sufficient tax revenues to recoup the initial investment expenses. Because of this long lag, their results are somewhat sensitive to the real interest rate used to discount future revenues.

Even if investment does not fully "pay for itself", fiscal correction through public investment cuts may still be a very inefficient adjustment strategy if public capital is productive. This is illustrated by Calderón and Servén (2003) for the case of Latin America's infrastructure. They make use of equation (4a), taking $\theta = 0$, and letting growth depend on the public investment ratio.[38] On the whole, their calculations suggest that the solvency-enhancing impact of infrastructure investment cuts falls quickly as the initial level of government indebtedness rises. At zero initial debt, cuts in infrastructure investment translate 100 percent into net worth increases, but the proportion declines to less than 60 percent if debt equals 40 percent of GDP, and to only 15 percent when debt reaches 80 percent of GDP. In the Latin American context of the late 1980s and 1990s, this means that infrastructure cuts in low-debt Colombia were 80 percent effective at enhancing solvency, whereas in high-debt Bolivia, their effectiveness was only around 20 percent. These exercises are subject to a host of caveats, which make them illustrative rather than conclusive, but they do suggest that, in some Latin American countries, fiscal austerity involving major infrastructure spending cuts not only entailed a substantial growth cost, but also may have been largely ineffective at strengthening public finances.

4. Alternative Rules

If conventional cash deficit and debt targets unduly discourage productive public spending, what is the solution? Targeting the cash deficit is just one among many possible fiscal rules. The obvious alternative is to look for other fiscal targets and rules that enforce solvency but do not do it at the expense of public investment.[39]

In general, fiscal rules should meet some basic requirements: they should be transparent and easy to monitor, ensure government solvency, make good economic sense even in the long run, and properly accommodate different initial conditions.[40] In

[38] To quantify this dependence, they rely on estimates of the parameters of an aggregate production function augmented with infrastructure, complemented with the estimation of empirical equations linking the accumulation of infrastructure assets to observed investment-to-GDP ratios.
[39] See Mintz and Smart (2006) for an overview of alternative rules and their effects on spending decisions.
[40] Buiter (2004).

effect, rules pose a tradeoff between simplicity and economic rigor, which different rules solve in different ways. A cash deficit rule meets the requirements of transparency and easy monitoring but, as discussed above, its economics leave much to be desired. And the lack of explicit allowance for initial conditions tends to make cash deficit rules especially burdensome for countries whose public infrastructure development is lagging, as their choices narrow to postponing such development further, entrusting it to the private sector's decisions, or resorting to large tax efforts to finance it – against the dictates of tax smoothing and intergenerational equity.[41]

One of the leading alternatives to the conventional cash deficit rule is the *golden rule*, which prevents the government from running a deficit on current account but allows borrowing to finance (net) investment – i.e., if the borrowing is used to create assets. To put it differently, the golden rule requires that the public sector's income statement – which excludes public investment but includes the depreciation of public capital -- be in surplus. This idea of separating the current and the capital budgets is hardly new,[42] but has been revived in the last few years (H.M. Treasury 2002, Blanchard and Giavazzi 2004). Under the golden rule, public debt dynamics and the tax ratio are given by

$$\dot{b} \leq i - p\delta k - gb$$
$$\tilde{\tau} \geq c + (p\delta - \theta)k + rb$$

where the second inequality reflects the restriction that the current balance cannot be in deficit. In the long run, public debt is fully backed by public capital; i.e., $b \leq pk$.[43]

Unlike conventional deficit targets, the golden rule allows spreading the cost of investment over time. Through this mechanism, Blanchard and Giavazzi (2004) show that reformulating the Stability and Growth Pact in terms of a golden rule would allow other European Union member countries to devote more resources to improving their infrastructure without violating the deficit limits thus redefined. Different versions of the golden rule are currently in effect in some countries, most notably the U.K., where its application is accompanied by a public debt ceiling restricting overall government indebtedness to 40 percent of GDP.[44]

However, the golden rule also has major shortcomings.[45] Some are conceptual: the fact that debt is fully backed by assets under the golden rule does not suffice to ensure solvency, because there is no guarantee that the assets will yield a return high enough to cover the interest on the debt that financed their acquisition. The assets could yield low or no return (they could be 'white elephants'). Even if they do yield high returns, the state might be unable to capture them.

