Banco Central de Chile
Documentos de Trabajo

Central Bank of Chile
Working Papers

N° 187

Octubre 2002

INFRASTRUCTURE COMPRESSION AND PUBLIC SECTOR SOLVENCY IN LATIN AMERICA

César Calderón William Easterly Luis Servén

Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
Huérfanos 1175, primer piso.
Teléfono: (56-2) 6702475, Fax: (56-2) 6702231

Documento de Trabajo
N° 187

Working Paper
N° 187

INFRASTRUCTURE COMPRESSION AND PUBLIC SECTOR SOLVENCY IN LATIN AMERICA

César Calderón
Banco Central de Chile

William Easterly
Institution of International Economics

Luis Servén
The World Bank

Resumen

El drástico recorte de gasto en infraestructura pública es un elemento básico en la mayoría de programas de ajuste fiscal tanto en países industriales como en países en desarrollo. La austeridad fiscal de América Latina durante los 80s y 90s se caracterizó por una marcada contracción del gasto en infraestructura. En 5 de los 9 principales países de la región, la menor inversión en infraestructura contribuyó en más de la mitad del ajuste fiscal total. Sin embargo, el ajuste fiscal sesgado contra la acumulación de infraestructura puede ser perjudicial. Un recorte del gasto en infraestructura no sólo reduce el déficit público (elevando en valor neto del sector público) sino que también conduce a una caída en la acumulación del acervo de infraestructura y por ende del crecimiento del producto. Ello a su vez implica una reducción de la capacidad del servicio de la deuda de la economía, lo cual debilita el valor neto del sector público (Easterly, 2001). El presente artículo evalúa cuantitativamente el costo de la contracción del gasto público en infraestructura sobre el crecimiento económico para las principales economías de América Latina durante el periodo de austeridad fiscal de los 80s y 90s, así como la efectividad de estos menores gastos como mecanismo para mejorar la solvencia del sector público.

Abstract

Public investment and infrastructure spending are often singled out for drastic cuts at times of fiscal retrenchment. Fiscal austerity in Latin America during the 1980s and 1990s was characterized by a sharp contraction in infrastructure spending. In 5 of the 9 major Latin American countries, infrastructure investment cuts contributed half or more of the total fiscal adjustment. However, the compression of infrastructure spending does not guarantee the sustainability of the public sector. Infrastructure spending cuts not only reduce the public deficit (thereby raising the public sector's net worth) but also leads to a decline in infrastructure stock accumulation and in output growth as well. This in turn implies a reduction in the economy's debt-servicing capacity, thus weakening the public sector net worth (Easterly, 2001). In the present paper we quantitatively assess the growth cost of public infrastructure compression for major Latin American economies during the fiscal austerity period of the 1980s and 1990s, and examine the effectiveness of infrastructure spending cuts as a device to enhance public sector solvency.

The views expressed in this paper are those of the authors and should not be taken as those of the World Bank or the Central Bank of Chile.

E-mail: ccaldero@bcentral.cl.

1. Introduction

Public investment and infrastructure spending are often singled out for drastic cuts at times of fiscal retrenchment. This phenomenon, which has been amply documented in industrial and developing economies alike,[1] admittedly reflects compelling political-economy reasons – to give an example, cutting investment in new roads, or maintenance of existing ones, is likely to entail much less political fallout than civil service downsizing.

But fiscal adjustment centered on the compression of public infrastructure spending often reflects a simple-minded approach to the sustainability of public finances, concerned only with government liabilities and ignorant of the role of public sector assets (Buiter 1990). In such a framework, 'fiscal adjustment' may mean little more than a parallel reduction in both liabilities (e.g., debt) and assets (e.g., infrastructure) of the public sector that leaves its net worth unaffected – a kind of fiscal adjustment that has been termed 'illusory' (Easterly, 1999).

The period of fiscal austerity that most of Latin America underwent during the 1980s and 1990s was characterized by a sharp contraction in infrastructure spending. Table 1 provides a summary illustration of the role that infrastructure investment cuts played in the process of fiscal adjustment of major Latin American economies. The first column of the table shows the change in public infrastructure investment, as a percentage of GDP, between 1980-84 and 1995-98. Of the nine countries shown, seven experienced infrastructure investment cuts, particularly large in the cases of Bolivia, Brazil and Argentina, but significant also in Mexico, Peru and Chile. Only Colombia and Ecuador exhibited modest increases in public infrastructure investment over the period in question.

The second column reports the change in the primary (i.e., non-interest) surplus of the consolidated non-financial public sector over the same period. All countries except Venezuela showed a reduction in their primary deficit, of considerable magnitude in Mexico, Bolivia, Argentina and Colombia.

The third column calculates the portion of the observed fiscal adjustment attributable to the public infrastructure compression. In five of the nine countries the infrastructure investment cut contributed half or more of the total fiscal adjustment. The case of Brazil is especially remarkable: the cut in public infrastructure investment was nearly twice as large as the cut in the overall primary deficit. In Chile, Argentina, Bolivia and Peru the contribution of infrastructure cuts was substantial as well. Venezuela illustrates an even more troubling phenomenon: the deficit actually rose, in spite of the infrastructure cut.

[1] See the references cited in Calderón, Easterly and Servén (2002).

Table 1
Contribution of Public Infrastructure Investment Cuts to Fiscal Adjustment (*Average 1980-84 vs. Average 1995-98)*

Country	Change in Public Infrastructure Investment (% GDP) [1]	Change in Primary Deficit (% GDP) *a/* [2]	[1]/[2] (Percentages)
Argentina	-2.85	-5.31	53.8
Bolivia	-3.10	-6.15	50.3
Brazil	-3.08	-1.77	174.3
Chile	-1.41	-2.39	58.8
Colombia	0.04	-4.69	...
Ecuador	0.68	-1.81	...
Mexico	-1.98	-6.28	31.5
Peru	-1.51	-3.11	48.6
Venezuela	-0.41	1.88	…

a/ Negative values in column [2] imply a reduction in the primary deficit, that is, improvements in the non-interest fiscal balance.

