The Limits of Stabilization

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INFRASTRUCTURE, PUBLIC DEFICITS, AND GROWTH IN LATIN AMERICA

Edited by
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Finally, we would like to stress that the views stated in this book are only those of the authors and should not be attributed to the institutions with which they are affiliated.

1

Introduction

William Easterly and Luis Servén

SUPPOSE THAT A DEVELOPING-COUNTRY policymaker proposed the following *adjustment program* to the International Monetary Fund (IMF) and the World Bank: her government would repay public external debt, which carries an interest rate of 9 percent a year, by substituting debt from another source that carries an interest rate of 20 percent a year. The proposal would be swiftly dismissed by the international financial institutions (IFIs), perhaps with unflattering remarks about the policymaker's knowledge of the basic laws of economics.

Yet this kind of adjustment program describes a part of the package of many Latin American macroeconomic stabilization programs of the past two decades, often supported by the IMF or the World Bank. Instead of "debt from another source," we have cuts in spending on maintenance and construction of public sector infrastructure, which is estimated almost universally to have a high rate of return. The World Bank (1994, p. 17) estimated rates of return to infrastructure investment during 1983–92 ranging from 19 percent (telecommunications) to 29 percent (highways). Gyamfi, Gutierrez, and Yepes (1992) estimated economic rates of return of more than 70 percent for operations and maintenance on roads in Latin America. The World Bank (1992, p. 57) estimated a rate of return of 117 percent for nonwage operations and maintenance in irrigation in the mid-1980s in Indonesia.

Cutting spending on a project with a high rate of return is economically equivalent to borrowing at that high rate of interest—both free up resources today in return for lost resources tomorrow. Many Latin American governments cut infrastructure spending in the era of macroeconomic reform—a line item in the adjustment program that set adjustment back rather than forward.

It is true that Latin American governments needed to adjust. The Latin American debt crisis began on August 18, 1982, when Mexican Finance Minister Jesus Silva Herzog announced that Mexico could no longer service its external debt to international commercial banks. It soon became apparent to everyone that most Latin American countries had excessive debt and needed to retrench severely if debt ratios were to be manageable. Because the excessive borrowing was caused largely by persistent budget deficits, fiscal adjustment became an unavoidable task.[1]

When fiscal adjustment was insufficient, what had been an external debt crisis became a high-inflation crisis because governments resorted to printing money to finance their deficits in the absence of foreign lending. Countries like Argentina, Brazil, and Peru experienced extreme inflation episodes in the 1980s or early 1990s, and had to undertake severe fiscal adjustment to bring inflation under control. In these and other Latin American economies, placing public finances on a sustainable course was an essential step to restore macroeconomic stability.

At the same time, there was a welcome shift in ideology throughout Latin America during the last two decades away from the state-led, inward-looking development paradigm of the 1960s and 1970s toward more reliance on markets, free trade, and the private sector. Growing disenchantment with pervasive government intervention in the economy—ranging from price and interest rate controls to direct state involvement in the production of numerous goods and services—opened the way to a new development model in which market forces played the leading role in the allocation of resources. The state withdrew from most production activities in favor of the private sector in a radical paradigm shift aiming to raise economic efficiency and long-term growth.

There is no question that fiscal retrenchment was necessary and that Latin America's state-led model had been exhausted. What is questionable is the extent to which public infrastructure spending bore the brunt of adjustment. This is by no means a new discovery; earlier analyses have already documented the fact that in developing countries infrastructure expenditures often suffer a disproportionate compression in times of fiscal austerity.[2] This book offers unambiguous evidence that the Latin American experience of the 1980s and 1990s conformed to the same pattern.

The compression of infrastructure spending is largely a consequence of the myopic use of the current budget deficit to GDP ratio as the single yardstick to assess fiscal performance. It could be avoided easily if economic analysts—including the IFIs—were to change their thinking and evaluate adjustment in terms of the only budget constraint that matters economically, namely, the *intertemporal* budget constraint. As will be discussed later in more detail, this constraint says that the present value of all future government revenues must be sufficient to cover the existing stock of debt plus the present value of all future government spending. For this calculation, the present value of revenue and expenditure is evaluated at the interest rate the government pays on its marginal borrowing. Any project with a higher return than that interest rate should be undertaken, because it makes it easier to meet the intertemporal budget constraint regardless of the effect of the project on the current budget deficit.

Many infrastructure maintenance and construction projects have such high rates of return that they satisfy this condition. Yet for a long time the IFIs and the international financial community continued to view infrastructure cuts as a valid means to fiscal adjustment. Various rationalizations have been offered for this approach. One is that some macroeconomic crises are caused by shortages of liquidity rather than the kind of insolvency the intertemporal budget constraint covers. Cutting infrastructure spending could free up some short-term funds to avoid such damaging expedients as printing money. This argument is suspect, however. The role of the IFIs is precisely to ease liquidity crises in a way that preserves long-run growth potential while avoiding short-run destabilization. But, to return to the argument in the first paragraph, recommending cuts in infrastructure spending says that the adjusting country should resolve the liquidity squeeze by taking out a loan at an interest rate of 30 to 70 percent. An adjustment program meant to resolve a liquidity crisis should not have to resort to such costly sources of financing.

A second rationalization for cutting infrastructure spending is that even if infrastructure spending has high returns, these returns may accrue to the society rather than the government. If the macroeconomic problem is caused by an excessive budget deficit, then infrastructure cuts could improve the budget picture even though they worsen the economy's long-run potential. This argument is shortsighted in several ways. First, if infrastructure cuts lower growth, then this will have a negative fiscal impact (described below). Second, fiscal policy can be designed to capture a good share of the high social returns to infrastructure spending.

A third argument in favor of infrastructure cuts during fiscal adjustment is that the spending is often going to white elephants that do not have a high rate of return. This is clearly true in some cases.[3] It would be naïve to believe that everything called *infrastructure spending* in the fiscal accounts is necessarily productive, or that such spending should be the only—or even the main—indicator of public infrastructure performance. Also, governments and IFIs should pay close attention to the incentives facing the government bureaucracy to provide efficient infrastructure services. However, these caveats fail to justify an across-the-board cut in infrastructure spending during fiscal adjustment. It would be far better to cut just the white elephants and to improve incentives for service delivery, while preserving the productive new construction and maintenance projects from fiscal austerity.

Finally, the argument is often made that the private sector could take over many aspects of infrastructure provision, and so cutting public infrastructure spending is not such a big deal. This argument accords well with Latin America's shift away from the state-led development model of the 1960s and 1970s. Private provision of infrastructure is a promising area and private infrastructure provision will be examined at great length in this book. However, with few exceptions, private provision is still at a relatively early stage in most countries (with the telecommunications sector as the main exception). For the most part, infrastructure is provided publicly almost everywhere, and has been throughout the history of the now-rich countries. Even where private infrastructure provision is viable, the transition from public to private ownership has to be thought out carefully. Opening infrastructure industries to private sector involvement can make a lot of sense, but to cut high-return public infrastructure spending and expect the private sector to fill the breach overnight is a leap of faith.

The conclusion is that cutting high-return public infrastructure indiscriminately during fiscal adjustment does not make sense in either macroeconomic or microeconomic terms. It makes about as much sense as the satirical business principle: "We take a loss on every item, but we make it up on volume."

This book provides the main facts on the pattern of infrastructure spending under macroeconomic adjustment in Latin America over the past two decades along with evidence on its rate of return. No claim is made that the infrastructure cuts were so pervasive as to make the entire adjustment package in each country a step backward. It would also be illusory to assert that all spending classified as infrastructure necessarily led to maintenance or creation of productive capital. The point needs to be stressed, however, that spending cuts in Latin America included some high-return projects that never should have been cut in an exercise designed to move to public sector solvency. The opening up of infrastructure industries to private sector participation has had mixed results and so far has not resolved Latin America's infrastructure problems.

This introductory chapter presents an analytical framework highlighting the relevant concepts on the intertemporal budget constraint and the growth impact of infrastructure. Then this organizing framework is used to summarize the main findings of the other chapters in the book.

The Intertemporal Budget Constraint and Fictional Adjustment

Many authors have identified the government's intertemporal budget constraint as the ultimate constraint on the government's fiscal activities (see, for example, Anand and van Wijnbergen 1989; Auerbach 1997; Blanchard and others 1990; Buiter 1990; Buiter and Patel 1992, 1997; and Easterly 1999). Schematically, the intertemporal budget constraint states:[4]

$$\begin{bmatrix} \text{Present value of tax revenues net of transfers} \\ -\text{ Present value of public consumption} \\ +\text{ Present value of seigniorage} \\ +\text{ Present value of excess return on public capital} \end{bmatrix} \geq \begin{bmatrix} \text{Initial public debt} \\ -\text{ Initial public capital} \end{bmatrix} \quad (1.1)$$

The left-hand side of this expression is the present value of the entire future stream of the government's augmented noninterest surpluses on current account. Such augmented surpluses consist of four ingredients: taxes net of transfers; public consumption (the difference between the taxes net of transfers and public consumption is the current primary surplus);[5] revenues from money printing; and the difference between the financial rate of return on public capital (net of depreciation) and the discount rate, which—for lack of a better term—will be called excess return. The latter is positive if the cash rate of return on public assets is higher than the discount rate, and negative otherwise.[6] Note that this refers only to the direct cash return on public capital. There can also be indirect revenue effects if public capital affects other fiscal variables. Most important, such indirect effects may arise through the impact of public capital on private capital and output and thereby on future tax collection, whose present value is the top item on the left-hand side of the intertemporal budget constraint. This issue will be reexamined later.

The right-hand side of expression 1.1 is government debt net of public assets. Here debt should include both explicit and implicit debt as well as contingent liabilities.[7] Solvency requires that the present value of augmented current primary surpluses be no less than initial net debt. Intuitively, for the government to be solvent it has to run a surplus large enough to cover not only the interest on its (net) debt, but also some payment toward the principal.

In contrast with the intertemporal budget constraint, the conventional deficit identity highlights the current accumulation of public debt. Furthermore, the focus is on explicit debt and, typically, limited attention is paid to implicit and contingent liabilities.

In light of the intertemporal budget constraint, it is easy to understand the many tricks countries play to lower the conventional budget deficit (or the rate of debt accumulation) while avoiding real, long-term fiscal adjustment. The tricks range from rearranging the time profile of revenues or expenditures without altering their present value, to lowering the rate of debt accumulation by reducing the rate of asset accumulation, to replacing explicit liabilities or recorded expenditures with hidden liabilities kept off the books.

For example, oil-producing countries with adjustment programs pumped oil out of the reserves in the ground faster than they did during periods without adjustment programs. They got more current revenue at the cost of making less oil revenue available for sale in the future, thus lowering the current deficit at the expense of the future deficit, and failing to improve the long-run fiscal picture.[8]

Governments can also simply shift expenditures and revenues across time to meet today's cash deficit targets. Often they resort to the expedient of delaying payments to government workers or suppliers. These arrears lower this year's cash deficit and explicit public debt, while increasing next year's cash deficit and the implicit public debt.[9]

These tricks are not exclusive to developing countries. They are also used frequently by industrial nations. Consider the United States during the effort to contain deficits at the time of the Gramm-Rudman bill. The Congress in fiscal 1987 postponed a $3 billion payday for military personnel into the following fiscal year. The Defense Secretary, Caspar Weinberger, also stretched out procurement of new weapons systems to lower the current expenditure, even though the stretch-out increased per unit costs (see Kee 1987, p. 11).

Governments can also shift taxes over time. There are many anecdotes of developing countries getting advance payments of taxes to meet IMF program deficit targets (see Kopits and Craig 1998). In the same way, the U.S. Congress moved about $1 billion in excise tax collections forward to meet the Gramm-Rudman deficit ceiling in fiscal 1987 (as discussed in White and Wildavsky 1989, p. 514).

Reducing the rate of asset accumulation—that is, public investment—is another commonly used approach to deficit reduction. It has been amply used in developing-country adjustment programs, as documented, for example, by Servén and Solimano (1992) and, in Latin America, by this volume. From the intertemporal budget constraint above, a reduction in public investment will improve the solvency position of the public sector if the rate of return on public capital falls short of the discount rate. However, it is important to note that this test needs to compare the discount rate with the *total* return on public capital—that is, not only the direct cash return but also the indirect one accruing through the impact of public capital on future output and tax collection.

Privatization of state assets is a more expeditious way to reach the same end. If the government uses the proceeds to retire public debt, privatization reduces simultaneously the stocks of public assets and public debt in the right-hand side of (1.1). The reduction need not be one-for-one, however, because the volume of debt that can be retired depends on the price at which the assets are sold. In general, the sale price will reflect the present value of the future returns accruing to the purchaser. If these are the same as the returns that would have accrued to the government, then privatization is unlikely to help solvency.[10] In other words, solvency is strengthened only if the government manages to sell the assets at a price above the present value of the net future returns that it could have derived from holding them.

Again, both developing and industrial countries have resorted to these means to achieve deficit or debt reduction. For example, in the United States, the Gramm-Rudman initiative gave impetus to the idea of selling off state assets and counting the proceeds as revenue, fictitiously lowering the deficit—but with uncertain effects on solvency. Congress had long stalled on privatization of the railway company, Conrail, until Gramm-Rudman came along. When Gramm-Rudman created incentives for getting privatization revenues to meet budget targets, the Congress suddenly hurried up and sold Conrail.

Another sleight of hand is to reduce current expenditure today in return for a contingent or off-budget liability. For example, the government can switch from granting subsidies to state enterprises to guaranteeing bank loans made to them to cover their losses. This creates the appearance of a deficit reduction and a slowdown in the accumulation of explicit debt. When the enterprises eventually default on their debt, however, the government has to pay off the debt and so winds up paying for state enterprise losses just as it had been when subsidies were explicit. Egypt, for example, phased out budgetary support to state enterprises in 1991, but allowed loss-making enterprises to continue to operate on bank overdrafts and foreign loans. The Egyptian government periodically had to cover for loan defaults by these enterprises.[11]

Even more creatively, governments can also shift subsidies to state enterprises off the books by having public financial institutions (whose balances are seldom included in government deficit definitions) provide subsidized lending to the state-owned enterprises (SOEs). In Argentina, before 1990, the central bank gave a subsidized interest rate on loans to loss-making public enterprises, reducing their interest costs and their losses (see Mackenzie and Stella 1996).

Off-budget liabilities have played a particularly important role in connection with the privatization of infrastructure assets. To raise the sale price, governments have often provided price or rate-of-return guarantees to the purchasers, or have guaranteed their borrowing. For example, to protect the private owners from demand uncertainty, the Colombian government offered a minimum revenue guarantee to some toll-road concessions in the 1990s. Similarly, the Spanish government provided exchange rate guarantees on the foreign loans to toll-road concessions in the 1970s. In private power generation projects in Pakistan, *take or pay* clauses were common to shelter investors from the risk that installed capacity could go unutilized. (All these examples are from Irwin and others 1997.)

Guarantees can make sense in the context of infrastructure projects because these involve large sunk costs and are highly vulnerable to opportunistic government behavior (for example, through expropriatory regulation), two features that make them especially risky. Yet the guarantees represent contingent government liabilities that are seldom accounted for explicitly. They shift the risk from the private owners of the infrastructure assets to the government. When the guarantees are called, typically at times of recession, their fiscal impact can be significant. The proper design and valuation of guarantees on infrastructure projects have been studied at length elsewhere, and will not be pursued here (see Irwin and others 1997, and Brixi and Schick 2001).

This brief catalogue suggests the assorted tricks that at one time or another have passed for fiscal adjustment—while having in reality little effect on public solvency. Europe's recent experience with the Maastricht Treaty offers an excellent case study on the use of tricks to meet deficit and debt targets. Cheating was widespread during the run-up to the May 1998 selection of countries to join the European Monetary Union, which involved complying with the deficit and debt targets set out in the Stability Pact of the Maastricht Treaty.

For example, Greece, not then a member of the European Union but trying hard to become one, announced in 1998 plans to privatize 11 state enterprises and three to four state banks. Among the enterprises were such potentially profitable companies as Hellenic Telecommunications Organization, Hellenic Petroleum, Water Supply Co., and two subsidiaries of Olympic Airways. Revenue from Greek privatizations was expected to total 0.8–0.9 percent of gross domestic product (GDP) in 1998–99 (from Dow Jones Newswires March 15, 1998).

Belgium was even less subtle, selling $2.5 billion worth of gold reserves on March 19, 1998, and using the proceeds to reduce public debt by 1 percent of GDP. Sales of mobile phone licenses also brought revenue that could be applied to lower both deficit and debt.

France used a more intricate device. France Telecom made a one-time payment to the government of 0.5 percent of GDP in return for the government shouldering Telecom's pension liabilities, an increase in implicit government liabilities not transparently recorded as government debt. The proceeds reduced the deficit according to a European Commission ruling! This conjuring trick accounted for half of France's deficit reduction in 1997 (see Dow Jones Newswires March 25, 1998; *Economist* December 14, 1996; and European Commission 1998). One skeptic noted that "the French budget process suggests that interpretive flexibility is simply being shifted from the Maastricht criteria to national accounting practices" (Hildebrand 1996).

Like France, Austria got a one-time payment from a state enterprise (the Postsparkasse) in return for assuming pension liabilities (European Commission 1998). Like Belgium, other temporary Austrian revenues came from sales of mobile phone licenses. Austria used a further sleight of hand, reclassifying some state enterprises from government to corporate sector, such as Asfinag, with substantial debts (Dow Jones Newswires April 8, 1998).

Italy was more transparent: it levied a one-time Eurotax to meet the Maastricht deficit target in 1997, but announced that 60 percent of the tax would be refunded in 1999 (*Economist Intelligence Unit* April 23, 1998). The budget plan also foresaw lower debt from the proceeds of privatizing the highway management network, Autostrade, and the airline, Alitalia.

Even the conservative Germans engaged in some illusory fiscal adjustments. They reclassified public hospitals into the corporate sector in 1997, taking their debts out of general government debt (European Commission 1998). They also delayed interest payments on the public debt to lower the 1997 deficit, accelerated sales of shares in Deutsche Telekom, and used central bank profits from reserve revaluation to pay off debt inherited from East Germany. (See *Economist Intelligence Unit* April 23, 1998, and Dow Jones Newswires May 14, 1998.)

Fiscal Adjustment and Infrastructure Spending

Cutting productive infrastructure spending can be a similarly fictional type of fiscal adjustment. It may even be counterproductive, in the sense of weakening the solvency position of the government rather than strengthening it.

Infrastructure spending by the government enters the intertemporal budget constraint in three places. First, it is part of total government spending—both investment spending related to the acquisition of infrastructure assets and recurrent spending for operations and maintenance. Second, it raises future public revenues (a level effect)—both direct revenues to the extent that infrastructure user charges exist, and indirect revenues to the extent that an increase in infrastructure leads to permanently higher output and tax collection. This can be thought of as increasing government assets that will yield positive revenues in the future. Third and most important, if infrastructure spending raises the rate of growth of the economy, it will affect the sustainability of a given primary surplus.

To highlight these facts, it is convenient to rewrite the intertemporal budget constraint in a slightly different form (see Buiter 1990):

$$\left\{\begin{array}{l}\text{Present value of current primary surplus/GDP}\\ -\ \text{Present value of public investment/GDP}\\ +\ \text{Present value of seigniorage/GDP}\end{array}\right\} \geq [\text{Initial public debt/GDP}]. \tag{1.2}$$

This formulation differs from the previous one in two ways. First, all flow revenues and expenditures related to public infrastructure capital have been added to the left-hand side of the equation (for simplicity, noninfrastructure capital is ignored). As a result, the right-hand side now contains only the public debt stock. Second, all magnitudes have been expressed as ratios to GDP. As a consequence, the rate used to discount future revenues and expenditures to arrive at their present value is now a *net* discount rate, given by the difference between the original (gross) rate and the rate of growth of GDP. The assumption is that this net discount rate is positive.[12]

The government is solvent if the above inequality holds. In fact, the *government net worth* is the difference between the left-hand and right-hand sides of (1.2). If it is negative, the government is insolvent with the current fiscal policies, debt levels, and net discount rate—including the prevailing growth rate. Restoring solvency then requires some combination of higher growth, fiscal adjustment, and debt relief.

If one thinks of a long-run steady state in which fiscal revenues and expenditures remain constant relative to GDP,[13] then it is easy to simplify the above expression to highlight the various effects of infrastructure spending mentioned earlier. In a long-run equilibrium, the preceding expression can be rewritten:

$$\frac{\left(\begin{array}{l}\text{Current primary surplus/GDP} \\ - \text{Public investment/GDP} \\ + \text{Seigniorage/GDP}\end{array}\right)}{[\text{Discount rate} - \text{GDP growth rate}]} \geq [\text{Public debt/GDP}]. \tag{1.3}$$

This expression is familiar from the fiscal solvency literature (Blanchard and others 1990, Buiter 1990, Buiter and Patel 1997, and Cuddington 1997). With strict equality, it becomes a condition for stabilizing the ratio of debt to GDP, and can be viewed as defining the primary surplus (augmented by seigniorage) required to keep constant the debt ratio for a given net discount rate.[14] Thus the government is solvent if it is able to run a (augmented) primary surplus at least as large as that required to keep constant the debt-to-GDP ratio.

Cuts in infrastructure investment reduce the public investment/GDP ratio and, other things being equal, tend to enhance solvency. Changes in infrastructure spending affect also the current primary surplus, through their derived effects on revenues (for example, from user charges) and expenditures (for example, operations and maintenance). But, in addition to these conventional effects, changes in infrastructure spending can also have an important impact on the intertemporal budget balance—for a given primary surplus relative to GDP—through their effect on the growth rate. A cut in infrastructure spending that over time leads to reduced growth raises the net discount rate and therefore lowers, other things being equal, the value of the left-hand side of (1.3). Thus, it requires a permanent increase in the augmented primary surplus (or a decrease in the debt ratio) to restore government net worth to its previous level.[15]

More generally, any adverse shock to economic growth (like infrastructure shortages) is a fiscal shock that tends to bring the current public sector stance away from solvency. Conversely, anything that increases growth makes a given primary surplus more likely to achieve solvency. It is well-known that growth plays a critical role for government solvency.[16] Budget planners in the United States are sufficiently familiar with this result to rely on optimistic growth projections to make future budgets balance. Surprisingly enough, however, there has been little talk of the role of growth when designing fiscal adjustment packages in developing nations.

Furthermore, the effect of growth on fiscal solvency is larger the greater the stock of initial debt (this can be easily seen by multiplying both sides of [1.3] by the denominator of the left-hand side). The intuition here is that growth effects on net worth are larger the greater your initial debt, because higher debt forces you to run a higher primary surplus to service it. This means that any growth effect of infrastructure cuts is more costly in a high-debt country than in a low-debt country. A corollary is that an additional percentage point of growth reduces the amount of fiscal adjustment needed for solvency more in a high-debt country than in a low-debt country.

Under what conditions does public infrastructure spending have powerful growth effects? It is likely to have a more positive effect when public infrastructure spending strongly complements private capital. If some forms of private capital can easily substitute for public infrastructure capital (as will be examined in the chapters on private provision of infrastructure services), then the growth effects of public infrastructure cuts will be lessened. In the end, it is an empirical issue. Easterly and Rebelo (1993) found in a large sample of countries that public infrastructure spending (measured as public spending on transport and communication) raised growth significantly, but the aggregate of all public enterprise investment spending had a negative effect on private investment. This suggests that there are many forms of public investment that substitute for private capital, but public spending on transport and communication is not one of them, at least over the sample period and countries considered by Easterly and Rebelo. Servén (1998) found a similar result for India.

More generally, is opening up of infrastructure activities to the private sector sure to yield sufficient private investment to offset the cuts in public infrastructure provision? There is no reason to expect that this private–public offset will occur automatically. On the one hand, the opening-up needs to take place in the presence of an enabling institutional and regulatory framework capable of attracting private investment of the necessary volume and efficiency. On the other hand, the private sector response may be far from uniform across infrastructure industries because the complementarity/substitutability between public and private projects may well differ across industries. The empirical record reviewed in this book offers clear proof of the lack of uniformity across infrastructure industries.

Overview of This Volume

This book presents the results of recent research sponsored by the World Bank's Latin America and Caribbean Region on the macroeconomic dimensions of infrastructure in the area. Drawing from the experience of more than a decade of public sector retrenchment from infrastructure activities and their opening up to private sector involvement, the main objective of the research was to assess the consequences of this changed private–public partnership from the perspective of growth, public finances, and the quantity and quality of infrastructure services.

In this general context, the book covers three main themes. First, it documents in detail the major trends in infrastructure provision in Latin America, offering a comparative perspective on the evolution of infrastructure spending and infrastructure stocks and on the changing roles of the public and private sectors. Second, the book provides a rigorous implementation of the analytical framework outlined in the first part of this introduction to gauge the impact of these infrastructure trends on growth and public finances in Latin America. Third, it takes a first look at the macroeconomic consequences of private sector involvement and examines how the private sector response across countries and sectors has been shaped by regulatory and other factors.

A brief summary of the book's contents is as follows. Chapter 2 sets the stage for the analysis in subsequent chapters by laying out the main facts regarding the performance of Latin America's infrastructure sectors during the period of macroeconomic adjustment and fiscal austerity that spans much of the 1980s and 1990s. The chapter builds from a comprehensive cross-country data set on public and private infrastructure expenditure, infrastructure stocks, and (to the extent that information permits) their quality. These data were assembled for this research and used throughout the book. A detailed review of this information, using the successful economies of East Asia as a benchmark for comparison, reveals that over the 1980s and 1990s Latin America fell considerably behind in both infrastructure quantity and quality.

This widening gap can be attributed to a large extent to the generalized decline in infrastructure investment relative to GDP across Latin America over the period under consideration: as the chapter documents, infrastructure spending is a good predictor of subsequent growth in infrastructure assets. The decline in infrastructure spending was led by the contraction of public infrastructure investment, which in a few countries virtually collapsed. Much, although not all, of the public spending decline can be traced to fiscal adjustment. In several of the region's major countries the cut in public infrastructure spending amounted to half or more of the reduction in the budget deficit accomplished in those years.

Contrary perhaps to popular perception, there is little evidence that the downward trend in public infrastructure investment mirrored the increased involvement of the private sector in infrastructure provision.

Chapter 2 shows that in many cases higher private investment came along with higher public investment as well, suggesting that the public and private sectors often played complementary—rather than competing—roles. In most countries, private infrastructure investment did rise significantly with the opening up of infrastructure industries to private participation, but did so unevenly. The private sector response was most vigorous in telecommunications, and much weaker in roads and water. Finally, the evidence is not yet conclusive on the impact of increased private participation on the efficiency and quality of infrastructure, although for telecommunications private sector involvement is clearly associated with an improvement in service quality indicators.

Against this background, chapters 3 and 4 put to work the analytical framework outlined earlier based on the intertemporal budget constraint. Chapter 3 provides a careful assessment of the contribution of Latin America's infrastructure gap to her output gap vis-à-vis the successful economies of East Asia. Over the 1980s and 1990s, the output gap between the two regions widened dramatically. Several studies have identified a close cross-country association between output growth and infrastructure growth, and this raises the question of what was the contribution of the widening infrastructure gap to the output gap.

To answer this question, chapter 3 uses an infrastructure-augmented production function and, to identify it empirically, lays out an econometric framework able to separate the exogenous component of infrastructure growth from the endogenous one resulting from the impact of growing income on the demand for infrastructure services. The results from implementing this approach on a large cross-country time-series data set reveal a significantly positive effect of the exogenous component of infrastructure stocks on output, which is shown to be robust to alternative econometric specifications and measures of infrastructure stocks.

These empirical estimates are then used to assess the contribution of Latin America's lagging infrastructure accumulation to its lagging growth performance. Although there is a considerable degree of diversity across countries in the region, on average Latin America's infrastructure slowdown relative to East Asia could account for as much as one-third of the widening output gap between both regions.

The substantial growth impact of infrastructure in Latin America that these results indicate suggests that the fiscal retrenchment of the 1980s and 1990s, which entailed a considerable degree of infrastructure compression and hence a potentially significant growth cost, represented a highly inefficient way to adjust public finances, as implied by the analytical framework outlined above. Chapter 4 examines this question and provides a detailed quantitative assessment of the efficiency of infrastructure cuts in enhancing public sector solvency in Latin America.

To do this assessment, the chapter considers the three components of the link between public infrastructure spending and public sector solvency: the effect of infrastructure spending on stock accumulation, the contribution of stock accumulation to output growth, and the impact of growth on the primary deficit. These three ingredients are then combined to gauge the contribution of infrastructure cuts to public solvency—or, to put it differently, the extent to which the short-run favorable effect of spending cuts on public finances is offset by declining long-term revenue collection capacity caused by reduced growth.

This analysis yields some key insights. First, the GDP growth cost of reduced infrastructure asset accumulation resulting from lower public investment was substantial in Latin America, exceeding 1 percent a year in several countries. As a result, much of the supposedly favorable effect of the investment cuts on the public sector balance was offset by higher future deficits resulting from lowered output growth. However, this offset, as well as the magnitude of the growth cost, show considerable variation across countries, depending on their respective levels of public debt and the composition of the infrastructure investment contraction. Estimated offset coefficients for major Latin American countries range from a low of 20 percent to a high exceeding 80 percent. The conclusion from this analysis is that, by engaging in this kind of fiscal adjustment biased against infrastructure, some Latin American governments may have figuratively shot themselves in the foot.

As already noted, the private sector response to the opening up of Latin America's infrastructure industries has been characterized by considerable diversity across countries and infrastructure sectors. Chapters 5 and 6 shift the focus of analysis to the causes and consequences of this uneven change in the degree of private participation.

Chapter 5 provides an empirical assessment of the impact of private entry on major macroeconomic aggregates—per capita GDP, private investment, and current and capital expenditures of the public sector. The analysis uncovers a contrast between private sector entry in utilities and in transport. For example, private participation in transport is associated with increases in current public spending and decreases in public investment. The opposite happens with private participation in utilities. Thus, in the former case private investment crowds out public investment but likely requires increased subsidies, whereas in the latter these conclusions are reversed. Contrary perhaps to common perception, the general implication is that private sector involvement does not have an obvious favorable effect on public finances, which should sound a cautionary note for those policymakers looking to privatization of infrastructures as a remedy for their fiscal troubles.

The opening up of infrastructure to private initiative in different Latin American countries has taken place under a wide variety of regulatory frameworks. In some cases, the opening up preceded the establishment of regulations and regulatory bodies. As already noted, infrastructure projects often entail large sunk costs, which put them at high risk of expropriation through adverse changes in regulation. Hence a sound and credible regulatory framework can make a big difference in lowering perceived expropriation risk and attracting private investment.

Chapter 6 presents an assessment of the role that the regulatory framework has played in Latin America in this regard. Using data on private investment in infrastructure in nine major countries, and taking advantage of the diversity of private entry experiences and regulatory environments across countries and infrastructure sectors, the chapter provides an empirical evaluation of the impact of key aspects of the regulatory regime: the passage of formal legislation liberalizing the investment regime, the establishment of a regulatory body, the degree of autonomy of the regulator, the size of the regulatory body, the sharing of risk between investor and regulator, and so on. It should be stressed that this is the first systematic exploration of these issues from a macroeconomic perspective, and as such its findings should be taken as tentative and suggestive of directions for further research.

The results show that the existence of a regulatory body by itself does not have much effect on private participation once the passage of liberalization legislation has been taken into account. Among the features of the regulatory framework relevant for investment, the chapter finds that systems in which regulators are appointed by the executive are associated with higher private sector involvement than if the selection of the regulator goes through the legislative branch, a fact that may reflect the critical role of regulatory predictability and credibility. Furthermore, private investment is positively associated with the regulator not being funded solely by the government, which likely echoes the importance of regulatory independence from the perspective of private investors.

Final Remarks

The findings reported in this volume reveal a mixed record regarding Latin America's experience with the public sector's withdrawal from infrastructure activities and its opening up to private initiative. But a clear message emerges that fiscal austerity centered on the sale of public assets and the compression of growth-enhancing expenditures—in the hope that the private sector will come to the rescue—is not a promising way to place Latin America's public finances on a firm footing.

Illusory fiscal adjustment has been a worldwide phenomenon in recent years. The summary by Eichengreen and Wyplosz (1998) of European countries' adjustment to the Maastricht criteria is apposite: "European governments have relied on one-off measures—central bank sales of gold, refundable euro taxes, appropriation for the general budget of public enterprise reserves, and sales of strategic petroleum reserves—to meet the Maastricht fiscal criteria for 1997." Europe has seen a backlash to this widespread cheating, and European policymakers are now finally grappling with such long-term issues as how to deal with their crushing pension obligations. Yet concerns remain that the rules set forth in the Stability Pact may permanently reduce the public sector's contribution to infrastructure capital accumulation, and various proposals have been advanced for some kind of "Golden Rule" or other similar provision to protect public investment in Europe (see Balassone and Franco 2000).

The fact that "everyone is doing it" offers little consolation for Latin Americans against the consequences of cosmetic fiscal adjustment based on disinvestment in infrastructure capital. The restoration of both fiscal solvency and long-term growth will require a more farsighted approach to fiscal adjustment that protects the growth-enhancing spending done by Latin American governments.

Fortunately, there is increasing awareness among policymakers that an intertemporal perspective on budget deficits and fiscal adjustment measures is the only way to properly evaluate their effect on fiscal solvency. It is hoped that this volume will contribute to this trend.

Notes

1. See, for example, Edwards (1995) for a comprehensive account of macroeconomic adjustment in Latin America during the 1980s and early 1990s.

2. For example, Hicks (1991) reviewed several fiscal contraction episodes in developing countries during the 1990s and found that infrastructure was the item suffering by far the largest spending cuts in relative terms.

3. For example, Balassone and Franco (2000) noted that Italy has consistently maintained one of the highest ratios of public investment to GDP among industrial countries, but its relative position in terms of infrastructure stocks has failed to improve.

4. There are several alternative ways to present the intertemporal budget constraint. The method followed here is that of Buiter (1990, chapter 5).

5. This is not exactly the conventional primary surplus. The top item in the left-hand side of (1.1) excludes the direct cash revenues derived from public capital assets, which are instead included in the *excess return* item. Thus, the primary surplus measured here excludes such revenues.

6. Also, if public investment does not translate one-for-one into public capital accumulation (because of inefficiency and waste in public procurement, for example), then an additional term with a negative sign would appear on the left-hand side of the solvency constraint. It would simply capture the present value of the divergence between cumulative investment expenditure and the capital stock.

7. Implicit liabilities are those involving a moral or expected obligation that is not established by law or contract. Contingent liabilities are those triggered by an event that may or may not occur. See Brixi 2003.

8. Easterly 1999. In general, such a procedure would enhance solvency only if the rate of increase of the price of oil falls short of the discount rate.

9. The 1986 *Government Finance Statistics Manual* (IMF 1986, p. 31) recommended cash rather than accrual accounting. Current practice uses a mixture of cash and accrual accounting. When arrears become a serious problem, the conventional approach to deficits in developing countries will often show the deficits explicitly as a financing item for an accrual-based deficit target. The 1996 GFS Manual (IMF 1996, p. 16) recommended accrual accounting. However, arrears still can be used to temporarily meet a gross public debt target because they are not included in the gross public debt.

10. To put it differently, privatization is likely to enhance solvency if the net returns that the purchaser can derive from operating the asset exceed those that the government would have been able to obtain. This can be the case if the purchaser is able to extract monopoly profits that the government was not exploiting, or also if the purchaser can operate the asset more efficiently than the government.

11. The Egyptian example is from World Bank (1997, p. 84).

12. Otherwise the economy is dynamically inefficient. In any case, the solvency constraint is trivially satisfied if $r < g$.

13. This implies that revenues and expenditures grow at the same rate as GDP. The time series analysis in chapter 4 suggests that this is not an unrealistic assumption for the long run.

14. This is simply accounting and it does not address the issue of whether the given public debt ratio is optimal.

15. A similar argument was provided by Buiter (1990, chapter 13), who showed rigorously that public investment cuts can be inflationary in the long run—in other words, they may force the government to increase its recourse to money printing to balance the fiscal accounts.

16. Easterly (2001) discussed this point at length.

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2

Latin America's Infrastructure in the Era of Macroeconomic Crises

César Calderón, William Easterly, and Luis Servén

DID THE QUANTITY AND QUALITY OF Latin America's infrastructure suffer from the prolonged period of macroeconomic stabilization and fiscal austerity in the 1980s and 1990s? To address that question, this chapter provides a comprehensive overview of the evolution of Latin America's infrastructure stocks, quality, and spending over the past decades. The chapter does not attempt to answer the question posed in a formal econometric manner that specifies the counterfactual of what would have happened if Latin America had not entered a period of macroeconomic crises. Instead some illustrative facts are given that may be consistent with some answers to this question and not with others.

A long-standing literature has noted that fiscal adjustment is often implemented through cuts in public investment, including infrastructure. As Roubini and Sachs (1989) observed, "In periods of restrictive fiscal policies . . . capital expenditures are the first to be reduced (often drastically)." During fiscal adjustment, the 1988 *World Development Report* of the World Bank (p. 113) found that governments cut capital spending by far more (about 35 percent) than other public sector categories like wages (which were cut by about 10 percent). Also, Hicks (1991) found that from 1970 to 1984, in countries with declining government expenditure, governments cut capital expenditures by more than current expenditures (–27.8 percent and –7.2 percent, respectively).