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[41] See Van Ewijk (1997) for an estimation of the huge welfare loss that taxpayers would incur if the public investment program of the Netherlands had to be financed fully through taxes.
[42] A classic reference is Musgrave (1939). See Bassetto and Sargent (2005) for a historical background.
[43] If the rule were instead designed to allow debt finance of gross (instead of net) investment, then long-run debt could exceed the stock of public capital, since in the steady state $b \leq (1 + \delta / g)pk$.
[44] H.M. Treasury (2004, page 4).
[45] Balassone and Franco (2000), Buiter (2001) and Calmfors and Corsetti (2003) emphasize its limitations.

Other limitations are practical: by treating differently current and capital spending, the golden rule offers an incentive for opportunistic misclassification of unproductive expenditures as 'investment', so as to allow financing them with public debt and facilitate the achievement of the rule's zero current balance. Such opportunistic behavior is made easier by the lack of a clear-cut conceptual distinction between both types of expenditures.

An alternative to the golden rule that overcomes these limitations – at least in theory -- is the *permanent balance rule*, which is a direct application of the intertemporal budget constraint.[46] Analogously to consumers' behavior under the permanent-income hypothesis, the rule allows governments to borrow when revenue is temporarily low or when present investment opportunities are greater than future investment opportunities.

To highlight the rule's operation, we can restate the solvency condition for the general case in which the growth rate, the real interest rate and the direct financial return on public capital are all time-varying:

$$\int_t^{\infty} e^{-\int_t^s (r(u)-g(u))du} \left[\tilde{\tau}(s)+\theta(s)k(s)-c(s)-i(s)\right]ds - b(t) \geq 0 \qquad (11)$$

It is convenient to define the *permanent* values of the variables, denoted by a bar over the corresponding symbols, as:

$$\bar{x} \equiv \left[\int_t^{\infty} e^{-\int_t^{\infty}(r(u)-g(u))du} ds\right]^{-1} \int_t^{\infty} e^{-\int_t^{s}(r(u)-g(u))du} x(s)\, ds$$

Restating (11) in terms of these permanent values, we get:

$$\frac{\left[\bar{\tilde{\tau}}+\bar{\theta}\,\bar{k}-\bar{c}-\bar{i}\right]}{\bar{r}-\bar{g}} - b \geq 0 \qquad (11')$$

The permanent balance rule is based on an extreme form of tax smoothing: it amounts to setting a constant tax / GDP ratio that over the long run suffices to finance the government's present and future expenditure (net of the financial yield on public capital):

$$\tilde{\tau} = \bar{\tilde{\tau}} \geq \bar{c} + \bar{i} - \bar{\theta}\,\bar{k} + (\bar{r}-\bar{g})b$$

Under this tax policy, public debt dynamics can be written

[46] Buiter and Graafe (2004).

$$\dot{b} \leq (c - \bar{c}) + (i - \bar{i}) - (\theta\, k - \bar{\theta}\, \bar{k}) + [(r - \bar{r}) - (g - \bar{g})]b$$

Therefore, the rate of debt accumulation permitted by the rule depends on the deviation of the different fiscal variables from their permanent levels. From the public investment viewpoint, three issues deserve mention: first, the rule allows increasing indebtedness when public investment is above its long run level -- i.e., as public assets are being built up; second, the rule takes into account the future returns on public capital; and third, the rule can also accommodate the indirect return on public capital arising from future growth.

How does the permanent balance rule stack up against the requirements outlined above? It ensures solvency, provides a suitable treatment of productive expenditures, and avoids tax variability. In addition, it allows for the effect of initial conditions on debt accumulation limits.[47] Conceptually, the rule fulfills all the requirements. But it entails rather stringent informational requirements. In particular, to set taxes today as stated by the rule, the policy maker needs access to long-term fiscal projections specifying the trajectory of the primary surplus far into the future. Construction of such projections raises significant technical and, even more crucially, incentive-compatibility problems (see Irwin 2005).