We should note that in all likelihood these figures understate the contribution of infrastructure compression to fiscal adjustment, since in most cases recurrent infrastructure expenditures on O&M were cut along with investment, so that the total decline in infrastructure-related spending exceeded the investment cut. However, the unavailability of cross-country time-series data prevents us from including the corresponding figures in the above table. Even ignoring this, the data cast doubt on the quality of the fiscal retrenchment observed in several Latin American countries, given the adverse impact of persistent infrastructure compression on long-term growth.

From the perspective of public sector solvency, the key issue is that fiscal adjustment biased against infrastructure accumulation can be largely self-defeating. The immediate effect of infrastructure spending cuts is to reduce the public deficit, and thereby to increase the public sector's net worth. But this is only the beginning of the story. Reduced infrastructure expenditures lead over time to a decline in infrastructure stock accumulation and, as shown in Calderón and Servén (2002), in output growth as well. This in turn implies a reduction in the economy's debt-servicing capacity, thereby weakening public sector net worth, as argued by Easterly (2001). This adverse indirect impact on net worth via output growth can partly (or, under extreme conditions, even fully) offset the direct favorable impact of infrastructure spending cuts, making the latter a very inefficient –even counter-productive – strategy to enhance public sector solvency.

In this paper we assess quantitatively the growth cost of public infrastructure compression for major Latin American economies during the fiscal austerity period of the 1980s and 1990s, and examine the effectiveness of infrastructure spending cuts as a device to enhance public sector solvency. Because of data constraints,[2] the analysis is limited to nine major Latin American countries for which the required information on public infrastructure spending could be collected – Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela.[3]

2. Framework

The starting point of the analysis is the public sector's net worth, which can be defined as the present discounted value of its present and future stream of budget surpluses minus its stock of debt outstanding. In terms of ratios to GDP, this can be formally expressed as:[4]

$$w_t \equiv \frac{W_t}{Y_t} = \left[\int_t^{\infty} e^{-(r-g)(s-t)} s_s ds \right] - \frac{D_t}{Y_t} \qquad (1)$$

Here W denotes public net worth, r is the real interest rate and g is the rate of GDP growth (with both assumed constant over the indefinite future), s_t represents the primary surplus of the public sector (i.e., the non-interest budget surplus) as a ratio to GDP, and D_t/Y_t is the ratio of public debt to GDP at time t. Assuming $r>g$,[5] the public sector is solvent when W_t/Y_t is non-negative. According to equation (1), this depends upon the ability of the government to run sufficiently large budget surpluses in the future so as to service its debt.

We can further decompose the primary surplus into infrastructure spending G_Z and everything else; that is, $s_t = p_t - (G_Z/Y)_t$, where p is the primary surplus before infrastructure expenditures and G_Z/Y is the ratio of infrastructure spending to GDP. It is important to recognize that the non-infrastructure primary surplus as a proportion to GDP could itself depend on the growth rate of the economy: other things equal, faster growth rates may imply larger surpluses (or smaller deficits) through a rising tax/GDP ratio or a declining expenditure/GDP ratio; hence in principle $p=p(g, .)$.

Assuming that the non-infrastructure primary surplus and the ratio of infrastructure spending to GDP remain constant for the indefinite future, (1) can be further simplified to

[2] The sources of the data used in this paper are listed in the appendix of Calderón, Easterly and Servén (2002).

[3] Because much of infrastructure spending is often done by lower levels of government and/or public enterprises, it is important to base the analysis on infrastructure spending data for a broad definition of the public sector. This could be collected only for the countries listed in the text. An alternative would be to use the IMF's Government Finance Statistics – as done, for example, by Jonakin and Stephens (1999) -- which offer much broader country coverage. However, that source covers only the Central Government, and thus provides a very limited view of public infrastructure spending.

[4] In the discussion that follows, for simplicity we ignore seigniorage as a source or government revenue. This is of no consequence for the argument, except in the unlikely case that the ratio of seigniorage collection to GDP is affected by changes in infrastructure investment.

[5] If $g>r$ the economy is dynamically inefficient and *any* debt stock, no matter how large, is consistent with solvency.

$$w_t = \frac{p(g, .) - (G_Z / Y)}{r - g} - \frac{D_t}{Y_t} = w(r, g, G_Z / Y, D_t / Y_t) \qquad (2)$$

Taking *r* and the initial debt / GDP ratio as exogenously given, the impact of infrastructure spending relative to GDP on net worth is

$$dw_t = \left[\underbrace{-\frac{1}{r-g}}_{Direct\ effect} + \underbrace{\left(\frac{\partial w}{\partial g} + \frac{\partial w}{\partial p} \cdot \frac{\partial p}{\partial g} \right) \frac{dg}{d(G_z / Y)}}_{Indirect\ effect} \right] d(G_z / Y) \qquad (3)$$

This expression highlights the two ingredients mentioned earlier: the direct effect via the infrastructure spending component of the primary surplus, and the indirect effect arising from the impact of infrastructure accumulation on growth. The latter in turn may affect net worth through two channels: first, by impacting on the level of the non-infrastructure component of the primary deficit *p*; second, by altering the present value of a given stream of future primary deficits, through the term 1/(*r*-*g*), along the lines described by Easterly (2001).

We can simplify this expression further by taking the approximation $g \approx \Delta y$ and noting that the growth impact of infrastructure spending can be expressed as the growth contribution of infrastructure stock accumulation times the impact of infrastructure spending on stock accumulation:

$$\frac{dg}{d(G_Z / Y)} = \frac{dg}{d\Delta z} \cdot \frac{d\Delta z}{d(G_Z / Y)} = h_z \cdot \frac{d\Delta z}{d(G_Z / Y)} \qquad (4)$$

where Δz is the change in the log of infrastructure stocks, and $h_z \equiv \frac{dg}{d\Delta z}$ is the growth contribution of infrastructure stock accumulation. Empirical estimates of h_z for various infrastructure assets were calculated in Calderón and Servén (2002).