Servén (1997) found that Latin American public investment fell 2.5 percent of gross domestic product (GDP) from the 1970s to the 1980s, when the region was adjusting. East Asia, which did not need to adjust in the 1980s, had an increase of 3.7 percent. The World Bank (1994) found that when African countries lowered their budget deficits from 1981–86 to 1990–91, "most of the cuts were in capital spending" (p. 47). De Haan, Sturm, and Sikken (1996) found that public investment is reduced during times of fiscal stringency in Organisation for Economic Co-operation and Development (OECD) countries. Easterly (1999) argued that governments that do not really want to adjust engage in the *illusion* of adjustment by cutting both public debt and public assets (infrastructure).

This chapter begins by assessing trends in quantity and quality of infrastructure using data on 19 Latin American and Caribbean countries, excluding the smaller Caribbean economies because their data availability is more limited and to avoid influencing the region-wide statistics with too many observations from small island economies. The seven *East Asian Miracle* countries serve as a comparator group against which the performance of Latin America can be judged.

The chapter then looks at trends in infrastructure spending for nine major Latin American economies on which country data are available. The discussion examines the extent to which fiscal deficit reductions and public infrastructure spending reductions have moved together. The next step is to investigate to what extent the changes in public infrastructure spending were driven by the privatization of infrastructure and the increased private spending on infrastructure. Finally, panel data econometric analysis is used to link the time path of infrastructure quantity and quality to the path of infrastructure spending.

Information on the efficiency of infrastructure investment (that is, the unit cost of infrastructure stocks) and the quality of infrastructure stocks is notoriously scarce; therefore much of the analysis in this chapter relies on comparisons of infrastructure stocks and expenditures across countries and time periods. This raises a major caveat—that our infrastructure spending and infrastructure stock measures are noisy indicators of the accumulation and availability of infrastructure assets, respectively. Thus, more infrastructure investment and bigger stocks are not necessarily better because they could just reflect more waste of resources. It is important to keep in mind this fundamental limitation of the available data throughout the discussion in this chapter.

Comparative Trends in Latin American Infrastructure Quantity and Quality

The first step is to review the evolution of Latin America's infrastructure indicators.[1] To place it in perspective, the experience of Latin America is compared with that of a set of *successful* developing countries that did not need to undergo macroeconomic adjustment for most of the 1980s and 1990s—the East Asian Miracle economies (as given in World Bank 1994). These are Hong Kong (China), Indonesia, Republic of Korea, Malaysia, Singapore, Taiwan (China), and Thailand. Furthermore, an assessment of the progress of these two developing regions vis-à-vis the industrial economies of the OECD in terms of infrastructure indicators is also carried out.[2] The East Asian economies were growing faster than Latin American economies, so in principle faster growth in infrastructure could reflect demand as well as supply factors. Rigorous analysis of the infrastructure-growth nexus is deferred to chapter 3.

The initial focus is on the comparative performance in infrastructure stocks. Starting with telecommunications, figure 2.1a shows the evolution of main telephone lines per worker (that is, relative to the labor force) over the past two decades across the three regions under consideration. In each case the regional median is shown. The discrepancy is tremendous in the growth in phone lines per worker between Latin America and East Asia. In 1980, Latin America trailed East Asia by a relatively small margin—89 versus 132 main lines per 1,000 workers, with both regions far behind industrial economies. Since then, however, the number of phone lines has expanded much more rapidly in East Asia than in Latin America. As a result, by 1997 East Asia had more than twice as many phone lines per 1,000 workers as Latin America—500 versus 232, respectively.

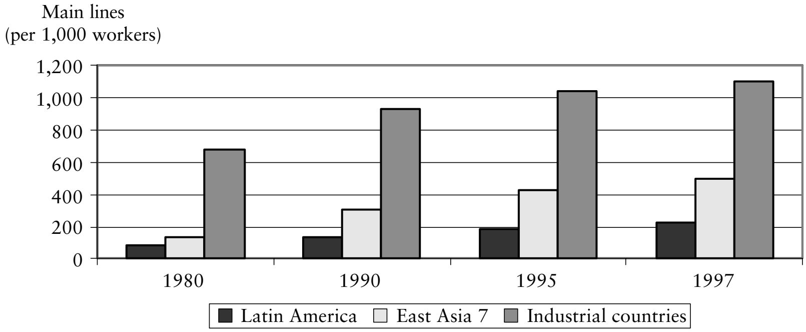
Figure 2.1a suggests an apparent stagnation in main phone lines in East Asia and industrial countries in the 1990s, but this turns out to be caused by the substitution of cell phones for land lines. The graph including cell phones (figure 2.1b) shows that in these two regions the expansion of total telephone lines has continued without interruption throughout the 1990s, making Latin America's lag relative to these two regions even greater than in the case of main phone lines. By 1997 the total number of phone lines per 1,000 workers was 718 in East Asia, compared with 289 in Latin America.

Other measures of the availability of telephone services portray a similar picture. Figure 2.1c reports regional medians of local connection capacity per worker. It confirms that a huge gap has opened between East Asia and Latin America since 1980, with few signs of abating in the 1990s. And the same pattern seems to emerge for newer telecommunications technologies. For example, figure 2.1d shows that in the late 1990s East Asia acquired a considerable lead over Latin America in the number of Internet hosts per worker.

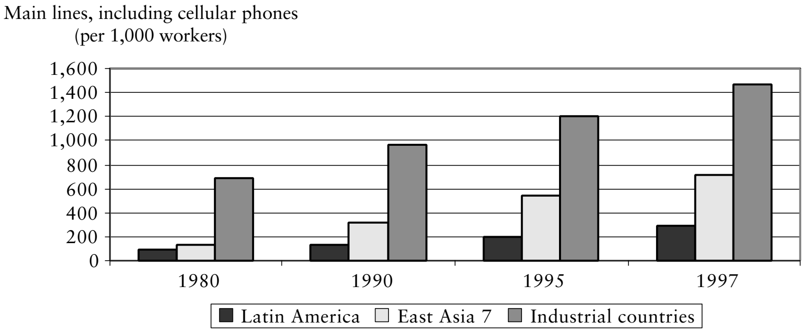
The regional indicators in the above figures conceal a wide range of variation across Latin American countries, however. Figure 2.1e shows that a few of them (Argentina, Chile, and Costa Rica) were roughly on par with East Asia in main phone lines per worker in 1997, with Uruguay even ahead of East Asia. At the other end of the

Figure 2.1 Comparative Performance in Infrastructure Stocks

a. Telephone Main Lines, 1980–97 (medians by region)



b. Total Telephone Lines, 1980–97 (medians by region)



c. Local Connection Capacity, 1980–97 (medians by region)

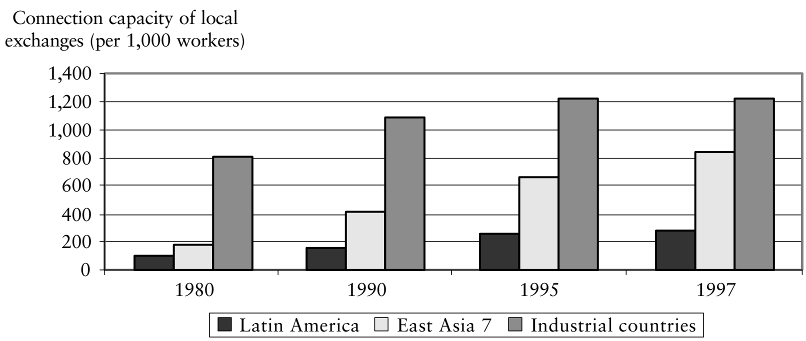
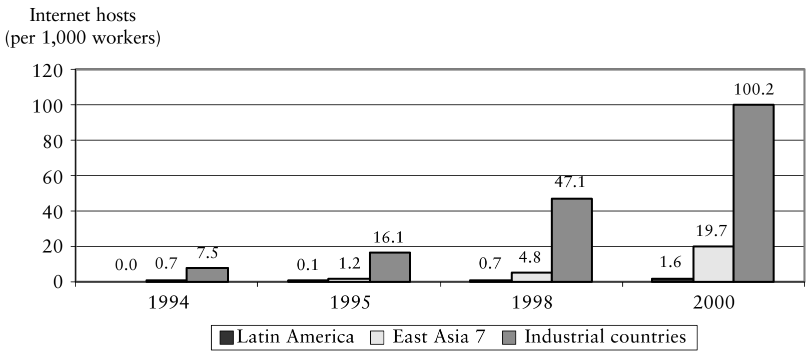
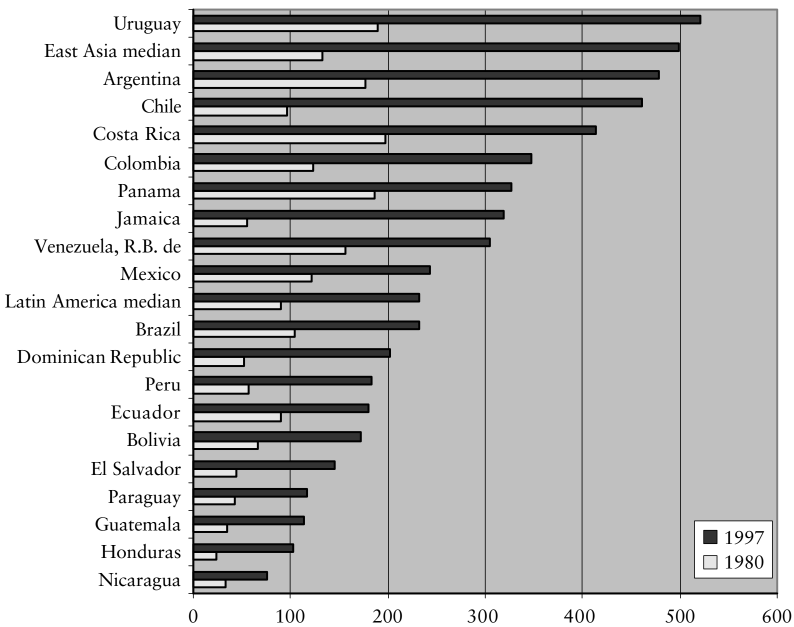


Figure 2.1 (continued)

d. Internet Hosts, 1994–2000 (medians by region)



e. Telephone Lines per Worker, 1980 and 1997 (lines per 1,000)



spectrum, three smaller economies (Guatemala, Honduras, and Nicaragua) lagged far behind. Even some major economies such as Brazil and Mexico have also lost considerable ground over time: they lagged way behind East Asia in 1997, even though in 1980 they had more phone lines per worker than the East Asia median.[3]

Figure 2.2 Power Generating Capacity by Region, 1980–97
(medians by region)

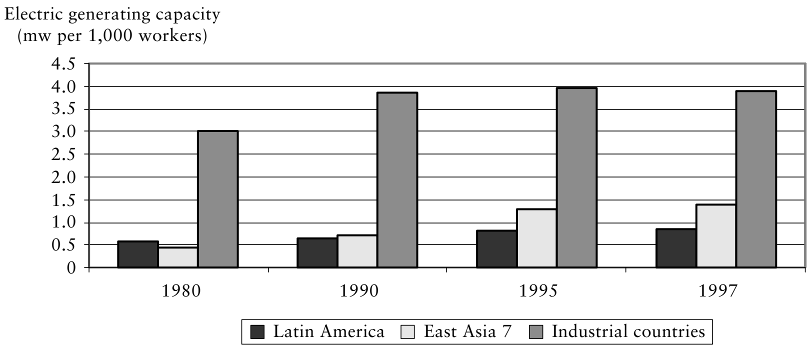


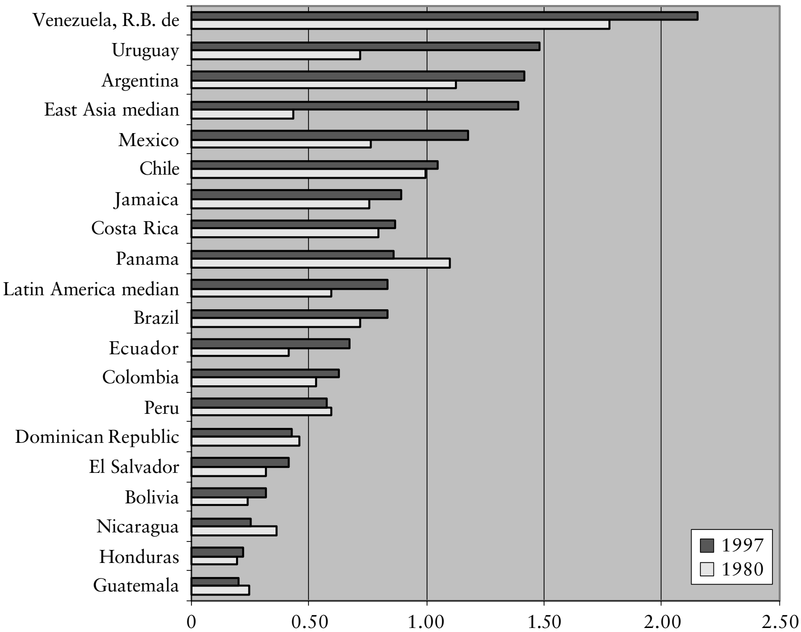
Figure 2.2 shows the trends in electricity generating capacity per worker. Here too East Asia has acquired a sizable advantage over Latin America during the past two decades. In 1980, East Asia's power generating capacity per worker was only 70 percent of Latin America's; in 1997, it had risen to 165 percent.

As in telecommunications, there is considerable cross-country variation in power generation capacity in Latin America. Figure 2.3 reveals that three countries exceeded the East Asia median in 1997—Argentina, Uruguay, and República Bolivariana de Venezuela. However, several major Latin American economies, such as Brazil, Colombia, Ecuador, and Peru, lagged far behind and have made little progress over the past two decades.

Figure 2.4a shows the length of the road network per worker in Latin America and the East Asian newly industrialized countries (NICs). Obviously, roads can vary greatly in quality, so cross-country comparisons have to be made with great care.[4] Here Latin America has remained ahead of East Asia throughout the period of analysis, although the gap between the two regions has narrowed considerably over time. Figure 2.4b presents similar information concerning overall transport routes, which include railways in addition to roads; the qualitative pattern is the same as in the preceding figure. Finally, figure 2.4c offers a comparative perspective of paved roads. Here the pattern is somewhat different. In 1980 Latin America was way ahead of East Asia in the length of the paved road network, but by the second half of the 1990s East Asia had reached virtual parity, with both regions still far behind industrial economies.

The country-specific detail in figure 2.5 shows that in all but one of the Latin American economies listed, the length of the road network

Figure 2.3 Power Generating Capacity per Worker by Country, 1980 and 1997 (megawatts per 1,000)



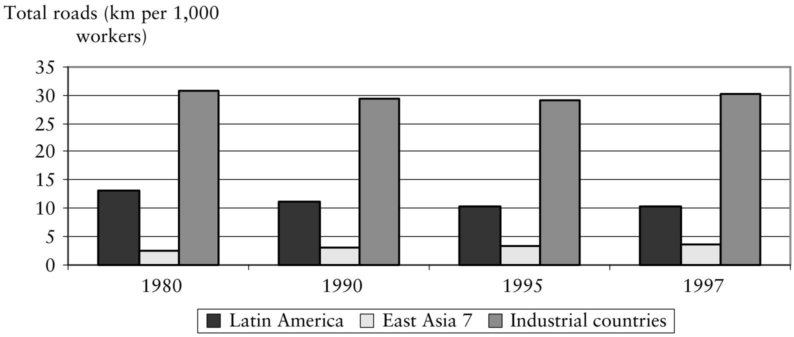
relative to the number of workers has declined over the past two decades. The only exception is Uruguay, which experienced a significant expansion even though in 1980 it was already the country with the largest road stock per worker. The picture in paved roads is similar—the majority of the region's countries witnessed a decline in their paved road stock per worker, in contrast with the expansion that took place in East Asia over the past two decades.

Figure 2.6 shows the trends in safe water availability, in terms of the fraction of the total population with access to safe water in the two regions. The data are much more limited than for the earlier indicators and span only the years 1988 to 1993. Over that period, East Asia showed a steady improvement in access to clean water, whereas Latin America suffered a deterioration. As a result, by 1993 the initial advantage of Latin America over East Asia had been reversed.

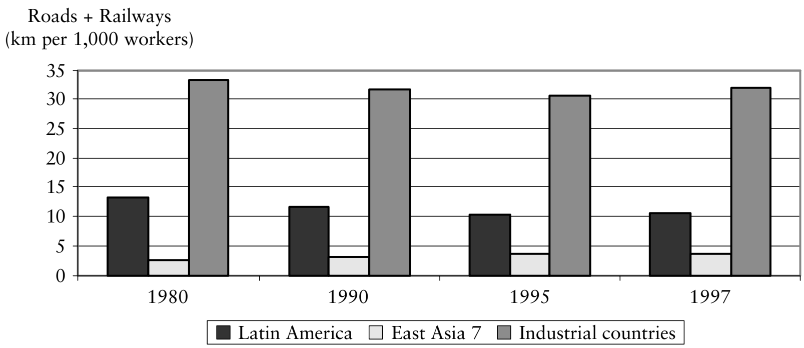
The next step is a review of indicators of infrastructure quality and excess demand. Unfortunately, the data are much sparser on these indicators and only three—telephone line waiting times, electrical power losses, and percentage of roads paved—offer a continuous time series over several decades. Figure 2.7a shows the waiting time for a telephone line, calculated as the number on the waiting list for main

Figure 2.4 Length Comparisons of Transportation Routes

a. Total Roads, 1980–97 (medians by region)



b. Roads plus Railways, 1980–97 (medians by region)



c. Paved Roads, 1980–97 (medians by region)

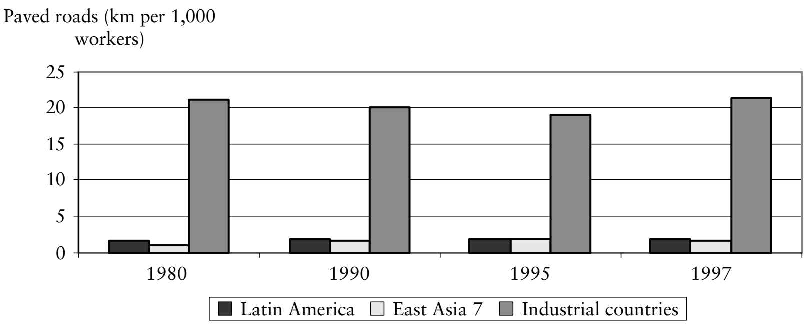
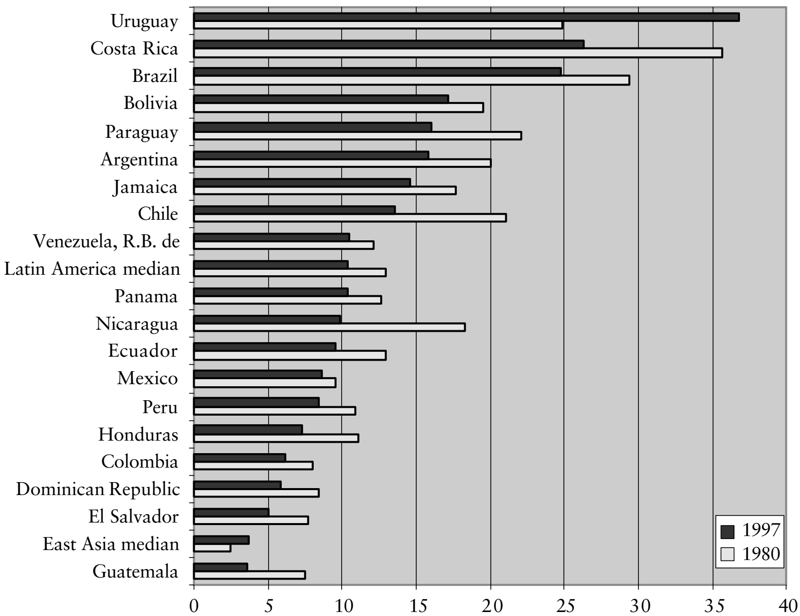


Figure 2.5 Road Length per Worker by Country, 1980 and 1997
(km per 1,000)



lines divided by the change in main lines in that year. In the early 1980s the median waiting time was 3 years in Latin America, versus 1.5 years in East Asia. In the 1980s and 1990s the backlog declined steadily in East Asia (and disappeared in industrial countries). In contrast, the median waiting time rose sharply in Latin America over the 1980s, to

Figure 2.6 Access to Clean Water, 1985–93
(medians by region)

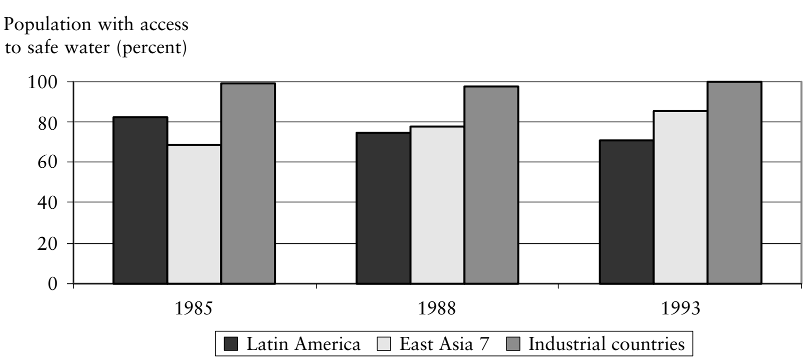
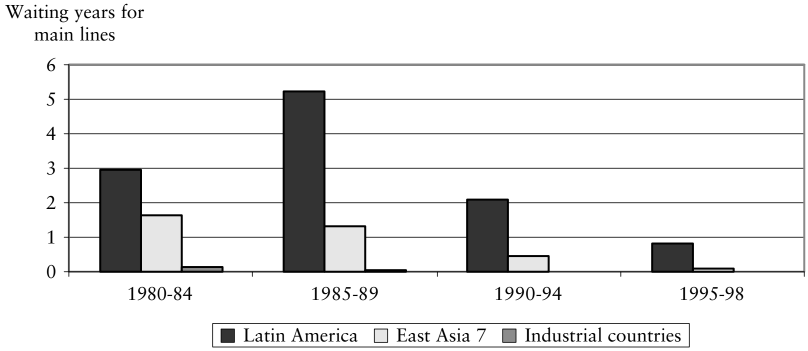
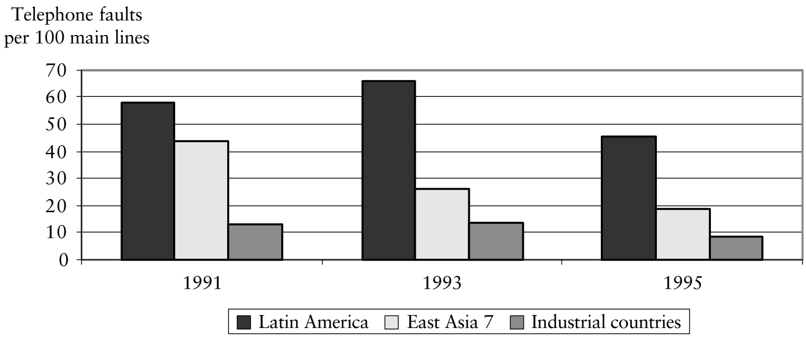


Figure 2.7 Infrastructure Quality and Excess Demand

a. Waiting Time for Main Lines, 1980–98 (medians by region)



b. Telephone Faults, 1991–95 (medians by region)



c. Unsuccessful Local Calls, 1991–95 (medians by region)

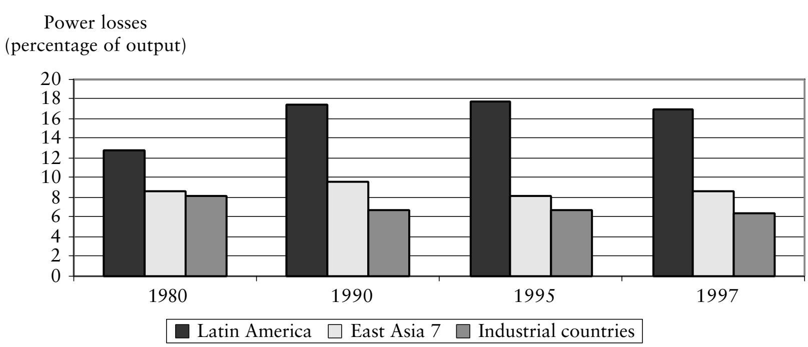
decline later in the 1990s. However, by 1997 Latin America still had a median waiting time in excess of half a year, whereas in East Asia the typical country had virtually no main line waiting list after 1994. This provides an indication of excess demand for phone lines in Latin America in the era of macroeconomic crises in the 1980s and 1990s and suggests strongly that the lag relative to East Asia was caused mainly by supply constraints rather than by lower demand.

Figures 2.7b and 2.7c report two measures of the performance of the phone network: the number of telephone faults per 100 lines and the percentage of unsuccessful local calls. In both cases the country coverage of the information is severely limited and the regional comparisons have to be made with caution because the regional aggregates include only a few countries. Furthermore, the available data refer only to 1991–95.

The percentage of unsuccessful local calls does not show much difference between Latin America and East Asia. In turn, the data on telephone faults per main line show much poorer quality of service in Latin America than in East Asia. Because data do not exist on earlier years, it is impossible to say whether Latin America's worse telephone service quality relative to East Asia's was caused by the macroeconomic crises of the past two decades or if it already existed prior to them. In any case, the obvious conclusion is that Latin America lags behind East Asia not only in the quantity of telecommunication services but also in their quality.

Regarding power, the percentage of transmission losses relative to total output offers a crude measure of the efficiency of the power network. Figure 2.8 offers a cross-regional perspective on power losses. The figure shows a clear deterioration in the power system during the era of fiscal austerity in Latin America in the 1980s and 1990s, with an incipient reversion only after 1995. In contrast, East Asia had roughly constant

Figure 2.8 Power Losses by Region, 1980–97
(medians by region)



electrical power losses. Thus, although Latin America's service quantity indicator (generating capacity per worker) shown above displayed a modest upward trend during the past two decades, the quality of that service deteriorated sharply.

Among Latin American countries, figure 2.9 shows that only Paraguay and Costa Rica improved on the East Asia norm for power losses in 1997. All other countries show higher power losses, strikingly large in some cases (Dominican Republic, Honduras, and Nicaragua). Moreover, only four countries (Chile, El Salvador, Jamaica, and Paraguay) experienced an improvement between 1980 and 1997.

Finally, a rough measure of the quality of the surface transportation network is given by the percentage of roads paved. This is shown in figure 2.10a, which reveals a sharp increase in the road quality thus measured in East Asia, with the percentage of roads paved rising from 60 to 75 percent between 1980 and 1990. In contrast, Latin America made virtually no progress along this dimension over the past two decades. The country-specific data (figure 2.10b) show a similarly bleak picture: all Latin American countries fall well short of the East Asia median, with Jamaica as the only country coming close to it.

Figure 2.9 Power Losses by Country, 1980 and 1997
(percentage of power output)

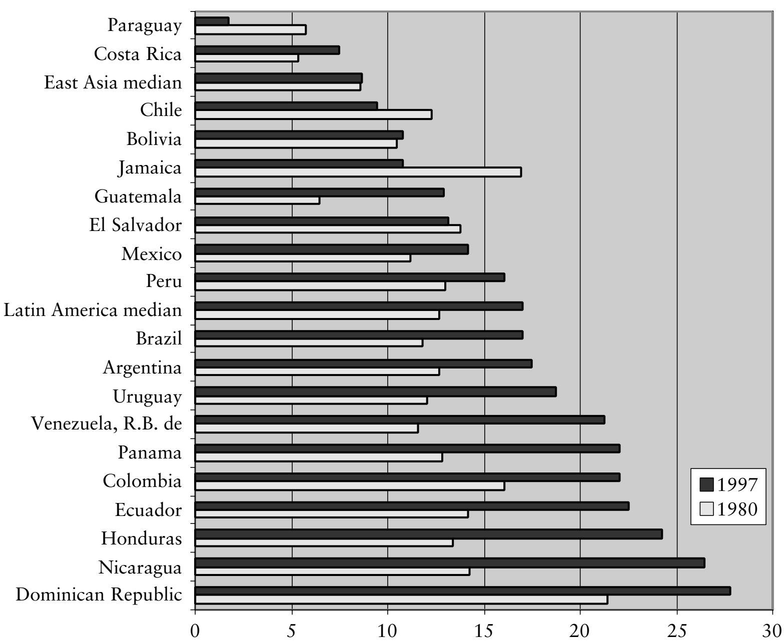
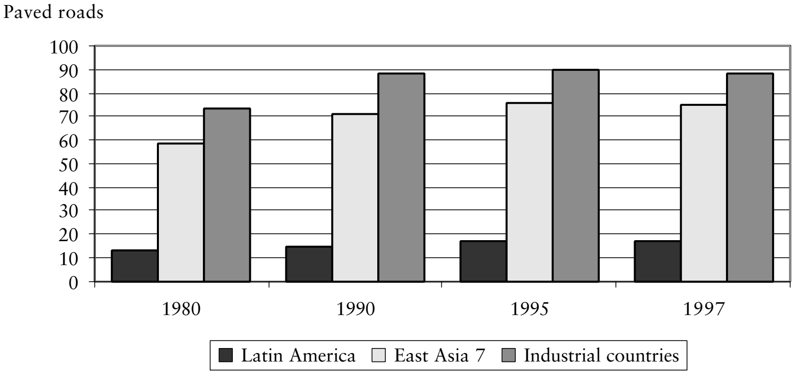
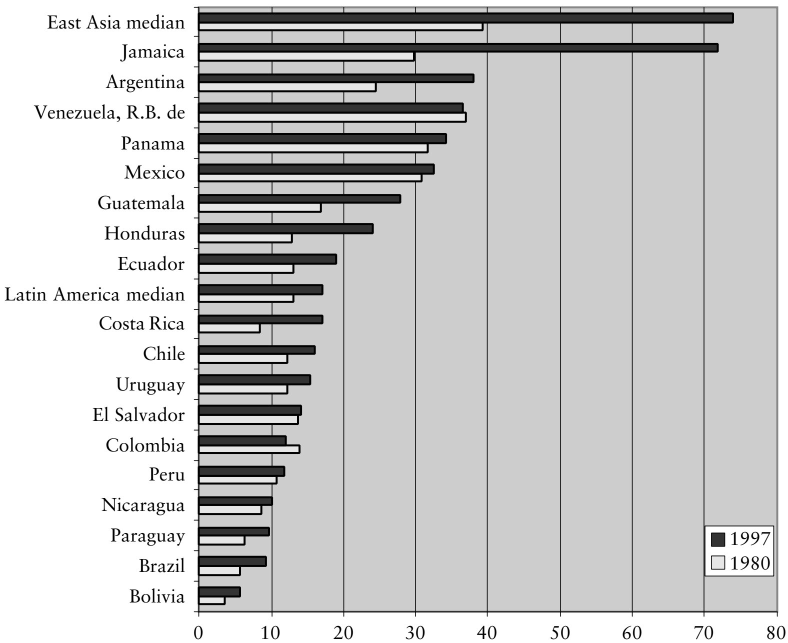


Figure 2.10 Comparisons of Surface Transportation Quality

a. Percentage of Total Roads Paved, 1980–97 (medians by region)



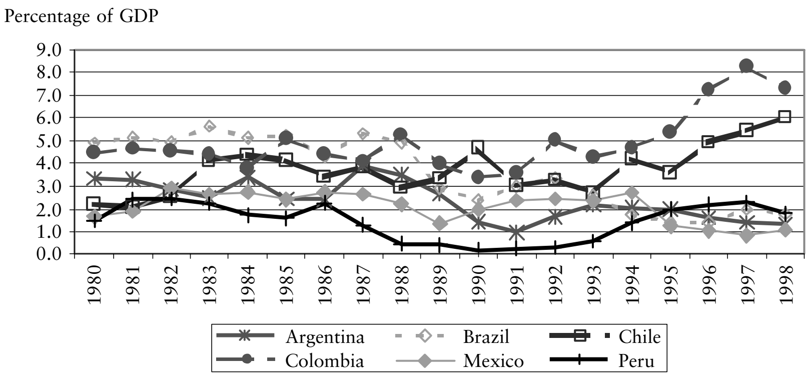
b. Paved Road Length, 1980 and 1997 (percentage of total road length)



Trends in Infrastructure Spending in Latin America

The comparative evidence just reviewed suggests that Latin America fell behind East Asia along most dimensions of infrastructure quantity and quality over the 1980s and 1990s, although performance varies a

Figure 2.11 Total Investment in Infrastructure in Selected Latin American Countries, 1980–98



great deal across Latin American countries. The next task is to assess whether these trends relate to the observed performance of infrastructure spending in the region. This is done using infrastructure investment data from major Latin American economies over the past two decades.[5]

Figure 2.11 depicts the trajectory of total infrastructure investment as a ratio to GDP in six major Latin American countries since 1980. The figure reveals three salient facts. First, the volume of infrastructure investment varies considerably across the countries shown. In the late 1990s, it ranged from 1 percent of GDP in Mexico to more than 7 percent in Colombia. Second, in most countries infrastructure investment experienced a substantial decline around the mid-1980s, which was reversed only partially, if at all, in the late 1990s. Third, Colombia and Chile are exceptions to this rule; they witnessed an infrastructure investment expansion, particularly during the late 1990s.

Investment performance varied also across infrastructure sectors. Figures 2.12a through 2.12d depict the trajectory of total investment, relative to GDP, in each of four important sectors—telecommunications, power, transport, and water. Investment in telecommunications displayed an upward trend in several countries, with Brazil and Mexico being the main exceptions (figure 2.12a). In power (figure 2.12b), by contrast, most countries witnessed an investment decline, particularly sharp in Brazil, which had been the leading investor in the early 1980s, and in Peru, where investment levels dropped to virtually nothing in the early 1990s. The only exception was Colombia, which more than doubled its power investment in the late 1990s.

In transport (figure 2.12c), investment also followed a declining trend after the mid-1980s, with Chile as the only country to display a sustained recovery at the end of the 1990s. In a few countries (Argentina, Brazil,

Figure 2.12 Investment in Infrastructure in Selected Latin American Countries, by Sector, 1980–98

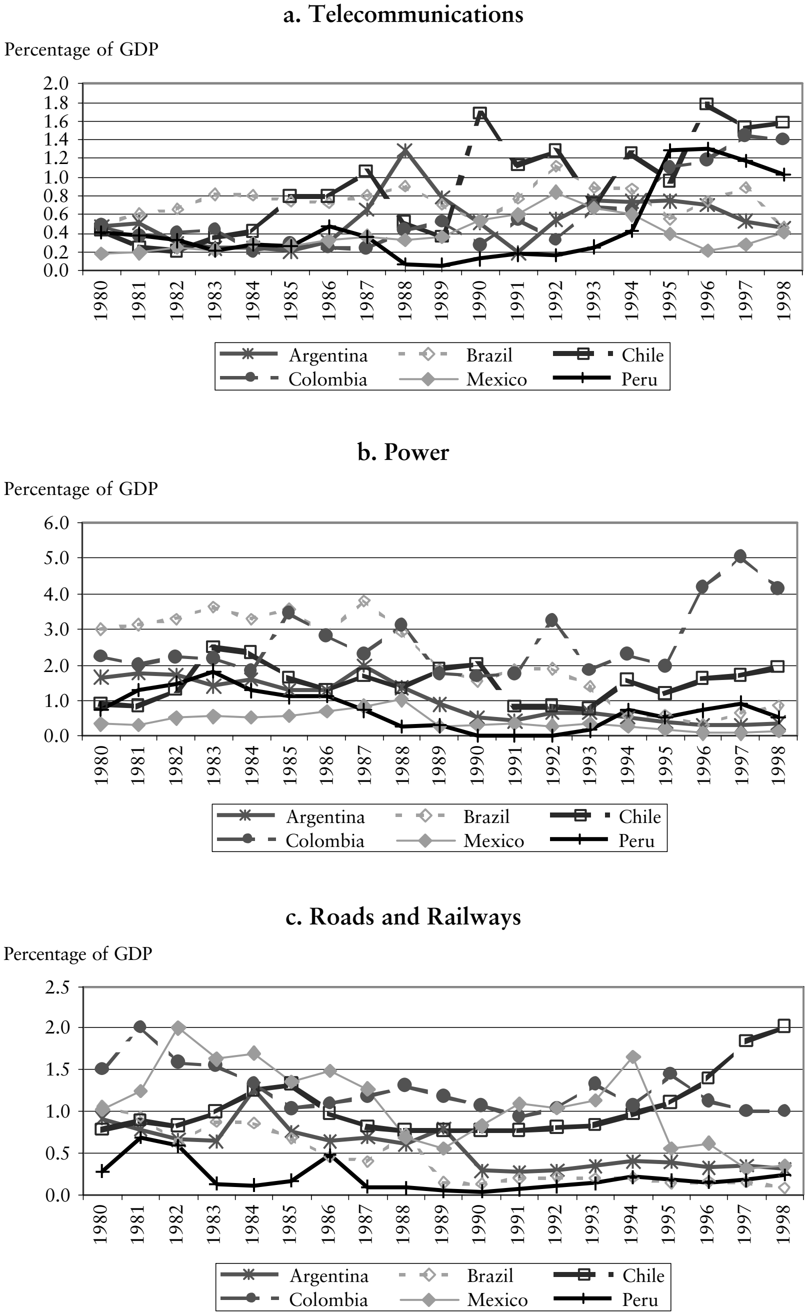
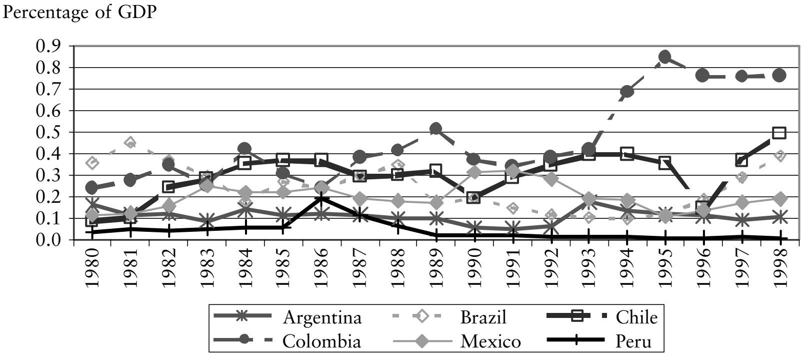


Figure 2.12 (continued)

d. Water



and Peru), investment remained at extremely low levels throughout the 1990s. Finally, in water and sanitation (figure 2.12d) both investment levels and trends were diverse across countries: investment fell to very low values in Peru but rose to record highs in Colombia in the late 1990s.