An even more direct way to target public sector net worth would be through a net worth fiscal rule, which would set expenditure and financing decisions so as to achieve a desired net worth trajectory. This imposes an even more demanding informational burden than the permanent balance rule, as it requires constructing a complete balance sheet of the public sector and estimating the net worth impact of alternative fiscal policy paths. These requirements clearly restrict the applicability of net worth rules. Nevertheless, net worth measures and targets have featured for some time among the core principles of fiscal management in New Zealand (Janssen 2001),[48] and have featured prominently also in some proposals for reform of the European Stability Pact.[49]

To confront the limitations of both the golden rule and the permanent balance (and net worth) rule, Mintz and Smart (2006) have recently proposed a compromise solution: a modified golden rule allowing debt finance of public investment in "self-liquidating" assets – i.e., those that that generate future user fee and/or tax revenue for the government so as to "pay for themselves" (such as in the case of utilities) -- but not of investment in assets that provide services at no charge. Further, government borrowing would be limited to some fraction of the value of the revenue-generating assets, just as firms do not finance all their assets with debt. These features would result in a fiscal rule more conducive to solvency than the original golden rule, without relying as much on

[47] The long-run debt / GDP ratio is not determined by the rule, but depends instead on the trajectory followed by the economy. Such indeterminacy can be avoided augmenting the rule with a long-run debt target, and letting the tax ratio adjust in response to deviations of the debt ration from the long-run target. This defines the "extended rule" of Buiter and Grafe (2004).
[48] The methods employed to evaluate net worth are described by Bradbury, Brumby and Skilling (1999).
[49] For example, one of the reform options outlined by Coeure and Pisani-Ferry (2003) is organized around the concept of the "indebtedness ratio that stabilizes net worth".

potentially unreliable long-term forecasts as does the permanent balance rule, or demanding as much information as a net worth rule.

V. Final Remarks

The conventional practice of using short-term cash flows to gauge the strength of public finances is deficient on several counts. It amounts to equating solvency, essentially an intertemporal issue, with liquidity, which is instead a short-term concept. This practice tends to introduce an anti-investment bias into fiscal discipline that can be, in effect, a bias against future growth, with potentially adverse consequences for public finances themselves.

Alternative fiscal rules, targeting the current balance, the permanent balance, or net worth, can help protect solvency without introducing such biases. Each of these rules has advantages and disadvantages, and none of them obviously dominated the others. Perhaps the best way in which governments can effectively reduce the biases created by the focus on short-term cash flows is by developing indicators of the long-term fiscal effects of their decisions, including accounting and economic measures of net worth, and where appropriate including such measures in fiscal targets and fiscal rules, replacing today's almost exclusive focus on liquidity and debt.[51]

One risk posed by more investment-neutral fiscal targets and rules is that, by enlarging the room for investment, they can also lead to more wasteful projects being adopted – such as roads to nowhere and loss-making power plants.[52] Wasteful investments could be due to faulty economic analysis or motivated by corruption and patronage. Hence, the extra degrees of freedom gained by adopting investment-neutral fiscal rules also raise the value of institutional and capacity enhancements that prevent public resource waste.

A key step in that direction is to enhance project selection procedures and capabilities, including more systematic reliance on cost-benefit analysis whenever this evaluation method is likely to be useful for decision making, such as when charging users is difficult or undesirable (for example, most roads). More generally, strengthening fiscal and budgetary institutions, and in particular fiscal checks and balances to correct the perverse political economy incentives that encourage wasteful spending (such as for purposes of political patronage) is essential to minimize the scope for waste disguised as public investment.