On the other hand, from (2) the impact of growth on net worth, holding the non-infrastructure primary surplus constant, and near a point where net worth is small, can be written as:

$$\left. \frac{\partial w_t}{\partial g} \right|_{w=0} = \frac{D_t / Y_t}{r - g} \qquad (5)$$

Thus, the impact of growth on net worth is positive and proportional to the initial debt stock, as emphasized by Easterly (2001).

Putting all these pieces together, we can express the effect of infrastructure spending changes on net worth as:

$$\frac{dw_t}{d(G_z/Y)} = \frac{1}{r-g}\left[-1+\left(\frac{D_t}{Y_t}+\frac{\partial p}{\partial g}\right)\cdot h_z \cdot \frac{d\Delta z}{d(G_z/Y)}\right] \tag{6}$$

The term in square brackets in the right-hand side of this expression can be interpreted as the impact of infrastructure spending on the *annuity value* of public net worth relative to GDP,[6] and the factor $(r\text{-}g)^{-1}$ serves to bring the annuity to present-value terms.

Given data on debt ratios and estimates of h_z, we still need to find empirical counterparts for $\frac{d\Delta z}{d(G_z/Y)}$ and $\frac{\partial p}{\partial g}$ to make this equation operational. The former expression provides the link between infrastructure spending and stock accumulation; the latter captures the impact of growth on the non-infrastructure primary surplus. We consider them in turn.

3. Infrastructure Spending and Infrastructure Stock Accumulation

The basic ingredient for the analysis of solvency is the link between public infrastructure spending and the time path of infrastructure stocks, $\frac{d\Delta z}{d(G_z/Y)}$ in (6) above. To quantify this, we use infrastructure investment and stock data for nine major Latin American countries – Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela – for which the necessary information disaggregated by type of asset (i.e., transport networks – inclusive of roads and railways -- power and telecommunications) could be collected. Importantly, the analysis includes only investment spending, and not other relevant expenditures – such as operations and maintenance – that may also affect the evolution of the quantity and quality of stocks over time.[7]

Figure 1 provides a hint at the link between infrastructure investment and the evolution of infrastructure endowments. The figure plots the average rate of growth of infrastructure stocks over 1980-97 – defined as the simple average of the growth rates of main phone lines, power generation capacity and kilometers of paved roads, all relative to the labor force – against the average rate of total (public plus private) infrastructure investment on these assets, for the nine Latin American countries listed above. In spite of the crude measures employed – which, among other things, ignore that the investment-asset accumulation link may be fairly different for the three assets lumped together here -- the

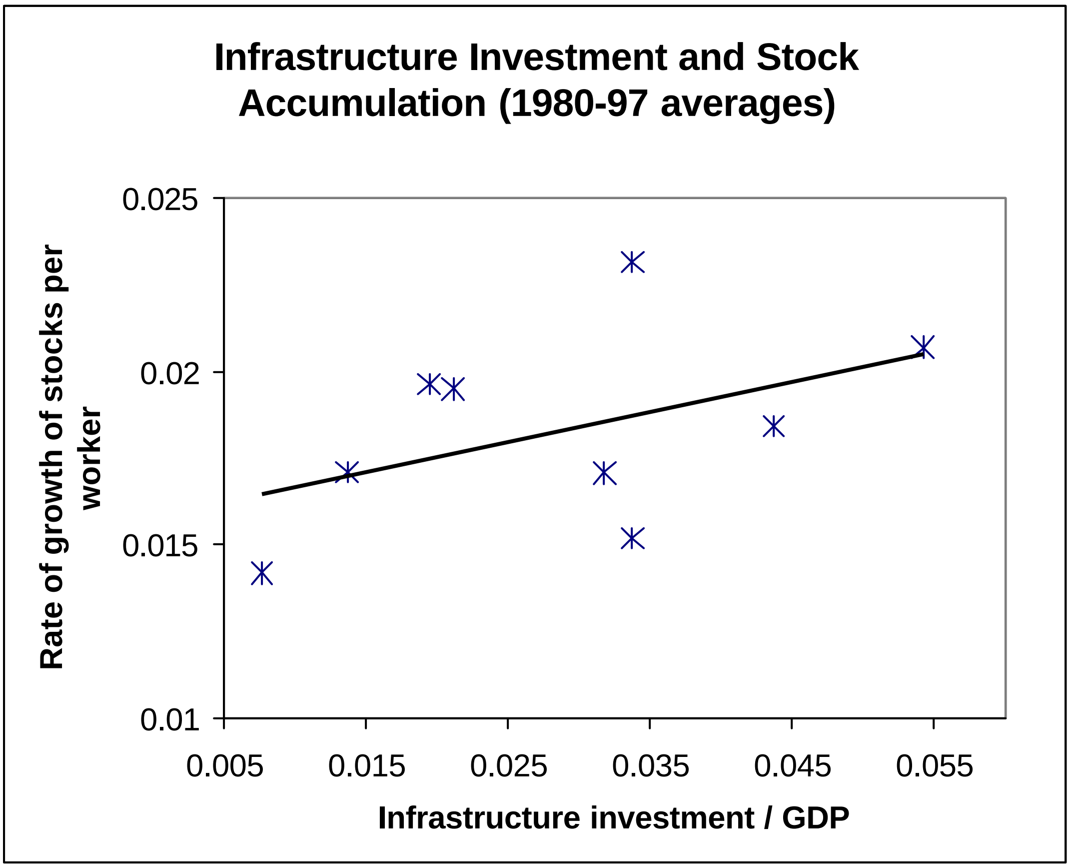
---

[6] Let the annuity value $a_t \equiv (r-g)w_t$. Then $\frac{da_t}{d(G_z/Y)}\Big|_{w_t=0} = (r-g)\frac{dw_t}{d(G_z/Y)}$, and the latter expression is just the term in square brackets in (4.6).

[7] O&M data are notoriously difficult to obtain on a comprehensive or even comparable basis across countries. This data limitation is also shared by Roller and Waverman (2001), who focus on OECD countries and provide, to our knowledge, the only other cross-country assessment of the link between infrastructure investment and stock accumulation available in the literature.

data points do suggest a positive relation between the two variables, with the data points clustering along an upward-sloping regression line.