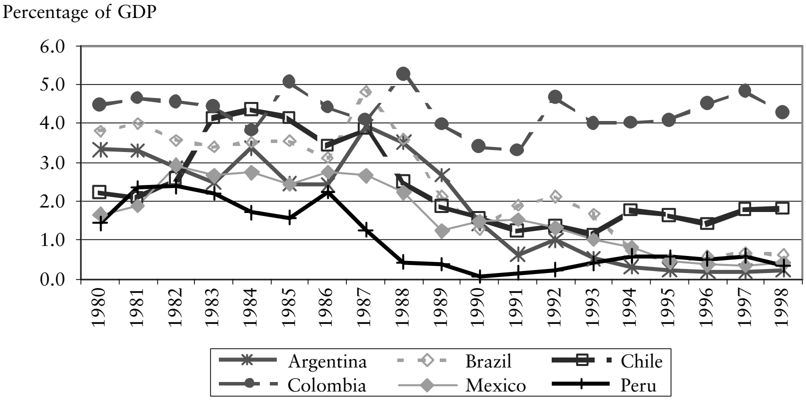
Behavior of Public Infrastructure Investment

To what extent did this performance of total infrastructure investment reflect the performance of public investment? With the public sector as the main or, in many cases, the only investor, the answer is that total and public investment moved closely together in most countries, at least until the mid-1990s. Figure 2.13 depicts the time path of public infrastructure investment as a percentage of GDP. Except for the late 1990s, the graph is strikingly similar to that for total investment (figure 2.11 above). It shows that public infrastructure investment collapsed after the mid-1980s in five of the six countries considered. The exception once again was Colombia, which succeeded in maintaining roughly unchanged public investment levels throughout the period.

How was public infrastructure spending affected by fiscal austerity in the 1980s and 1990s in Latin America? Part of this expenditure reduction may have reflected increasing efficiency in spending as measured by a reduction in the unit cost of new assets of given quality. But this is unlikely to account for the bulk of the spending cut. Instead, the contraction of infrastructure spending likely resulted from the fiscal retrenchment the region underwent.

It is possible to measure how much the change in infrastructure spending accounts for the observed change in the public sector surplus in each country. This is done in table 2.1, which compares the contraction

Figure 2.13 Public Investment in Infrastructure in Selected Latin American Countries, 1980–98



in public investment with the change in the public sector primary (or noninterest) surplus, with both measured between the early 1980s and the late 1990s. The table shows that total public investment fell in all countries listed except for Bolivia. Public infrastructure investment, in turn, fell in seven out of the nine countries in the table. It rose in Ecuador

Table 2.1 The Contribution of Infrastructure Compression to Fiscal Adjustment, Average 1980–84 versus Average 1995–98

	Reduction in public investment/ GDP		*Change in primary surplus/ GDP*	*Contribution of investment reduction to fiscal adjustment (percent)*	
Country	*Total [1]*	*Infrastructure [2]*	*[3]*	*Total [1]/[3]*	*Infrastructure [2]/[3]*
Argentina	3.97	2.85	5.31	74.7	53.8
Bolivia	−0.91	3.10	6.15	n.a.	50.3
Brazil	2.80	3.08	1.77	158.1	174.3
Chile	0.94	1.41	2.39	39.2	58.8
Colombia	0.45	−0.04	4.69	9.6	n.a.
Ecuador	1.57	−0.68	1.81	87.0	n.a.
Mexico	6.09	1.98	6.28	97.0	31.5
Peru	4.10	1.51	3.11	132.0	48.6
Venezuela, R.B. de	3.49	0.41	−1.88	n.a.	n.a.

n.a. Not applicable.
Source: Authors' calculations using the sources described in appendix 2A.

and showed virtually no change in Colombia. Comparison of columns one and two in the table reveals that in Bolivia, Brazil, and Chile, public infrastructure investment fell by *more* than total public investment, implying that noninfrastructure capital spending actually rose. The third column shows that the primary fiscal surplus rose in eight of nine countries considered (all except República Bolivariana de Venezuela). In some of them, the magnitude of the rise was considerable.

Columns four and five calculate the contribution of investment to the fiscal correction. Public investment contraction contributed significantly (that is, half of the total correction or more) to the adjustment in five of the eight adjusting economies. Infrastructure investment compression did the same in five economies. This is all the more remarkable because infrastructure investment is typically a relatively small component of total public spending. The role of infrastructure compression was particularly large in Brazil, where the cut in infrastructure investment was almost twice as big as the fiscal correction. República Bolivariana de Venezuela is an extreme case because it reduced total and infrastructure investment without improving its primary surplus, so that in effect the investment compression financed a reduction in public saving. At the other extreme, Colombia and Ecuador managed to improve their fiscal balances without cutting public infrastructure (or total) investment.

It is important to keep in mind that the figures in table 2.1 very likely understate the contribution of public infrastructure compression to the fiscal adjustment. The reason is that in most cases recurrent infrastructure expenditures on operation and maintenance (O&M) were cut along with investment, so that the total decline in infrastructure-related spending was larger than the spending cut.

This accounting decomposition does not impute a causal role to fiscal adjustment, or even establish a correlation between fiscal correction and infrastructure cuts. The (pooled) full-sample correlation between the primary surplus and the public infrastructure investment/GDP ratio is –0.195, with a standard error of 0.077. This suggests a significant negative relation between both variables, but ignores the role of country-specific factors. A simple way to take them into account is to regress public infrastructure investment on the primary surplus, controlling for country-specific effects and time trends. This is done in table 2.2, which shows a quantitatively small, but highly significant, negative association between the primary fiscal balance and public infrastructure investment.[6] However, there are significant country-specific time trends in infrastructure spending—negative in all cases except Ecuador and Colombia—which suggest that factors other than primary deficit adjustment may have been at work in the observed decline of public infrastructure investment.

Table 2.2 Regression of Public Infrastructure Investment/GDP on the Primary Balance/GDP

Variable	*Coefficient*	t-*statistic*
Primary surplus/GDP	−0.0661	−3.97
ARG-trend	−0.0019	−11.48
BOL-trend	−0.0017	−5.85
BRA-trend	−0.0022	−13.31
CHL-trend	−0.0011	−3.59
COL-trend	0.0001	0.51
ECU-trend	0.0005	1.50
MEX-trend	−0.0010	−4.52
PER-trend	−0.0010	−5.12
VEN, R.B. de–trend	−0.0005	−5.12
Adjusted R^2	0.842	
Number of countries	9	
Number of observations	170	

Note: FE–SUR = fixed effects–seemingly unrelated regressions; FE–SUR estimates, 1980–98.

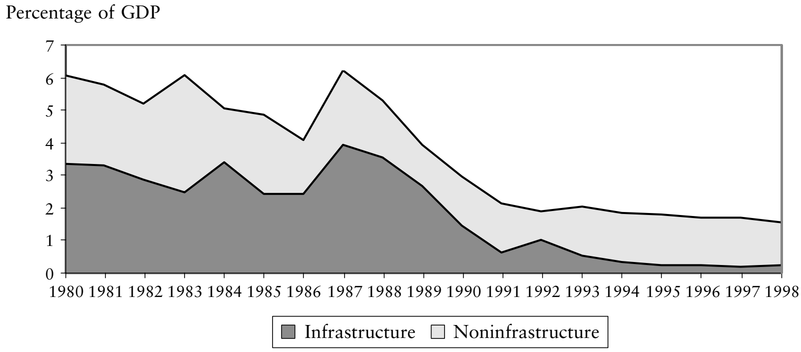
Source: Authors' calculations.

As noted above, only Colombia and Ecuador escaped the general trend toward infrastructure investment compression. These are also the only two countries, among those for which data exist, where the composition of public investment did not shift against infrastructure over the period of analysis. Figure 2.14 illustrates the changes over time in the composition of public investment between infrastructure and noninfrastructure items. It is immediately apparent that public infrastructure investment lost ground relative to noninfrastructure investment in all but the two countries mentioned. In these two countries, infrastructure investment accounted for roughly 50 percent of total public investment in the late 1990s, whereas in other countries (Argentina, Mexico, and República Bolivariana de Venezuela) it represented less than one-fourth of the total.

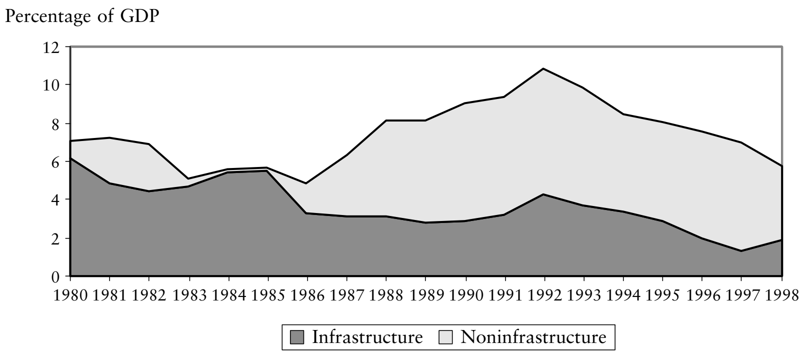
The decline in public infrastructure investment experienced by most countries was not evenly distributed across infrastructure sectors. Figure 2.15 (p. 43) breaks down public infrastructure investment into four major components—power, telecommunications, transport, and water. In Argentina, Brazil, Chile, and Peru, the sharpest investment decline occurred in the power sector. In other countries—Bolivia, Mexico, and República Bolivariana de Venezuela—the compression affected transport investment most severely. Also, in several countries public investment in telecom had practically disappeared by the end of the 1990s.

Figure 2.14 Public Investment in Infrastructure and Noninfrastructure, by Country

a. Argentina, 1980–98



b. Bolivia, 1980–98



c. Brazil, 1980–98

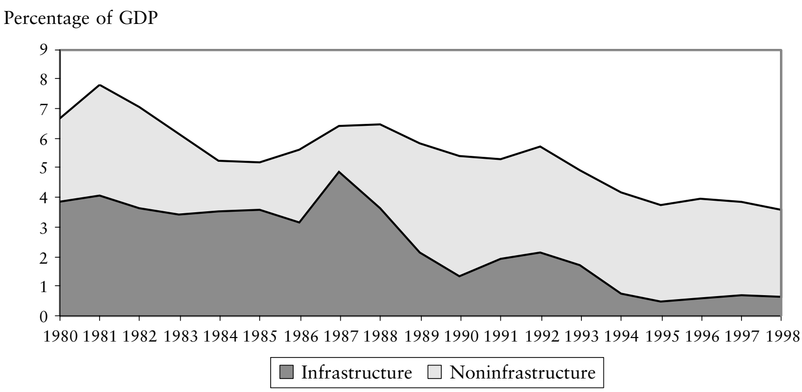
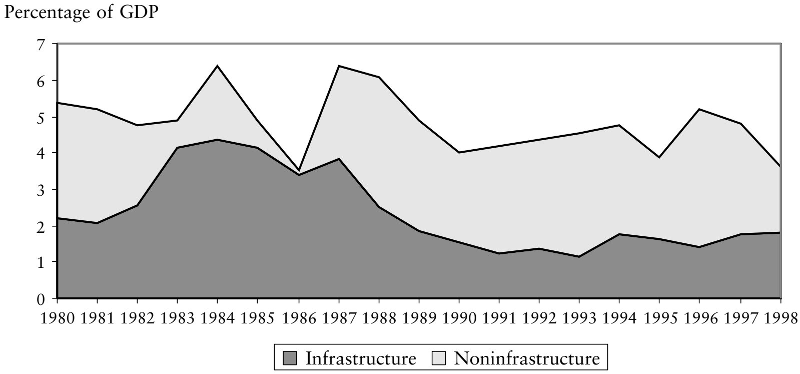
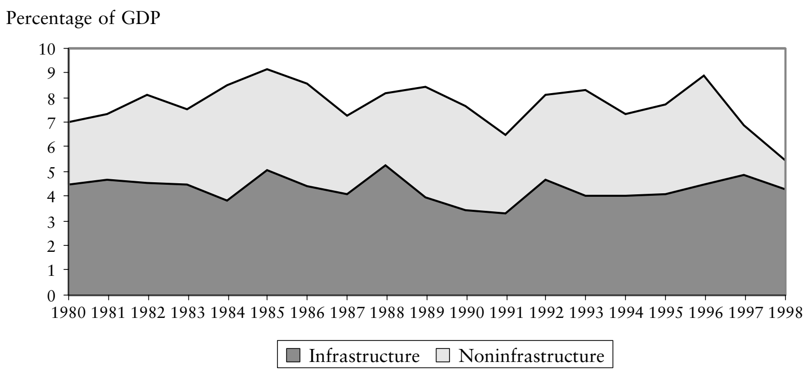


Figure 2.14 (continued)

d. Chile, 1980–98



e. Colombia, 1980–98



f. Ecuador, 1981–98

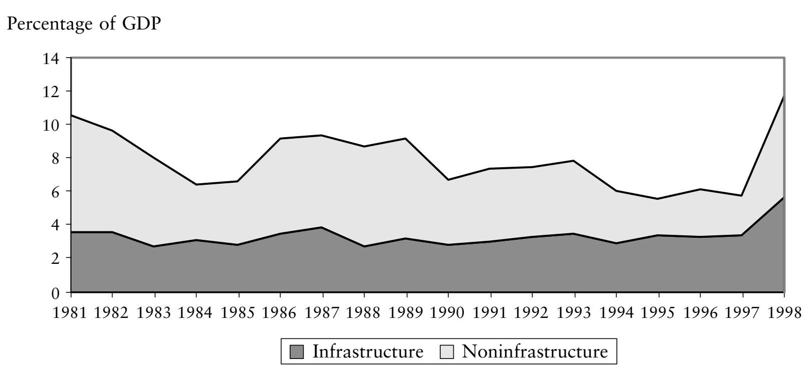
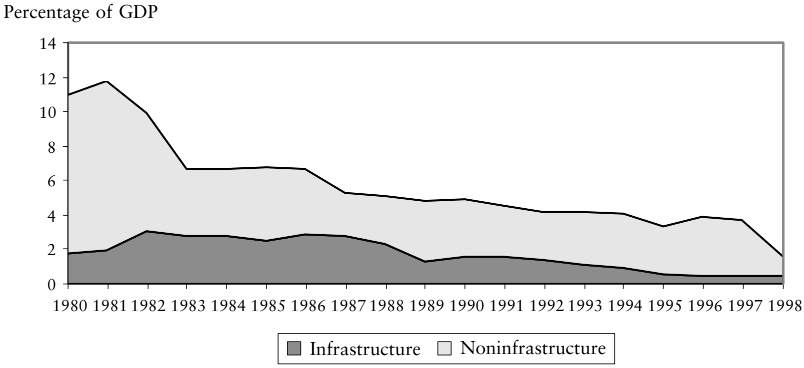
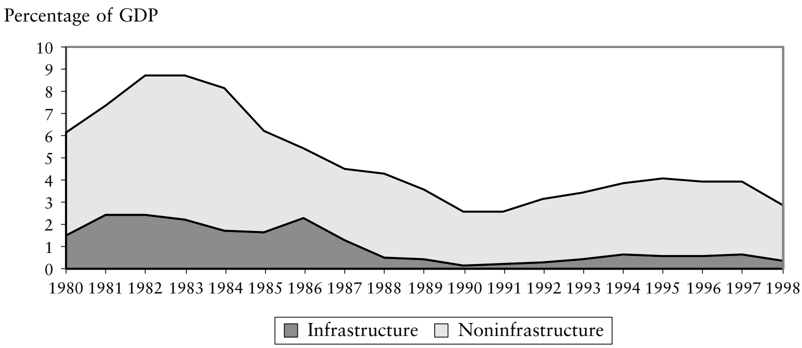


Figure 2.14 (continued)

g. Mexico, 1980–98



h. Peru, 1980–98



i. República Bolivariana de Venezuela, 1980–98

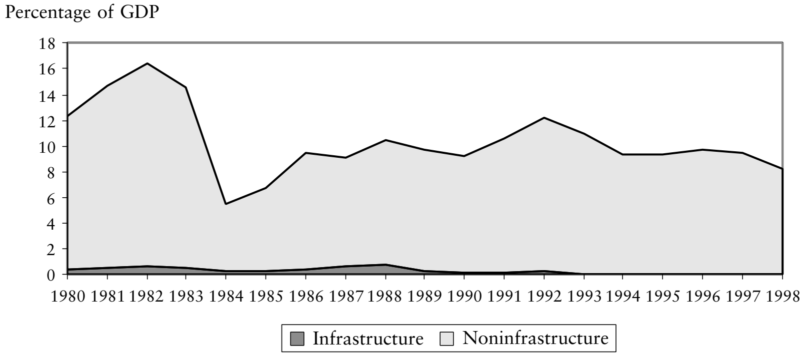
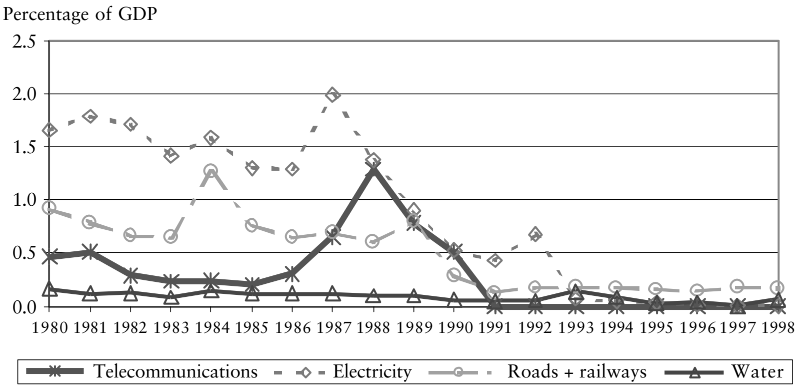
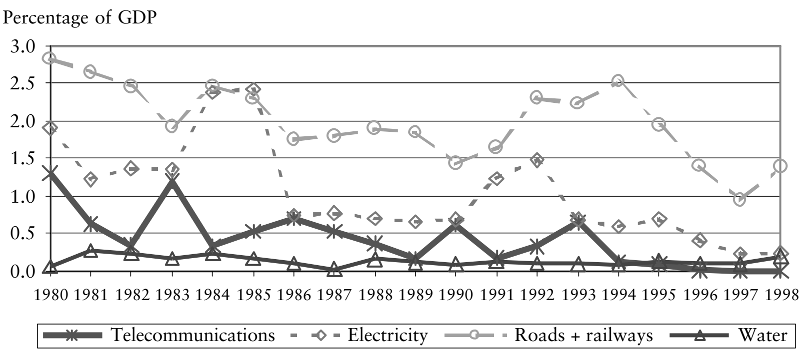


Figure 2.15 Public Investment in Infrastructure, by Sector and by Country

a. Argentina, 1980–98



b. Bolivia, 1980–98



c. Brazil, 1980–98

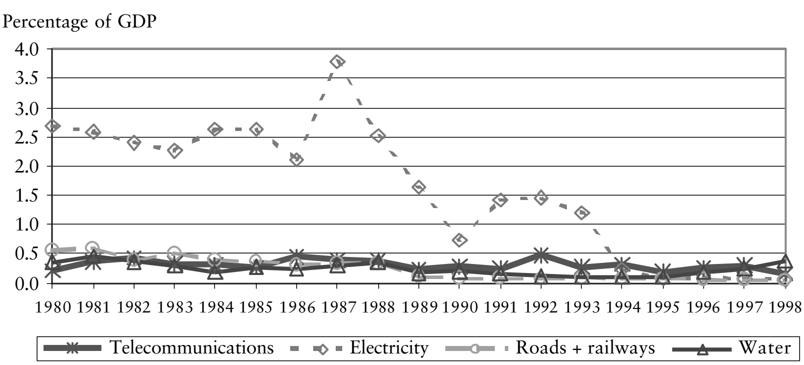
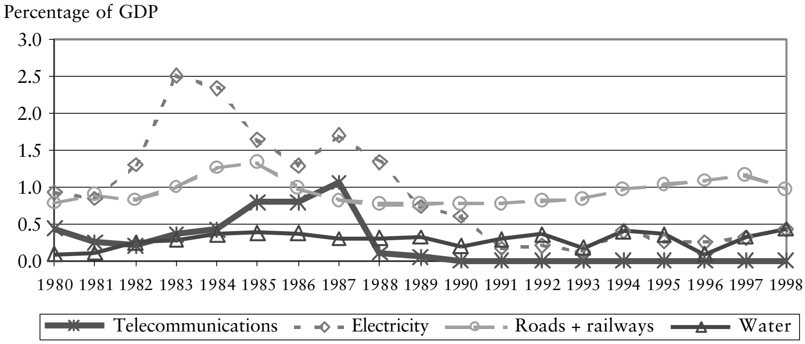
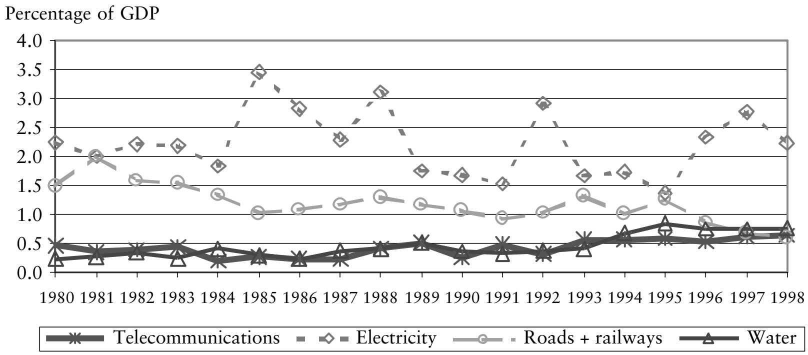


Figure 2.15 (continued)

d. Chile, 1980–98



e. Colombia, 1980–98



f. Ecuador, 1981–98

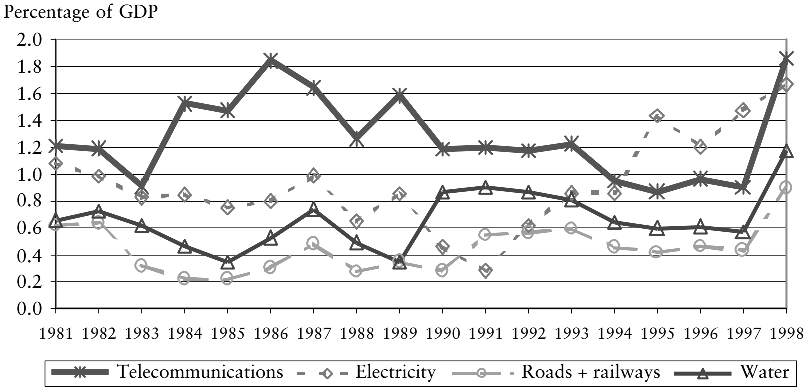
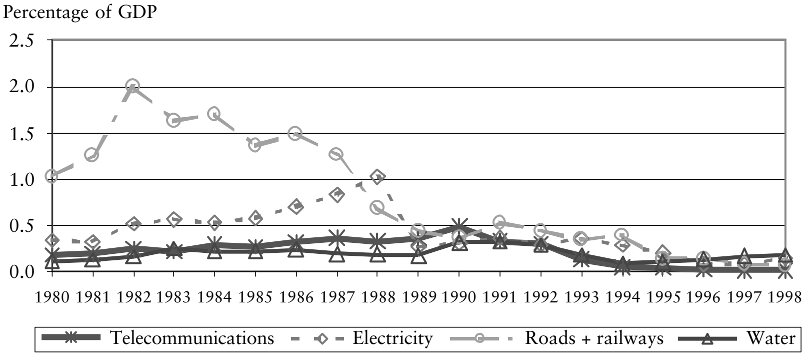
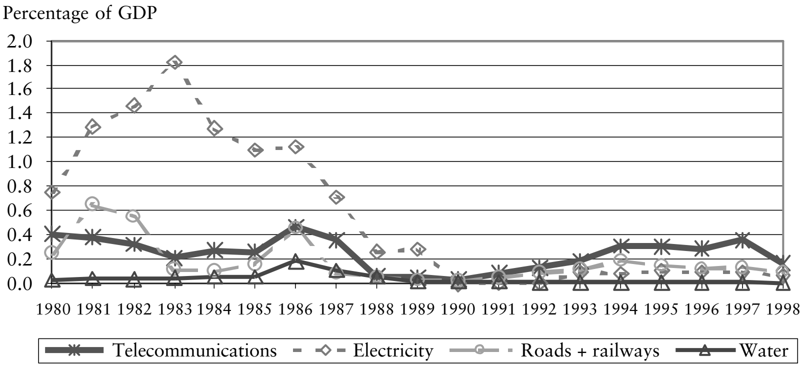


Figure 2.15 (continued)

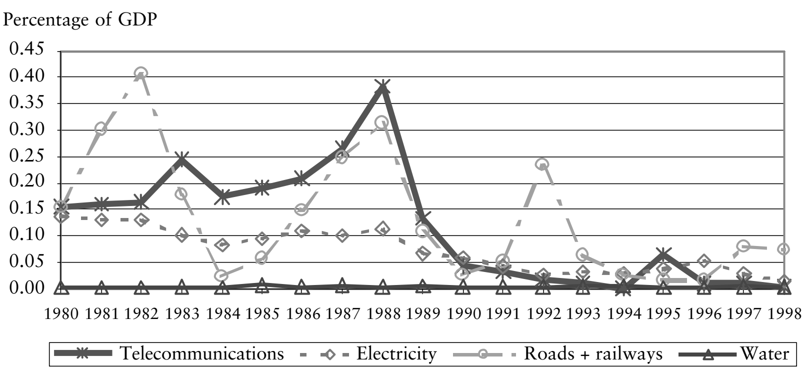
g. Mexico, 1980–98



h. Peru, 1980–98



i. República Bolivariana de Venezuela, 1980–98



In a few instances, particularly in the telecom sector, the declining public investment trend documented above reflected the increasingly important role of private infrastructure investment. But this was by no means a generalized phenomenon across countries and infrastructure sectors. The next section reviews the observed pattern of private investment.

Did Private Investment Replace Public Investment?

Many Latin American countries opened their infrastructure sectors to private enterprise in the late 1980s and early 1990s. Table 2.3 shows the approximate date of effective opening up in different infrastructure subsectors in the countries under analysis. The opening up took a variety of forms, ranging from privatization of public enterprises to management contracts and private concessions. Appendix 2B provides a full account of the reforms across countries and sectors (see also Estache, Foster, and Wodon 2001).

The private sector response to this opening up showed considerable diversity across countries and sectors. More detailed analyses of the response are provided in chapters 5 and 6. Here a descriptive account is given of the patterns of private infrastructure investment; the next section presents some formal empirical experiments.

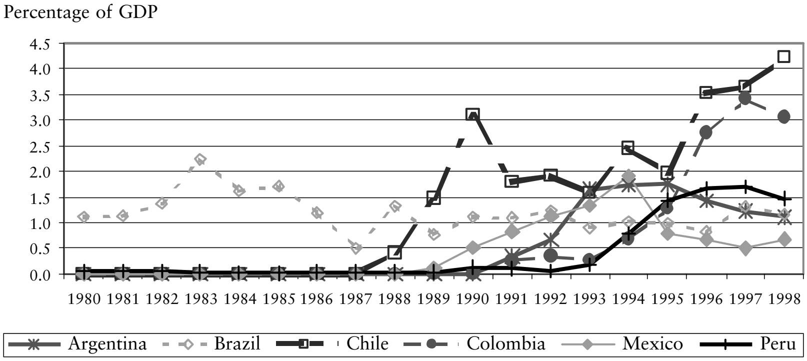
The evolution of private infrastructure investment relative to GDP in six major Latin American countries is depicted in figure 2.16. In five of the six countries, private investment took off in the late 1980s or

Table 2.3 Infrastructure Reform Dates

Country	*Telecom*	*Electricity*	*Roads*	*Rail*	*Water*
Argentina	1990	1992	1990	1990	1993
Bolivia	1987	1995	n.a.	1996	1997
Brazil	1995	1984	1996	1996	1995
Chile	1986	1986	1994	n.a.	1997
Colombia	1994	1992	1993	1995–97	1993
Ecuador	1994	1996	n.a.	n.a.	n.a.
Mexico	1990	1998	1989	1996	1993
Peru	1990	1994	n.a.	n.a.	n.a.
Venezuela, R.B. de	1991	1992	n.a.	n.a.	n.a.

n.a. Not applicable.
Source: See appendix 2B.

Figure 2.16 Private Investment in Infrastructure in Selected Latin American Countries, 1980–98



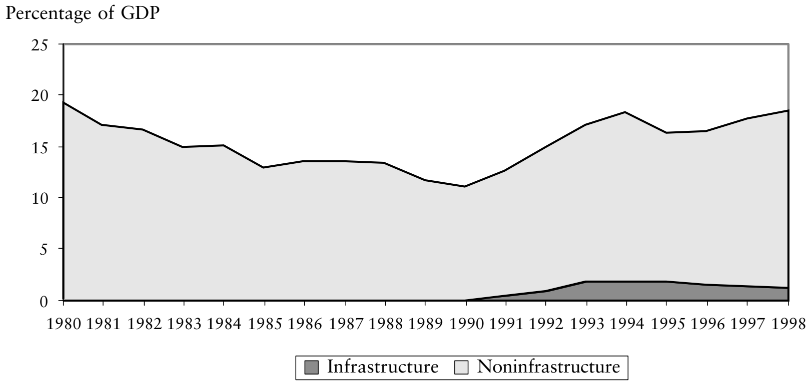
early 1990s. The exception is Brazil, where infrastructure investment of the private sector has hovered at around 1 percent of GDP over the past two decades. Among the other countries, Chile exhibited the earliest rise in private investment, followed thereafter by an upward trend that was also apparent in Colombia. In contrast, in Argentina and especially Mexico private investment appears to have stagnated in the second half of the 1990s. Also, in most countries, with Chile and Colombia as the exceptions, the total volume of private infrastructure investment remained quantitatively modest, at 1.5 percent of GDP or less.

In some countries, the rise in private infrastructure investment came along with an upward trend in overall private investment. Figure 2.17 shows that this trend occurred in Argentina, Chile, and Peru, and to a more limited extent, in Ecuador and Mexico. In other cases, however, the increase in private infrastructure investment was not matched by a parallel rise in other types of private investment. Examples of this latter situation were Bolivia, where noninfrastructure investment appears to have declined, as well as Colombia and República Bolivariana de Venezuela, where overall private investment displayed abrupt fluctuations during the period.

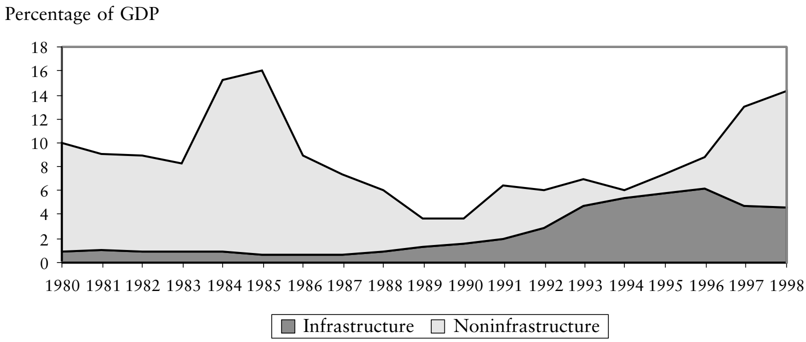
The rise in private infrastructure investment was uneven not only across countries but also across infrastructure sectors. Figure 2.18 (p. 51) depicts the time pattern of private investment by sector of destination in the nine countries under analysis. In a majority of countries—Argentina, Chile, Ecuador, Peru, and República Bolivariana de Venezuela—the telecommunications sector became the prime

Figure 2.17 Private Investment in Infrastructure and Noninfrastructure, by Country

a. Argentina, 1980–98



b. Bolivia, 1980–98



c. Brazil, 1980–98

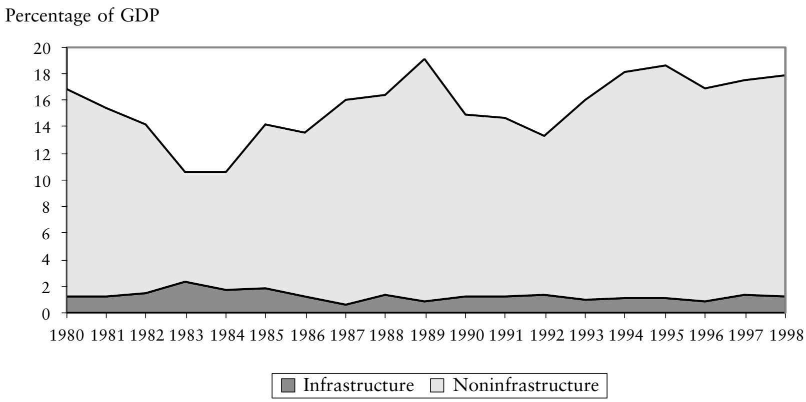
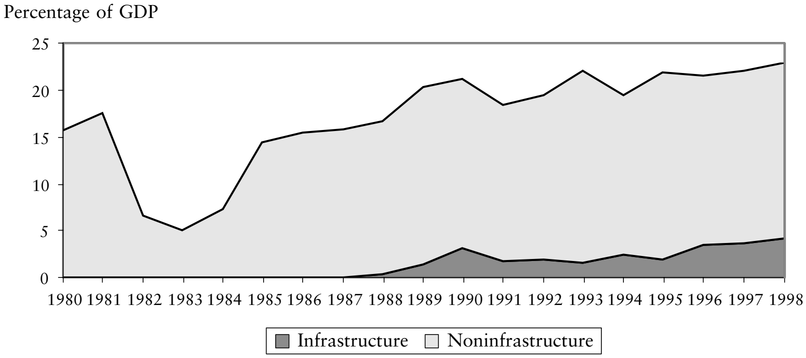
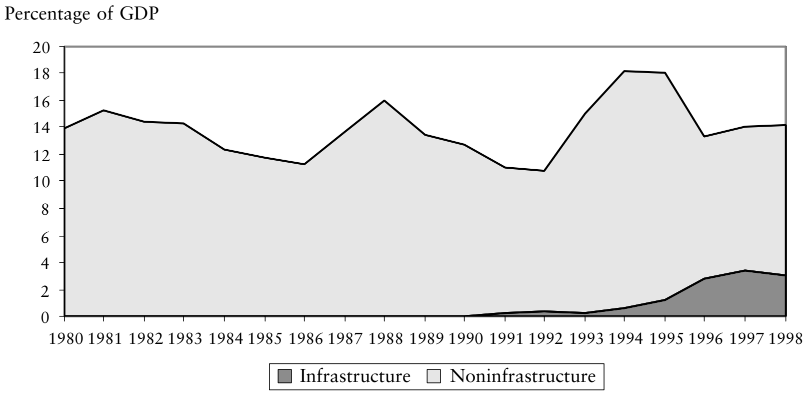