The preceding discussion does *not* imply that governments should stop paying attention to conventional measures of short-term fiscal performance such as the overall cash balance. After all, there are good reasons why short run fiscal aggregates should be closely watched. The overall cash balance (or, even better, the public sector borrowing requirement, which adds to the overall balance the public sector's net lending) offers a

[51] The3se issues are discussed at length by Easterly, Irwin and Servén (2007).
[52] See Keefer and Knack (2006) and Pritchett (2000).

fairly good approximation to the government’s financing needs, a primary concern for the fiscal authorities as well as financial market participants. It provides also an indication of the public sector’s contribution to aggregate demand and thus its stance from the viewpoint of short-term stabilization—although the primary deficit may be preferable for this purpose, and even more so if estimated in structural terms, correcting for the effects of cyclical conditions.

But the overall cash balance and gross debt are much less adequate as solvency measures, basically because they do not take into account the assets and the future incomes that the government may acquire by incurring debt today. This, of course, is hardly surprising: liquidity and solvency are fundamentally different concepts, and different indicators are needed to gauge them—as is the case in corporate finance. Forcing the overall balance to summarize all three dimensions—public sector solvency, liquidity, and macroeconomic stance—is asking too much from a single indicator.

Appendix

Analytical derivations

1. Derivation of Equation (8)

Taking the time derivative of equation (7), and using equation (5), the real growth rate can be written as follows:

$$g(s) = \alpha\left(\frac{i(s)}{pk(s)} - \delta\right) + (1-\alpha)\gamma \qquad \text{(A1)}$$

Thus, other things equal, the growth impact of a given change in the public investment ratio is smaller the higher the prevailing public capital-to-output ratio *k*. Combining equation (A1) with equation (5), we get a differential equation describing the trajectory of *k*, whose solution with a constant investment ratio is as follows:

$$k(s) = k_0 e^{-s(\gamma+\delta)(1-\alpha)} + \frac{i}{p(\gamma+\delta)}\left[1 - e^{-s(\gamma+\delta)(1-\alpha)}\right] \qquad \text{(A2)}$$

where k_0 denotes the capital-to-output ratio at time 0. Replacing this expression into equation (A1), the growth rate is as follows:

$$g(s) = \frac{\gamma i + e^{-s(\gamma+\delta)(1-\alpha)}\left[k_0 p(\gamma+\delta) - i\right]\left[(1-\alpha)\gamma - \alpha\delta\right]}{i + \left[k_0 p(\gamma+\delta) - i\right]e^{-s(\gamma+\delta)(1-\alpha)}} \qquad \text{(A3)}$$

Given the initial public capital ratio, this is an increasing function of the public investment rate *i*. Furthermore, the growth rate converges to γ as *s* goes to infinity. Replacing equations (A2) and (A3) into equation (4) (with $t = 0$ to simplify notation)—and still assuming a constant real interest rate *r* (with $r > \gamma$), as well as constant public consumption, investment, and tax ratios—direct integration yields equation (8) in the text.

2. The Case of Constant Marginal Productivity

The main text assumes that the marginal product of public capital declines with the capital stock, by taking $1 > \alpha > 0$ in the production function $Y(s) = A\,K(s)^{\alpha}\left[L(s)\,e^{\gamma s}\right]^{1-\alpha}$. Letting $\alpha = 1$, we get an *AK* growth model in which the marginal product of public capital is constant. In fact, it is easy to generalize this technology to $Y(s) = \beta + AK(s)$, where returns to scale are decreasing, constant, or increasing depending on whether β is positive, zero, or negative. Now the rate of output growth can be expressed as follows:

$$g(t)=\frac{\dot{Y}(t)}{Y(t)}=A\left(\frac{i(t)}{p}-\delta k(t)\right) \qquad \text{(A4)}$$

Thus, the (marginal) impact of public investment on growth is constant, but as long as $\delta \neq 0$ the growth rate is inversely related to the public capital-to-output ratio. Assuming that *c, i,* and $\tilde{\tau}$ are fixed, straightforward manipulations yield the following:[53]

$$\begin{aligned} nw = & \left[\frac{\theta}{r+\delta}k_0-b_0\right] + \frac{1}{r}\left[\tilde{\tau}-c+p\delta k_0\left(\frac{\theta}{p\left(r+\delta\right)}-1\right)\right] \\ & + \frac{1}{r}\,\frac{(i-p\delta\ k_0)}{p(r+\delta)-Ai}\left[(\tilde{\tau}-c)A+\theta-p(r+\delta)\right] \end{aligned} \qquad \text{(A5)}$$