Figure 1



To obtain a more rigorous assessment of the investment – asset accumulation link, we turn to econometric estimation. Since the detailed analysis is available elsewhere, we only reproduce here the main empirical results.[8] They are based on panel regressions with the change in the (log of) the respective infrastructure asset as dependent variable, and the corresponding rate of investment, relative to GDP, as independent variable. We then

[8] It is important to note that by regressing stock accumulation on total investment we are implicitly assuming that the contribution of public infrastructure investment to the accumulation of infrastructure assets is identical to that of private investment. We tested this assumption performing empirical experiments allowing for differential effects of public and private investment on overall stock accumulation. In power and telecommunications there is no evidence against the assumption that public and private investment contribute equally to asset accumulation. However, for transport routes the hypothesis test yields a p-value of 3 percent, which suggesting that the contributions of public and private investment do differ. For this reason, the calculations below have to be taken with some caution. See Calderón, Easterly and Servén (2002).

take the long-run effect of investment on stock accumulation derived from these regressions as our measure of $\frac{d\Delta z}{d(G_z/Y)}$.

The panel regressions use autoregressive-distributive lag specifications (ARDL). The lag order of the ARDL is dictated by a compromise between the need to allow for time-to-build in the accumulation of stocks, and the length of the available time series. For telecommunications, four lags proved sufficient. In the case of transport routes (roads and railways), we used up to six lags. Even this specification might be insufficient given the long delays often involved in the construction of power plants and railway routes; however, the short data samples available prevented us from using longer lag specifications.

Table 2 summarizes the empirical results of this procedure. As before, we present a variety of empirical specifications with and without country and time effects. We also experimented with alternative measures of telecommunications stocks (total lines instead of main lines) as well as alternative measures of transport routes (total and paved roads, instead of roads plus railways) with results very similar to those reported in the table. In the case of transport routes, rather than fixed effects we use each country's total land area (in logs) as additional explanatory variable.[9] In view of the relatively generous lag specification of the estimated equations, to save space the table only reports the long-run impact of investment on the rate of accumulation of the asset in question.

The top block in Table 2 reports the OLS estimates. For all three assets, the estimated long-run impact of investment on asset accumulation is positive and significant at the 5 percent level. However, the magnitude of the estimated impact, as well as the explanatory power of the ARDL equation, varies across assets: they are largest for telecom, and smallest for power.

The next block in the table adds country fixed affects to the telecom and power regressions, and land area for roads. The estimates do not change much in the case of telecom and roads, and the explanatory power of the empirical equations rises slightly. For power, however, the estimated long-run effect of investment rises dramatically, along with the R-squared, even though the fixed effects themselves only reach 10 percent significance.

[9] The area variable typically carried a positive coefficient significant at the 5 percent level or better, so we opted for retaining this specification for the transport equation. We also experimented with population density as additional variable, but it turned always insignificant in the regressions. Finally, we also estimated specifications including land area in the accumulation equations for phone lines and power, but the estimated coefficient on the area variable was always very far from significance at conventional levels.

Table 2
Relationship between Physical Stocks and Investment Spending in Infrastructure
Dependent Variable: Growth rate in physical infrastructure
Specification: Autoregressive Distributed Lag (ARDL) Model
Sample: 9 selected Latin American countries with annual data, 1970-98

Lag Structure for ARDL Model -->	Main Lines (4,4)	Energy (6,6)	Transport Total Roads+Railways (6,6)
I. Pooled OLS			
Total Investment	6.8922	1.9650	4.0704
(p-value)	(0.0006)	(0.0380)	(0.0532)
R**Squared	0.7674	0.1140	0.3624
II. Fixed-Effects			
Total Investment	8.7181	3.4201	4.6499
(p-value)	(0.0000)	(0.0297)	(0.0056)
ln Area	-	-	0.0519
(p-value)			(0.0192)
Fixed-Effects			
(p-value)	(0.0320)	(0.0697)	-
R**Squared	0.7837	0.2435	0.4889
III. Fixed- & Time-Effects			
Total Investment	7.9923	6.3847	6.0016
(p-value)	(0.0002)	(0.0587)	(0.0136)
ln Area	-	-	0.0590
(p-value)			(0.0041)
Fixed-Effects			
(p-value)	(0.0403)	(0.0813)	-
Time-Effects			
(p-value)	(0.0043)	(0.0156)	(0.0090)
R**Squared	0.8237	0.3244	0.5319

Note: the table reports the long-run elasticity of asset accumulation with respect to investment spending (as a ratio to GDP) derived from the ARDL estimates. In the case of roads, we use (log) land area rather than country fixed effects in specifications II and III. The sample includes annual data for 1970-98 on nine Latin American countries: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela.

Finally, the bottom block in Table 2 adds time dummies in the empirical specification, to control for cross-country common factors. The set of dummies was highly significant in all three equations. The estimates for telecom and roads show relatively modest changes, although the fit of the respective equations improves noticeably, especially for roads. As for power, the estimated long-run effect becomes much bigger, and the fit of the equation also improves. In view of the strong significance of the time dummies in these regressions, for the remainder of the analysis we take these latter estimates as our preferred measure of the impact of infrastructure spending on infrastructure asset accumulation $\frac{d\Delta z}{d(G_z/Y)}$.

4. The non-infrastructure primary surplus

The non-infrastructure primary surplus / GDP ratio is given by the difference between public revenues and non-interest spending exclusive of infrastructure items, with both expressed as ratios to GDP. In theory, the 'automatic stabilizer' view of fiscal policy suggests that revenue and spending ratios should both be affected by the economy's growth rate – the former positively, and the latter negatively. However, the automatic stabilizer function of fiscal policy is known to be very weak in developing economies in general, and Latin America is no exception to this rule (Talvi and Vegh 2000).