Figure 2.17 (continued)

d. Chile, 1980–98



e. Colombia, 1980–98



f. Ecuador, 1981–98

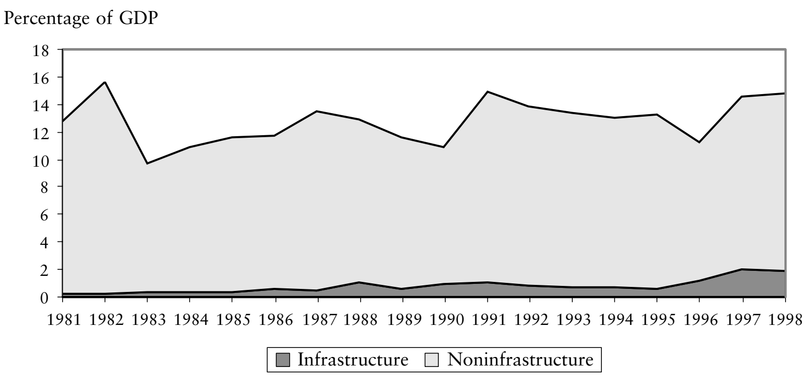
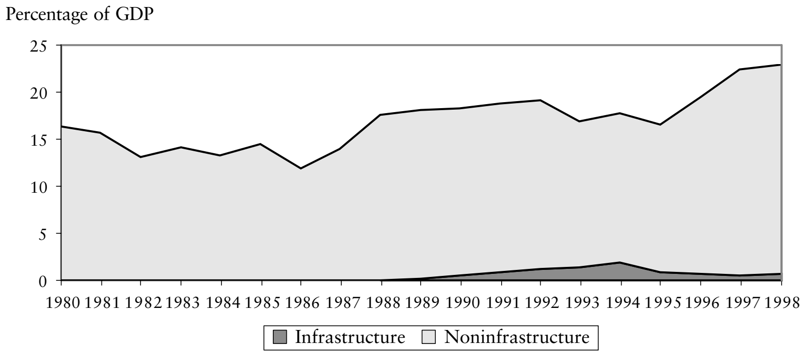
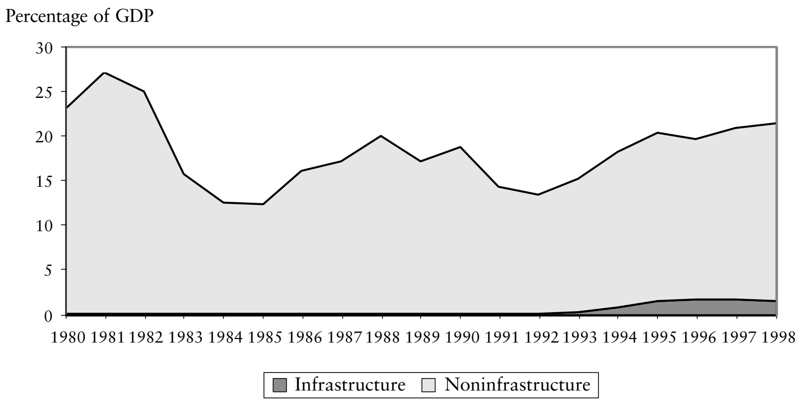


Figure 2.17 (continued)

g. Mexico, 1980–98



h. Peru, 1980–98



i. República Bolivariana de Venezuela, 1980–98

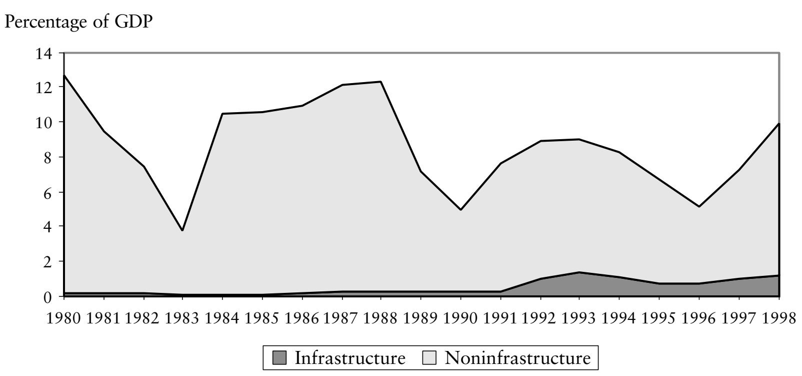
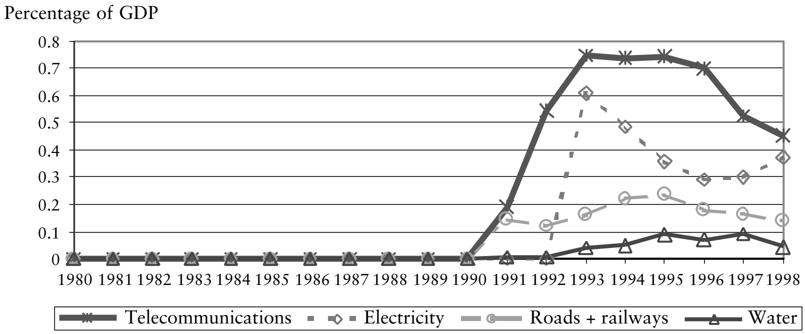
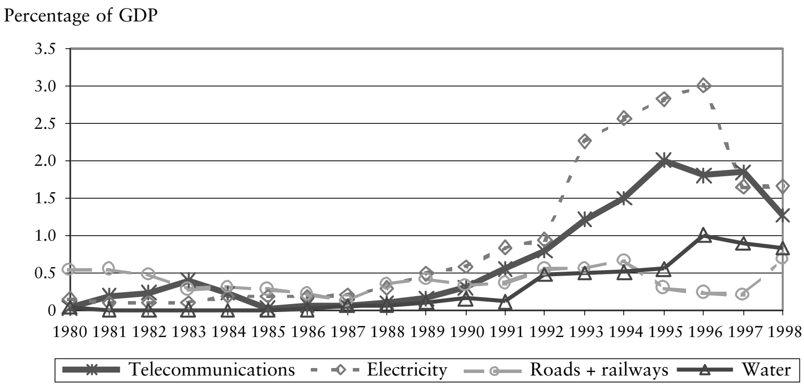


Figure 2.18 Private Investment in Infrastructure, by Sector and by Country

a. Argentina, 1980–98



b. Bolivia, 1980–98



c. Brazil, 1980–98

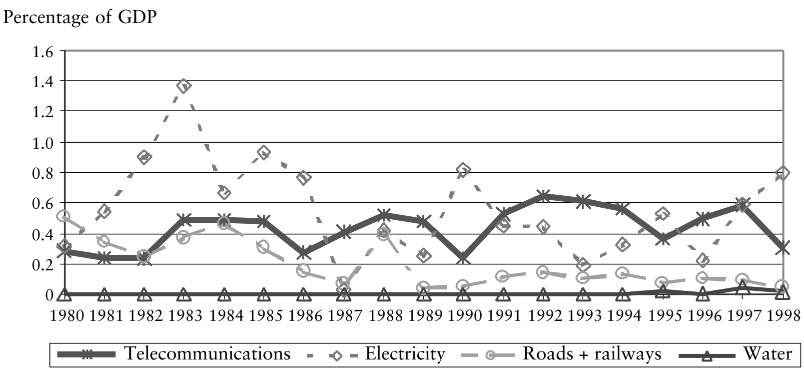
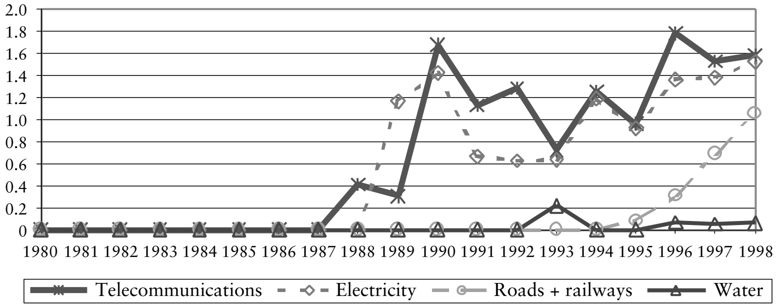


Figure 2.18 (continued)

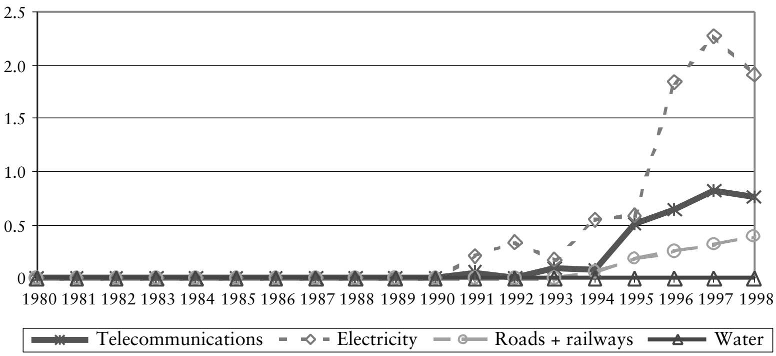
d. Chile, 1980–98

Percentage of GDP



e. Colombia, 1980–98

Percentage of GDP



f. Ecuador, 1981–98

Percentage of GDP

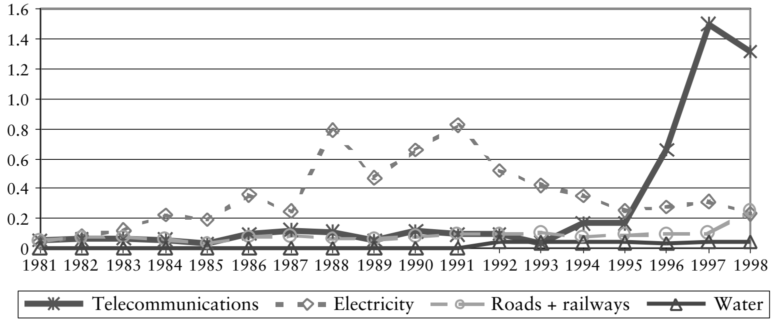
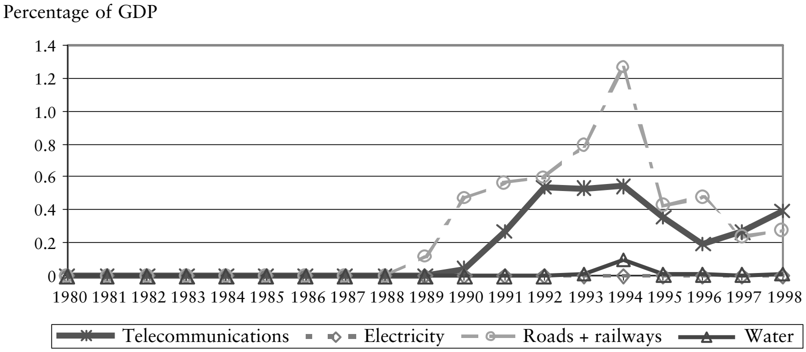
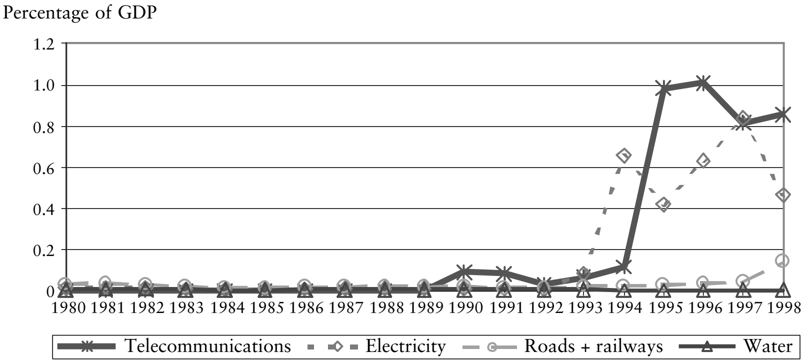


Figure 2.18 (continued)

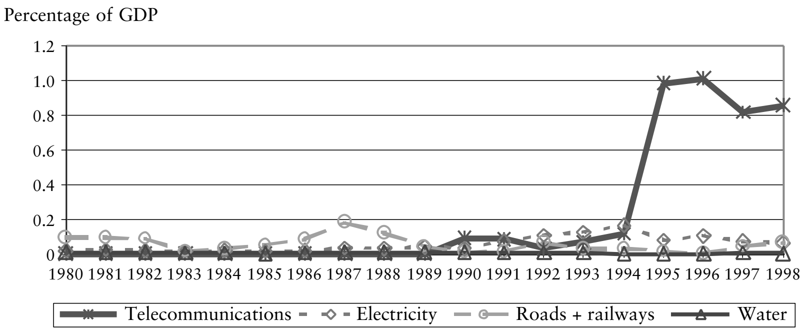
g. Mexico, 1980–98



h. Peru, 1980–98



i. República Bolivariana de Venezuela, 1980–98



destination of private infrastructure spending in the late 1990s. In contrast, the power sector took this role in Bolivia and Colombia. In Brazil there were no significant changes in the sectoral allocation of private infrastructure investment over the period under analysis. Finally, Mexico appears to have been the only country where the transport sector became a prime destination for private investment.

How did these sectoral patterns match the reforms introduced by most countries to open up their infrastructure sectors? To assess the response of private investment across countries and sectors to the reforms, the concept of *reform time* is used. To do this, the path of private infrastructure spending in each sector is examined before and after the year of reform identified in table 2.3 above, which is shown as year 0 in the panels of figure 2.19.[7]

Figure 2.19a shows the path of private telecommunications spending in the nine Latin American economies considered. Private investment in this sector surged in the wake of opening up to private initiative. The largest increases were in Argentina and Chile, where postreform private investment peaked at US$40–$60 per capita. These increases are impressive compared with the average prereform public spending, which was around US$12 per capita.[8]

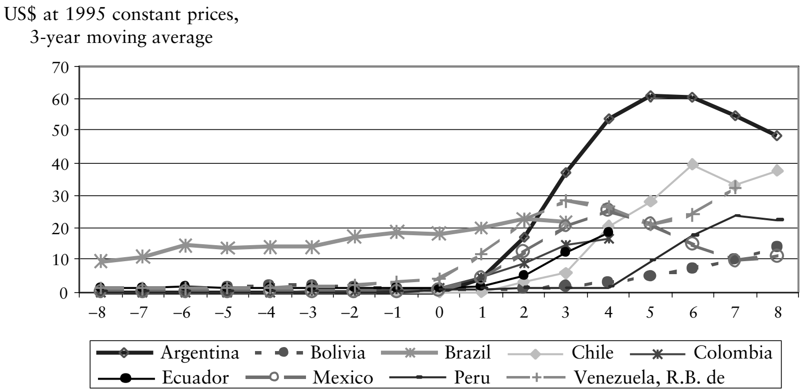
Similarly, figure 2.19b shows the path of private electricity spending before and after liberalization. In most countries, private spending in this sector rose sharply around the time of reform, although Ecuador is a conspicuous exception. In most cases, the increases fell short of the average prereform public spending per capita in the sector, which was around US$32.

For roads (figure 2.19c), Chile and Mexico show strong private spending increases, whereas the results seem more modest in the other countries reforming this sector. As a consequence, only in these two countries did total per capita spending actually rise after the reform. Also, in railways (figure 2.19d) only Argentina displayed a sharp increase in private spending per capita after the reforms. Even then, however, the increase was sufficient only to keep total spending roughly at its prereform level (around US$10). In the other countries, total spending per capita declined.

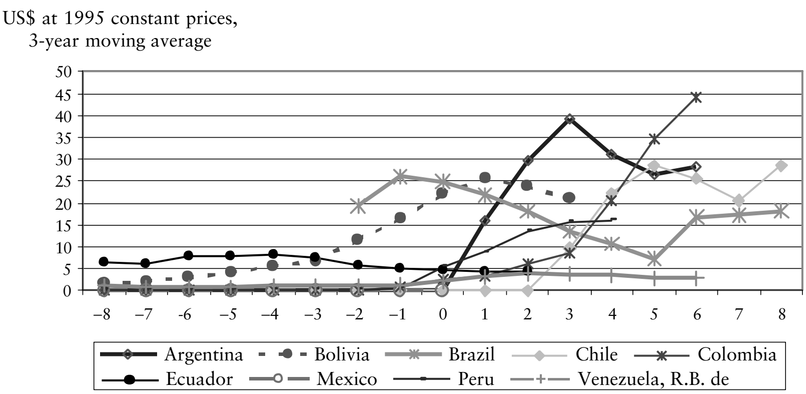
Finally, results are also uneven in the water sector (figure 2.19e). In Bolivia private water spending increased before liberalization, perhaps in anticipation of the reform. In Argentina, liberalization yielded significant increases in spending. In Chile, however, private spending in the water sector showed little change after reform. In spite of this diversity in private sector response, total per capita spending in the water sector rose in most countries. But the main reason for this is that, unlike in other sectors, public investment per capita in the water sector

Figure 2.19 Private Investment Per Capita around the Date of Reform in Selected Country, by Sector

a. Telecommunications



b. Electricity



c. Roads

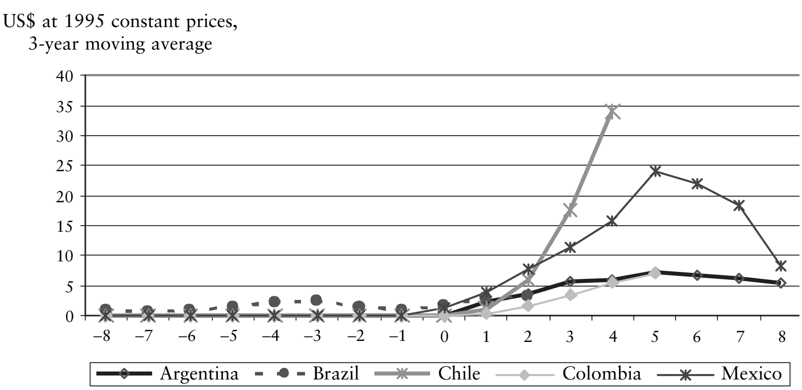
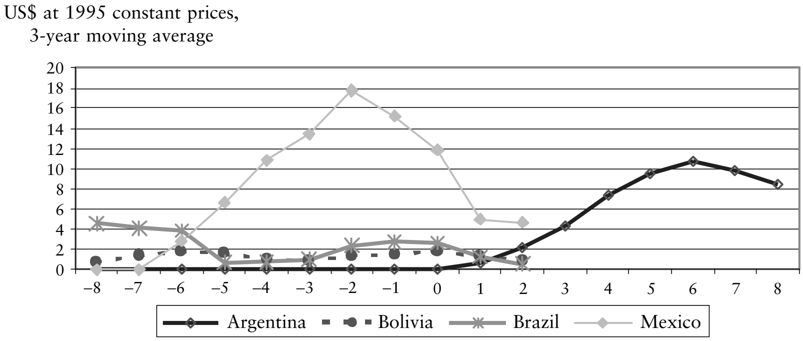
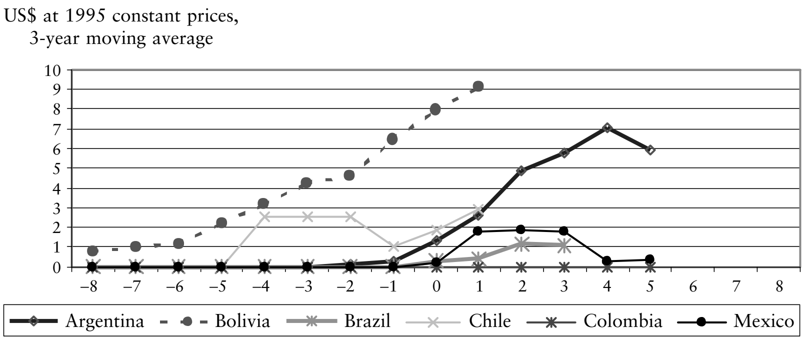


Figure 2.19 (continued)

d. Railways



e. Water



did not decline but instead showed a rising trend in the majority of countries.

In summary, these *reform time* graphs of private investment, as well as similar graphs constructed for public investment (not shown here to save space), do not seem to provide strong support for the popular perception that the reform and liberalization of infrastructure sectors led to a surge in private investment to replace declining public investment. The above graphs suggest that such a perception might be roughly correct in the case of the telecommunications sector, but in the other sectors the picture is more mixed.

This conclusion from the *reform time* graphs shown above is corroborated by the correlations shown in table 2.4. The overall correlation between public and private investment during the past two decades across the nine countries under study is statistically insignificant. Only two of the correlations by sector are significantly different from

Table 2.4 Correlation between Public and Private Infrastructure Investment, by Sector

Total infrastructure investment	−0.027
Power	−0.010
Telecommunications	−0.270**
Roads and railways	0.383**
Water	−0.112

Note: Ratios to GDP, nine countries, 1980–98.
** Significant at 5 percent.
Source: Authors' calculations.

zero. They correspond to the telecom sector, in which public and private investment are negatively correlated, and the transport sector, where the correlation is strongly positive.

A more formal test of the hypothesis that private infrastructure spending replaced public spending can be performed by noting that, if such a view were correct, one should see more of a reduction in public infrastructure spending in the countries and sectors where private infrastructure spending increased the most. To verify this, public infrastructure investment is regressed on private infrastructure investment, with both expressed as percentage of GDP.

Table 2.5 reports the results from three sets of regressions. The first two use aggregate private and public infrastructure investment and allow for country-specific constants and time trends, using a seemingly unrelated regressions (SUR) setup. The first specification reported in the table imposes a common coefficient on private investment for all nine countries. The result is surprising. The coefficient estimate equals 0.10 and is strongly significant, implying a positive statistical association between private infrastructure spending and public infrastructure spending, which suggests that the two are complements rather than substitutes. The country-specific trends (not reported to save space) are negative and significant in seven of the nine countries, with Colombia and Ecuador as the only exceptions. In other words, the data assign the reduction in public infrastructure spending to the preexisting trend rather than to the increase in private infrastructure spending.

The second experiment in table 2.5 reports results from a less restrictive empirical specification that permits the private investment/GDP ratio to carry different coefficients in each country. The estimated coefficients vary in sign and magnitude. Four are positive and five negative; their average equals 0.031. Four of the nine estimates are significant at the 5 percent level; three of these (Bolivia, Colombia, and Peru) are positive whereas the fourth (Brazil) is negative. These results reveal a considerable

Table 2.5 Regressions of Public Infrastructure Investment/GDP on Private Infrastructure Investment/GDP

1. Using aggregate investment by country	
(FE–SUR estimates with country-specific constants and trends)	
1a. Pooled estimate	0.108**
Number of significantly positive trends	1
Number of significantly negative trends	7
Adjusted R^2	0.838
1b. Country-specific estimates (9 total): average	0.031
Number of significantly positive estimates	3
Number of significantly negative estimates	1
Number of significantly positive trends	0
Number of significantly negative trends	7
Adjusted R^2	0.852
2. Using investment by country sector	
(FE estimates with country-sector-specific constants and trends)	
Country-sector-specific estimates (32 total): average	0.162
Number of significantly positive estimates	8
Number of significantly negative estimates	8
Number of significantly positive trends	2
Number of significantly negative trends	16
Adjusted R^2	0.859

Note: FE–SUR = fixed effects–seemingly unrelated regressions; nine countries, 1980–98.

** Significant at 5 percent.

Source: Authors' calculations.

degree of cross-country diversity in the relationship between private and public infrastructure investment. The pooling restrictions implicit in the earlier empirical specification (which assumed equal coefficients across countries) are clearly invalid: a Wald test of equality of coefficients across countries yields a p-value of less than 0.0001, unambiguously rejecting the null of equal coefficients. As for the country-specific time trends, most (seven out of nine) are significantly negative; the exceptions now are Chile and Ecuador, whose time trends are insignificant.

In the last experiment reported in table 2.5, the regression of public on private investment is repeated but different regression coefficients for each country and sector are allowed, along with country- and sector-specific time trends and intercepts using a fixed effects specification. After dropping country sectors with missing data, this yields a total of 32 regression estimates of the impact of private on public infrastructure investment.

Given the large number of parameters estimated, the table presents only a summary of the results. Again the coefficient estimates show a wide dispersion. Seventeen are positive and 15 negative, and their mean equals 0.16. Of the 16 estimates significantly different from zero at the 5 percent level, 8 are positive and 8 negative. In spite of this diversity, the sectoral distribution of the estimates (whose individual values are not shown in the table) is suggestive. The 8 significantly negative estimates correspond to the power (4 estimates) and telecom and water (2 each) sectors in various countries. It is interesting that none of the transport sector offset coefficients is significantly negative. In turn, the 8 positive coefficients are found in transport (4), power (2), telecom (1), and water (1). This pattern of coefficient signs would suggest some replacement of public by private investment in power, whereas in transport the relationship between public and private spending appears to be one of complementarity. For the country-sector-specific time trends, the vast majority (25 out of 32) remain negative. Among those statistically significant, 16 are negative and only 2 are positive.

The conclusion that can be drawn is that the observed decline in public infrastructure spending was not closely matched with those sectors and countries where private infrastructure spending surged. There is a great deal of diversity across countries and infrastructure sectors. In some individual cases private infrastructure spending increases did offset public infrastructure spending cuts. But in a large number of instances, the sectors where private spending increased the most were not those where public spending declined the most—or even where it declined at all. This suggests that private sector involvement did not lead to a generalized replacement of public spending with private spending. In principle, some degree of decline in aggregate spending might be consistent with unchanged asset accumulation if the unit cost of assets is declining over time (as one would expect to be the case). However, the pervasiveness and magnitude of the observed spending decline suggests that the opening up to private activity was not a panacea for Latin America's infrastructure woes.

Infrastructure Spending and the Quantity and Quality of Infrastructure

The final step of the analysis concerns the link between infrastructure investment trends and the evolution of standard indicators of infrastructure stocks and their quality. The first task is to assess to what extent spending on infrastructure gets translated into actual quantity increases of infrastructure. It could be that public spending is misclassified or is simply ineffective in creating new infrastructure. Pritchett (2000) reported many horror stories of public investment not translating into effective increases in capital.

This section examines the effect of total infrastructure spending, public and private, in the respective sectors on the growth of the corresponding infrastructure stocks for the nine Latin American countries where data exist. This is done by estimating regressions with the growth in physical infrastructure stocks as the dependent variable and infrastructure investment (as a ratio to GDP) as the explanatory variable.[9] Separate panel estimators for each of the infrastructure sectors under analysis are computed. In each case a dynamic specification is used to model the relationship between growth in physical infrastructure stocks and infrastructure investment, to capture lags in the capital accumulation process as well as inertia in investment decisions. Specifically, lags of both the dependent and independent variables are included in an autoregressive–distributive lag (ARDL) framework. 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. For power and transport (roads and railways), up to six lags were used. Although this specification might be insufficient given the long delays often involved in the construction of power plants and railway routes, the short data samples available prevented use of longer lag specifications.

Table 2.6 summarizes the empirical results of this procedure. The table reports a variety of empirical specifications with and without country and/or time effects, which respectively intend to capture country-specific and common factors affecting infrastructure accumulation. For transport routes, rather than fixed effects each country's total land area (in logs) was used as an additional explanatory variable.[10] In view of the generous parameterization of the estimated equations, to save space the table reports only the long-run impact of investment on the rate of accumulation of the asset in question.

The first entry in table 2.6 reports pooled ordinary least-squares (OLS) estimates. For all three assets, the estimated long-run impact of total infrastructure investment on asset accumulation is positive and significant at the 5 percent level (8 percent in the case of transport). The long-run coefficient estimate reflects the percentage increase in the rate of asset accumulation associated with a permanent increase in investment by 1 percent of GDP. Thus, for example, the coefficient at the top left corner in the table indicates that the rate of growth of phone lines per worker increases by 6.9 percent when telecom investment increases permanently by 1 percent of GDP.

The explanatory power of the estimated equations varies across assets. It is highest for telecom, where the simple ARDL specification chosen accounts for more than three-fourths of the observed variation in asset growth rates, and lowest for power, where only 11 percent of the variation is captured by the estimates. This echoes the concerns stated above

Table 2.6 Relationship between Physical Stocks and Investment Spending in Infrastructure

Estimation method	*Telecom main lines (4,4)*[a]	*Power (6,6)*[a]	*Transport total roads (6,6)*[a]	*Transport total roads + railways (6,6)*[a]
I. Pooled OLS				
Total investment	6.89	1.97	4.43	4.07
(p-value)	(0.00)	(0.04)	(0.08)	(0.05)
R^2	0.77	0.11	0.38	0.36
II. Fixed effects				
Total investment	8.72	3.42	4.63	4.65
(p-value)	(0.00)	(0.03)	(0.08)	(0.01)
ln area			0.04	0.05
(p-value)			(0.05)	(0.02)
Fixed effects (p-value)	(0.03)	(0.07)		
R^2	0.78	0.24	0.38	0.49
III. Fixed effects and time effects				
Total investment	7.99	6.38	5.22	6.00
(p-value)	(0.00)	(0.06)	(0.07)	(0.01)
ln area			0.04	0.06
(p-value)			(0.04)	(0.00)
Fixed effects (p-value)	(0.04)	(0.08)		
Time effects (p-value)	(0.00)	(0.02)	(0.01)	(0.01)
R^2	0.82	0.32	0.51	0.53

Note: Dependent variable is growth rate in physical infrastructure. 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. For roads and transport routes, 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 República Bolivariana de Venezuela. OLS = ordinary least-squares.

a. Lag structure for ARDL model.

Source: Authors' calculations.

that asset accumulation may reflect investment performance with long and variable lags, perhaps longer than allowed for in our empirical specifications because of the scarce number of observations available. Furthermore, for power the lag structure may vary considerably across countries, depending on the kind of power generation added to the system, because different types of power plants involve different construction lags.

The next entry in table 2.6 adds country fixed effects to the telecom and power regressions and land area for roads. The long-run estimates do not change much for telecom and roads, with some increase in the explanatory power of their empirical equations. For power, however, the estimated long-run effect of investment increases quite substantially, along with the R^2. The land area variable as well as the country fixed effects are significant (although only at the 10 percent level in the case of power).

Finally, the last entry in table 2.6 adds time dummies in the empirical specification, to control for omitted common factors driving asset accumulation across countries. This specification is also robust to the presence of (common) trends in asset unit costs—for example, a declining cost per megawatt (MW) of power generation capacity. The set of time dummies is highly significant in all three equations. The long-run coefficient estimates for telecom and roads show relatively modest changes, although the fit of the respective equations improves noticeably, especially in the case of roads whose R^2 now exceeds 50 percent. For power, the estimated long-run effect becomes much bigger, and the fit of the equation improves substantially, with the R^2 now exceeding 30 percent.

In summary, the conclusion from these empirical experiments is that infrastructure investment is a robust predictor of subsequent changes in the physical infrastructure stock across countries and over time. The evidence is particularly strong in the cases of telecommunications and transport routes. The simplicity of the empirical specifications employed and the relatively short time span of the available data suggest that the link between investment and infrastructure accumulation is probably much stronger in reality than the above experiments reveal. This suggests that reductions in public, and hence total, infrastructure spending have negatively affected the quantity of infrastructure available in Latin America over the past two decades.

Although no systematic evidence was found that private investment had replaced declining public investment in infrastructure, it is nevertheless possible that private spending might have translated into faster stock accumulation than public spending. The former might have shown greater efficiency than the latter by acquiring the same infrastructure stocks at a lower cost. In this scenario, the contribution of private investment to stock accumulation should be greater than that of public investment.

This possibility is investigated in table 2.7, which reports experiments similar to those performed in the preceding table but disaggregating total investment between its public and private components. If the latter is more efficient than the former, private spending should carry a significantly larger coefficient than public spending in the infrastructure stock accumulation regressions.

Table 2.7 Relationship between Physical Stocks, Public and Private Investment Spending in Infrastructure

Estimation method	*Telecom main lines (4,4,4)*[a]	*Power (6,6,6)*	*Transport total roads (6,6,6)*	*Transport total roads + railways (6,6,6)*[a]
I. *Pooled OLS*				
Private investment	3.82	0.61	14.61	14.57
(p-value)	(0.00)	(0.57)	(0.04)	(0.02)
Public investment	1.07	0.93	−0.24	−0.85
(p-value)	(0.15)	(0.04)	(0.06)	(0.03)
Equality tests (p-value)	(0.66)	(0.83)	(0.02)	(0.15)
R^2	0.78	0.12	0.44	0.44
II. *Fixed effects*				
Private investment	5.93	1.58	14.29	15.92
(p-value)	(0.00)	(0.07)	(0.04)	(0.06)
Public investment	4.08	1.23	0.07	0.10
(p-value)	(0.12)	(0.08)	(0.06)	(0.03)
Area (in logs)			0.01	0.01
(p-value)			(0.06)	(0.04)
Fixed effects (p-value)	(0.07)	(0.08)		
Equality tests (p-value)	(0.92)	(0.88)	(0.16)	(0.07)
R^2	0.80	0.17	0.44	0.50
IV. *Fixed effects and time effects*				
Private investment	6.00	2.28	12.70	15.47
(p-value)	(0.00)	(0.07)	(0.11)	(0.01)
Public investment	4.47	1.71	0.08	0.03
(p-value)	(0.02)	(0.09)	(0.00)	(0.04)
Area (in logs)			0.01	0.01
(p-value)			(0.03)	(0.04)
Fixed effects (p-value)	(0.03)	(0.19)		
Time effects (p-value)	(0.01)	(0.02)	(0.05)	(0.08)
Equality tests (p-value)	(0.95)	(0.37)	(0.03)	(0.03)
R^2	0.83	0.40	0.57	0.60

Note: Dependent variable is growth rate in physical infrastructure. 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 and transport routes, 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 República Bolivariana de Venezuela.

a. Lag structure for ARDL model.

Source: Authors' calculations.

The empirical results in the table provide only limited evidence in favor of this hypothesis. For transport routes, the coefficient of private investment is consistently much larger than that of public investment, although Wald tests show that the difference between the two is significant only when both time effects and land area are simultaneously included in the regression. In contrast, in telecommunications and power the coefficient of private investment is in most cases somewhat larger than that of public investment, but the tests of equality yield no strong evidence against the null hypothesis that the "bang-per-buck" of private and public investment is the same, regardless of whether country and time effects are included in the equation. However, it is important to stress that these results should be taken with caution, because the projects falling under private initiative could be systematically different from those undertaken by the public sector.

In summary, only limited evidence can be found that private investment was more effective than public investment in expanding infrastructure asset stocks. But what about the quality of stocks? Did enhanced private participation lead to an improvement in the quality of infrastructure stocks? On the one hand, in those countries that privatized

Table 2.8 Private Participation and Infrastructure Quality

Dependent variable	*Method*	*Coefficient on private sector share*	t-*statistic*	*Sample period*	*Total obs.*	R^2
Telephones						
Faults per 100 main lines	SUR	−52.89	−3.2	1982–98	65	0.63
	FE–SUR	−45.90	−2.7	1982–98	65	0.78
Percentage of unsuccessful calls	SUR	−18.75	−1.7	1990–98	26	0.63
	FE–SUR	−8.34	−0.8	1990–98	26	0.72
Years on waiting list for main lines	SUR	−0.16	−5.2	1970–98	150	0.72
	FE–SUR	−0.20	−7.1	1970–98	150	0.84
Electricity						
Power losses (percent of output)	SUR	2.64	3.2	1971–98	204	0.94
	FE–SUR	3.95	6.9	1971–98	204	0.98

Note: Regression of quality indicators on private sector investment share in nine selected Latin American countries. SUR = seemingly unrelated regressions. FE–SUR = fixed effects–seemingly unrelated regressions.

Source: Authors' calculations.

the infrastructure sector, some mixed evidence exists of quality improvements. Table 2.8 shows that all the telephone quality service indicators (telephone faults per line, percentage of unsuccessful local calls, and years spent on waiting list for phone service) get significantly better, the higher the share of the private sector in telecommunications spending. This result holds regardless of whether one controls for country fixed effects.

On the other hand, there is a perverse result in the electricity sector because power losses increase with increased private share of power spending. However, this again could reflect reverse causality because governments may have wanted to privatize inefficient enterprises in the power sector that were running high power losses. Also, it could reflect heterogeneity among public and private power projects, making their respective power losses not strictly comparable with each other.

Figures 2.20a through 2.20d explore the same issue in a different way. They present scatter plots relating infrastructure quality indicators to the share of the private sector in total infrastructure investment, using 10-year averages instead of the annual data underlying the regressions in table 2.8. This should make it easier to detect the changes in quality if these occur only gradually over time, as the new private sector projects reach completion and become numerous enough to affect overall infrastructure quality in a significant way. Each point in the graphs represents one country-decade observation.