The top line of this expression is analogous to that of equation (8) for the case of zero net investment (and $\gamma=0$). In turn, the second line captures the effects of a changing capital stock, which affects net worth through the already familiar return differential on new capital, and the (net) tax revenue collected on the output generated with the extra capital, $(\tilde{\tau}-c)A$. In fact, the term in the small square brackets is exactly the same as that in the numerator of equation (9), with $\partial Y/\partial K = A$.

From equation (A5), the impact of a permanent change in the public investment ratio is as follows:

$$\frac{d\ \ nw}{d\ \ i}=\frac{1}{r}\,\frac{p(r+\delta-A\delta k_0)}{\left[p(r+\delta)-Ai\right]^2}\left[(\tilde{\tau}-c)A+\theta-p(r+\delta)\right] \qquad \text{(A6)}$$

Furthermore, if net worth is initially zero this becomes—

$$\left.\frac{d\ \ nw}{d\ \ i}\right|_{nw=0}=\frac{1}{p(r+\delta-A\delta k_0)}\left[\frac{\theta-\left(r+\delta\right)p}{r}+\left(b_0-\frac{\theta-p\delta}{r}k_0\right)A\right] \qquad \text{(A7)}$$

[53] In deriving equation (A5), we need to assume that $p(r+\delta)>Ai$ for the present value of future primary surpluses to remain bounded. If this holds at time 0, then the numerator of (A6) and the denominator of (A7) must also be positive.

References

Aschauer, D. 1989. "Is Public Expenditure Productive?" *Journal of Monetary Economics* 23: 177–200.

Aschauer, D. 2000. "Public Capital and Economic Growth: Issues of Quantity, Finance, and Efficiency." *Economic Development and Cultural Change* 48(2), 391-406.

Balassone, F., and D. Franco. 2000. "Public Investment, the Stability Pact and the Golden Rule." *Fiscal Studies* 21 (2): 207–29.

Barro, R. 1990. "Government Spending in a Simple Model of Endogenous Growth." *Journal of Political Economy* 98 (5): s103–s125.

Bassetto, M., and T. Sargent. 2005. "Politics and Efficiency of Separating Capital and Ordinary Government Budgets." NBER Working Paper No. 11030, National Bureau of Economic Research, Cambridge, MA.

Blanchard, O., and F. Giavazzi. 2004. "Improving the SGP Through a Proper Accounting of Public Investment." CEPR Discussion Paper No. 4220, Centre for Economic Policy Research, London.

Bradbury, S., J. Brumby, and D. Skilling. 1999. "Sovereign Net Worth: An Analytical Framework." Treasury Working Paper 99/3, available at http://www.treasury.govt.nz/workingpapers/1999/99-3.asp.

Bruce, N., and S.J. Turnovsky. 1999. "Budget Balance, Welfare and the Growth Rate: 'Dynamic Scoring' of the Long-run Government Budget", *Journal of Money, Credit and Banking* 31(2), 162-186.

Buiter, W. 1990. *Principles of Budgetary and Financial Policy.* Boston: MIT Press.

Buiter, W. 2001. "Notes on 'A Code for Fiscal Stability'." *Oxford Economic Papers* 53 (1): 1–19.

Buiter, W. 2002. "The Fiscal Theory of the Price Level: A Critique." *Economic Journal* 112: 459–480.

Buiter, W. 2004. "How to Reform the Stability and Growth Pact." *Central Banking* 13.

Buiter, W., and C. Grafe. 2004. "Patching up the Pact: Suggestions for Enhancing Fiscal Sustainability and Macroeconomic Stability in an Enlarged European Union." *The Economics of Transition* 12 (1): 67–102.