To assess empirically the impact of growth on the non-infrastructure primary deficit, we regress the public revenue and spending ratios against the growth rate of GDP using data for 1970-1997 for a group of Latin American economies defined by data availability.[10] The results are reported in Tables 3 and 4. In each case, we present a variety of panel estimates that differ by the inclusion or exclusion of country fixed effects and time dummies in the regression specification. These are intended to control respectively for unobserved country-specific factors and for common factors influencing public revenue and expenditure across countries.[11]

Table 3 presents estimation results for tax revenues and total public revenues as a ratio to GDP. In addition to growth, the regressions also include the tax reform index of Morley, Machado and Pettinato (1999) as a determinant of public revenues. The regression sample is limited to Latin America, because the tax reform index is unavailable for other countries.

For both tax and total revenues we find a positive effect of tax reforms, as measured by the reform index, on the revenue / GDP ratio. However, in the case of tax revenues the impact is significant only when time dummies are excluded. As for GDP growth, which

[10] Since GDP growth is a stationary variable, we first check that the revenue and spending ratios are stationary as well – otherwise the regression just described will yield inconsistent parameter estimates. We follow a three-stage procedure, described in detail in the Appendix. First, we verify that revenues, expenditures and GDP are I(1) variables, using the panel unit root test of Im, Pesaran and Shin (1995). The test statistics cannot reject the null of a unit root for any of the three variables. Next, we use the same methods to test whether revenue and expenditure ratios to GDP contain unit roots. In all cases the presence of unit roots can be rejected once a deterministic trend is included. Then we proceed with standard estimation methods as described in the text.

[11] The regression results reported in the tables change very little with the addition of lags of the dependent and independent variables.

is the variable of interest here, its effect is always positive for tax revenues, and for total revenues too if country fixed effects are included in the regression. In the latter case, the estimated growth effect is significantly different from zero in the case of tax revenues. For total revenues, however, the growth coefficient is never significant.

Table 3
Taxes and Growth: Panel Data Regression Analysis

Regression	Dependent Variable	
	Tax Revenues (%GDP)	**Total Revenues (% GDP)**
I. Pooled OLS Regression		
Output Growth	0.009328 (0.0445)	0.004636 (0.0682)
Tax Reform	0.015260 (0.0092)**	0.101350 (0.0290)**
R**2	0.0507	0.0619
II. Within-Group Estimator		
Output Growth	0.066163 (0.0285)**	0.059223 (0.0419)
Tax Reform	0.014494 (0.0083)**	0.107407764 (0.0322)**
R**2	0.2388	0.1671
III. OLS with Time Effects		
Output Growth	0.007381 (0.0497)	-0.007541 (0.0738)
Tax Reform	0.017188 (0.0119)	0.091649 (0.0280)**
R**2	0.0312	0.0776
IV. OLS with Country and Time Effects		
Output Growth	0.083783 (0.0310)**	0.067663 (0.0437)
Tax Reform	0.016900221 (0.0125)	0.081524446 (0.0369)**
R**2	0.3421	0.2705

Note: The sample covers the years 1970-97. The countries included are: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, Guatemala, Guyana, Honduras, Haiti, Jamaica, Mexico, Nicaragua, Panama, Peru, Paraguay, El Salvador, Trinidad and Tobago, Uruguay and Venezuela. The number of observations in each panel is 425. The figures in brackets are standard errors.

In the case of spending (Table 4), we present results both for Latin America and a broader country sample. The growth coefficient estimates are uniformly negative, as expected, but they are significant only for the broader sample and only if fixed effects are included. For Latin America, the estimates are insignificant in every specification.

On the whole, both the revenue and expenditure estimates in tables 3 and 4 provide little evidence of any effects of growth on the non-infrastructure primary deficit. Thus, for practical purposes we shall take $\frac{\partial p}{\partial g} = 0$ in the calculations below.

Table 4
Government Spending and Growth: Panel Data Regression Analysis
Dependent Variable: Government Spending as a ratio to GDP

Regression	Sample of Countries	
	All Countries	**Latin America**
I. Pooled OLS Regression		
Output Growth	-0.07347526 (0.0544)	-0.07381075 (0.0667)
R**2	0.0207	0.027
II. Within-Group Estimator		
Output Growth	-0.09023846 (0.0351)**	-0.06600829 (0.0451)
R**2	0.0713	0.0436
III. OLS with Time Effects		
Output Growth	-0.04941513 (0.0543)	-0.03281551 (0.0748)
R**2	0.0578	0.0579
IV. OLS with Country and Time Effects		
Output Growth	-0.06482652 (0.0335)**	-0.0205474 (0.0471)
R**2	0.1484	0.1224

Note: The sample includes 60 countries over the 1960-97 period (1620 observations), of which 20 countries are from Latin America (540 observations). The sample of countries is: Argentina, Australia, Burundi, Benin, Bangladesh, Belize, Bolivia, Brazil, Chile, China, Cote d'Ivoire, Colombia, Costa Rica, Dominican Republic, Ecuador, Egypt, Ethiopia, Fiji, Gabon, Great Britain, Gambia, Greece, Guatemala, Honduras, Haiti, Indonesia, India, Japan, Kenya, Rep. Korea, Sri Lanka, Morocco, Mexico, Malta, Mauritania, Mauritius, Malawi, Malaysia, Nigeria, Nicaragua, Pakistan, Panama, Peru, Philippines, Papua New Guinea, Paraguay, Sudan, Singapore, El Salvador, Sweden, Syria, Thailand, Tunisia, Turkey, Uruguay, United States, Venezuela, South Africa, Zaire, and Zimbabwe. The figures in brackets are standard errors.

5. The Impact of Infrastructure Spending on Public Sector Net Worth

We can now put together the different pieces developed in the preceding analysis and illustrate the impact of government infrastructure spending on the public sector's net worth. To do this, it is convenient to focus on the effects of spending on the annuity value of net worth introduced earlier. From (6) and under $\frac{\partial p}{\partial g} = 0$, this can be expressed as:

$$\frac{da_t}{d(G_z/Y)} = (r-g)\frac{dw_t}{d(G_z/Y)} = -1 + \left[\frac{D_t}{Y_t} \cdot h_z \cdot \frac{d\Delta z}{d(G_z/Y)}\right] \qquad (7)$$

The term in square brackets is the indirect effect via growth from (3) above. As already noted, it tends to offset the direct impact of infrastructure spending changes on the annuity value of public sector net worth, which is itself negative and equal to minus one.