Figure 2.20 Infrastructure Quality and the Private Share of Investment in Infrastructure

a. Unsuccessful Local Calls versus Private Investment

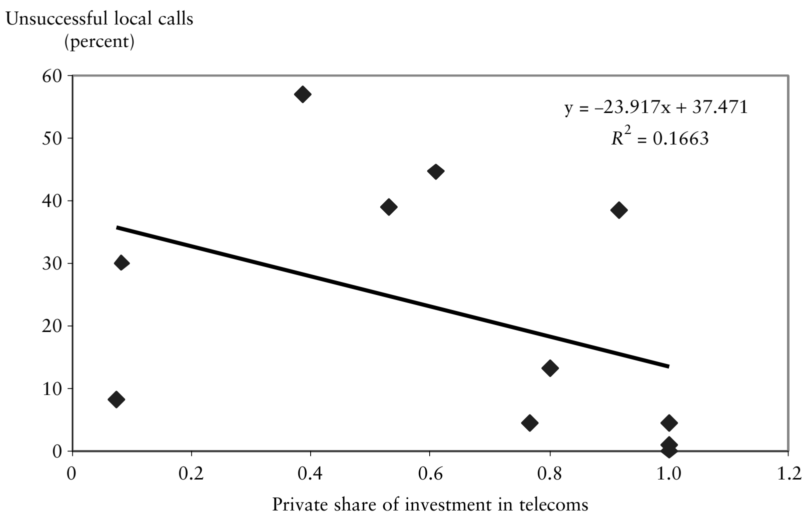
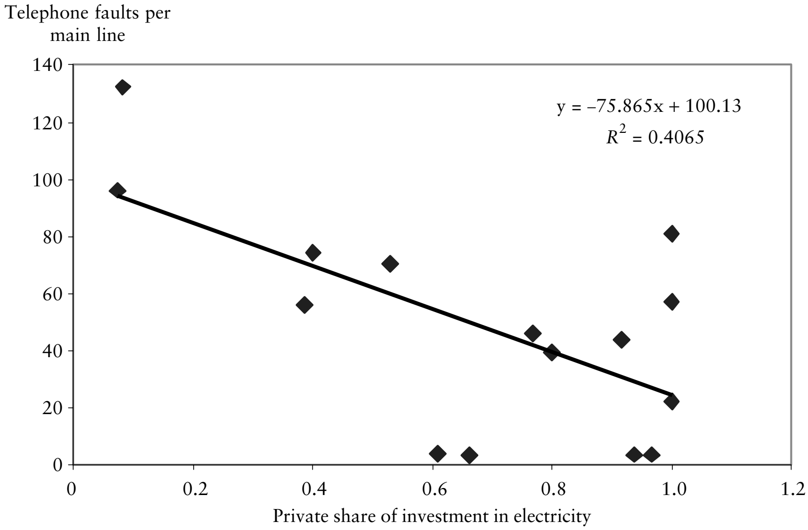


Figure 2.20 (continued)

b. Telephone Faults versus Private Investment



c. Waiting Years per Main Line versus Private Investment

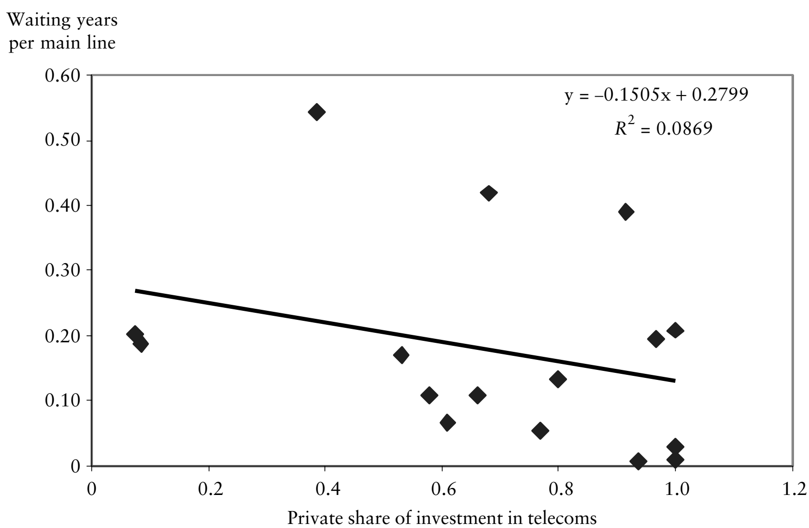
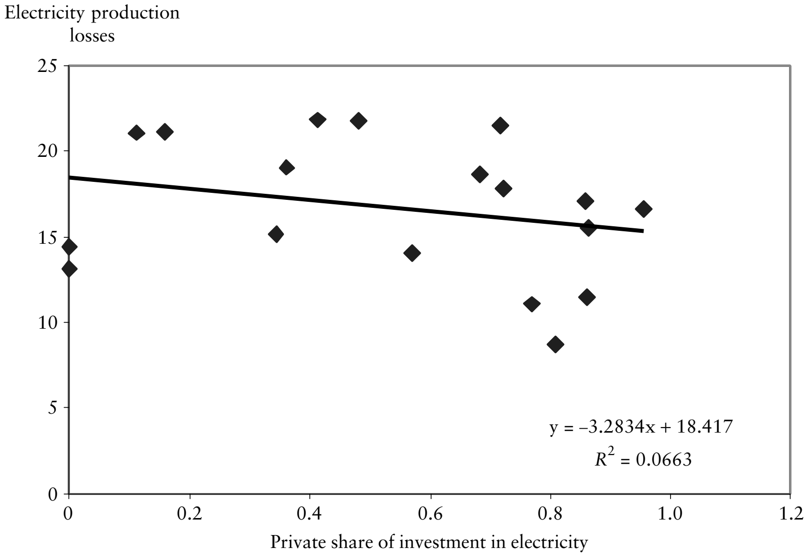


Figure 2.20 (continued)

d. Electricity Losses versus Private Investment



The verdict from the figures is similar to that emerging from the regressions: the association is clear between improving quality of telecommunications service and private participation. In the case of the power sector, there is also some hint at declining power losses, although the evidence appears much weaker than for telecommunications.

Conclusion

The 1980s and 1990s saw a widening of the infrastructure gap between Latin America and other successful developing economies like those in East Asia. A comparative review of a comprehensive set of infrastructure quantity and quality indicators reveals that during that period Latin America fell behind along most dimensions analyzed.

Latin American public infrastructure spending declined as a percentage of GDP during the era of macroeconomic crises in the 1980s and 1990s. Part of this decline is associated with fiscal adjustment (reductions in budget deficits), but the magnitude of this association is small and the trend in infrastructure spending is still down even after controlling for budget balances. This suggests that some portion of the reduction in public expenditure was not driven by deficit reduction. Furthermore, there is only limited evidence to support the common perception that privatization (specifically, private sector entry into infrastructure industries) explains the observed downward trend in public infrastructure spending. Although this seems to be true in a few cases, there are at least as many (or even more) instances in which higher private infrastructure spending is associated with *more* public infrastructure spending.

Private infrastructure spending did increase after the infrastructure sectors were opened up to private participation, but did so unevenly. Opening up to the private sector was most successful in telecommunications and electricity, with water, roads, and railways showing more uneven results; there were some laggards even in telecommunications and power. The levels of private infrastructure spending were generally below the prereform public infrastructure spending in each sector. Moreover, there was no universal tendency for public infrastructure spending to fall after liberalization.

Infrastructure spending is a good predictor of subsequent growth in infrastructure stocks; it is a particularly robust predictor for telephone lines and transport routes but also for power generation capacity. If the quantity of infrastructure has an effect on output levels, as a growing literature has argued (Canning 1999, and Röller and Waverman 2001) and the next chapter will assess, then fiscal retrenchment implemented through cuts in public infrastructure spending represents a myopic and potentially self-defeating adjustment strategy, because it lowers future output and thus the tax collection and debt-servicing capacity of the economy (Easterly 2001).[11] The evidence also suggests that under this kind of fiscal austerity, Latin America's infrastructure lag behind East Asia is unlikely to get better soon.

There is no clear evidence that private sector participation has raised the efficiency of infrastructure investment—as reflected by the translation of spending into asset accumulation. There is, however, some evidence that the increased private sector share of infrastructure has had some positive effect on infrastructure quality. All of the telephone service quality indicators improve with an increased private sector share in telecommunications, although the evidence regarding the relationship between power sector efficiency and private participation is less strong.

The conclusions from this chapter have to be taken with some caution because little information is available on measures of infrastructure quality and investment efficiency comparable across countries. Thus the conclusions have had to rely primarily on indicators of asset stocks and spending volumes. Nevertheless, the picture that emerges from our comprehensive review of the available data indicates strongly that Latin America's infrastructure sector performed poorly during the era of macroeconomic crises of the 1980s and 1990s. Privatization has so far been no panacea and a huge gap has opened relative to East

Asian NICs. As the next chapter will show, for Latin America to recover its long-run growth potential, increased attention to infrastructure policy is well warranted.

Appendix 2A. Infrastructure Database

The data underlying the analysis in this chapter come from the infrastructure database assembled for this work. The database includes both physical indicators of quantity and quality of infrastructure endowments and measures of public and private infrastructure investment expenditures. Here we give a brief description of both components of the dataset.

Physical Infrastructure Data

Public Utilities

Telephones and Telephone Main Lines. Following Canning (1998), we use the number of telephone sets and the number of main lines connected to local telephone exchanges as our measure of the provision of telephone services. Although both measures are highly correlated, Canning suggested that the number of telephone main lines is a better measure of the capacity of the telephone system. The variables taken from Canning's database are displayed in table 2A.1.

We extend Canning's data with more recent figures taken from the Annual Reports of the International Telecommunications Union (ITU). Furthermore, ITU provides other indicators that could be used to measure the quantity and quality of telephone services. A summary of the coverage and availability of those indicators is presented in table 2A.2.

Regarding coverage across regions, we can summarize the time-series dimensions for some regions as presented in table 2A.3.

From the table, it is clear that the quality indicators—faults per 100 main lines and waiting list for main lines—have more limited coverage, especially the former.

Table 2A.1 Telephone Service Variables

Variable	*Period*	*Source*
Number of telephone lines	Annual, 1960–95	ITU, AT&T, United Nations discontinued after 1995
Number of telephone main lines	Annual, 1960–98	ITU, AT&T, United Nations

Source: Canning 1998.

Table 2A.2 Summary of Coverage and Availability of Telephone Service Indicators

Variables	*Frequency/period*	*Cross-section and time dimensions*
I. System capacity		
Connection capacity of local exchanges	Annual, 1975–98; selected years: 1960, 1965, 1970	1975–98: between 55 and 175 countries; 1960–75: 10 countries; time series (TS): mean of 12 observations per country (opc) and median of 11 opc
II. Operation and access		
Main telephone lines in operation	Annual, 1975–97; selected years: 1960, 1965, 1970	1975–97: between 158 and 209 countries; 1960, 1965, 1970: more than 100
Percentage of main line equipment for direct international dialing	Annual, 1985–97	1985–97: between 80 and 109 countries; TS: mean of 5 opc and median of 4 opc
Percentage of urban main lines	Annual, 1980–97; selected years: 1960, 1965, 1970, 1975	1990–97: between 27 and 98 countries; 1980–89: no more than 10; 1960–75: only 2 countries (HKG, SGP); TS: mean of 3 opc and median of 1 opc
Percentage of residential main lines	Annual, 1975–97; selected years: 1960, 1965, 1970	1975–97: between 54 and 172 countries; 1960–75: no more than 6 countries; TS: mean of 10 opc and median of 9 opc
Number of local telephone calls	Annual, 1975–97; selected years: 1960, 1965, 1970	1975–97: between 12 and 52 countries; 1960, 1965, 1970: more than 7; TS: mean of 3 opc and median of 0 opc
Number of national long-distance telephone calls	Annual, 1975–97; selected years: 1960, 1965, 1970	1975–97: between 15 and 87 countries; 1960, 1965, 1970: 7; TS: mean of 5 opc and median of 1 opc

Table 2A.2 (continued)

Variables	*Frequency/period*	*Cross-section and time dimensions*
Percentage of households with a telephone (limited coverage)	Annual, 1975–97; selected years: 1960, 1965, 1970	1975–97: between 2 and 36 countries; 1960, 1965, 1970: only 1 (CAN); TS: mean of 1 opc and median of 0 opc
III. Costs		
Residential monthly telephone subscription (US$)	Annual, 1980–97	1990–97: between 119 and 176 countries; 1980–89: 23 countries; TS: mean of 6 and median of 7 opc
Residential telephone connection charge (US$)	Annual, 1980–97	1990–97: between 120 and 177 countries; 1980–89: 26 countries; TS: mean of 6 and median of 7 opc
IV. Quality		
Percentage of unsuccessful local calls	Annual, 1980–97	1990–97: between 45 and 98 countries; 1980–89: 6 countries; TS: mean and median of 2 opc, and a maximum of 14 (GBR)
Telephone faults per 100 main lines	Annual, 1980–97	1990–97: between 64 and 127 countries; 1980–89: 22 countries; TS: mean and median of 4 opc
Waiting list for main lines	Annual, 1975–97; selected years: 1960, 1965, 1970	1990–97: between 76 and 175 countries; 1960–75: 55 countries; TS: mean of 14 and median of 13 opc

Note: CAN = Canada; GBR = Great Britain; HKG = Hong Kong (China); SGP = Singapore.

Source: ITU, *World Telecommunications Development Report*, various years.

Table 2A.3 Telecommunications Indicators: Time-Series Coverage by Region

Region/ statistics	*Main lines (ML)*	*Main lines in operation*	*Number of telephones*	*Connection capacity*	*Faults per 100 main lines*	*Waiting list for main lines*
I. Latin America and the Caribbean (42 countries)						
Average	27	23	23	12	3	12
Median	28	24	33	12	3	13
Min/max	0/38	14/26	0/36	0/23	0/14	0/24
II. East Asia and the Pacific (35 countries)						
Average	25	20	17	11	4	13
Median	26	24	20	9	4	13
Min/max	0/38	0/26	0/36	0/25	0/9	0/26
III. Western Europe (25 countries)						
Average	28	23	20	13	5	17
Median	38	26	25	16	5	20
Min/max	0/38	0/26	0/35	0/23	0/17	0/26

Source: ITU, *World Telecommunications Development Report*, various years.

Energy. The measure of infrastructure in electricity, as taken from Canning (1998), is the electricity generating capacity (in kilowatts). We have annual observations for the 1950–95 period. The main sources for these data were the United Nations' *Energy Statistics* and *Statistical Yearbook*. In table 2A.4 we report other variables that could be used as proxies for energy.

We extend these data using mainly the United Nations' *Energy Statistics* and *Statistical Yearbook*. In table 2A.5 we present some basic information on the time-series coverage of the indicators for infrastructure in the energy sector.

Sanitation and Sewerage. For this category we have found observations only for selected years within the 1970–97 period. The main source is the World Bank's *World Development Indicators*. The variables are the percentages of population with access to safe water and sanitation in urban and rural areas. We also report total access. The limited coverage of the series could be observed in table 2A.6, which summarizes the time dimension in some selected regions.

Public Works

Roads. Canning (1998) presented two indicators for the stock of infrastructure in roads (table 2A.7).

Table 2A.4 Variables Used as Proxies for Energy

Variables	*Frequency/ period*	*Cross-section and time dimensions*
I. Output and consumption		
Electric power consumption (in kwh or kwh per capita)	Annual, 1960–97	1971–97: 130 countries; 1960–70: 27 countries; Time series (TS): mean of 17 opc, median of 26 opc, with a maximum of 37 observations for 27 countries
Electric production	Annual, 1960–97	1971–97: 109–129 countries; 1960–70: 24 countries; TS: mean of 16 opc, median of 26 opc, with a maximum of 37 observations for 24 countries
II. Quality		
Electric power transmission and distribution losses (percent of output)	Annual, 1960–97	1971–97: 100–129 countries; 1960–70: 24 countries; TS: mean of 16 opc, median of 18 opc, with a maximum of 37 observations for 24 countries

Source: World Bank, *World Development Indicators*, various years; United Nations, *Statistical Yearbook* CD-ROM, various issues; United Nations, *The Energy Statistics Yearbook*, various years.

We extend these data using recent issues of the International Road Federation *World Road Statistics* (see table 2A.8). According to Canning (1998), the raw data on road length seem too unreliable to be useful; even using national sources it appears impossible to construct data that are consistent either across countries or over time. Canning used the percentage of the main paved and unpaved road network as a measure of quality.

Other available indicators are limited in coverage and capture only the transportation impact of these roads.

Irrigation. The main source for measures in this category is the World Bank's *World Development Indicators* (table 2A.9).

The time-series dimension for these indicators in some important regions are summarized in table 2A.10.

Other Transport Sectors: Railways. The only measure provided by Canning (1998) is the rail route length. The main data sources for the

Table 2A.5 Energy Indicators: Time-Series Coverage by Region

Region/ statistics	*Electricity generation capacity*	*Electricity power consumption (kwh per capita)*	*Electricity power consumption (kwh)*	*Electricity power production (kwh)*	*Electricity power transmission and distribution losses (% output)*
I. Latin America and the Caribbean (42 countries)					
Average	27	15	15	14	14
Median	36	26	26	26	22
Min/max	0/36	14/27	0/37	0/26	0/26
II. East Asia and the Pacific (35 countries)					
Average	20	13	13	13	13
Median	24	0	0	0	0
Min/max	0/36	0/37	0/37	0/37	0/37
III. Western Europe (25 countries)					
Average	24	25	25	25	25
Median	36	37	37	37	37
Min/max	0/36	0/37	0/37	0/37	0/37

Source: United Nations, *Energy Statistics* and *Statistical Yearbook,* various years.

Table 2A.6 Sanitation and Sewerage Indicators: Time-Series Coverage by Region

Region/	*Safe water (percentage of population with access)*			*Sanitation (percentage of population with access)*		
statistics	*Total*	*Rural*	*Urban*	*Total*	*Rural*	*Urban*
I. Latin America and the Caribbean (42 countries)						
Average	3	3	3	2	2	2
Median	4	3	3	2	1	2
Min/max	0/7	0/7	0/7	0/5	0/5	0/5
II. East Asia and the Pacific (35 countries)						
Average	3	3	3	2	2	2
Median	3	3	3	2	1	2
Min/max	0/7	0/8	0/8	0/5	0/6	0/6
III. Western Europe (25 countries)						
Average	3	3	3	2	2	2
Median	3	2	2	2	1	1
Min/max	0/7	0/7	0/7	0/5	0/5	0/5

Source: World Bank, *World Development Indicators*, various years.

Table 2A.7 Indicators for Roads

Variables	*Frequency/period*	*Problems*
Total road length (in km)	Annual, 1950–97	Frequent gaps and large changes. Differences in the definition of roads across countries and over time.
Paved road length (in km)	Annual, 1950–97	Large variations in quality. Data do not reflect the width of the road and do not account for the age of the road.

Source: Canning 1998; International Road Federation, *World Road Statistics*, various issues; United Nations, *Statistical Yearbook*, various issues.

Table 2A.8 Other Indicators for Roads

Variables	*Frequency/period*	*Cross-section and time dimensions*
Road traffic (vehicles per km)	Annual, 1990–97	1990–97: between 13 and 60 countries; Time series (TS): mean of 2 opc, median of 0 opc, with a maximum of 9 observations for 8 countries
Roads, goods transported (million of tons per km)	Annual, 1990–97	1990–97: between 23 and 57 countries; TS: mean of 2 opc, median of 0 opc, with a maximum of 10 observations for 4 countries

Source: World Bank, *World Development Indicators*, various years; International Road Federation, *World Road Statistics*, various years.

Table 2A.9 Indicators for Irrigation

Variables	*Frequency/period*	*Cross-section and time dimensions*
Irrigated land (hectares)	Annual, 1960–97	1960–96: between 143 and 164 countries; Time series (TS): mean of 25 opc, median of 36 opc, with a maximum of 36 observations for 134 countries
Irrigated land (percentage of crop land)	Annual, 1960–97	1960–96: between 136 and 156 countries; TS: mean of 23 opc, median of 36 opc, with a maximum of 36 observations for 122 countries

Source: World Bank, *World Development Indicators*, various years.

Table 2A.10 Irrigation: Time-Series Coverage by Region

Region and statistics	*Irrigation*	
	As percentage of crop land	*In hectares*
I. Latin America and the Caribbean (42 countries)		
Average	27	27
Median	36	36
Min/max	0/36	0/36
II. East Asia and the Pacific (35 countries)		
Average	18	18
Median	25	27
Min/max	0/36	0/36
III. Western Europe (25 countries)		
Average	16	20
Median	0	36
Min/max	0/36	0/36

Source: World Bank, *World Development Indicators*, various years.

length of railway lines are Mitchell's *International Historical Statistics* (1992, 1993, 1995) until 1980 and The World Bank's *Railways Database* (available online) thereafter. Canning (1998) also used national sources to supplement these data.[12]

The World Bank has developed the *Railways Database* that comprises data for 1980–97. From this database we have some variables that could be useful to measure capacity and quality of the railways: stock of main diesel locomotives; stock of main electric locomotives; passenger–kilometer (in millions); goods transported, freight ton–kilometer (in millions); goods transported, freight ton–kilometer per wagon (000); diesel locomotive availability (in percent); operating ratio with normalization; and operating ratio without normalization.

Finally, we summarize the time-series information across countries for some selected regions (table 2A.11).

Data on Investment in Infrastructure

The sample covers nine Latin American countries at an annual frequency over the period 1970–98.

Definition of Public Sector

Table 2A.12 presents the definition of public sector used in the figures of public investment in infrastructure.

Table 2A.11 Roads and Railways: Time-Series Data for Selected Regions

Region/statistics	*Roads* Route length (km)	Paved route length (km)	*Railways* Route length (km)
I. Latin America and the Caribbean (42 countries)			
Average	12	15	26
Median	9	12	34
Min/max	0/34	0/34	0/38
II. East Asia and the Pacific (35 countries)			
Average	14	13	20
Median	9	0	32
Min/max	0/36	0/36	0/38
III. Western Europe (25 countries)			
Average	21	17	24
Median	30	22	36
Min/max	0/36	0/36	0/38

Source: World Bank, *Railways Database*, various years.

Definition of Transport Sector

The definition of the transport sector varies somewhat across countries, as shown in table 2A.13.

Table 2A.12 Public Sector Definitions Used in the Figures of Public Investment in Infrastructure

Country	*Telecom*	*Power*	*Transport*	*Water*
Argentina	GG+SOE	GG+SOE	GG+SOE	GG+SOE
Bolivia	GG+SOE	GG+SOE	GG+SOE	GG+SOE
Brazil	GG+SOE	GG+SOE	GG+SOE	—
Chile	GG+SOE	GG+SOE	GG+SOE	—
Colombia	GG+SOE	GG+SOE	GG+SOE	GG+SOE
Ecuador	GG+SOE	GG+SOE	GG+SOE	GG+SOE
Mexico	GG+SOE	GG+SOE	GG+SOE	GG+SOE
Peru	GG+SOE	GG+SOE	GG+SOE	GG+SOE
Venezuela, R.B. de	GG+SOE	GG+SOE	GG+SOE	GG+SOE

— Not available.

Note: GG denotes general government spending on infrastructure. SOE denotes state-owned enterprise spending on infrastructure.

Source: National sources listed below.

Table 2A.13 Definition of the Transport Sector

Country	*Transport Sector*
Argentina	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.
Bolivia	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.
Brazil	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.
Chile	We have aggregate data only for investment in transport. This includes all categories (roads, railways, ports, and airports). There is no breakdown for any of these four categories.
Colombia	We have aggregate data only for investment in transport. This includes all categories (roads, railways, ports, and airports). There is no breakdown for any of these four categories.
Ecuador	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.
Mexico	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.
Peru	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.
Venezuela, R.B. de	We have investment data for both roads and railways (separately). We do not have data on investment in ports and airports.

Note: Aggregate data on investment in the transport sector includes spending on roads, railways, ports, and airports. However, we do not have the specific investment in each subsector. We lack data on railways for Chile and Colombia.

Source: National sources listed below.

National Sources of Information for the data on Infrastructure Investment

To obtain data on infrastructure investment, we gathered information mostly from national sources. Here is the list of documents used, by country.

Argentina, 1970–98

Infrastructure—General Information:

Fundación de Investigaciones Económicas Latinoamericanas. 1992. "Capital de Infraestructura en la Argentina: Gestión Pública, Privatización y Productividad." Buenos Aires.

Secretaria de Hacienda. "Cuenta de Inversión 1994–97." Sub-Secretaria del Presupuesto. Ministerio de Economía, Buenos Aires.

Telecommunications:

Celani, Marcelo. 1998. "Determinantes de la Inversión en Telecomunicaciones en Argentina." CEPAL Serie Reformas Económicas No. 9. Santiago de Chile.

Power:

Adrián Romero, Carlos. 1998. "Regulación e Inversiones en el Sector Eléctrico Argentino." CEPAL Serie Reformas Económicas No. 5. Santiago de Chile.

Transport:

Delgado, Ricardo. 1998. "Inversiones en Infraestructura Vial: La Experiencia Argentina." CEPAL Serie Reformas Económicas No. 6. Santiago de Chile.

Bolivia, 1980–98

Infrastructure—General Information:

Antelo, Eduardo. 2000. "Politicas de Estabilización y de Reformas Estructurales en Bolivia a partir de 1985." CEPAL Serie Reformas Económicas No. 62. Santiago de Chile.

Barja Daza, Gover. 1999. "Las Reformas Estructurales Bolivianas y su Impacto sobre Inversiones." CEPAL Serie Reformas Económicas No. 42. Santiago de Chile.

Instituto Nacional de Estadística. Varios números. "Bolivia en Cifras."

World Bank. 1993. "Bolivia: Public Expenditure Review." Washington, D.C.

Telecommunications:

Barja Daza, Gover. 1999. "Inversión y Productividad en la Industria Boliviana de Telecomunicaciones." CEPAL Serie Reformas Económicas No. 16. Santiago de Chile.

Power:

Barja Daza, Gover. 1999. "Inversion y Productividad en la Industria Boliviana de la Electricidad." CEPAL Serie Reformas Económicas No. 15. Santiago de Chile.

Brazil, 1970–98

Infrastructure—General Information:

Cavalcanti Ferreira, Pedro. 1996. "Investimento em Infra-estrutura no Brasil: Fatos Estilizados e Relacoes de Longo Prazo." *Pesquisa e Planejamento Economico* 26 (2) (August).

Cavalcanti Ferreira, Pedro, and Thomas Georges Malliagros. 1998. "Impactos Produtivos da Infra-estrutura no Brasil: 1950–95." *Pesquisa e Planejamento Economico* 28 (2) (August).

———. 1999. "Investimentos, Fontes de Financiamiento e Evolucao do Setor de Infra-estrutura no Brasil: 1950–96." *FGV EPGE Ensaios Economicos* 346.

Coes, Donald V. 1994. "Macroeconomic Crises, Policies and Growth in Brazil, 1964–90." World Bank Comparative Macroeconomic Studies. Washington, D.C.

Rigolon, Francisco J. Z. 1998. "O Investimento em Infra-estrutura e a retomada do crescimento economico sustentado." *Pesquisa e Planejamento Economico* 28 (1) (April).

Chile, 1980–98

Infrastructure—General Information:

Ministerio de Obras Públicas, Transportes y Comunicaciones. 2000. "Inversión en Infraestructura: Rol sobre el Crecimiento, Desarrollo Económico y la Globalización." Santiago, Chile: Gobierno de Chile.

Moguillansky, Graciela. 1999. "La Inversión en Chile: ¿El Fin de un Ciclo en Expansión?" Santiago, Chile: Fondo de Cultura Económica Chile S.A.

Moguillansky, Graciela, and Ricardo Bielschowsky. 2000. "Inversión y Reformas Económicas en América Latina." Santiago, Chile: Fondo de Cultura Económica Chile S.A.

Colombia, 1973–98

Infrastructure—General Information:

Departamento Administrativo Nacional de Estadística (DANE). 1996. "Cuentas Nacionales: Gastos en FBKF por sector institucional según finalidad 1973–95." Bogotá.

We should note that DANE data have been computed according to commitments and not on a cash flow basis. Additionally, depreciation of the existing stock has been considered.

Transport:

Ministry of Transport. 1995. "El Transporte en Cifras, 1970–94." Bogotá.

Ministry of Transport. 1997. "El Transporte en Cifras, 1970–96." Bogotá.

Ecuador, 1981–98

Infrastructure—General Information:

Banco Central del Ecuador. Varios números. *Boletín Anuario*.

CEPAL/PNUD. 1993. "La Política Fiscal en Ecuador, 1985–91." Serie Política Fiscal No. 35. Santiago de Chile.

World Bank. 1991. "Reformas del Sector Público para lograr el crecimiento en una época de decreciente producción petrolera." Washington, D.C.

———. 1993. "Ecuador Public Expenditure Review: Changing the Role of the State." Washington, D.C.

Mexico, 1970–98

Infrastructure—General Information:

Banco de México. 1995. "La Encuesta de Acervos, Depreciación y Formación de Capital." México, DF.

Presidencia del Gobierno. 1999. "IV Informe del Gobierno: México 1988–98." México, DF.

———. 2000. "V Informe del Gobierno: México 1989–99." México, DF.

Secretaría de Hacienda de México. Various years. "Inversión Pública Federal por Entidad Federativa." México, DF.

Peru, 1970–98

Infrastructure—General Information:

Banco Central de Reserva del Perú. Varios números. "Memoria Anual." Lima.

CUANTO S.A. Varios números. "Perú en Números." Lima.

Instituto Nacional de Estadística e informática (INEI). Varios números. "Anuario Estadístico." Lima.

República Bolivariana de Venezuela, 1980–98

Infrastructure—General Information:

Oficina Central de Estadística e Informática. Varios números. "Anuario Estadístico." Caracas.

World Bank. 1992. "Venezuela: Decentralization and Fiscal Issues." Washington, D.C. (December).

Telecommunications:

Comisión Nacional de Telecomunicaciones (CONATEL). Website info: www.conatel.gov.ve/indicadores.htm.

Appendix 2B. The Liberalization of Infrastructure Industries in Latin America

This appendix provides a brief chronology of the opening up of Latin America's infrastructure sectors to private participation (tables 2B.1,

Table 2B.1 Infrastructure Reform Laws
(year of enactment, by sector)

	Energy		Transport			
Country	*Electricity*	*Gas*	*Roads*	*Railways*	*Telecom*	*Water*
Argentina	1989	1989	1989	1989	1989, 1998	1989, 1992
Bolivia	1994	n.a.	1998[a]	1998[a]	1996	2000
Brazil	1995	n.a.	1993[b]	1994–95	1995	n.a.
Chile	1985	1986	1990	1990	1985, 1994	1988–89
Colombia	1991	n.a.	1991	n.a.	1991	n.a.
Ecuador	1994	n.a.	n.a.	n.a.	pending	n.a.
Mexico	n.a.	n.a.	1989	1995	1989, 1996	n.a.
Peru	1992	n.a.	n.a.	n.a.	1992, 1998	n.a.
Venezuela, R.B. de	pending	n.a.	n.a.	n.a.	1990, 1997	n.a.

n.a. Not applicable.

a. A concession law appeared in 1998, although three concessions had been granted to the private sector after 1996, before the concession law was passed.

b. In early April 2000, the government announced a new format for the toll-road concessions to come.

Source: Country summaries in the appendix.

Table 2B.2 Sale and/or Concession of Public Enterprises in Infrastructure Sectors
(starting year)

	Energy		Transport			
Country	*Electricity*	*Gas*	*Roads*	*Railways*	*Telecom*	*Water*
Argentina	1992	1992	1990[d]	1990[d]	1990	1993[d]
Bolivia	1995	..	..	1996[d]	1996	1997[d]
Brazil	1996	1997[a]	1996[d]	1996[d]	1996	..
Chile	1986	1986[b]	1993[d]	1995–97	1986	1993[d]
Colombia	1992	1996[b]	1994[d]	..	..	..
Ecuador	pending	..	..	..	..	..
Mexico	..	1995–97[c]	1989[d]	1996[d]	1990	1994[d]
Peru	1994	..	..	..	1994	..
Venezuela, R.B. de	pending	..	..	..	1991	..

.. Negligible.

a. Some partial divestitures were carried out. The bulk of gas generation and distribution is in public hands.

b. Only one privatization was carried out (Promigas).

c. Repsol was partially privatized in two stages, 1995 and 1997.

d. O&M with major private capital expenditure (concessions).

Source: Country summaries in the appendix.

Table 2B.3 Greenfield Projects in Infrastructure Sectors
(starting year)

	Energy		*Transport*			
Country	*Electricity*	*Gas*	*Roads*	*Railways*	*Telecom*	*Water*
Argentina	1992	1996	..	..	1990	..
Bolivia	1997	..	..	..	..	..
Brazil	1984	1998	..	1996	1984	1995
Chile	1990	1995	..	..	1986	1996
Colombia	1993	1994	..	..	1994	1997
Ecuador	1996	..	..	..	1994	..
Mexico	1998	1996	..	..	1990	1993
Peru	1996	..	..	..	1990	..
Venezuela, R.B. de	1992	..	..	..	1991	..

.. Negligible.
Source: Country summaries in the appendix.

2B.2, and 2B.3). The discussion focuses on the nine countries under consideration in the main text and draws from national sources.[13]

Overview

For each country and sector examined, we highlight (a) the timing of the sale or the concession of public enterprises to the private sector; (b) the opening up to private greenfield projects, that is, investment primarily related to the acquisition of new assets; and (c) the passage of reform legislation, which may precede or follow private sector entry into old or new infrastructure projects. In some cases reform legislation is passed in two waves: the first one aims at allowing private entry, whereas the second establishes the regulatory framework in the liberalized sector.

Drawing from the country summaries that follow, it is possible to construct a comparative timetable for each of these three reform dimensions. This is done in tables 2B.1, 2B.2, and 2B.3. On the basis of these tables, we construct table 2.3 in the main text, which for each sector and country takes as the relevant date the earliest one of the three dates in the tables above.

Some specific issues should be kept in mind. First, in the telecommunications sector, there are typically two stages: privatization and liberalization (of access and/or tariffs), when the monopoly status disappears and competition is allowed. Second, in the power sector, privatization and liberalization typically came together. Third, in the gas sector, whenever private participation is allowed, the private sector's main task is related to pipeline projects.

Country Summaries

Argentina

Argentina started its privatization program in 1989 after the approval of the Ley de Reforma del Estado (No. 23696) under the Menem presidency. That law authorized privatization of public enterprises (PE). The comprehensive privatization program was launched jointly with an ambitious program of structural adjustment. During 1990–92, 20 public enterprises were fully or partially privatized.

In the electricity sector, privatization of the three public enterprises, Servicios Eléctricos del Gran Buenos Aires (SEGBA), Hidroeléctrica Nor-Patagónica S.A. (HYDRONOR S.A.), and Agua y Energía Eléctrica de Argentina (AYEE) started in 1992. Although greenfield projects have been proposed since 1992, the bulk of them have taken place after 1995.

The publicly owned companies in the gas and petrol sectors were also privatized. Gas del Estado was privatized in 1992. Only one greenfield project was proposed in 1996 with a total investment of US$350 million.

The Empresa Nacional de Telecomunicaciones (ENTEL) started privatizing in 1990 and was divided into four new private companies (Telecom S.A., Telefonica de Argentina, Telinter, and Startel). Like Mexico and the República Bolivariana de Venezuela, the publicly owned telecommunication companies were sold with a monopoly on basic service for a fixed period of exclusivity, but with requirements to expand and improve basic service. Greenfield projects were also proposed after 1990, although most of them took place after 1995 because of the monopoly structure of the sector after privatization.

After 1990 the private sector was awarded toll concessions on most transited roads. The concessionaires of toll roads are responsible for maintenance, construction, and reconstruction operations. There are no greenfield projects in the sector. Concessions of railways (freight network, passenger, and commuter urban railroads) also started in 1990. There are no greenfield projects in the sector.

Finally, water supply and sewerage services were decentralized to the provinces in 1980, but the central government retained control over services in the capital city. In 1993 a concession was granted for the operation of water and sanitation services in Buenos Aires, through franchise bidding, to the private sector. Additionally, since 1995, some concessions

(Build-Rehabilitate-Operate-Transfer, BROT) have been awarded to the private sector to operate potable water supply and sewerage services in the provinces of Santa Fe, Cordoba, Corrientes, and Tucuman. There are no greenfield projects in the sector. Legal support for water and sanitation reforms comes from the Ley de Reforma del Estado in 1989, and the Decree 9999/92 to define the regulatory framework.

Bolivia

In the telecommunications sector, the government established a new legal and regulatory framework in 1996. The new law facilitated, among other things, the immediate entry by the private sector into such areas as leased lines, cellular phones, and data transmission. To capitalize the sector, ENTEL became a mixed corporation whose shares were owned by the government and by ENTEL workers. Although greenfield projects have existed since 1987, they were negligible in number and investment volume relative to other countries until 1996, when they started to become more important and once the new telecommunication regulation was enacted.

The general electricity law, approved in December 1994, mandated vertical deintegration of the sector. Currently, in the electricity sector, the state-owned, vertically integrated Empresa Nacional de Electricidad S.A. (ENDE) owns about 62 percent of the installed capacity and supplies around 56 percent of the generation sold at the bulk power level. The investor-owned, vertically integrated Corporación Boliviana de Energía Eléctrica (COBEE) owns some 19 percent of the total installed generating capacity. The privately owned Cooperativa Rural de Electrificacion (CRE) provides distribution services in Sta Cruz. Only one greenfield project was proposed in 1997 with an investment volume of US$97 million.

Provision and distribution of gas is in public hands. Only one greenfield project was proposed, in 1998, with an investment volume of US$2.2 billion. The sector has not been liberalized.

Some railways concessions were provided to the private sector in 1996–97. No greenfield projects have been proposed. A law for concessions was enacted in 1998.

Roads management, maintenance, construction, and reconstruction are under government control. No greenfield projects have been proposed. A concessions law was enacted in 1998.

Finally, only a few concessions were granted to the private sector for water supply and sewerage services in 1997. No greenfield projects have been proposed. A new law has been presented recently (2000) to allow private participation in the sector.

Brazil

Brazil started its privatization process under the Collor de Melo presidency in October 1991. The process began with a reduced number of public enterprises in the tradable goods sector (mining, manufactures).

Currently, in the electricity sector, Centrais Electricas Brasileiras S.A. (Electrobras) is a federal utility holding company, with four regional integrated generating and transmission utility subsidiaries. The federal government owns, via Electrobras' newly created subsidiary Sistema Nacional de Transmissao de Energia Elétrico (SINTREL), the two high-voltage interconnected transmission systems. State government and municipalities own most of the distribution utilities. The state of Tocatins started to privatize its distribution utility in 1990; other state-owned (central and noncentral government) utilities were considered for privatization in 1995, with privatization beginning in 1996. Although greenfield projects started to appear in 1984, they were negligible in volume. The bulk of this type of project in the power sector appeared in 1996, together with the privatization process.

Only some partial divestitures were carried out in the gas sector in 1997. The bulk of the generation and distribution of gas is in public hands. Only one important greenfield project (BROT type) was proposed in the sector in 1998 with a total investment volume of US$2.2 billion. The sector is not liberalized.

In the telecommunications sector, full divestitures started in 1996. There have been greenfield projects since 1984, although of negligible size and number. Greenfield projects started to become significant in number and volume after 1997, together with the privatization process.