Calderón, C., and L. Servén. 2003. "The Output Cost of Latin America's Infrastructure Gap," In *The Limits of Stabilization: Infrastructure, Public Deficits, and Growth* *in Latin America,* eds. W. Easterly and L. Servén, 95–118. Stanford University Press.

Calderón, C., and L. Servén. 2004a. "Trends in Infrastructure in Latin America." Policy Research Working Paper No. 3400, World Bank, Washington, DC.

Calderón, C., and L. Servén. 2004b. "The Effects of Infrastructure Development on Growth and Income Distribution." Policy Research Working Paper No. 3401, World Bank, Washington, DC.

Calderón, C., and L. Servén. 2007 "Is Infrastructure Capital Productive?" Unpublished manuscript.

Calmfors, L., and G. Corsetti. 2003. "How to Reform Europe's Fiscal Policy framework." *World Economics Journal* 4(1)

Canning, D. 1999. "A Database of World Stocks of Infrastructure, 1950-95." *World Bank Economic Review* 12 (3): 529–47.

de Haan, J., J. Sturm, and B. Sikken. 1996. "Government Capital Formation: Explaining the Decline." *Weltwirtschaftliches Archiv* 132 (1): 55–74.

Demetriades, P., and T. Mamuneas. 2000. "Intertemporal Output and Employment Effects of Public Infrastructure Capital: Evidence from 12 OECD Economics." *Economic Journal* 110 (465): 687–712.

Easterly, W. 1999. "When Is Fiscal Adjustment an Illusion?" *Economic Policy* 28: 57–86.

Easterly, W., T. Irwin and L. Servén (2007): "Walking up the down escalator: public investment and fiscal stability", *World Bank Research Observer* (forthcoming).

Easterly, W., and S. Rebelo. 1993. "Fiscal Policy and Economic Growth." *Journal of Monetary Economics* 32 (3): 417–58.

Easterly, W., and L. Servén. 2003. *The Limits of Stabilization: Infrastructure, Public Deficits and Growth in Latin America*. Stanford University Press.

Engel, E., R. Fischer, and A. Galetovic. 2003. "Privatizing Highways in Latin America: Is It Possible to Fix What Went Wrong?" *Economía* 4(1), 129-158.

Esfahani, H., and M. T. Ramirez. 2003. "Institutions, Infrastructure, and Economic Growth." *Journal of Development Economics* 70 (2): 443–77.

Estache, A. 2005 "What Do We Know about Sub-Saharan Africa's Infrastructure and the Impact of Its 1990s Reforms ?" Unpublished manuscript, The World Bank.

Ferreira, P., and C. Araujo. 2005. "On the Economic and Fiscal Effects of Infrastructure Investment in Brazil", Fundação Getulio Vargas Ensaio Econômico #613.

Futagami, K., Y. Morita, and A. Shibata. 1993. "Dynamic Analysis of an Endogenous Growth Model with Public Capital." In *Endogenous growth*, eds. T. Anderson and K. Moene, 217-235. Oxford: Blackwell.

Gali, J., and E. Perotti. 2003. "Fiscal Policy and Monetary Integration in Europe." *Economic Policy* 533–72.

Ghosh, S., and U. Roy. 2004. "Fiscal Policy, Long-Run Growth and Welfare in a Stock-Flow Model of Public Goods." *Canadian Journal of Economics* 37: 742–56.

Glomm, G., and B. Ravikumar. 1997. "Productive Government Expenditures and Long-Run Growth." *Journal of Economic Dynamics and Control* 21: 183–204.

H.M. Treasury. 2002: *Reforming Britain's Economic and Financial Policy.* Palgrave.

H.M. Treasury. 2004: "Long-term public finance report: An analysis of fiscal sustainability". December.

Hicks, N. 1991. "Expenditure Reductions in Developing Countries Revisited." *Journal of International Development* 3 (1): 29–37.

IMF (International Monetary Fund). 2003. *Fiscal Adjustment in IMF-Supported Programs.* Washington, DC: IMF.