Using the empirical estimates just discussed, the extent of this offset is computed in Table 5, which calculates the impact on the annuity value of public net worth of a permanent cut in spending on each of the three infrastructure assets considered – i.e., the right-hand side of (7). The calculation is presented for different values of the debt/GDP ratio. It is important to stress that these computations are based on a very simple framework and rely on first-order approximations that admittedly might be very rough. Thus, the calculations should be viewed as illustrative rather than definitive.

Subject to these caveats, the top line of the table shows that with a zero public debt stock, a infrastructure spending cut translates one-for-one into increased net worth. The reason is that at zero debt the reduced growth resulting from slower infrastructure expansion has no (first-order) effect on the economy's sustainable debt stock – thus the growth slowdown is of no consequence for public solvency.

As the debt stock rises, however, the table shows that a considerable portion of the favorable impact of spending cuts on public sector net worth is offset by the solvency-weakening effect of reduced growth. For example, if the public debt stock equals 20 percent of GDP, then a cut in public telecommunications investment by 1 percent of GDP raises the annuity value of public net worth by only 0.78 percent of GDP – in other words, 22 percent of the spending cut is offset by future reduced growth. The offset is numerically very similar for all three assets – slightly higher for transport routes, and lower for telecom.

Table 5
Impact on the Annuity Value of Net Worth of a Cut in Infrastructure Investment by 1 percent of GDP

(as a percentage of GDP)

Initial Public Debt to GDP ratio	Cut in Investment in: Telecommunications	Power Generation Capacity	Transportation Routes
0.0	1.00	1.00	1.00
0.2	0.78	0.79	0.76
0.4	0.56	0.58	0.52
0.6	0.35	0.38	0.28
0.8	0.13	0.17	0.04

Note: For each value of the public Debt to GDP ratio, the table shows the impact on annualized net worth, as percent of GDP, of a decline in investment in each infrastructure asset by one percentage point of GDP.

At higher levels of public indebtedness, the offset is much larger. For example, when the public debt / GDP ratio reaches 80 percent, our estimates imply that a cut in infrastructure investment by 1 percent of GDP raises the annuity value of net worth by an small amount between 0.04 and 0.17 percent of GDP – depending on the asset composition of the spending cut.[12]

Given this assessment of the impact of public infrastructure investment on public sector net worth, to what extent did Latin America's public infrastructure compression of the 1980s and 1990s really contribute to stronger public finances? Our empirical estimates allow again an illustrative, if not conclusive, answer to this question. Importantly, the numerical illustration below assumes that changes in public infrastructure investment are translated one-for-one into changes in *total* infrastructure investment – in other words, private investment remains unaffected.

With this important qualification, Table 6 provides an illustrative assessment of the impact of the observed changes in public infrastructure investment. In essence, the table repeats the generic calculations in Table 5 but using the actual debt ratios and infrastructure investment changes observed in the nine Latin American countries under consideration between the early 1980s and late 1990s.

The first column in the table reports the actual change in public investment in the three infrastructure assets under analysis over the period in question. All countries listed, except for Ecuador, witnessed an investment decline, particularly marked in Argentina, Bolivia and Brazil.[13]

The second column calculates the impact on annual GDP growth derived from these spending cuts. It is computed adding up the individual growth effects of the observed changes in public investment in each of the infrastructure assets considered, with the individual calculations based on the parameter estimates of the output contribution of each asset. Again it is important to emphasize that these calculations assume that changes in public investment translate fully into changes in aggregate infrastructure investment. Hence they reflect the partial-equilibrium growth impact of public sector retrenchment, before changes in private infrastructure investment.

The adverse growth impact obtained in this manner is considerable in the case of the three countries already mentioned, for which the GDP growth cost roughly amounts to 3 percent per annum. It is also significant for Mexico, Chile and Peru (around 1.5 to 2 percent per year). At the other end, the adverse growth impact is small in Colombia and Venezuela – who experienced only small investment cuts. Finally, the growth effect is positive in Ecuador, which increased public infrastructure spending over the period under consideration.

---

[12] At even higher debt stocks, the offset could become more than full, and the spending cut would actually *reduce* the public sector's net worth.

[13] Note that these figures differ somewhat from those in Table 4.1. The reason is that Table 4.6 only considers investment in transport routes, power and telecommunications, while Table 4.1 includes in addition investment in other items, such as water and gas.

Column 4 in Table 6 presents the impact on the annuity value of public sector net worth from these public spending changes. The sign of the impact is positive for all countries showing spending cuts, and negative for the only one showing an increase (Ecuador). However, the bang-per-buck varies considerably across countries. This is due primarily to their different levels of public indebtedness -- and marginally also to the different composition of the investment cuts by infrastructure asset (not shown in the table) observed in each country.

Table 6
Impact of Actual Infrastructure Investment Changes on the Annuity Value of Public Net Worth: 1980-84 vs. 1995-98

(as a percentage of GDP)

Country	**Change in Infrastructure Investment (% GDP)** ***a/*** **[1]**	**Implied Change in the Growth Rate**	**Public Debt (% GDP)** ***b/***	**Implied Change in Annualized Public Net Worth (%GDP) [2]**	**Offset Coefficient 1 - | [2]/[1] |**
Argentina	-2.65%	-2.83%	23.48%	1.99%	25.06%
Bolivia	-3.03%	-3.25%	83.00%	0.33%	88.97%
Brazil	-2.98%	-3.15%	22.25%	2.28%	23.56%
Chile	-1.49%	-1.57%	42.55%	0.82%	44.71%
Colombia	-0.44%	-0.45%	21.28%	0.34%	21.73%
Ecuador	0.56%	0.58%	50.67%	-0.26%	52.47%
Mexico	-1.95%	-2.26%	42.21%	0.99%	48.92%
Peru	-1.48%	-1.55%	48.74%	0.72%	51.28%
Venezuela	-0.41%	-0.43%	21.03%	0.32%	22.05%

a/ Actual change in public investment in roads, power and telecommunications between 1980-84 and 1995-98. b/ Sum of the domestic and external public debt / GDP ratios averaged over the 1980-94 period

Thus, in highly-indebted Bolivia, a cut in public infrastructure spending by 3 percent of GDP raises the annualized net worth of the public sector by only 0.3 percent of GDP, while a similar spending cut in lower-debt Brazil yields a net worth increase of over 2 percent of GDP.