As for roads, a Federal Road Concession Program for toll roads was created in 1993, with a first wave of concessions taking place in 1994–95. The second wave of concessions was prepared in 1996. However, state and municipal governments manage the bulk of the road network. In early April 2000, the government announced a new format for the toll-road concessions to come. There are no greenfield projects in the sector.

Initially railways were under full control of the public sector through three public operators: Rede Ferroviaria Federal (RFFSA), Ferrovias Paulistas (FEPASA), and Companhia Vale Rio Doce (CVRD). However, poor performance resulted in pressures to privatize the sector. Concessions were granted in the rail sector in 1996–98. The bids (FEPASA, RFFSA) were for the operation and maintenance of each network for 30 years. Only one greenfield project was proposed in 1996 with a volume of US$1.26 billion.

Finally, no privatization program was carried out in the water and sewerage sectors. A negligible number of greenfield projects were proposed after 1995 and were generally modest in investment volume. The sector has not been liberalized.

Chile

Chile was a leader in privatization, having started in 1975. Two privatization waves can be distinguished: the first during 1975–82 and the second during 1985–89. In 1990 the new democratic government modified the privatization process, announcing that the sale of controlling stakes to the private sector would be limited to a few, small public enterprises; in other cases only a minority participation would become available to private investors. The government also announced its willingness to allow private participation in public infrastructure projects (water and sewerage, roads, and railways).

Concessions have been a main tool for promoting competition. Laws regulating the electric and telecommunications sectors in Chile guarantee all firms applying for a concession the right to receive it. Concessions have been provided to any private sector agent seeking them, even in industries or stages of production and distribution that are closer to being natural monopolies. The rationale is that the regulator, by increasing the number of producers, favors consumers by creating the conditions for more competition, but the result is that concessions frequently overlap.

In the telecommunications sector, the Corporación de Fomento de la Producción (CORFO), a state-owned corporation, owned 89.5 percent of Compañía de Telecomunicaciones de Chile (CTC) and 99 percent of ENTEL until 1986. The privatization of these two public telecommunication enterprises started in 1986 and was completed in 1990. In 1994 competition for national long-distance service was finally allowed and in 1997 seven firms joined CTC and ENTEL to compete in the domestic long-distance service market. Also, competition in the cellular mobile telephone industry increased.

The second wave of privatization in the electricity sector ran from 1986 until 1990. The two public enterprises, Empresa Nacional de Energía S.A. (ENDESA) (generation, distribution) and Compañía Eléctrica de Chile (CHILECTRA) (distribution) were privatized and split into different enterprises. Greenfield projects appeared in 1990 and started to be significant in volume (even if not in number) in 1994. Currently all power generation is in the hands of the private sector.

In the gas sector no privatization as such was carried out. Generation or exploitation is still in public hands, transportation of gas is done by public enterprises or by entities with concessions, and gas distribution is carried out by entities with concessions only since 1986, when the law for concessions was enacted. Greenfield projects in the sector are negligible.

In the road and rail sector, railway privatization started in 1995 with partial divestiture of Ferrocarril del Pacífico S.A. (FEPASA) and it continued with the full divestiture of Ferrocarril Regional del Norte (FERRONOR) in 1997. Since 1993 the government has been approving concessions to the private sector to manage the road network. There are no greenfield projects in the transport sector.

Between 1988 and 1989, new legislation decentralized responsibility for publicly owned water and sewerage services in Chile, by creating autonomous regional service companies. The national government owns the majority of shares in these companies through its Development Corporation. A national regulatory agency, the Superintendence of Sanitary Services, was created to regulate both public and private water and sewerage services. Under Chilean law, all water service companies, whether public or private, are structured as stock corporations and operate by virtue of concessions granted by the Ministry of Public Works. Concessions, which are granted for an indefinite period of time, have been awarded since 1993. No greenfield projects are present in the sector.

Colombia

The Constitucion Politica of 1991 was established to put an end to the state monopoly in public services. After the constitution, a significant number of public enterprises were singled out for privatization, among them major mining, banking, and tourism enterprises.

On the telecommunications side, Colombia chose to open the sector to new competition instead of privatization. Several greenfield projects were presented after 1994.

Reform of the power sector started in 1992 (including privatization of some public entities) and finished in 1998, having achieved a major degree of private participation in the sector. A number of greenfield projects appeared after 1993.

In the gas industry only one privatization was carried out in 1996 (Promigas). Greenfield projects are negligible in the gas sector.

Some concessions of highways were approved in 1994. However, railway management remains under public sector control. There are no greenfield projects in the transport sectors.

Finally, water supply and sewerage services were not privatized and only one greenfield project was proposed, in 1997.

Ecuador

In the telecommunications sector, the Instituto Ecuatoriano de Telecomunicaciones (IETEL) was owned entirely by the Ecuadorian state. IETEL also had the monopoly for local, long-distance, and international telephone service. IETEL had the authority to regulate the telecommunication sector until 1992, when a separate regulatory organization was set up to perform this task—the Superintendencia de Telecomunicaciones (SUPTEL)—along with a new state-owned corporation named Empresa Estatal de Telecomunicaciones (EMETEL). This corporation took over the assets of IETEL and was granted monopoly status for the provision of local, long-distance, and international telephone services. In preparing EMETEL for privatization, in June 1997, the government divided the firm into two limited liability companies. After rescheduling the auction for both companies several times, when the final date arrived (November 20, 1997) none of the interested investors submitted a bid. Only a few small greenfield projects were carried out after 1994 (two a year).

In the electricity sector, the main entities are the state-owned and vertically integrated Instituto Ecuatoriano de Electrificación (INECEL); the investor-owned utility Empresa Eléctrica de Ecuador (EMELEC), which has been subject to INECEL's technical and financial control since 1985; and several private and municipal entities. Legislation submitted to congress in 1994 proposed to restructure the sector, advocating deregulation and competition. The proposed law would divest all government-owned assets in generation, transmission, and distribution after reorganizing INECEL and consolidating distribution utilities into four or five enterprises. All new investment would be undertaken by the private sector. However, the privatization process is still pending. Only one greenfield project was initiated in 1996 with a total investment cost of US$30 million.

Mexico

In 1989 a law allowing privatization of the telecommunication state-owned enterprise was enacted. Before the privatization in 1990, Telecomunicaciones de México (TELMEX) was a 66-percent-state-owned corporation, with the rest in the hands of local private shareholders. In 1990, TELMEX was granted a monopoly on fixed line telephone services until August 1996. After 1996 other firms offered long-distance services, but TELMEX will maintain the monopoly for local fixed telephone services until 2026. Cellular telephones and value-added services were opened to competition immediately. Since privatization, several firms have been awarded licenses for cellular and long-distance telephone service. Greenfield projects in the sector started to be significant after 1996.

In the electricity sector, the Comisión Federal de Electricidad (CFE) is a state-owned enterprise that currently owns and operates most generating plants serving the public power system and provides all transmission and distribution service except in Mexico City. Since 1992, private power generators in the form of independent power producers (IPPs), self-generators, co-generators, and power importers are allowed to participate in the sector. Greenfield projects are almost negligible (only one in 1998). The liberalization of the sector is, then, still pending.

In the gas sector, Repsol was partially privatized in two stages, 1995 and 1997. Additionally, greenfield projects started to have some weight in 1997.

Until the early 1990s, publicly owned Ferrocarriles Nacionales de Mexico (FNM) was the largest company in the railway sector. The process of reform took off with President Carlos Zedillo. In February 1995 the Mexican Congress approved an amendment to the constitution opening opportunities for private sector investment. Privatization started in December 1996 with concessions of 50 years. These concessions allow bidders to operate, exploit, and build new lines. The second stage of the privatization process was the sale of the shares owned by the government in the concessionaire companies through a public bidding process open to private investors. By June 1999, the process of opening the main Mexican rail lines to private operators was almost finished and virtually the whole Mexican railroad system had been privatized.

During 1987–94, the government awarded 52 concessions of toll roads to the private sector. In April 1997, the government announced a new plan in the road sector and, in late 1997, assumed all bank liabilities along with temporary ownership of 23 toll roads.

In the water and sewerage sector, the Federal District Water Commission awarded general contracts for a 10-year period (with the possibility of extension) in 1993. Other concessions were awarded to the private sector after 1994 and a small number of greenfield projects have been developed since 1993. Private operators are involved in distribution and commercial activities, but not in production. Additionally, most private participation in the sector has been carried out through PTOs (Plantas de Tratamiento), so that full liberalization of the sector is still pending.

Peru

In the telecommunications sector, the Peruvian government sold 35 percent of its shares in ENTEL and Compañía Peruana de Teléfonos

(CPT) to Telefónica Internacional of Spain in 1994. Telefónica took over the operation of both firms and within a year the firms merged into a newly formed firm called Telefónica del Peru. At the time of privatization the firms were licensed to provide local and long-distance telephone services in the whole Peruvian territory. The license granted a five-year monopoly in fixed and long-distance service (ending in 1999). Competition in public payphones, cellular (local), cable TV, and value-added service was allowed. Two firms, Telefonica and Tele2000–Bellsouth, provide cellular mobile telephone service. However, competition in the cellular sector was allowed only in Lima until 1998 when Tele2000–Bellsouth won the concession for Band B for the rest of Peru. The number of greenfield projects in the telecommunications sector is almost negligible, with three projects in 1990 (US$150 million) and one in 1995 (US$30 million). The reason for this is the five-year monopoly status in fixed and long-distance service given to Telefonica del Peru. Thus, competition in the sector is still very weak.

The power sector underwent restructuring and initiated a major privatization program in 1994, following enactment of a new Electric Concession Law in 1992. The law opened the sector to private participation in all areas; required the separation of generating, transmission, and distribution functions and ownership; and aimed at complete divestiture of all state-owned sector enterprises. Currently, 62 percent of Peru's generation capacity and 75 percent of the country's distribution system are in private hands. Although the number of greenfield projects in the sector has been negligible so far, additional competition is being promoted.

No liberalization has taken place in the rest of the infrastructure sectors.

República Bolivariana de Venezuela

Before privatization, the Venezuelan state owned 100 percent of the assets in the telecommunications sector. Compañía Anónima Nacional de Teléfonos de Venezuela (CANTV) had a monopoly in local and long-distance service. Since 1988, it was also the sole provider of cellular phone services. In May 1991, a license for the provision of cellular telephone service was awarded to Telcel Celular S.A., a consortium of Venezuelan investors and BellSouth. Thus, Telcel Celular S.A. started competing with CANTV in the cellular phone business nationwide. In November 1991, CANTV was privatized and received a 35-year concession contract. The license granted a monopoly status for a period of nine years in local and long-distance (national and international) telephone services. That is the reason for the limited number of greenfield projects in Venezuela since 1991 (four in 1998 and only one project from 1991 to 1996). The sector was not liberalized until more recently (1997).

In the electricity sector, there are five state-owned and seven investor-owned utilities (IOUs) The largest state-owned enterprises are Electrificación de Caroni (EDELCA) and Compañía Anónima de Administración y Fomento Eléctrico (CADAFE). Electricidad de Caracas (EdC) is the main IOU, supplying most of Caracas and holding part ownership in three other IOUs. Distribution systems were reorganized into regional enterprises before privatization. CADAFE is being reorganized into four regional distribution units, a separate transmission unit, and separate hydro and thermal generating units, with privatization expected for many of these units. There have been a few greenfield projects since 1992 (a total of five each year, stopping in 1996). Liberalization of the sector is, then, pending. No liberalization has taken place in the rest of the infrastructure sectors.

Notes

1. The data are drawn from the infrastructure database assembled for this research. A summary description of the sources and coverage is given in appendix 2A.

2. OECD is defined here excluding the Republic of Korea and Mexico.

3. The country detail is similar in the case of total phone lines and local connection capacity, and therefore for the sake of brevity is not presented.

4. This is particularly so in the case of unpaved roads. An indicator preferable to road length, used in the text, would be their length in terms of lane–kilometers equivalent, but such information is not widely available across countries and over time. However, even this improved metric cannot reflect the overall efficiency of the road network, which can vary greatly across countries.

5. The data sources are described in appendix 2A.

6. The small magnitude of the regression coefficient is somewhat puzzling. Allowing for lagged effects of the primary balance does not lead to significant changes.

7. To smooth some large jumps in the data series, we use a centered three-year moving average in the graphs. This means that they would not be greatly affected qualitatively if the reform date were to be shifted forward or backward by one or two years.

8. We calculate the prereform public spending per capita as the average over 1970–89 for all countries that have data on the sector, in 1995 dollars.

9. Other experiments using instead the log of real infrastructure spending, or its ratio to the lagged stock, as explanatory variable yield qualitatively similar results, so we do not report them here. In the cases of telecom and transport routes, we also experimented with alternative definitions of the dependent variable: total phone lines, rather than main lines, for telecommunications; and total and paved roads, rather than total roads plus railways, for transport. The results were virtually indistinguishable from those reported in the table.

10. 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 an additional variable, but it always turned 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.

11. We return to these issues in chapters 3 and 4.

12. Canning suggested, however, that the data on the length of the line could present some problems. First, they do not take account of the number of tracks in the railway. Second, there are changes in the coverage because of the treatment of rail lines owned by companies for industrial use and not open to the public (for example, railways owned by the sugar industry in Latin America).

13. The material in this appendix is based on background work by Pilar Blanco.

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3

The Output Cost of Latin America's Infrastructure Gap

César Calderón and Luis Servén

CHAPTER 2 SHOWED THAT OVER THE last two decades Latin America lost substantial ground vis-à-vis other developing and industrial regions in the quality and quantity of infrastructure assets. Although there was considerable diversity across countries in the magnitude of this phenomenon, it affected virtually all infrastructure sectors in all of the region's countries.

Table 3.1 provides a summary illustration of Latin America's infrastructure growth relative to that of the seven successful economies of East Asia (the "tigers").[1] The table presents the change in the infrastructure gap over 1980–97—measured by East Asia's infrastructure stocks per worker relative to those of Latin America—using both regional averages and medians.

The two sets of figures tell the same story. Latin America's infrastructure gap grew by a huge margin in the last two decades: 40 to 50 percent for road length, 50 to 60 percent for telecommunications (defined as the total number of main telephone lines), and as much as 90 to 100 percent in power generation capacity. The loss of ground was particularly marked in the 1980s for all three assets in the table. In the 1990s Latin America continued to fall behind at a rapid pace in power generation capacity, but its loss of ground in transport routes proceeded at a slower pace than in the previous decade and the gap in telecommunications infrastructure ceased to expand.[2]

The consequences of this loss of ground for growth and welfare in the region are a matter of concern. Lack of adequate infrastructure services results in lower productivity and higher production costs for private producers. Poor road and telecommunication networks

Table 3.1 The Widening Infrastructure Gap, Latin America versus East Asia
(percentage change in relative infrastructure stocks per worker)

	Medians by region			*Simple averages by region*		
Infrastructure asset	*1980–97*	*1980–89*	*1990–97*	*1980–97*	*1980–89*	*1990–97*
Main phone lines	63.58	45.86	–14.01	47.61	42.52	2.98
Power generating capacity	101.21	50.03	40.66	91.14	45.61	39.56
Roads	43.98	21.34	10.09	52.53	36.11	13.14
Memo item:						
Change in relative GDP per worker	88.89	52.66	26.60	90.24	55.75	26.55

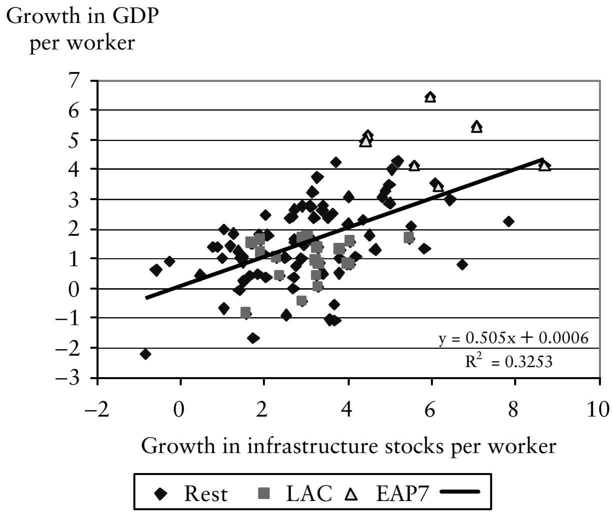
Note: Each cell in the table shows the percentage change in the stock of the respective infrastructure asset in East Asia minus the same change in Latin America.
Source: Authors' calculations.

increase transport and, more generally, logistic costs, which—for Latin America—have been shown in comparative studies to exceed the international norm by wide margins (Guasch and Kogan 2001). The reduced profitability in turn discourages private investment. Through all these channels, the result is lower output growth. For later reference, the bottom of table 3.1 also shows that the gap in gross domestic product (GDP) per worker (in terms of adjusted purchasing power parity [PPP]) between East Asia and Latin America grew by some 90 percent over 1980–97. As with infrastructure, Latin America's loss of ground was particularly marked in the 1980s.

Figure 3.1 brings out graphically the association between infrastructure accumulation and growth performance. The figure plots the average growth rate of GDP per worker over the last four decades against the average rate of growth of infrastructure endowments—with the latter measured by the simple average of the growth rates of phone lines, kilometers of roads, and power generation capacity, all in per-worker terms. Even with this crude measure of infrastructure stocks, a strong positive correlation is apparent between infrastructure accumulation and growth performance. A simple cross-country regression of growth on infrastructure accumulation yields a highly significant positive regression coefficient and an R^2 of 32 percent.

Strong as this empirical association is, it need not reflect causation from infrastructure services to aggregate output. The observed correlation could reflect reverse causation from GDP to infrastructure demand, or the action of third factors affecting both GDP and

Figure 3.1 Infrastructure Accumulation and Growth, 1960–97 (country averages, percent)



Note: EAP7 = seven countries in the East Asia and Pacific region; LAC = Latin America and the Caribbean region; Rest = all other countries.

infrastructure stocks. Thus, the key question is: what was the role of Latin America's growing infrastructure gap in the widening of the output gap? The rest of this chapter is devoted to answering that question.

Methodological Approach

The empirical approach of this chapter is based on the estimation of an aggregate production function augmented with infrastructure capital. The analysis is related closely to that in Canning 1999, and follows a recent literature concerned with the contribution of infrastructure to aggregate output (Canning and Bennathan 2000, Demetriades and Mamuneas 2000, Esfahani and Ramirez 2002, and Röller and Waverman 2001).

For simplicity, the approach taken here follows the literature in adopting a Cobb–Douglas specification of the infrastructure-augmented production function:[3]

$$y = \alpha k + \beta h + \gamma z + (1 - \alpha - \beta + \gamma)l \qquad (3.1)$$

where y is aggregate value added (GDP), k is the physical noninfrastructure capital stock, l denotes labor, h is human capital, and z is a measure of infrastructure capital. All the variables are expressed in logs, and constant returns to scale are assumed.

It is important to note that (3.1) implicitly assumes that infrastructure services are a fixed proportion of the infrastructure capital stock. Thus, other things being equal, larger stocks should be reflected in higher aggregate output. This approach is analogous to that conventionally used in standard production functions excluding infrastructure, which assume that physical and human capital services are proportional to the respective stocks k and h.

In principle, the parameter γ in (3.1) should capture the elasticity of output with respect to infrastructure for given values of the other inputs. However, this presumes that k includes noninfrastructure capital only. In reality, what this includes is data on the *total* capital stock, including both infrastructure and other physical assets. Thus, infrastructure capital appears twice in the equations—as part of k, and separately as z. Hence, the parameter γ captures the extent to which the productivity of infrastructure *exceeds* (if $\gamma > 0$) or falls short of ($\gamma < 0$) the productivity of noninfrastructure capital. See Canning 1999 for further discussion.

The contribution of infrastructure capital to output can be found by noting that the measured capital stock is a weighted sum of infrastructure and other physical assets, with weights given by their respective relative prices. Thus, letting $\tilde{k}$ denote noninfrastructure physical capital, one can write:

$$k \approx \frac{\tilde{K}}{\tilde{K} + p_z Z}\tilde{k} + \frac{p_z Z}{\tilde{K} + p_z Z} z \tag{3.2}$$

where uppercase letters denote the anti-logs of lowercase variables; p_z is the relative price of infrastructure capital in terms of noninfrastructure capital; and the assumption is that the latter is approximately equal to the price of overall capital, under the presumption that infrastructure assets are typically a small fraction of the total capital stock.[4]

Combining (3.1) and (3.2), the elasticity of output with respect to infrastructure can be expressed:

$$\frac{\partial y}{\partial z} = \mathrm{g} + \mathrm{ua} \equiv \mathrm{h}_z \tag{3.3}$$

where

$$\mathrm{u} \equiv \frac{p_z Z}{\tilde{K} + p_z Z} \tag{3.4}$$

is the share of infrastructure in the overall physical capital stock. These expressions involve log-linear approximations around an arbitrary point (for example, the sample mean), and hence θ should be evaluated accordingly. In practice, because infrastructure stocks typically account for relatively small portions of the overall capital stock, the difference between η_z and the *naïve* estimate γ should be fairly modest.

Finally, it is worth noting that (3.4) captures only the *direct* impact of infrastructure on output, leaving aside the possible indirect impact occurring through the effects of infrastructure on the accumulation of other productive inputs, of which the most important is noninfrastructure capital. To the extent that both types of capital are gross complements in production (as assumed here), an increase in infrastructure capital raises the profitability of noninfrastructure capital and, other things being equal, should lead over time to a higher $\tilde{K}$, which in turn should cause a further output expansion. By ignoring this indirect effect, the contribution of infrastructure to output over the long term is likely to be underestimated in the calculation below.[5]

Empirical Implementation

For estimation purposes, equation 3.1 above is rewritten in terms of ratios to the labor force:

$$y_{it} - l_{it} = a_i + b_t + \alpha(k_{it} - l_{it}) + \beta(h_{it} - l_{it}) + \gamma(z_{it} - l_{it}) + \varepsilon_{it} \qquad (3.5)$$

Here the subscripts i and t are used to index countries and years, respectively; the terms a_i, b_t capture country-specific and time-specific productivity factors; and ε_{it} is a random disturbance that will be assumed uncorrelated across countries and over time.

The objective is to estimate the parameters of equation 3.5 using a large panel data set. Annual data for the period 1960–97 from 101 industrial and developing countries are used—or close to 4,000 observations. In practice, some of the instrumental variable estimators employed below use up several lags of the variables to construct instruments, so that the effective data set comprises 101 countries and 3,232 observations. To ensure comparability across estimators, the data set is limited to this reduced sample even when employing simpler estimators using no lags.[6]

Sample coverage and data sources are described in detail in the appendix. The measures used for output (GDP) and physical capital per worker are based on suitably expanded versions of the Summers-Heston data set (Summers and Heston 1991), whereas the (log) human capital stock is measured by the number of years of secondary schooling of the working-age population.[7]

Regarding infrastructure capital, the focus is primarily on the three standard indicators of infrastructure endowments used in table 3.1: electricity generating capacity (in gigawatts), road length (in kilometers), and the number of main telephone lines. However, some experiments are also performed with alternative measures of infrastructure capital. Each of these variables is scaled dividing by the total labor force. Although these measures of infrastructure capital are admittedly crude—in particular, they do not capture variations in the quality of infrastructure—they are chosen because of their broad availability across countries and over time, and their frequent use in the recent empirical growth literature.

There is by now a considerable literature reporting empirical estimates of equations similar to (3.5) above (see Gramlich 1994 for an overview). In the present panel context, there are four main issues to take into consideration: cross-country heterogeneity, common factors, measurement error, and endogeneity.

The first issue is the possible cross-country heterogeneity of the production technology. Imposing a common technology when in reality production functions vary across countries would lead to inconsistent estimates. To address this issue, country-specific effects a_i are allowed for in the estimations below. Omission of fixed effects is known to lead to a large overstatement of the contribution of infrastructure to output (see, for example, Holtz-Eakin 1994, and Röller and Waverman 2001).

A second specification issue concerns the possible existence of omitted common factors—such as the world business cycle—causing output to move together across countries. These common factors can result in cross-country residual correlation, which in turn leads to invalid inferences with the estimation methods to be used below. To eliminate the common factors, time-specific effects in the estimated regressions are allowed for; this is equivalent to a regression in which each variable enters as a deviation from its cross-sectional mean in the year in question.

The third problem is measurement error, which is likely to be important particularly for infrastructure stocks. There are two reasons for this. On the one hand, the quality of the stocks (for example, the condition and capacity of roads or the reliability of power plants) can vary greatly not only across countries but also within countries. It is unfortunate that data on the quality of infrastructure are not readily available for a large cross-country time-series data set such as the one under consideration.[8] On the other hand, the timing of changes to the reported infrastructure stocks is to some extent arbitrary. For example, impassable roads or unusable portions of railway track may remain in the books for some time before being suddenly removed from the reported stock figures, or new power plants may not become fully operational until some time after completion. Formally, these considerations imply that infrastructure may be measured with error, so that the time-varying disturbance ε_{it} may include a measurement error correlated with the infrastructure variables. Standard estimates of (3.5) would therefore be subject to attenuation bias, most likely causing underestimation of the coefficients of the infrastructure stocks.

Related to this is the problem of endogeneity, which may affect the infrastructure regressors in (3.5) and perhaps the physical and human capital stocks per worker. It can be argued that infrastructure stocks are jointly determined with output per worker, but the positive correlation of infrastructure stocks with output found in the data could merely reflect the fact that the income elasticity of infrastructure demand is positive. Arguably, similar considerations could be made for the physical and human capital stocks.

In the univariate case, standard least-squares estimation in the presence of reverse causation from output to infrastructure would lead to an upward bias in the infrastructure coefficient; in the multivariate case the situation is more complex and the direction of the bias cannot be established a priori—and even more complex in the presence of measurement error that may introduce attenuation bias.

One way to address the two-way causality between infrastructure and output would be to develop a fully specified simultaneous model of infrastructure supply and demand. Unfortunately, this would pose stringent data requirements well beyond the scope of this research.[9]

An alternative, less-demanding way to tackle both measurement error and endogeneity is to use an instrumental-variable estimation approach. However, there are few exogenous instruments available with the broad time-series and cross-country coverage needed here. Demographic variables are perhaps the only obvious source of identifying information, because they are likely to affect the demand for infrastructure (as well as physical and human capital) services without being subject to reverse causation or correlated with the infrastructure measurement error. Thus, urban population and population density (both in logs) are used as outside instruments.[10]

These strictly exogenous instruments are complemented with appropriate *internal* (that is, weakly exogenous) instruments constructed along the lines of Griliches and Hausman (1986) and Arellano and Bond (1991), given by suitably lagged values of the explanatory variables in (3.5). Specifically, the first differences of (3.5) are used to remove the country-specific effect:[11]

$$\Delta(y_{it} - l_{it}) = c_t + \mathrm{a}\Delta(k_{it} - l_{it}) + \mathrm{b}\Delta(h_{it} - l_{it}) + \mathrm{g}\Delta(z_{it} - l_{it}) + \Delta \mathrm{e}_{it} \tag{3.6}$$

where $c_t = b_t - b_{t-1}$. Under appropriate assumptions about the serial correlation of ε_{it} (the time-varying disturbance, possibly inclusive of measurement error), lagged levels of the variables on the right side become valid instruments. In particular, if ε_{it} is serially uncorrelated and the regressors are weakly exogenous (that is, uncorrelated with *future* realizations of ε_{it} but not with its current or past realizations), then the second and higher lags of the regressors become valid instruments in (3.6). More generally, if ε_{it} follows a moving average process of order q, then lags $q+2$ and higher of the regressors would become valid instruments.

Validity of the instruments used in the estimation can be tested directly through Sargan tests of orthogonality between the instruments and the error term, as well as indirectly through tests of first- and higher-order autocorrelation of the errors (see Arellano and Bond 1991). For example, if ε_{it} is serially uncorrelated, then its first difference included in (3.6) should display first- but no higher-order autocorrelation, in which case twice-lagged regressors are indeed valid instruments, as stated earlier.

The above discussion characterizes the generalized method of moments (GMM) estimator in first differences of Arellano and Bond (1991). However, under additional assumptions, a more efficient IV estimator may be available: the system GMM estimator of Blundell and Bond (1998), which combined estimation of (3.6) and (3.5) using lagged *differences* of the regressors as instruments in the level equation 3.5.[12] The validity of these *additional* instruments can be checked through difference-Sargan tests of orthogonality between the extra instruments and the error term.

Estimation Results

Table 3.2 reports the sample correlations among the dependent and independent variables. The figures below the main diagonal reflect the correlation among the levels of the variables, whereas those above the diagonal correspond to their first differences. Anticipating some of the experiments below, two alternative infrastructure measures are presented for transport routes, total roads, and total roads plus railways (with the latter variable available only for a smaller country sample), and two measures as well for telecommunications—main lines and total lines, including cellular.[13]

In both levels and differences, real GDP per worker shows a significant correlation with each of the infrastructure measures and with the physical and human capital stocks per worker. Among the infrastructure variables, the biggest correlation with GDP corresponds by

Table 3.2 Sample Correlations

Variable	*GDP*	*Physical capital*	*Secondary schooling*	*Electricity generating capacity*	*Roads*	*Transport routes*	*Main phone lines*	*Total phone lines*
GDP	n.a.	0.21**	0.04**	0.07**	0.05**	0.05**	0.13**	0.14**
Physical capital	0.71**	n.a.	0.01	0.05**	0.02	0.02	0.06**	0.06**
Secondary schooling	0.39**	0.34**	n.a.	–0.05**	−0.01	0.00	0.05**	0.11**
Electricity generating capacity	0.50**	0.47**	0.29**	n.a.	0.03	0.03	0.07**	0.05**
Roads	0.23**	0.20**	0.02	0.21**	n.a.	1.00**	0.03	0.03
Transport routes	0.22**	0.20**	0.02	0.19**	1.00**	n.a.	0.04**	0.03
Main phone lines	0.58**	0.55**	0.30**	0.60**	0.27**	0.25**	n.a.	0.97**
Total phone lines	0.60**	0.57**	0.32**	0.59**	0.28**	0.26**	1.00**	n.a.

n.a. = Not applicable.

Note: All variables are measured per worker and (except schooling) expressed in logs. Values below the main diagonal refer to the variables in levels; values above the diagonal refer to first differences.

**Significant at 5 percent.

Source: Authors' calculations.

far to the telecommunication measures. Unsurprisingly, the magnitude of the correlations is much bigger when the variables are expressed in levels than when they are expressed in differences. In turn, the infrastructure measures are also positively correlated with each other, again more so in terms of levels than in terms of differences. Finally, there seems to be little difference between the two alternative measures of transport routes (their correlation exceeds 0.99 in both levels and differences) and the two measures of telecommunications infrastructure (their correlation is 0.97 in differences and virtually 1.00 in levels).

Before proceeding to GMM estimation, table 3.3 reports empirical results using simpler estimators for equation 3.5.[14] The first two columns present ordinary least-squares (OLS) estimates on the cross-section (column one) and pooled sample (column two), neither of which is robust to heterogeneity, measurement error, or endogeneity of the regressors. The two sets of estimates are similar: in both cases a

Table 3.3 Infrastructure-Augmented Production Function: Alternative Estimates

	1	2	3	4
Variable	*Cross-section OLS*	*Pooled OLS*	*Within*	*2SLS*
Physical capital	0.472	0.387	0.245	0.414
	(5.324)	(7.685)	(7.199)	(7.644)
Secondary schooling	–0.005	0.016	0.135	0.017
	(0.123)	(0.474)	(2.758)	(0.492)
Electricity generating capacity	0.030	0.051	0.068	0.047
	(0.512)	(1.137)	(2.294)	(1.002)
Roads	–0.055	–0.046	0.026	–0.049
	(1.702)	(1.473)	(0.707)	(1.586)
Main phone lines	0.147	0.185	0.133	0.169
	(2.433)	(4.432)	(4.544)	(3.883)
R^2	0.954	0.939	0.987	0.939
1st-order autocorrelation (p-value)	n.a.	0.000	0.341	0.000
2nd-order autocorrelation (p-value)	n.a.	0.000	0.945	0.000
Number of observations	101	3,232	3,232	3,232
Number of countries	101	101	101	101

Note: Dependent variable is log GDP per worker. 2SLS = two-stage least-squares. All variables are measured per worker and (except schooling) expressed in logs. t-statistics in brackets are heteroskedasticity-consistent.

Source: Authors' calculations.

sizable output contribution of the capital stock and a significant effect of telecommunications infrastructure are found. The remaining coefficients are insignificant, although that on transport routes approaches statistical significance with a counterintuitive negative sign. The pooled OLS results also show strong evidence of serial correlation of the residuals, a clear symptom of misspecification.

Column three reports the within estimator, which controls for country-specific effects but not for endogeneity or measurement error. In the presence of the latter, the within transformation can lead to badly misleading estimates (see Griliches and Hausman 1986). In the present case, it can be seen that all the regressors carry positive coefficients, all significantly different from zero except for that of transport routes. Among the infrastructure variables, telecommunications carries a much larger coefficient than the rest, similar to the OLS results.[15]

The estimators presented so far ignore the issues of measurement error and endogeneity. Column four reports two-stage least-squares (2SLS) estimates of (3.5) using as instruments the current and first three lags of urban population and population density, plus the second lags of the explanatory variables.[16] The estimates obtained in this manner are similar to the pooled OLS estimates and equally disappointing. Apart from the physical capital stock, only the telecommunications variable is significant. Moreover, a Sargan test rejects the validity of the instrument with a p-value of less than 0.001—an unsurprising outcome in view of the strong evidence of autocorrelation of the residuals shown in the table, which provides a clear indication of misspecification.

Table 3.4 turns to GMM estimation using alternative specifications and instrument sets. Column one reports the base specification, using the difference-GMM estimator and the same instrument set as in the last column of table 3.3—twice-lagged levels of the explanatory variables plus the current value and three lags of the exogenous demographic variables. Comparison of these GMM estimates with the within estimates in table 3.3 shows that in every case the former are larger in magnitude than the latter, which hints at the possible presence of attenuation bias in the within estimates.[17] Moreover, the GMM estimates of the coefficients of all three infrastructure variables are all statistically significant (although only at the 10 percent level in the case of power). They are also of roughly similar magnitude. Finally, the diagnostic tests provide support for the selected specification—the Sargan test shows no evidence against the validity of the instruments and, as anticipated, the serial correlation tests hint at first-order but no higher-order serial correlation of the differenced-error term.

Column two provides a robustness check by lagging the instruments one extra period—that is, using the third rather than the second lags of

Table 3.4 Alternative GMM Estimates

Model specification, instruments	1	2	3	4
	Differences			*System*
	Levels t − 2	*Levels* t − 3	*Demographics*	*Levels + differences*
Physical capital	0.363	0.361	0.351	0.222
	(10.832)	(11.034)	(7.903)	(7.867)
Secondary schooling	0.148	0.169	0.159	0.222
	(3.361)	(3.815)	(3.443)	(5.520)
Electricity generating capacity	0.112	0.123	0.177	0.109
	(1.809)	(2.148)	(2.468)	(2.970)
Roads	0.119	0.117	0.105	–0.005
	(2.197)	(2.195)	(1.241)	(0.084)
Main phone lines	0.151	0.140	0.138	0.147
	(3.634)	(3.236)	(3.168)	(6.164)
Wald test of joint significance (*p*-value)	0.000	0.000	0.000	0.000
Sargan test (*p*-value)	0.319	0.312	0.141	0.002
1st-order autocorrelation (*p*-value)	0.111	0.106	0.143	0.555
2nd-order autocorrelation (*p*-value)	0.793	0.794	0.888	0.778
Number of observations	3,232	3,232	3,232	3,232
Number of countries	101	101	101	101

Note: All variables are measured per worker and (except schooling) expressed in logs. Dependent variable is log GDP per worker. Heteroskedasticity-consistent *t*-statistics in brackets.

Source: Authors' calculations.

the regressors as instruments (in addition to the demographic variables). The results are virtually identical to those in the preceding column, and the diagnostic tests continue to lend support to the specification.

So far, lagged infrastructure and physical capital stocks have been used as instruments. One might object that these variables belong in the production function—if infrastructure assets take time to become productive—so that they do not provide identifying information. This assertion can be tested by dropping them and limiting the instrument set to the exogenous demographic variables. Thus in column three of table 3.4 only the current and first two lags of urban population and population density, as well as their squares, are included as instruments, along with the second lag of the schooling variables. Nevertheless, the estimation results are similar to those in the preceding columns. The only exception is the coefficient on power generating capacity, which becomes considerably larger than before. All other coefficients are virtually unchanged, although that on roads is now estimated with poor precision.

Finally, in column four the system GMM estimator of Blundell and Bond (1998) is used, combining the levels equation 3.5 with the first-difference equation 3.6, and adding as instruments for the former the twice-lagged first differences of the same instruments used in column one. The parameter estimates that result are somewhat different from those obtained from the difference-GMM estimator. If anything, they are close to the within estimates in the previous table. However, the Sargan test clearly rejects the validity of the instruments, whereas the difference-Sargan test (not shown in the table) yields a p-value of less than 0.001 percent and thus provides an equally strong indication of misspecification. This suggests that the stationarity condition discussed earlier, required for the validity of the system GMM estimator, does not hold in our data.