Irwin, T. 2005. "Accrual accounting, long-term fiscal projections and public investment", unpublished manuscript.

Irwin, T., M. Klein, G. Perry, and M. Thobani. 1997. *Dealing with Public Risk in Private Infrastructure*. Washington, DC: World Bank.

Janssen, J. 2001. "New Zealand's Fiscal Policy Framework: Experience and Evolution." New Zealand Treasury Working Paper 01/25, Wellington, New Zealand

Jonakin, J., and M. Stephens. 1999. "The Impact of Adjustment and Stabilization Policies on Infrastructure Spending in Latin America." *North American Journal of Economics and Finance* 10: 293–308.

Kalaitzidakis, P., and S. Kalyvitis. 2004. "On the Macroeconomic Implications of Maintenance in Public Capital." *Journal of Public Economics* 88: 695–712.

Kalyvitis, S. 2003. "Public Investment Rules and Endogenous Growth, with Empirical Evidence from Canada." Scottish Journal of Political Economy 50, 90-110.

Keefer, Philip, and Stephen Knack. 2006. “Boondoggles, Rent-Seeking and Political Checks and Balances: Public Investment under Unaccountable Governments.” *Review of Economics and Statistics*.

Lane, P. 2003. “The Cyclical Behavior of Fiscal Policy: Evidence from the OECD.” *Journal of Public Economics* 87 (12): 2661–675.

Mintz, J., and M. Smart. 2006. “Incentives for public investment under fiscal rules”, World Bank Policy Research Working Paper 3860.

Musgrave, R. 1939. “The Nature of Budgetary Balance and the Case for a Capital Budget.” *American Economic Review* 29 (2): 260–71.

Pereira and Pinho. 2006. “Public Investment, Economic Performance and Budgetary Consolidation: VAR Evidence for the 12 Euro Countries.” The College of William and Mary. Department of Economics, Working Paper 40

Perotti, R. 2004. “Public Investment: Another (Different) Look.” Bocconi Univerity Innocenzo Gasparini Institute for Economic Research IGIER Working Paper No. 277. Milan, Italy.

Pritchett, L. 2000. “The Tyranny of Concepts: CUDIE (Cumulated, Depreciated, Investment Effort) Is Not Capital.” *Journal of Economic Growth* 5 (4): 361–84.

Rioja, F. 2003a. “The Penalties of Inefficient Infrastructure.” *Review of Development Economics* 7: 127–37.

Rioja, F. 2003b. “Filling Potholes: Macroeconomic Effects of Maintenance versus New Investments in Public Infrastructure.” *Journal of Public Economics* 87: 2281–304.

Röller, L., and L. Waverman. 2001. “Telecommunications Infrastructure and Economic Development: A Simultaneous Approach.” *American Economic Review* 91 (4): 909–23.

Romp, W., and J. de Haan. 2007. “Public Capital and Economic Growth: A Critical Survey.” *Perspektiven der Wirtshaftspolitik* 8, 6-52.

Roubini, N., and J. Sachs. 1989. “Government Spending and Budget Deficits in the Industrial Countries.” *Economic Policy* 8: 99–132.

Talvi, E., and C. Végh. 2000. “Tax Base Variability and Procyclical Fiscal Policy.” NBER Working Paper No. 7499, National Bureau of Economic Research, Cambridge, MA.

Turnovsky, S. 1997. "Fiscal Policy in a Growing Economy with Public Capital." *Macroeconomic Dynamics* 1: 615–39.

Turnovsky, S., and W. Fisher. 1995. "The Composition of Government Expenditure and Its Consequences for Macroeconomic Performance." *Journal of Economic Dynamics and Control* 19 (4): 747–86.

van Ewijk, C. 1997. "Infrastructure, Intergenerational Conflict and the Golden Rule of Finance," De Economist 145 (3), pp. 447-460.

Zagler, M., and G. Durnecker. 2003. "Fiscal Policy and Economic Growth." *Journal of Economic Surveys* 17 (3): 397–418.