The last column in the table gives an idea of the efficiency of these infrastructure-spending cuts as a device to raise public net worth. It reports the fraction of the spending cuts that was *not* reflected in an increase in annualized net worth – i.e., the overall offset coefficient. The offset is largest in Bolivia, where it exceeds 80 percent. In the other countries the offset coefficient ranges between 20 and 50 percent – i.e., between 20 and 50 percent of the observed infrastructure investment cuts failed to improve the public sector's financial position. These offset coefficients suggest that in most countries infrastructure investment cuts represent a very inefficient strategy for strengthening public finances.

One important caveat of these calculations is that by equating cuts in public infrastructure investment with cuts in *total* infrastructure investment – i.e., ignoring the private sector response to the public sector's retrenchment -- they lead to an overstatement of the growth reduction due to public spending cuts and hence to an overstatement of the offset coefficients. It is true that in some Latin American countries – with Chile as the leading example – private infrastructure investment did expand considerably as public investment contracted, dampening (or even reversing) the adverse impact of public spending cuts on the accumulation of infrastructure assets. Hence, to the extent that the decline in total infrastructure investment is typically less pronounced than the decline in public infrastructure investment, the calculations above provide an upper bound on the adverse growth implications and thus the inefficiency of public infrastructure investment cuts as a means to enhanced public solvency.

On the other hand, however, the infrastructure investment data for Latin America would not support the general conclusion that public investment cuts are offset by private investment rises. Indeed, the evidence shows considerable diversity across countries and infrastructure sectors in the region in terms of the private sector.[14] In other words, public sector retrenchment *per se* does not lead to a private investment takeoff. Other ingredients – such as an appropriate regulatory and institutional environment – are necessary to encourage private sector involvement in infrastructure activities.[15] In this sense, the above calculations underscore the dangers posed by public infrastructure compression for growth and public finances when those necessary ingredients, and thus the private sector response, are lacking.

6. Summary

Public infrastructure spending often takes a major toll at times of fiscal contraction. The experience of Latin America over the last two decades accords with this observation. In several of the region's large economies, infrastructure investment cuts accounted for half or more of the reduction in the primary deficit achieved between the early 1980s and the late 1990s. Moreover, this figure probably understates the total contribution of infrastructure spending cuts, given that infrastructure O&M expenditures likely fell in most countries along with investment.

The analysis in this paper has shown that fiscal adjustment through public infrastructure compression can be largely self-defeating in the long run, because of its adverse effect on growth and hence on the debt-servicing capacity of the public sector. The calculations reported here show that the growth cost of reduced infrastructure asset accumulation resulting from lower investment was substantial – in several countries, the estimated adverse impact on the long-run growth rate of GDP exceeds 1 percent per annum. As a result, much of the supposedly favorable effect of the investment cuts on public finances was likely offset by higher future deficits resulting from reduced future output – although the magnitude of the growth cost and the fiscal offset show considerable variation across countries, depending on their levels of public indebtedness and the asset composition of the infrastructure investment contraction.

[14] See Calderón, Easterly and Servén (2002).
[15] See Estache and Pargal (2002).

Obviously, the main implication of these results is *not* that infrastructure spending should never be cut under any circumstances. The lesson instead is that under plausible conditions infrastructure compression may represent a highly inefficient way to achieve fiscal adjustment. Its consequences for future growth and public revenues should be carefully considered, and assessed against those of cuts in other spending items, when deciding on a course of action for fiscal retrenchment.

References

Buiter, Willem (1990): *Principles of budgetary and financial policy*. MIT Press.

Calderón, César; William Easterly, and Luis Servén (2002). How did Latin America's Infrastructure Fare in the Era of Macroeconomic Crises? The World Bank, Mimeo

Calderón, César; Luis Servén (2002). "The Output Cost of Latin America's Infrastructure Gap." The World Bank, Mimeo

Easterly, William (1999). "When is fiscal adjustment an illusion?" *Economic Policy*, 57-86.

_______ (2001). "Growth Implosions, Debt Explosions, and My Aunt Marilyn: Do Growth Slowdowns Cause Public Debt Crises?", World Bank Policy Research Working Paper.

Estache, Antonio; Pargal, Sheoli (2002) "The Private Sector Response: Trends, Determinants and Challenges." The World Bank, Mimeo

Hicks, Norman L. (1991) "Expenditure Reductions in Developing Countries Revisited", *Journal of International Development*: vol. 3, No. 1, 29-37.

Im, Kyung So; M. Hashem Pesaran and Yongcheol Shin (1995) "Testing for Unit Roots in Heterogeneous Panels". Manuscript, University of Cambridge (Revised Version: December 1997)

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.

Morley, Samuel A.; Roberto Machado and Stefano Pettinato (1999) "Indexes of Structural Reform in Latin America". *CEPAL Serie Reformas Economicas 12*, January.

Röller, L. and L. Waverman (2001): "Telecommunications infrastructure and economic development: a simultaneous approach", *American Economic Review* 91, 909-23.

Talvi, E. and C. Vegh (2000). "Tax base variability and procyclical fiscal policy", NBER Working Paper 7499.

Appendix
Testing for Unit Roots in Public Revenues and Public Expenditures

As a preliminary step for the revenue and expenditure regressions in the text, we assess the time series properties of the different measures of government revenues and spending, as well as real output. We apply panel unit root techniques developed by Im, Pesaran and Shin (1995). They jointly test the null hypothesis that every time series in the panel is non-stationary. The approach consists in running ADF unit root tests for each country, and averaging the t-values of the test statistics found. If the data from each country are statistically independent then, under the null, the average t-value approximates the average of independent random draws from a distribution with known expected value and variance (that is, those for a non-stationary series). This provides a much more powerful test of the unit root hypothesis than the usual single time series test (Im, Pesaran and Shin, 1995).