In view of these results, the remaining experiments are based on the difference-GMM estimator and retain the same set of instruments as in the base specification of column one in table 3.4. Using this as a starting point, table 3.5 presents experiments using alternative specifications. Column one reproduces the initial specification for ease of comparison. In column two, roads plus railways are used, rather than roads alone, to summarize the transport network infrastructure. This leads to the loss of some 10 percent of the sample. The parameter estimate on the combined transport variable is similar to that obtained earlier using roads only, although the point estimate is somewhat imprecise. As for the other parameters, the coefficient on power increases about 50 percent relative to its value in column one, whereas that on phone lines declines somewhat. However, these changes are modest

Table 3.5 First-Difference GMM Estimates of Alternative Specifications

	Specification			
Variable	*1*	*2*	*3*	*4*
Physical capital	0.363	0.365	0.363	0.365
	(10.832)	(12.642)	(10.768)	(10.718)
Secondary schooling	0.148	0.119	0.139	0.153
	(3.361)	(2.780)	(3.274)	(2.792)
Electricity generating capacity	0.112	0.174	0.118	0.123
	(1.809)	(2.642)	(1.910)	(2.000)
Roads	0.119		0.117	0.119
	(2.197)		(2.180)	(2.109)
Roads + railways		0.116		
		(1.646)		
Main phone lines	0.151	0.113		0.152
	(3.634)	(2.284)		(2.832)
Total phone lines			0.161	
			(3.507)	
Main phone lines squared				–0.009
				(0.039)
Wald test of joint significance (p-value)	0.000	0.000	0.000	0.000
Sargan test (p-value)	0.319	0.607	0.329	0.261
1st-order autocorrelation (p-value)	0.111	0.115	0.12	0.110
2nd-order autocorrelation (p-value)	0.793	0.536	0.793	0.789
Number of observations	3,232	2,941	3,232	3,232
Number of countries	101	92	101	101

Note: All variables are measured per worker and (except schooling) expressed in logs. Dependent variable is log GDP per worker. Heteroskedasticity-consistent t-statistics in parentheses.

Source: Authors' calculations.

relative to the respective standard errors. The other coefficients remain unchanged.

Next, in column three main phone lines are replaced with total (main + mobile) phone lines as the indicator of telecommunications infrastructure. This makes virtually no difference for any of the parameter estimates, or for the diagnostic statistics, all of which are almost identical to those in column one.

Finally, in column four, nonlinear effects of telecommunications equipment are explored along the lines reported in Röller and

Waverman (2001); the authors found that the elasticity of output to telecommunications stocks increases with the level of the telecommunications stock. To explore this issue, the square of main phone lines per worker is added to the equation. Its estimated coefficient turns out to be negative, but wholly insignificant; the remaining coefficients show virtually no change. Thus the conclusion is that the data show little indication of nonlinear effects of telecommunications infrastructure.[18]

In all the specifications reported in table 3.5, the diagnostic statistics support the model. The Sargan tests show no evidence against the choice of instruments, and the serial correlation tests provide a mild suggestion of first- but no higher-order autocorrelation.

The Output Cost

As noted earlier, the empirical estimates reported so far do not capture the *total* contribution of infrastructure to output because infrastructure stocks are already included in the overall capital stock. To identify that impact it is necessary to compute the elasticity of output with respect to infrastructure assets, as in equations 3.3 and 3.4.

To compute the share of the different infrastructure stocks in the overall capital stock, data on the cost of infrastructure assets collected by Canning and Bennathan (2000) are used. There are some caveats, however. These costs are available only for a limited number of countries, and do not necessarily correspond to assets of homogeneous quality. They also show a large degree of cross-country variation. For the purposes of this chapter, because the primary interest is the performance of Latin America, the capital stock shares are computed using the cost data available for countries in this region and the average ratios of the relevant stocks over 1980–97; then the medians of the country-specific figures are taken as relevant regional value. Limited experiments with alternative ways to construct these shares led usually to roughly similar results; however, because many other procedures are possible, the results have to be taken as illustrative. They are reported in the middle column of table 3.6.

According to the figures in the table, telecommunications infrastructure accounts for a little more than 1 percent of the overall capital stock, whereas power and roads represent 14 percent and 16 percent, respectively. Using these shares for the calculation in equation 3.4, the elasticities reported in the third column of the table are obtained. As it turns out, the elasticities of the three infrastructure stocks are all of similar magnitude, with the largest corresponding to

Table 3.6 Elasticity of Output per Worker with Respect to Capital per Worker

Capital asset	*Regression estimate*	*Share of total capital stock*	*Total elasticity*
Infrastructure capital			
Main phone lines	0.152	0.012	0.156
Power generating capacity	0.112	0.140	0.163
Roads	0.119	0.163	0.178
Noninfrastructure capital	0.363	0.685	0.249

Note: Capital stock shares are the medians of country values computed on the basis of cost data from Canning and Bennathan (2000) and from asset stock data for Latin America.

Source: Authors' calculations.

roads and the smallest to phone lines. The differences are very small, however—on the order of a few hundredths of a percent—and because of the uncertainties surrounding the underlying calculations, a common value for all three is used below, which as a working hypothesis is placed at 0.16.

This estimated elasticity can be used to provide a rough idea of the contribution of infrastructure stocks to the diverging performance of GDP per worker between Latin America and the East Asian tigers over the last two decades. More precisely, this is achieved calculating the portion of the change in the gap in GDP per worker between the two regions that can be attributed to the differential evolution of their respective infrastructure stocks—the infrastructure gap—that was portrayed in table 3.1 above.

This is done in table 3.7, which shows the role of each infrastructure asset in the widening GDP gap, as well as the combined role of all three vis-à-vis the other inputs—human capital and noninfrastructure physical capital. The table reports calculations using both unweighted means and regional medians.

The estimated contributions of the infrastructure assets are substantial. The top line in the table shows that all three assets combined account for about one-third of the widening GDP gap between East Asia and Latin America. In other words, the differential evolution of infrastructure assets in Latin America and East Asia widened the cross-regional gap in GDP per worker by some 30 percent over 1980–97.

Of this total, the largest contribution (nearly half) corresponds to power generating capacity, whereas phone lines and roads combined had an impact of similar magnitude to that of power infrastructure on the GDP gap. This relative ranking of assets is unsurprising in view of

Table 3.7 The Infrastructure Gap and the Output Gap: Contribution of Various Inputs to the Change in Relative GDP per Worker, Latin America versus East Asia, 1980–97

Inputs	*Medians by region*	*Simple averages by region*
1. Infrastructure	33.40	30.61
Main phone lines	10.17	7.62
Power generating capacity	16.19	14.58
Roads	7.04	8.40
2. Noninfrastructure capital	30.28	29.86
3. Human capital	10.88	7.07
Sum	74.56	67.53
Actual change in GDP per worker	88.90	90.24
Residual	14.33	22.71

Note: The contribution of each input to the change in relative output is calculated multiplying the change in the input by the respective output elasticity estimate. The elasticities used are those in table 3.6.

Source: Authors' calculations.

their respective evolution depicted earlier in table 3.1, according to which power had the worst performance over the two decades under analysis. It is worth noting also that the results are similar whether regional medians or averages are employed in the calculation.

The table also shows the contributions of the two conventional inputs—physical (noninfrastructure) and human capital. The slower accumulation of physical capital in Latin America relative to East Asia accounts for another 30 percent increase in the output gap—an amount similar to that attributable to infrastructure. Finally, the differential evolution of human capital across the two regions is responsible for up to another 10 percent increase in the output gap.

The bottom line in the table shows that the estimated model tends to underpredict the change in the output gap between the two regions. Between 15 and 20 percent of the latter is left unexplained.

Table 3.8 offers an individual-country perspective on the same phenomenon. For each country, the table reports the change in the infrastructure gap and the income gap (vis-à-vis the East Asia average) over 1980–97, as well as the contribution of the former to the latter. The first three columns of the table show that over the period in question nearly every country in Latin America lost ground relative to East Asia in all three infrastructure assets considered. The only exceptions were

Table 3.8 The Infrastructure Gap and the Output Gap: Contribution of the Change in Relative Infrastructure Stocks to the Change in Relative GDP per Worker, East Asia versus Selected Latin American Countries, 1980–97

(percent)

	Relative changes per worker				*Contribution of infrastructure to the change in relative output*				
	Infrastructure stocks								
Country	*Power*	*Roads*	*Telecom*	*Output [1]*	*Power*	*Roads*	*Telecom*	*Total [2]*	*[2]/[1]*
Argentina	93.48	45.84	51.36	86.78	15.89	7.79	7.70	31.39	36.17
Bolivia	90.29	35.49	56.01	85.69	15.35	6.03	8.40	29.78	34.76
Brazil	100.75	39.71	71.84	92.25	17.13	6.75	10.78	34.65	37.56
Chile	111.22	66.66	−5.67	44.53	18.91	11.33	−0.85	29.39	66.00
Colombia	99.06	48.25	47.42	82.46	16.84	8.20	7.11	32.16	39.00
Costa Rica	108.55	52.76	76.99	87.85	18.45	8.97	11.55	38.97	44.36
Dominican Republic	123.84	104.15	14.01	82.72	21.05	17.71	2.10	40.86	49.39
Ecuador	68.45	53.22	80.76	107.00	11.64	9.05	12.11	32.80	30.65
Guatemala	134.87	97.07	33.71	88.85	22.93	16.50	5.06	44.49	50.07
Honduras	103.09	65.02	5.58	92.22	17.52	11.05	0.84	29.42	31.90
Jamaica	100.05	41.38	−24.72	98.29	17.01	7.04	−3.71	20.34	20.69
Mexico	73.23	33.14	82.48	94.15	12.45	5.63	12.37	30.45	32.34
Nicaragua	153.53	84.19	66.73	113.80	26.10	14.31	10.01	50.42	44.31
Panama	140.67	41.93	94.40	89.19	23.91	7.13	14.16	45.20	50.68
Peru	119.62	48.79	33.86	102.92	20.34	8.29	5.08	33.71	32.75
El Salvador	90.46	66.11	33.83	91.91	15.38	11.24	5.07	31.69	34.48
Uruguay	43.94	−16.91	49.79	76.99	7.47	−2.87	7.47	12.06	15.67
Venezuela, R.B. de	97.37	36.49	84.21	105.13	16.55	6.20	12.63	35.39	33.66

Note: For each country, the contribution of each infrastructure asset to the change in relative output is calculated multiplying the change in the asset stock (relative to the East Asia median) by the respective output elasticity estimate from table 3.7.

Source: Authors' calculations.

Chile and Jamaica in telecommunications and Uruguay in roads. Every country listed in the table also lost ground in power generation capacity per head, and the extent of the lag was particularly dramatic in the Dominican Republic, Guatemala, Nicaragua, and Panama. Except for Panama, these countries were also the least dynamic in the stock of roads, whereas Ecuador, Mexico, and Panama lost the most ground in telecommunications.

The table also shows that the contribution of the infrastructure gap to the gap in income per worker—computed in the same way as in the preceding table—was positive for every country listed. In other words, in every country the widening infrastructure gap added to the income gap over the sample period. The output cost of lagging infrastructure was particularly large in Central America: in Guatemala, Nicaragua, and Panama the loss of ground in infrastructure assets widened the income gap by more than 40 percent relative to East Asia. At the other end, Jamaica and Uruguay were the least bad performers—that is, their loss of ground in infrastructure involved only a relatively modest cost in output per worker.

Summary

Over the last 20 years Latin America fell behind in infrastructure quantity and quality vis-à-vis other developing and industrial regions. Virtually all countries and infrastructure sectors in the region were affected by this relative slowdown, which was particularly pronounced in the 1980s.

The analysis in this chapter shows that this widening infrastructure gap can account for a considerable fraction—about one-third on average—of the increase in Latin America's output gap relative to the successful East Asian economies over the 1980s and 1990s. Lagging telecommunication assets, power generation capacity, and road networks all contributed to Latin America's loss of ground in output per worker. Although there is a fair degree of diversity across the region's economies in the magnitude of this effect, lagging infrastructure in every one of the countries analyzed added to the output lag vis-à-vis the East Asian tigers.

These conclusions are based on empirical estimates of the contribution of infrastructure stocks to aggregate output computed over a large cross-country time-series data set, using an infrastructure-augmented production function specification. This framework yields positive and significant estimates of the output contributions of all three infrastructure assets considered, and of physical and human capital as well.

This analysis has to confront some difficulties, however, such as the potential endogeneity of infrastructure stocks and the fact that they are subject to measurement error because of heterogeneity in infrastructure quality across countries and over time, among other things. To overcome these problems, instrumental variable estimators combining internal and external instruments are used. On the whole, the empirical results support the approach taken. There is little evidence against the validity of the instruments, and the estimates do not change significantly when alternative instrument sets are used or the instrument set is restricted to exogenous demographic variables only. This can be viewed as confirmation that the empirical estimates capture the effect of the exogenous component of infrastructure on output, and hence provide a valid basis for the chapter's inferences on the role of the infrastructure slowdown in the slowdown of Latin America's growth over the period of analysis.

Appendix

Sample Coverage and Data

To estimate the production functions presented in tables 3.2 to 3.5, annual data for 101 countries for 1960–97 (38 observations per country) were collected. Note that in the regression framework all figures are expressed as magnitudes per worker. Output has been approximated by using the real GDP in 1990 PPP U.S. dollars from Summers and Heston (1991), complemented by the data from the Global Development Network Growth Database created by William Easterly at the World Bank. Analogously, data on domestic capital stock from Summers and Heston and Easterly were used. The labor input is proxied by the total labor force as reported by the World Bank's *World Development Indicators*.

Regarding infrastructure stocks, physical indicators were used for the different infrastructure sectors. First, the number of telephone main lines served as a proxy for infrastructure in telecommunications. We complemented the data in Canning (1998) with recent figures from the International Telecommunications Union (ITU) annual reports. Second, the data on electricity generating capacity (in kilowatts) were taken from the United Nations *Energy Statistics* and *Statistical Yearbook*. Finally, data on road length (in kilometers) were used for the transportation sector. The data were obtained from the International Road Federation *World Road Statistics*. One caveat regarding these data, as noted by Canning (1999), is that they may exhibit significant variations in quality. In particular, they do not reflect the width of the roads or their condition.

Notes

1. Hong Kong (China), Indonesia, Republic of Korea, Malaysia, Taiwan (China), Thailand, and Singapore.

2. However, if one looks at total (main + mobile) phone lines rather than just main lines, the relative performance of Latin America in the 1990s was worse than shown in the table—the gap with East Asia continued to expand in the 1990s, although at a slower pace than in the 1980s.

3. Canning and Bennathan (2000) and Demetriades and Mamuneas (2000) also presented estimates using translog specifications.

4. A similar procedure was followed by Canning and Bennathan (2000).

5. On this see Demetriades and Mamuneas (2000), who distinguished between the *short run* with noninfrastructure capital predetermined, and the *long run*, over which noninfrastructure capital adjusts to its optimal value. They also defined an *intermediate run* in which the capital stock partially adjusts to its equilibrium level.

6. However, empirical estimates using the entire sample are very similar to those using the reduced sample.

7. This accords with the finding of Barro and Sala-I-Martin (1995) that the growth contribution of secondary education is more significant than that of primary and higher education. For this study empirical specifications using broader definitions of human capital (inclusive of primary and/or tertiary schooling) yield more imprecise estimates of the contribution of human capital, and have only minimal effects on the coefficients of the physical capital and infrastructure variables. To save space, they are not reported.

8. Note that by including time and country effects in the empirical specification one can account for country-specific levels, as well as cross-country changes, in infrastructure quality—but not for country-specific quality changes. However, as noted by Esfahani and Ramirez (2002), using a panel data set similar to the one used in this study, standard infrastructure quality measures (such as power losses as percentage of power output or phone faults per telephone line) are strongly correlated with infrastructure quantity indicators. Hence the variation in the latter captures to a considerable extent the variation in the former as well.

9. In particular, one would need cross-country time-series data on the prices of infrastructure services, which are not available for a broad country sample such as the one considered here. The only example of such an approach in the recent literature is Röller and Waverman (2001), who developed an empirical supply–demand model along the lines in the text but including only telecommunications infrastructure. The model is estimated using data for Organisation for Economic Co-operation and Development (OECD) economies.

10. These two variables are among the determinants of infrastructure demand in Esfahani and Ramirez (2002), and thus provide a source of identification in their empirical model.

11. Note that lagged levels of the variables on the right side are unlikely to provide valid instruments for the estimation of (3.5) because of the presence of time-invariant country-specific factors that may be correlated with the levels of the regressors at all lags.

12. For lagged differences of a regressor x to provide a valid instrument for the levels equation, it is necessary that $E[a_i x_{it}] = E[a_i x_{is}]$ for all t and s. This is essentially a stationarity assumption (see Blundell and Bond 1998).

13. Railway data are unavailable for some 300 country-year observations.

14. Except for column one, all estimates reported in this and later tables include a full set of year dummies that were highly significant in all cases.

15. Various panel cointegration estimates were also computed, using the techniques of Kao and Chiang (2000) for nonstationary panels, with results very similar to the within estimates in table 3 (see also Baltagi 2000). These estimates are subject to the same measurement error and simultaneity biases as the within estimator. They are not reported here to save space.

16. In anticipation of other experiments reported later, the instrument set includes also second lags of primary and tertiary schooling, total roads per worker, and total phone lines per worker.

17. The GMM estimates are not very different from those reported by Esfahani and Ramirez (2002), who found that the elasticities of output with respect to power generation capacity and telephone lines are, respectively, around 0.13–0.16 and 0.08–0.10.

18. It is also useful to compare these estimates with the results of Röller and Waverman (2001) for OECD countries. Their production function specification ignores human capital and roads and power, does not impose constant returns, and employs a nonlinear transformation of the stock of phone lines. It can be shown that if the same transformation were used here, the resulting estimate of the elasticity of output with respect to phone lines would be very similar to that reported by Röller and Waverman. The elasticity with respect to physical capital, however, is much higher in their case (more than 0.50).

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4

Infrastructure Compression and Public Sector Solvency in Latin America

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PUBLIC INVESTMENT AND INFRASTRUCTURE spending are often singled out for drastic cuts at times of fiscal retrenchment. Chapter 1 noted that this has been a common feature in episodes of fiscal adjustment in developing countries, and chapter 2 highlighted its key role in Latin America's attempts to correct public sector imbalances over the last two decades. But the same phenomenon has been amply documented in industrial economies. For example, out of a total of 32 episodes of significant budget consolidation in European Union (EU) countries over the period 1980–97, public investment fell relative to gross domestic product (GDP) in 25 cases, and in 23 of them investment fell by more than other primary spending. The fiscal targets of the Maastricht Treaty may have given new impetus to this practice. Eight EU countries that flunked the deficit criterion in 1992 had managed to meet it by 1997. All eight had lowered their public investment ratios, and seven of them had reduced investment more than other primary outlays.[1]

There are several reasons for this pattern of fiscal adjustment. It reflects, in part, a worldwide trend of increased reliance on markets and the private sector, along with reduced government involvement in production. In some cases it is also a reaction to the excessive expansion of public investment (including projects clearly identifiable as white elephants) during boom times. Also, there are admittedly compelling political economy reasons for this kind of adjustment—for 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 flawed approach to the sustainability of public finances. This approach is concerned only with government liabilities and ignores the role of public sector assets—in other words, the flow of future public revenues (Buiter 1990). In such a framework, *fiscal adjustment* may mean little more than a parallel reduction in both liabilities (such as debt) and assets (such as infrastructure) of the public sector that leaves its net worth unaffected, or, even worse, reduces net worth if the rate of return on the assets (inclusive of both their direct and indirect returns) exceeds the cost of the debt. Chapter 1 termed this kind of fiscal adjustment illusory.

As chapter 2 documented, the period of fiscal austerity that most of Latin America underwent during the 1980s and 1990s was characterized by a sharp contraction in infrastructure investment. In most cases recurrent infrastructure expenditures on operation and maintenance or O&M (for which cross-country data are unfortunately unavailable) were cut along with investment, so that the total decline in spending related to infrastructure was larger than the investment cut. But 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 documented in chapter 3.

From the perspective of public sector solvency, the key issue is that fiscal adjustment biased against infrastructure accumulation can be largely self-defeating. As chapter 1 argued, the immediate effect of infrastructure spending cuts is to reduce the public deficit and, other things being equal, 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 chapter 3, in output growth as well. This in turn implies a reduction in the economy's debt-servicing capacity, thereby weakening public sector solvency, as discussed in chapter 1. 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 counterproductive—strategy to enhance public sector solvency.

This chapter assesses quantitatively the growth cost of public infrastructure compression for major Latin American economies during the fiscal austerity period of the 1980s and 1990s, and examines the effects of infrastructure spending cuts on public sector net worth.

Thus, the chapter puts to work the analytical framework of chapter 1 using the empirical information on infrastructure and its contribution to growth presented in chapters 2 and 3, respectively.

Two limitations of this analysis should be stated from the outset. First, the analysis intends to be illustrative rather than definitive. Its purpose is to provide an idea of the orders of magnitude of the factors shaping the solvency impact of infrastructure spending changes, and not to give the last word on their exact value. Second, because of the limited availability of infrastructure spending data, the analysis is limited to the same nine Latin American countries that were the focus of much of chapter 2—Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, and República Bolivariana de Venezuela.[2]

Framework

The analytical approach follows Easterly (2001) and is based on a suitably modified version of the framework outlined in chapter 1. It is also closely related to the framework used by Buiter (1990, chapter 13), with the main difference that the focus here is on a growing economy rather than one approaching an equilibrium with constant output.

The starting point is the public sector's budget identity describing the dynamics of public debt:

$$\dot{b}(t) = (r - g)b(t) - \sigma(t).$$

Here b is the stock of public debt relative to GDP, r is the real interest rate, g is the rate of GDP growth (with both assumed constant for simplicity), and σ represents the augmented primary surplus of the public sector (that is, the noninterest budget surplus plus seigniorage revenues) as a ratio to GDP. From the dynamics of public debt it follows that

$$b(t + \tau) = e^{(r-g)\tau}b(t) - \int_{t}^{t+\tau} e^{(r-g)(s-t)}\sigma(s)ds.$$

Solvency means that the government cannot forever pay the interest on its outstanding debt simply by issuing more debt. Ultimately, the debt/GDP ratio will have to grow at a rate below the real interest rate minus the growth rate of real GDP. More precisely, what is required is $\lim_{\tau\to\infty} e^{-(r-g)\tau}b(t + \tau) \leq 0$; in other words, that the present discounted value of the debt stock far into the future not be positive, with the discount rate given by the difference between the real interest rate and the real growth rate.[3] It is easy to see from the above expression that this is equivalent to requiring

$$\omega(t) \equiv \int_t^{\infty} e^{-(r-g)(s-t)}\sigma(s)ds - b(t) \geq 0. \tag{4.1}$$

In other words, net worth ω, defined as the present discounted value of the government's present and future stream of budget surpluses augmented for seigniorage, minus its stock of debt outstanding (all relative to GDP), cannot be negative.[4] This is just a restatement of expression 1.2 in chapter 1.

The augmented primary surplus can be further decomposed into seigniorage, infrastructure spending, and everything else. Take seigniorage revenue first. This can be expressed as μh, where μ is the rate of growth of the stock of base money and h is the money stock/GDP ratio. Using this fact, the augmented primary surplus can be written $\sigma(t) = p(t) - i(t) + \mu(t)h(t)$, where p is the primary surplus before infrastructure expenditures and i is the ratio of infrastructure spending to GDP. It is important to recognize that the noninfrastructure primary surplus as a proportion of GDP could itself depend on the growth rate of the economy: other things equal, faster growth rates might imply larger surpluses (or smaller deficits) through a rising tax/GDP ratio or a declining expenditure/GDP ratio; hence, in principle, $p = p(g, .)$. In turn, the money/GDP ratio should depend basically on the nominal interest rate; that is, letting π denote the inflation rate, $h = h(r + \pi)$, with $h' < 0$.

Consider a long-run equilibrium in which the money/GDP ratio, the noninfrastructure primary surplus, and the ratio of infrastructure spending to GDP all remain constant. For the money stock to remain constant relative to GDP, it must be the case that $\mu = g + \pi$, that is, the rate of money growth must equal the rate of growth of nominal GDP. In such conditions (4.1) can be further simplified to

$$\omega = \frac{p(g, .) - i + (g + \pi)h(r + \pi)}{r - g} - b. \tag{4.2}$$

Taking r, π, and the initial debt/GDP ratio as given, the impact of a change in infrastructure spending on net worth is

$$d\omega = \left[\underbrace{-\frac{1}{r-g}}_{\text{Direct effect}} + \underbrace{\frac{\partial\omega}{\partial g}\frac{dg}{di}}_{\text{Indirect effect}}\right] di. \tag{4.3}$$

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 direct effect is unambiguously negative, implying that it makes infrastructure spending and net worth move in opposite directions. In turn, the indirect effect via growth is likely to be positive. Inspection of (4.2) shows that the indirect effect works through three channels: first, by affecting the level of the noninfrastructure component of the primary deficit p; second, by changing the ratio of seigniorage revenue to GDP; and, third, by altering the present value of a given stream of augmented primary deficits through the term $1/(r - g)$, along the lines described by Easterly (2001) and already mentioned in chapter 1.

This expression can be simplified further by noting that the growth impact of infrastructure spending can be expressed as the growth contribution of infrastructure stock accumulation (analyzed in chapter 3) times the impact of infrastructure spending on stock accumulation (examined in chapter 2):

$$\frac{dg}{di} = \frac{dg}{d\Delta z} \cdot \frac{d\Delta z}{di} = \eta_z \cdot \frac{d\Delta z}{di} \tag{4.4}$$

where Δz is the rate of growth of infrastructure stocks, and $\eta_z \equiv \frac{dg}{d\Delta z}$ is the growth contribution of infrastructure stock accumulation.

In turn, from (4.2), the impact of growth on net worth, holding the noninfrastructure primary surplus constant and near a point where net worth is small, can be written as

$$\left.\frac{\partial \omega}{\partial g}\right|_{\omega=0} = \frac{b + h}{r - g}. \tag{4.5}$$

Thus, the impact of growth on net worth is positive and proportional to the initial stocks of debt and money. For the debt stock, this has already been emphasized by Easterly (2001). The intuition is that an additional percentage point of growth reduces the amount of fiscal adjustment needed for solvency more in a high-debt country than in a low-debt country, and more so the smaller the net discount factor $r - g$. As for money, the argument is similar: higher growth allows larger seigniorage revenue collection, and the present value of those extra revenues is larger the greater the money/GDP ratio and the smaller the net discount factor.

Putting all these pieces together, the effect of infrastructure spending changes on net worth can be expressed as

$$\frac{d\omega}{di} = \frac{1}{r - g}\left[-1 + \left(b + h + \frac{\partial p}{\partial g}\right) \cdot \eta_z \cdot \frac{d\Delta z}{di}\right] \tag{4.6}$$

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, and the factor $(r - g)^{-1}$ serves to bring the annuity to present-value terms.[5]

This latter expression shows how the direct contribution of infrastructure spending cuts to raising net worth is offset by adverse growth effects, and identifies what factors determine the magnitude of such offset. Thus, the offset is larger if debt and money ratios to GDP are high, if infrastructure makes a large contribution to output, and if infrastructure asset accumulation closely tracks infrastructure spending.

Thus, the actual extent of this offset is an empirical matter. Assessing its magnitude requires data on debt and base money ratios and empirical counterparts for η_z, $\frac{d\Delta z}{di}$, and $\frac{\partial p}{\partial g}$. The first of these expressions provides the link between infrastructure stock accumulation and growth; the second ties together infrastructure spending and stock accumulation; and the third captures the impact of growth on the noninfrastructure primary surplus. They are examined in turn.

Empirical Implementation

Take first the link between infrastructure stocks and growth. This was examined in chapter 3, which presented empirical estimates of η_z for various infrastructure assets in an aggregate production function framework, using a large cross-country time-series data set and employing a variety of econometric specifications. In the vast majority of cases, those estimates showed positive and significant contributions to aggregate output of all infrastructure assets considered. For the purposes of this chapter, the estimates of η_z reported in table 3.6 will be used.

Consider next the link between public infrastructure spending and the time path of infrastructure stocks: $\frac{d\Delta z}{di}$ in (4.6) above. In theory, stock accumulation should track spending (especially investment) closely, but in reality variation in the quality and cost of assets across countries and over time can make the link much more tenuous.[6] Perhaps as a result of this, there have been very few assessments of the spending-accumulation link, especially in a cross-country (not to mention multi-asset) framework. One rare exception is the recent work by Röller and Waverman (2001), who explored the effects of investment in telecommunications on phone line density in industrial countries.

Chapter 2 above presented a preliminary quantification of the link between infrastructure spending and asset accumulation for the nine Latin American countries—Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, and República Bolivariana de Venezuela—for which the necessary information disaggregated by type of asset (in other words, transport networks [inclusive of roads and railways], power, and telecommunications) could be collected. Note the caveat that the analysis included only investment spending and not other relevant expenditures (such as O&M) that may also affect the evolution of the quantity and quality of stocks over time.[7]

In spite of this limitation, the regression results reported in chapter 2 using a variety of specifications reveal a highly significant association between infrastructure investment and the ensuing trajectory of infrastructure assets. Variation of the former across countries and over time accounts for a considerable portion of the observed variation in the latter, which is particularly high in the case of telecommunications and transport routes. Furthermore, the results are robust to the use of alternative definitions of the relevant asset stocks—total instead of main phone lines, or roads alone instead of roads plus railways.

Thus, for the analysis in this chapter, the estimates of the long-run effect of investment on asset accumulation derived from those regressions, and reported in table 2.6, are taken as the proper measure of $\frac{d\Delta z}{di}$. Specifically, the calculations below use the estimates obtained from the third specification in table 2.6.[8]

The final ingredient required for empirical implementation of the analytical framework outlined in the previous section is the response of the primary surplus, exclusive of infrastructure spending, to changes in the growth rate of GDP. On this point, the *automatic stabilizer* view of fiscal policy suggests that revenue and spending ratios should both be affected by changes in the economy's growth rate over the cycle—the former positively and the latter negatively. However, the automatic stabilizer function of fiscal policy is known to be weak in developing economies in general, and Latin America is no exception to this rule (Talvi and Vegh 2000). Furthermore, the present analysis is concerned more with long- than with short-term growth, and on this front theoretical predictions regarding the response of fiscal revenues and expenditures to changes in growth are much less clear.

For these reasons, the assessment of the impact of growth on the noninfrastructure primary deficit offered below is based on regressions of public revenue and spending ratios on the growth rate of GDP using data for 1970–97 for a group of Latin American economies defined by data availability.[9] The results are reported in tables 4.1 and 4.2. In each case, a number of panel estimates were computed, variously including or excluding 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. Other experiments were also performed allowing for dynamics in the impact of growth on revenue and expenditure ratios, but they are not reported to save space.[10]

Table 4.1 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

Table 4.1 Taxes and Growth: Panel Data Regression Analysis

Specification and variable	*Dependent variable*	
	Tax revenues (% GDP)	*Total revenues (% GDP)*
I. OLS		
Output growth	0.009	0.005
	(0.045)	(0.068)
Tax reform	0.0153	0.101
	(0.009)**	(0.029)**
R^2	0.051	0.062
II. Within-group estimator		
Output growth	0.066	0.059
	(0.029)**	(0.042)
Tax reform	0.014	0.107
	(0.008)**	(0.032)**
R^2	0.239	0.167
III. OLS with time effects		
Output growth	0.007	–0.008
	(0.050)	(0.074)
Tax reform	0.017	0.092
	(0.012)	(0.028)**
R^2	0.031	0.078
IV. OLS with country and time effects		
Output growth	0.084	0.068
	(0.031)**	(0.044)
Tax reform	0.017	0.082
	(0.013)	(0.037)**
R^2	0.342	0.271

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, R.B. de. The number of observations in each panel is 425. The figures in parentheses are standard errors. OLS = ordinary least-squares.

** Significant at 5 percent.

Source: Authors' calculations.

Table 4.2 Government Spending and Growth: Panel Data Regression Analysis

	Sample	
Specification and variable	*All countries*	*Latin America*
I. OLS		
Output growth	–0.073	–0.074
	(0.054)	(0.067)
R^2	0.021	0.027
II. Within-group estimator		
Output growth	–0.090	–0.066
	(0.035)**	(0.045)
R^2	0.071	0.044
III. OLS with time effects		
Output growth	–0.049	–0.033
	(0.054)	(0.075)
R^2	0.058	0.058
IV. OLS with country and time effects		
Output growth	–0.065	–0.021
	(0.034)**	(0.047)
R^2	0.148	0.122

Note: Dependent variable is government spending as a ratio to GDP. The sample includes 60 countries over the 1960–97 period (1,620 observations), of which 20 countries are from Latin America (540 observations). The sample of countries is Argentina; Australia; Bangladesh; Belize; Benin; Bolivia; Brazil; Burundi; Chile; China; Colombia; Costa Rica; Côte d'Ivoire; Dominican Republic; Ecuador; Egypt; El Salvador; Ethiopia; Fiji; Gabon; Gambia, The; Great Britain; Greece; Guatemala; Haiti; Honduras; India; Indonesia; Japan; Kenya; Korea, Rep. of; Malawi; Malaysia; Malta; Mauritania; Mauritius; Mexico; Morocco; Nicaragua; Nigeria; Pakistan; Panama; Papua New Guinea; Paraguay; Peru; Philippines; Singapore; South Africa; Sri Lanka; Sudan; Sweden; Syria; Thailand; Tunisia; Turkey; Uruguay; United States; Venezuela, R.B. de; Zaire; and Zimbabwe. The figures in parentheses are standard errors.

** Significant at 5 percent.

Source: Authors' calculations.

limited to Latin America because the tax reform index is unavailable for other countries.

For both tax and total revenues, the estimates reveal a positive effect of tax reforms, as measured by the reform index, on the revenue/GDP ratio. However, for tax revenues the impact is significant only when time dummies are excluded. As for GDP growth, which is the variable of interest here, its effect is always positive for tax revenues and also for total revenues, except in the regression including only time effects. The impact of growth is generally insignificant, however. The exception to this rule is provided by the regressions of tax revenues including fixed effects, which exhibit a positive and significant growth coefficient. For total revenues, the growth coefficient is never significant.

For spending (table 4.2), results are shown for both Latin America and a broader country sample. The growth coefficient estimates are uniformly negative, as could be expected from the automatic stabilizer view of fiscal policy, 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, therefore, both the revenue and expenditure estimates in tables 4.1 and 4.2 provide little evidence of any major effects of growth on the noninfrastructure primary deficit. Thus, for practical purposes the calculations below shall take $\frac{\partial p}{\partial g} = 0$.

The Impact of Infrastructure Spending on Public Sector Net Worth

It is now possible to 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 (4.6) and using $\frac{\partial p}{\partial g} = 0$, this can be expressed as

$$\frac{da}{di} = (r - g)\frac{d\omega}{\partial i} = -1 + \left[(b + h) \cdot \eta_z \cdot \frac{d\Delta z}{di}\right] \tag{4.7}$$

The term in square brackets is the indirect effect via growth from (4.3) 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 4.3, 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—that is, the right side of (4.7). The calculation is presented for different values of the debt/GDP ratio. It is important to stress once again that these computations are

Table 4.3 Impact on the Annuity Value of Net Worth of a Cut in Infrastructure Investment by 1 Percent of GDP
(percent of GDP)

Initial public debt/GDP (percent)	*Initial base money/GDP (percent)*	*Cut in investment in*		
		Telecommunications	*Power generation capacity*	*Transport routes*
0	0	1.00	1.00	1.00
10	10	0.78	0.79	0.79
30	10	0.56	0.58	0.57
50	10	0.35	0.38	0.36
70	10	0.13	0.17	0.15

Note: For each value of the debt/GDP ratio, the table shows the impact on annualized net worth, as percentage of GDP, of a decline in investment in each infrastructure asset by 1 percent of GDP.

Source: Authors' calculations.

based on a very simple framework and rely on first-order approximations that admittedly may be very rough. Thus, the calculations should be viewed as illustrative.

Subject to these caveats, the first row of the table shows that with a zero public debt stock and a zero base money stock (equivalently, ignoring seigniorage) an infrastructure spending cut translates one-for-one into increased net worth. The reason is that at zero debt and seigniorage, 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 these illustrative calculations in the table, the stock of base money is set at 10 percent of GDP. When the public debt stock equals 10 percent of GDP, 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 similar regardless of which of the three assets considered—transport routes, power, or telecom—is the object of the spending cut.

At higher levels of public indebtedness, the offset is much larger. For example, when the public debt/GDP ratio reaches 70 percent (and the base money stock still remains at 10 percent of GDP), the estimates imply that a cut in infrastructure investment by 1 percent of GDP raises the annuity value of net worth by only a small amount—between 0.13 and 0.17 percent of GDP, depending on the asset composition of the spending cut.[11]

Given this assessment of the impact of public infrastructure investment on public sector net worth, one may ask to what extent Latin America's public infrastructure compression of the 1980s and 1990s contributed to stronger public finances. The empirical estimates allow, again, an illustrative, if not conclusive, answer to this question. It is important to note that 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. This is obviously not what was observed in practice, and in this sense the experiments conducted here reflect a partial equilibrium, before the adjustment of private investment.