In practice, before carrying out the ADF regressions, we remove any common time effect. Hence, we regress the variable on a set of time dummies and take the residuals. This reduces the risk of correlation across countries. Also, in each case, the ADF regressions with a constant, a deterministic trend, and 5 augmenting lags, is run using the residuals after removing the common time-effects.

(A) Government Revenues. We use data on government revenues and real GDP for the Latin American countries that have a complete data set over the 1970-95 period, that is, 17 countries and 26 observations per country. From the results reported in Table A1, we cannot reject the existence of a unit root for all our variables in levels. However, we reject the unit root hypothesis for the first differences. Finally, we can also reject the unit root hypothesis when expressing the revenue measures as ratio to GDP. We use the latter specification in the regressions.

(B) Government Spending. Using data on government spending and real output for a sample of 60 countries over the 1970-97 period, we test the stationarity of both series (in logs). In Table A1, we show that the series are non-stationary in levels and stationary in differences, that is, they are I(1) processes. We next express spending as a ratio to GDP, and find that we can reject the presence of a unit root. We use the latter specification in the regressions.

Table A.1
Panel Unit Root Tests
Government Revenues, Government Spending and Real Output

Variable	**Levels**		**First Differences**	
	Demeaned	**Detrended**	**Demeaned**	**Detrended**
A. Government Revenues and Real Output, 1970-95				
Real Output (in logs)	-1.38	-1.57	-2.04*	-2.51*
Tax Revenue (in logs)	-1.14	-1.70	-2.03*	-2.51*
Current Revenue (in logs)	-1.35	-2.04	-2.10*	-2.50*
Tax Revenue / GDP	-1.74	-2.59*	-2.36*	-2.79*
Current Revenue / GDP	-1.79	-2.70*	-2.42*	-2.84*
B. Government Spending and Real Output, 1970-97				
Real Output (in logs)	-1.19	-2.10	-2.13*	-2.43**
Govt. Spending (in logs)	-1.40	-2.23	-2.14*	-2.45*
Govt. Spending / GDP	-1.71	-2.41*	-2.43*	-2.50*

*Notes: We report the t-bar statistic, defined as the sample average of the t-statistics obtained from the ADF regressions of individual countries. Before performing ADF regressions for individual countries, we remove the common time dummies for all variables. For the critical values of the t-bar statistic, see Table 4 in Im, Pesaran, and Shin (1995). * (**) indicates that the test statistic exceeds the 5 (10) percent critical value.*

Documentos de Trabajo
Banco Central de Chile

NÚMEROS ANTERIORES

Working Papers
Central Bank of Chile

PAST ISSUES

La serie de Documentos de Trabajo en versión PDF puede obtenerse gratis en la dirección electrónica: http://www.bcentral.cl/Estudios/DTBC/doctrab.htm. Existe la posibilidad de solicitar una copia impresa con un costo de $500 si es dentro de Chile y US$12 si es para fuera de Chile. Las solicitudes se pueden hacer por fax: (56-2) 6702231 o a través de correo electrónico: bcch@bcentral.cl.

Working Papers in PDF format can be downloaded free of charge from: http://www.bcentral.cl/Estudios/DTBC/doctrab.htm. Printed versions can be ordered individually for US$12 per copy (for orders inside Chile the charge is Ch$500.) Orders can be placed by fax: (56-2) 6702231 or e-mail: bcch@bcentral.cl.

DTBC-186 — Octubre 2002
The Ouput Cost of Latin America's Infrastructure Gap
César Calderón y Luis Servén

DTBC-185 — Octubre 2002
How did Latin America's Infrastructure Fare in the Era of Macroeconomic Crises?
César Calderón, William Easterly y Luis Servén

DTBC-184 — Octubre 2002
The Direction of Causality between Financial Development and Economic Growth
César Calderón y Lin Liu

DTBC-183 — Septiembre 2002
A Review of the Literature on Early Warning Systems for Banking Crises
Alejandro Gaytán y Christian A. Johnson

DTBC-182 — Septiembre 2002
Are Devaluations Really Contractionary?
I. Igal Magendzo

DTBC-181 — Septiembre 2002
Política Monetaria y Mecanismos de Transmisión: Nuevos Elementos para una Vieja Discusión
Verónica Mies, Felipe Morandé y Matías Tapia

DTBC-180 Septiembre 2002
Turnover and Regulation:The Chilean Pension Fund Industry
Solange Berstein y Alejandro Micco

DTBC-179 Septiembre 2002
Empalme PIB: Series Anuales y Trimestrales de 1986 a 1995, Base 1996. Documento Metodológico
Víctor Correa, Antonio Escandón, René Luengo y José Venegas

DTBC-178 Agosto 2002
An Evaluation of Monetary Regime Options for Latin America
Andrew Berg, Eduardo Borensztein y Paolo Mauro

DTBC-177 Agosto 2002
Desestacionalización de Series Económicas: El Procedimiento Usado por el Banco Central de Chile
Héctor Felipe Bravo, Leonardo Luna, Víctor Correa y Francisco Ruiz

DTBC-176 Agosto 2002
Is There Enough Evidence Against Absolute Convergence?
Rómulo A. Chumacero

DTBC-175 Agosto 2002
Dollarization and Economic Performance: What do We Really Know?
Sebastian Edwards e I. Igal Magendzo

DTBC-174 Agosto 2002
Productivity and Economic Growth: The Case of Chile
Harald Beyer B. y Rodrigo Vergara M.

DTBC-173 Agosto 2002
Greenfield FDI vs. Mergers and Acquisitions: Does the Distinction Matter?
César Calderón, Norman Loayza y Luis Servén

DTBC-172 Julio 2002
15 Years of New Growth Economics: What Have We Learnt?
Xavier Sala-i-Martin

DTBC-171 Julio 2002
Inflation Targeting in Brazil, Chile, and Mexico: Performance, Credibility, and the Exchange Rate
Klaus Schmidt-Hebbel y Alejandro Werner