With this important qualification, table 4.4 provides a preliminary assessment of the solvency impact of the observed changes in public infrastructure investment. The table repeats the generic calculations in table 4.3, but uses the actual debt and base money 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 total change in public investment in the three infrastructure assets under analysis over the period in question. All the countries listed, except Ecuador, witnessed an investment decline, most markedly Argentina, Bolivia, and Brazil.[12]

The second column calculates the impact of those spending cuts on annual GDP growth. The impact is computed by 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 for Argentina, Bolivia, and Brazil, where the estimated GDP growth cost is 3 percent a year. It is also significant for Chile, Mexico, and Peru (around 1.5 to 2 percent a year). At the other end of the spectrum, the adverse growth impact is small in Colombia and República Bolivariana de Venezuela, which experienced only small investment cuts. Finally, the growth effect is positive in Ecuador, which increased public infrastructure spending over the period under consideration.

Table 4.4 Partial-Equilibrium Effect of Actual Infrastructure Investment Changes on the Annuity Value of Public Net Worth, 1980–84 versus 1995–98

Country	*Change in public infrastructure investment (percent of GDP)*[a] *[1]*	*Implied change in growth rate (percent)*[b]	*Debt to GDP ratio (percent)*[c]	*Base money to GDP ratio (percent)*[d]	*Implied change in annualized public net worth (percent of GDP) [2]*	*Offset coefficient (percent) 1 – ([2]/[1])*
Argentina	–2.65	–2.75	23.48	4.00	1.90	28.45
Bolivia	–3.03	–3.13	83.00	6.14	0.25	91.85
Brazil	–2.98	–3.10	22.25	2.30	2.22	25.54
Chile	–1.49	–1.58	42.55	3.19	0.77	48.45
Colombia	–0.44	–0.36	21.28	4.60	0.34	21.40
Ecuador	0.56	0.56	50.67	3.42	–0.25	54.84
Mexico	–1.95	–2.07	42.21	3.79	0.99	48.91
Peru	–1.48	–1.53	48.74	3.99	0.67	54.57
Venezuela, R.B. de	–0.41	–0.41	21.03	3.55	0.31	24.65

a. Actual change in public investment in transport routes, power, and telecommunications between 1980–84 and 1995–98.
b. Calculated using the estimates in tables 2.6 and 3.6.
c. Sum of the domestic and external public debt/GDP ratios averaged over the 1980–94 period.
d. Currency outside banks relative to GDP.
Source: Authors' calculations.

The next two columns in the table show each country's debt and money ratios to GDP. Because in several of the countries considered bank reserves earned interest during at least part of the sample period, the money ratio reported corresponds only to currency outside banks, which always earns no interest and is therefore closer in spirit to the concept of base money employed in the analytical model above.

Column five in table 4.4 presents the impact of these public spending changes on the annuity value of public sector net worth. 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 primarily because of their different levels of public indebtedness, and marginally because of the different composition of the investment cuts by infrastructure asset (not shown in the table) observed in each country.

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 0.25 percent of GDP, whereas a similar spending cut in lower-debt Brazil yields a net worth increase of more than 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—in other words, the overall offset coefficient. The offset is largest in Bolivia, where it exceeds 90 percent. In the other countries the offset coefficient ranges between 20 percent and 55 percent—that is, between 20 percent and 55 percent of the observed infrastructure investment cuts failed to improve the public sector's financial position. These offset coefficients strongly suggest that in most countries infrastructure investment cuts represent a very inefficient strategy for strengthening public finances.

One important caveat to these calculations is that by equating cuts in public infrastructure investment with cuts in *total* infrastructure investment—in other words, ignoring the private sector response to the public sector's retrenchment—the calculations lead to an overstatement of the growth reduction caused by public spending cuts and hence to an overstatement of the offset coefficients. It is true that in some 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 was typically less pronounced than the decline in public infrastructure investment (or, to put it differently, that infrastructure asset accumulation declined less than proportionately with the public investment contraction), the calculations above provide an upper bound on the adverse growth implications and thus the inefficiency of public infrastructure investment cuts as a means of enhancing public solvency.

However, the infrastructure investment data for Latin America do not support the simplistic view that public investment cuts are automatically offset by private investment rises. The evidence shows considerable diversity across countries and infrastructure sectors in the region in terms of private sector response.[13] 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.[14] 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.

Summary

Public infrastructure spending often takes a major hit 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 chapter 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 a year. 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 varies considerably across countries, depending on their levels of public indebtedness and the asset composition of the infrastructure investment contraction.[15]

The main implication of these results is not that infrastructure spending should never be cut under any circumstances. The lesson instead is that under realistic circumstances 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.

Appendix 4A

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 tested the null hypothesis that every time series in the panel is nonstationary. The approach consists in running augmented Dickey-Fuller (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 nonstationary 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).

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. In each case, the ADF regressions using those residuals are run with a constant, a deterministic trend, and five augmenting lags.

(A) Government Revenues. We use data on government revenues and real GDP for the Latin American countries that have a complete data set for 1970–95, that is, 17 countries and 26 observations per country. From the results reported in table 4A.1, 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.

Table 4A.1 Panel Unit Root Tests, Government Revenues, Government Spending, and Real Output

	Levels		*First differences*	
Variable	*Without trend*	*With trend*	*Without trend*	*With trend*
A. Government revenues and real output, 1970–95 (annual)				
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 (annual)				
Real output (in logs)	–1.19	–2.10	–2.13**	–2.43*
Government spending (in logs)	–1.40	–2.23	–2.14**	–2.45**
Government spending/GDP	–1.71	–2.41**	–2.43**	–2.50**

Note: The table reports the t-bar ($\bar{t}_{NT}$) statistic, defined as the sample average of the t-statistics obtained from the ADF regressions of individual countries. Before performing the ADF regressions for individual countries, we remove the common time dummies from all variables. For the critical values of the $\bar{t}_{NT}$ statistic, see table 4 in Im, Pesaran, and Shin (1995).

* Significant at 10 percent.

** Significant at 5 percent.

Source: Authors' calculations.

(B) Government Spending. Using data on government spending and real output for a sample of 60 countries for 1970–97, we test the stationarity of both series (in logs). In table 4A.1, we show that the series are nonstationary 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.

Notes

1. The performance of public investment during episodes of fiscal adjustment in European countries is examined at length by Balassone and Franco (2000).

2. The sources of the data used in this chapter are listed in appendix 2A. Because much of infrastructure spending is often done by lower levels of government or by public enterprises, it is important to base the analysis on infrastructure spending data for a broadly defined public sector. These data 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 of the countries concerned, and thus provides a very limited view of public infrastructure spending.

3. As already noted in chapter 1, if $g > r$, so that the discount rate is negative, the economy is dynamically inefficient and any debt stock, no matter how large, is consistent with solvency.

4. This is not the only possible definition of government net worth, but is a convenient one for the purposes of the discussion in this chapter.

5. Let the annuity value $a \equiv (r - g)\omega$. Then $\frac{da}{di}|_{\omega=0} = (r - g)\,\frac{d\omega}{di}$, and the latter expression is just the term in square brackets in (4.6).

6. See Pritchett (2000) for a discussion of this point.

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 the study of Röller and Waverman (2001) cited in the text.

8. Observe that the regressions in question relate stock accumulation to total investment, implicitly assuming that the contribution of public infrastructure investment to the accumulation of infrastructure assets is identical to that of private investment. This assumption was tested in chapter 2, and the results of the tests were reported in table 2.7. Although in power and telecommunications there is no evidence against the hypothesis that public and private investment contribute equally to asset accumulation, for transport routes the results suggest that the contributions of public and private investment do differ. For simplicity, this divergence is ignored here, and therefore the calculations below have to be taken with some caution.

9. Because GDP growth is a stationary variable, it is necessary to check first that the revenue and spending ratios are stationary as well—otherwise the regression just described will yield inconsistent parameter estimates. This is done following a three-stage procedure, described in detail in appendix 4A. The first stage verifies 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, the same methods are used 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. This allows the use of standard estimation methods as described in the text.

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

11. 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. This situation is similar to the one explored by Buiter (1990, chapter 13), in which public investment cuts lead to lower output and taxes in the long run and thus require higher inflation to balance the fiscal accounts via seigniorage.

12. Note that these figures differ somewhat from those reported in chapter 2. The reason is that table 4.4 considers only investment in transport routes, power, and telecommunications, whereas the data shown in chapter 2 include, in addition, investment in other items such as water and gas.

13. See chapter 2 for further details.

14. This is discussed in chapter 6.

15. The calculations presented here are subject to a number of caveats. They gloss over possible heterogeneity in the cost and/or quality of infrastructure

assets across countries and over time. They also reflect a partial-equilibrium view before any private sector investment response. For this reason, the results reported in this chapter have to be taken as a preliminary illustration rather than a definitive assessment.

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5

Macroeconomic Effects of Private Sector Participation in Infrastructure

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THE RELEVANCE OF THE DESIGN OF institutions for the effectiveness of policies is now well recognized by policymakers (see World Bank 2002b for a recent survey of the evidence). This design becomes particularly important where reforms have significantly changed the types and roles of players. The restructuring of the infrastructure sector to increase competition and private sector participation in Latin America over the last decade provides a clear example of such an institutional change. Since the late 1980s, many Latin American countries have progressively opened their infrastructure sectors to private operators, seeking a remedy to structural deficits and hoping to foster investment and growth.

The literature on the impact of these reforms can be classified into three broad types. The first type focuses mostly on the macroeconomic effects of a macroeconomic view of the reforms—the *macro–macro* group. The second examines the sector-specific effects of sector-specific reforms—the *micro–micro* group, and the third, the macroeconomic effects of sector-specific reforms—the *micro–macro* group. The *macro–macro* category is by far the most populated. The field has been able to generate fairly detailed econometric analyses from the relatively good macroeconomic databases available (see McGillivray and Morrissey 1999 for a recent survey).

The *micro–micro* group has generated fewer analytically strong studies, partially because detailed relevant data are not easy to obtain.

Most of the published articles have focused on Argentina and Chile, where enough time has gone by to generate reasonable time-series data (see Guasch 2001 for an overview). A much more modest literature has underpinned the third category—the *micro–macro* group that examines the macroeconomic effects of sector-specific reforms—even if these sectoral reforms have been key components of the overall macroeconomic restructuring agenda. Exceptions include the literature on the general equilibrium effects of reform or the literature on convergence (see De la Fuente 2000; or Estache, Foster, and Wodon 2002).

This chapter contributes to the *micro–macro* literature by offering a first empirical assessment of the macroeconomic effects of increased private sector participation in the management and financing of the infrastructure sectors (PPI, or private participation in infrastructure) in Latin America.[1] The chapter's main purpose is to provide empirical evidence of the effects on several key macroeconomic variables of the increased role of *privatization,* defined as the decision to rely on the private sector to implement projects.[2] In this analysis some institutional factors are isolated and country effects are controlled for, recognizing that each country in the region may face different sources of risks.

Given these objectives, the chapter suffers from at least two major drawbacks. First, the quality of the data available is a significantly restrictive factor and limits the possibility of drawing very strong policy conclusions. This drawback is, however, also a source of strength because it highlights the main direction for additional analytical work. Second, the chapter lacks an explicit theoretical model to justify a finding that increased PPI should have specified *micro–macro* effects.[3] However, the goal here is not to test any specific theory but rather to provide, if possible, statistically significant evidence on the sign (or direction) and size of the effects of PPI on the most common macroeconomic indicators.

In this chapter, general empirical relationships are specified between each of the macroeconomic variables and different subsets of instruments that summarize when and how private participation was introduced in each country and under which institutional environment. The results cannot be interpreted as causal associations; they represent correlations that can only hint at what the macroeconomic impact of privatization (if any) has been so far in Latin America.

In spite of these limitations, useful results were obtained relying on standard econometric techniques. First, pooled data models were estimated ignoring country-specific effects. These models provide both initial values for the *micro–macro* effects and a benchmark for comparisons. However, if unobserved individual heterogeneity (that is, country-specific effects) is relevant in the statistical relationships, its omission yields biased estimates. To overcome this problem, panel data models that allow for an explicit testing of individual heterogeneity were also estimated.[4] The differentiation between these two types of model specifications yields evidence on the effects of the privatization policies for the region as a whole as well as for average country-specific effects.

The remaining sections of the chapter are organized as follows. In the next section, the methodology followed to draw a minimum set of robust policy implications on the effects of PPI is discussed. The sample and the most relevant variables used are then described. The main results of the impact of private participation policies on each macroeconomic variable are given. Finally, a summary of the main empirical implications is presented.

Testing the Macroeconomic Effects of PPI

There is no simple way to anticipate the overall macroeconomic effects of a policy opening infrastructure to the private sector in a particular country because many tradeoffs are at stake. The best that can be done with the kind of data available is to focus on *reduced* forms that net out structural positive and negative effects of the reforms on the key macroeconomic variables, which cannot be separated out in the usual way because of lack of data. From the viewpoint of private investment, for instance, many privatization policies are expected to bring about positive results in the medium term or in the long run if the overall efficiency of the economy is improved as a result of the policy changes. However, the long-run payoffs may be preceded by short-run costs if increased competition reduces margins and profits and thus hampers the investment capabilities of private investors.

Because the sectors can be studied only at a very aggregate level and sector-specific reforms are difficult to pick up, only the accumulated effects of the policy changes year after year can be identified and these effects cannot be assigned to any specific policy change. That is why the focus of this chapter is on a limited concern that has not been studied so far. The focus is on identifying the outcomes that genuinely can be attributed to the net effects of private sector participation in infrastructure projects. The size of the outcomes is also computed but is for now less interesting because it probably represents a large number of offsetting effects.

With these limitations in mind, the chapter proposes a formal test of the consequences of infrastructure privatization on four selected macroeconomic variables: total gross domestic product (GDP) per capita, private investment, public investment, and current public expenditures. The first dependent variable is measured in levels. By focusing on per capita figures, it is possible to get a modest look at the impact on poverty through income levels. The other three are calculated as a percentage of the GDP. Within infrastructure, the distinction is made between *utilities* (electricity, gas, water, sanitation, and telecommunications) and *transportation* (airports, ports, railways, and roads) to test for possible differences.[5] Because the timing of the changes and the policy environment vary significantly across countries, a time trend and variables that represent the institutional framework are controlled for simultaneously. In addition, the possible existence of (unobservable) country effects is specifically taken into account and tested.[6]

Formally, the data are handled in two separate ways. First, all available data are used, pooling together the whole information set into a single sample. In this pooled data case, where each country and year is treated as a separate observation (denoted by subscript *i*) and no individual heterogeneity is allowed, the following linear relationship for each of our four macroeconomic variables is specified and estimated:[7]

$$y_i = \alpha + d_i'\beta + x_i'\gamma + \xi_i. \tag{5.1}$$

The term y_i represents the dependent variable, α is the intercept, d_i' is a vector of dummies that accounts for private participation and its starting year, and x_i' is a vector of control variables that includes a time trend and others that characterize the country's institutional framework. Finally, ξ_i is a normally distributed error term, uncorrelated with the regressors, and α, β, and γ the (vectors of) parameters to estimate.

The variables included in x reflect the political and governance situation, taking into account the degree of political stability of the country (approximated by the degree of internal conflict) and the strength of the governance structure of the country. According to the specification of x'_i it is possible to derive separate models from expression 5.1. In the first one (Model 1), the macroeconomic variables are explained by two dummy variables that reflect whether some form of private participation exists in utilities and in transport (they will be labeled *DU* and *DT*, respectively). The second model (Model 2) tests, in addition, for the effect of investment associated with a specific form of private sector participation on each one of the macroeconomic variables. Three types of privatization contracts associated with private investment are distinguished: divestures or sale of the assets (*DIV*), concessions (*CONC*), and greenfield projects (*GP*), which are new investments such as new power generators or toll roads. Each of these variables is defined as the share of total investment from privatization associated with each contract type.

The expected sign on these explanatory variables varies with the macroeconomic variable explained. If the predictions of the advocates of privatization are credible, one should expect a net positive effect of infrastructure privatization for GDP per capita and for domestic investment as percentage of GDP, because these are some of the core macroeconomic promises of privatization. For the share of public investment in GDP and for the share of current expenditures, the a priori expectation would be a negative sign, because infrastructure privatization is expected to reduce the overall size of the public sector. In addition, stronger institutions are likely to generate better macroeconomic performance.

The second model tested makes use of the panel characteristics of the sample, where a number of individuals (21 countries, denoted by subscript j) are repeatedly observed through time ($t = 1985, \ldots, 1994$). In the panel data case it is now possible to study specifically whether there are country-specific effects not included in expression 5.1. For each of our macroeconomic variables, the linear relationship that is tested becomes

$$y_{jt} = \alpha + d'_{jt}\beta + x'_{jt}\gamma + \eta_j + \xi_{jt}. \tag{5.2}$$

Both dependent and independent variables have time-variability, but Model 1 and Model 2 could be estimated again, using the same definitions of x provided above. The most significant difference between (5.2) and the pooled data case is that a country-specific effect (labeled η_j) is explicitly accounted for, whereas the error term ξ_{jt} is again normally distributed and uncorrelated with the regressors.

It is precisely the nonappearance of the country-specific term that may bias the estimates in the pooled data case because of a standard *omitted-variable* problem (Amemiya 1985). Panel data models allow for a method to correct this problem, using either a fixed effects or a random effects approach. In the first case, the (unobserved) individual heterogeneity is represented as a parametric shift in expression 5.2. It is *as if* a new intercept, $\alpha_j = \alpha + \eta_j$, time-invariant and particular to each country, were defined and the estimation by ordinary least-squares (OLS) would explicitly consider it. In the random effects case, the individual heterogeneity term is assumed to be part of the error term, $u_{jt} = \eta_j + \xi_{jt}$. The error becomes autocorrelated, and the model must be estimated by generalized least-squares (GLS).

Unfortunately, both approaches do not always yield the same result, as observed by Hausman (1978). However, if the effects of omitted variables can be appropriately summarized by a random variable and the (unobserved) individual effects may also represent the ignorance of the investigator, it does not seem unreasonable to treat in one case the source of ignorance as fixed (α_j) and in the other case as random (u_{jt}). It appears that one way to encompass the fixed effects (FE) and the random effects models is to assume from the outset that the effects are random and use GLS to estimate them. The immediate check, summarized in the Hausman test, would be then to contrast whether the heteroskedasticity of the model allows a fixed effect approach.[8] The Hausman test is used when there are two estimators of the parameter vector β (for example, β_{GLS} and β_{FE}). Under the null hypothesis (H_0), individual effects are not correlated with the regressors, β_{GLS} is consistent and efficient, but β_{FE} is inefficient. Under the alternative H_1, β_{FE} is consistent but β_{GLS} is inconsistent. This allows a routinely performed comparison between fixed effects and random effects estimates.

A final important question regarding model specification is related to potential dynamic effects in our estimated relationships. Unless the economies behave in a hyper-rational way and manage to internalize instantaneously the effects of reform policies, the optimal lag for the dummies included in vector *d* should be different from zero. It is natural to expect that privatization may not convey its full (positive or negative) consequences immediately. Instead, based on a simple look at the facts in the region, a reasonable lag of one or two years should be considered. These dynamic effects are investigated by estimating—for each of our dependent variables, for each data case (pooled versus panel), and for each of our models (Models 1 and 2)—slightly different variations on (5.1) and (5.2), where the dummies have been lagged one and two periods. The results of all these estimations, reported below, permit analysis of the macroeconomic effects of privatizations, by type of process, considering the existence of country-specific effects, and taking into account short-run versus medium-run impacts.

The Variables, the Data, and Their Limitations

A sample of 21 Latin American and Caribbean countries, excluding only Belize, French Guyana, and Surinam among mainland states, was collected. In principle, this geographical dispersion offers enough variety of infrastructure reform experiences and of income levels to yield useful policy conclusions. The time period covered stops in 1998, just before the effects of the Asian crisis started to have a major impact on the financing of Latin America's infrastructure.

The specific sample size for each macroeconomic variable considered in this study varies across the models estimated because comparable data could not be obtained for all variables for all countries. The largest samples cover all of the 21 countries. The smallest focuses on only 16 countries. Because the overall sample tracks the changes in the role of the private sector in infrastructure for 14 years (from 1985 to 1998), the econometrics can make use of panel-of-data approaches as described above. Because there are several variables for which no information was available for some years, the panel is unbalanced.[9]

The macroeconomic dependent variables—GDP per capita, total public investment, total private investment, and current public expenditures—are from the *World Development Indicators* produced by the World Bank (2002a) and are all expressed in 1995 U.S. dollars at constant prices.[10]

Table 5.1 summarizes the ranking of the countries covered by the sample, for the sample time average, and for each one of the macroeconomic variables. At first glance the table shows the lack of consistency of countries in ranking, suggesting that there are enough differences in behavior across variables to justify a separate analysis of each macroeconomic variable individually. The table also shows the main sources of imbalance in our data panel. The fiscal deficit is the least complete variable because values for El Salvador, Guatemala, Guyana, Honduras, and Jamaica are missing.

The data quality issues already referred to start here. A measurement problem may exist in the definition of several of these macroeconomic variables in relation to the concerns addressed here. According to the World Bank's *World Development Indicators* database, public expenditure, and public investment all refer to the central government alone. However, much infrastructure-related activity is usually developed by public enterprises that may finance themselves outside the central government's budget. These data are thus not picked up by this database as public investment and get picked up only as part of total investment by national accounts. The only way any change resulting from increased private participation can be identified is through the decline in transfers from the central government to the public enterprises, once these are replaced by private operators.

This measure is imprecise, however, because public sector accounts are not very detailed at the sector level and hence the data could produce imprecise results. For example, the data fail to capture much of the impact on recurrent public expenditures and on public investment in utilities privatization when current or capital expenditures on utilities

Table 5.1 Main Macroeconomic Variables: Levels and Ranking

	GDP		*Public investment*		*Private investment*		*Current expenditure*	
Country	*Ranking*	*Value (1)*	*Ranking*	*Value (2)*	*Ranking*	*Value (2)*	*Ranking*	*Value (2)*
Argentina	1	7065.76	20	1.49	14	19.04	17	8.29
Bolivia	17	863.76	4	7.86	18	15.36	10	12.34
Brazil	3	4269.94	19	2.32	11	21.38	5	16.00
Chile	7	3444.01	7	5.02	6	23.87	14	10.44
Colombia	11	2182.56	5	7.82	10	21.61	9	12.56
Costa Rica	9	2471.03	8	4.95	3	26.58	4	16.49
Ecuador	14	1518.33	9	4.64	13	20.54	13	10.45
El Salvador	15	1488.07	13	3.65	17	15.56	12	10.79
Guatemala	16	1398.81	17	2.67	19	14.29	21	6.38
Guyana	19	671.65	1	15.91	1	29.64	2	19.00
Haiti	21	440.21	10	4.59	21	10.45	20	7.84
Honduras	18	697.03	6	7.61	4	25.43	11	11.81
Jamaica	13	1567.49	—	—	2	29.23	7	14.85
Mexico	5	4102.54	16	3.23	7	22.70	15	9.51
Nicaragua	20	476.69	2	12.40	5	23.97	1	24.01
Panama	8	2847.40	15	3.54	9	21.94	3	17.66
Paraguay	12	1793.86	11	4.49	8	22.26	19	7.86
Peru	10	2391.83	14	3.62	12	21.31	18	8.23
Trinidad and Tobago	4	4247.32	18	2.51	16	17.72	6	15.22
Uruguay	2	4989.11	12	3.76	20	12.97	8	13.43
Venezuela, R.B. de	6	3510.81	3	9.60	15	18.67	16	8.63

— Not available.

Note: GDI = gross domestic investment. (1) in US$ per capita; (2) in percentage of GDP.

Source: World Bank 2002a, and authors' elaboration.

prior to privatization were made by public enterprises rather than the government, because the balance sheets of public enterprises are seldom well integrated in the published government budgets. Furthermore, this effect may differ for different types of infrastructure (for example, telecommunications and power usually belonged to the realm of public enterprise whereas roads and ports were typically under the central government), and at different government levels. Fortunately, in Latin America—with the major exception of Brazil (in the case of roads, for example)—the most relevant privatization transactions in the region generally involved the central government.

The second matter of concern with the variables is the specific definition of privatization. A set of *infrastructure privatization dummies (d* in the econometric model) were relied on, constructed from the World Bank PPI database on private participation in infrastructure projects (World Bank, PPI Project Data Base, available at http://rru.worldbank.org.) The dummies are as follows:

- *DU:* takes a value of 1 starting on the first year there is a private utility project in a specific country (for example, a private power generator or a private cellular operator).
- *DT:* takes a value of 1 starting on the first year there is a (significant) private operator of transport infrastructure in a specific country.

Table 5.2 shows the first year in which each dummy takes the value of 1. The main problem with this variable is that it reflects the start of

Table 5.2 First Year for Private Participation in Utilities and Transport

Country	*Utilities*	*Transport*	*Country*	*Utilities*	*Transport*
Argentina	1990	1991	Honduras	1994	n.a.
Bolivia	1987	1996	Jamaica	1990	n.a.
Brazil	1985	1985	Mexico	1991	1991
Chile	1987	1995	Nicaragua	1993	n.a.
Colombia	1991	1994	Panama	1996	1994
Costa Rica	1989	n.a.	Paraguay	1992	n.a.
Ecuador	1985	1985	Peru	1985	1985
El Salvador	1995	n.a.	Trinidad and Tobago	1991	n.a.
Guatemala	1994	1997			
Guyana	1991	n.a.	Uruguay	1992	1993
Haiti	1995	n.a.	Venezuela, R.B. de	1985	1985

n.a. Not applicable.

Note: Average. Dummies *DU* and *DT* take value 1 from the starting year onward.

Source: World Bank 2002a, and authors' elaboration.

reliance on some form of project finance scheme rather than a major effort to restructure the sector and to rely systematically on private finance and operation for most of the sector. The correlation between the variable constructed this way and a variable that would focus on major policy changes is strong but far from perfect. The decision was made to stick to this approach because project finance data are more closely related to the actual investment levels that are expected to influence the levels of macroeconomic indicators, in particular for the public sector.

In addition, the attempt was made to distinguish between contract types associated with each project. To do so, the following variables associated with the three types of infrastructure privatization were constructed:

- *DIV:* the number of divestitures or asset sales contracts in each year because of infrastructure privatizations for each of the two broad subsectors for each country
- *GP:* the number of greenfield project contracts in each year because of infrastructure privatizations for each of the two broad subsectors for each country
- *CONC:* the number of concessions contracts in the database in each of the two subsectors.

Each contract type variable is multiplied by the relevant dummy to ensure that the contract type only kicks into the regression after the first privatization in utilities and transport has started. This is recognized by a *DT* and *DU* suffix attached below to each contract type in Table 5.3, which summarizes the results.

Table 5.3 shows that the institutional explanatory variables used as regressors in the model specifications (5.1) and (5.2) above are the following: two institutional variables (labeled by x in the model) have been obtained from the *World Development Indicators*. The index of political stability (D) is approximated by the inverse of the degree of violence and its impact on the ability of the government to govern. The countries are ranked on a scale of 1 to 12 with the lowest rating allocated to the most unstable countries (for example, countries during a civil war) and the highest rating to the stable countries. The quality of the political system of the country (F) is also approximated by a ranking on a scale of 1 to 6. A ranking of 1 is allocated to the most corrupt countries. A value of 6 is allocated when a country is perceived to be corruption-free.[11]

Table 5.3 Average Value of the Institutional Variables between 1985 and 1998

Country	*Political stability*	*Corruption*	*Country*	*Political stability*	*Corruption*
Argentina	9.9	3.4	Honduras	5.8	2.1
Bolivia	5.9	2.1	Jamaica	9.1	2.6
Brazil	8.9	3.6	Mexico	9.4	3.1
Chile	7.4	3.2	Nicaragua	5.3	4.7
Colombia	5.4	2.7	Panama	8.0	2.1
Costa Rica	9.3	4.9	Paraguay	9.4	1.2
Ecuador	9.8	3.1	Peru	5.1	3.0
El Salvador	4.7	2.5	Trinidad and Tobago	8.8	2.8
Guatemala	6.3	2.5			
Guyana	7.7	1.7	Uruguay	8.3	3.0
Haiti	4.7	1.4	Venezuela, R.B. de	10.4	3.0

Note: Political stability is measured from 1 (low) to 12 (high). Corruption goes from 1 (bad) to 6 (clean).

Source: World Bank 2002a.

The Results

LIMDEP v.7.0 econometric software was relied on to obtain OLS and GLS estimates of the linear specifications (5.1) and (5.2) described above. For each dependent variable (GDP per capita, private investment, public investment, and public expenditure), tables are provided, first for Model 1 (where privatization dummies are separated into transportation and utilities) and then for Model 2 (where contract types for transportation and utilities are separately identified). Each table is divided into two main columns that allow an explicit comparison between the pooled data case (that is, not taking into account the presence of country-specific effects) and the panel data case.

Finally, the results presented in each column distinguish between the situation where the privatization dummies are simultaneous (zero lag) or are lagged one or two periods to identify delays or adjustments in the *macro–micro* effects. All estimated coefficients are accompanied by the standard goodness of fit statistics (*t*-coefficients at 95 percent of confidence, adjusted R^2 values, and the corresponding log-likelihood ratios).[12] Panel data results (which specifically account for the presence of individual heterogeneity) correspond to the random effects specification, except when the result of the Hausman test suggests that fixed effects could be more appropriate.

Finally, the ultimate comparison between pooled data estimates and panel data estimates (in other words, whether country-specific effects are relevant or not) can be carried out through a general specification test on the covariance properties of the panel residuals. There are different tests for this purpose in the literature. The standard LM-test proposed by Breusch and Pagan (1979) was chosen because its calculation is simpler. The LM statistics, whose null hypothesis in this case implies that individual effects are not relevant, are shown. Tests are carried out in the final rows of each table.

Effects of Private Participation in Infrastructure on GDP per Capita

Table 5.4 summarizes the estimates of Model 1 using GDP per capita as the dependent variable, both for the pooled data case and the panel data case. Because the comparison tests show that panel data estimates (using the fixed effects approach) are preferred to pooled data estimates, the results worth considering are those in the final columns. Moreover, although the goodness of fit measures are to be taken cautiously in panel estimations, the values of the adjusted R^2 are relatively high. The preferred regression suggests that the trend matters strongly and that the institutional variables are highly significant with the expected sign, even when lagged dummies are included in the regression.

As for the main focus of this chapter, the coefficients on the PPI dummies, *DU* and *DT*, suggest that only PPI in transport infrastructure seems to have a positive (and significant) effect on GDP per capita, both when considered unlagged and when a lag of one or two periods is included. These results are somewhat surprising, but imply that the effect of PPI on growth varies across infrastructure types in Latin America. The lagged dummies do not alter the signs or size of these effects very much, suggesting that the impact of PPI in transport may be distributed over time. Table 5.5 summarizes the results for Model 2, in which the dummies are separated by type of PPI (divestures, *DIV*; greenfield projects, *GP;* and concessions, *CONC*). The estimation methodology is consistent with table 5.4, because the Hausman test suggests that fixed effects are preferable and the LM test does not reject the existence of country-specific effects.

The institutional variables in the panel data estimations are, respectively, positive and negative for D and F, with the same interpretation as above. However, the disaggregated effects of PPI types show several new results. First, divestitures and greenfield projects have significant and positive effects for utilities (even when lagged one

Table 5.4 Effects of PPI on GDP Per Capita (Model 1)

	Pooled data case						*Panel data case (fixed effects)*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	158.661	0.52042	174.878	0.51919	205.508	0.54850						
TIME	−43.922	−1.641	−52.253	−1.74169	−58.1843	−1.71985	18.7264	3.36999	17.9955	3.01499	21.3374	3.18398
D	242.708	6.94567	252.367	6.73199	257.547	6.42126	28.3979	3.18444	25.2048	2.78471	23.7823	2.50583
F	264.676	3.20049	249.947	2.83498	236.825	2.47938	−106.00	−3.8653	−82.446	−3.00623	−67.1605	−2.31178
DU	−641.87	−2.5325					−29.439	−0.5787				
DT	1433.55	6.90419					489.852	8.40341				
DU-1			−591.80	−2.25789					3.21975	0.6350		
DT-1			1453.3	6.51564					504.02	8.31114		
DU-2					−530.48	−1.95242					30.2842	0.57773
DT-2					1465.98	6.04391					480.864	7.00114
Adj. R^2	0.3273		0.31729		0.3025		0.98041		0.9821		0.9823	
Log Lr	−2546.68		−2368.4		−2190.09		−2016.3		−1860.7		−1715.89	

Comparison tests

Estimation method	*Unlagged*			*Lag =1*			*Lag =2*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.	LM test	d.f.	Prob.
	492.75	1	0.0000	432.92	1	0.0000	386.69	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	10.99	5	0.05167	18	5	0.0029	21.34	5	0.0006

Note: Dependent variable is GDP per capita. *t*-ratios are calculated at 95 percent level of confidence. Blank cells represent different lags.
Source: Authors' computations.

Table 5.5 Effects of PPI on GDP Per Capita (Model 2)

	Pooled data case						*Panel data case (fixed effects)*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	523.698	1.8647	678.623	2.23009	841.8	2.52653						
TIME	−109.31	−4.8668	−118.527	−4.67099	−128.067	−4.41238	16.954	3.34287	18.8212	3.41408	23.0818	3.76959
D	225.598	7.08405	229.748	6.7498	228.998	6.27975	23.5891	2.57865	20.6748	2.19548	17.6267	1.82271
F	260.585	3.44418	235.477	2.94337	220.828	2.56155	−73.6671	−2.47859	−61.1194	−2.05414	−58.2651	−1.94686
DIVDU	128.391	4.99402					12.9868	2.22143				
GPDU	99.394	2.51293					38.75	4.03708				
CONCDU	209.51	1.43128					21.8197	0.77787				
DIVDT	−836.1	−0.5994					722.373	2.6597				
GPDT	476.72	0.43957					−9.805	−0.04648				
CONCDT	165.07	1.07172					25.503	0.85045				
DIVDU-1			106.818	3.41141					13.1279	1.8994		
GPDU-1			98.48	2.49363					36.4376	3.86373		
CONCDU-1			183.028	1.21337					17.097	0.61229		
DIVDT-1			−867.062	−0.61826					672.495	2.54702		
GPDT-1			−2125.38	−0.90207					−178.181	−0.3913		
CONCDT-1			404.275	1.50967					29.2965	0.54961		
DIVDU-2					118.364	3.95182					18.0522	2.77911
GPDU-2					102.304	2.54982					31.2365	3.34042
CONCDU-2					128.024	0.80218					29.884	1.04156
DIVDT-2					−841.789	−0.5937					663.142	2.55595
GPDT-2					−1522.47	−0.61293					83.771	0.18168
CONCDT-2					323.96	1.13581					−6.28027	−0.1131

Adj. R^2	0.4159	0.4169	0.4111	0.9795	0.9811	0.9821
Log Lr	−2523.87	−2344.90	−2166.67	−2020.16	−1866.01	−1715.32

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*			*Lag = 2*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.	LM test	d.f.	Prob.
	566.59	1	0.0000	493.99	1	0.0000	419.37	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	16.95	9	0.0495	17.36	9	0.043	14.89	9	0.0939

Note: Dependent variable is GDP per capita. *t*-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

and two periods). Concessions, on the other hand, do not yield significant coefficients. For transport, only divestitures seem to have a relevant impact on GDP per capita. Divestitures are sometimes viewed as the strongest form of commitment to the private sector to take care of the delivery of the services. What this suggests, at least in a first analysis, is that only the strongest commitment to a private sector role has an impact on GDP per capita.

Effects of Infrastructure PPIs on Private Investment

Table 5.6 shows the results from Model 1 using private investment (as directly reported by the *World Development Indicators* database [1999]) as the dependent variable. An interest rate variable, LR (the lending rate listed in IMF 2002), was added to ensure a better specification of the model for both the pooled data case and the panel data case.

As in table 5.4 above, country-specific effects are relevant, according to Breusch and Pagan's LR test, but now the Hausman tests suggest that random effects, instead of fixed ones, are the preferable way to specify η_j. In general, it seems that this model is not as good in explaining what happens to private investment.

The trend continues to be a significant factor as is the degree of political stability. The measure of corruption used does not perform well because it does not appear to have a statistically significant effect. Most interesting is that the PPI dummies (except for *DT* when lagged two periods) are never significant.

Table 5.7 tells a very similar story. Again, panel data (with random effects) are preferable to pooled data, but the overall significance of the model is lower than for GDP per capita. As for our variable of concern, the emerging story is interesting. It suggests that greenfield projects can make a difference but do so with a negative sign, implying some *crowding-out* of other private investment projects. The results also show, somewhat expectedly, that concession contracts in transport have a positive lagged effect on private investment. As is well known by the specialists of investment promotion programs, good transport services are crucial to attract investment. These results confirm their experience.

Because there was some concern about the quality of the dependent variable used, the models were also run by redefining private investment as the difference between total investment and public investment. This analysis is carried out in table 5.8, where Model 1 (and Model 2, which was not reported here) has been reestimated using this new definition of the dependent variable. The estimates—once more, panel

Table 5.6 Effects of PPI on Private Investment (Model 1)

	Pooled data case						*Panel data case (random effects)*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	11.861	8.02367	12.0409	6.98812	0.36487	2.20199	14.9078	8.81839	14.7674	8.14323	0.47517	3.80217
TIME	0.29529	2.41093	0.32733	2.28893	0.4425	2.02643	0.36130	3.68471	0.43668	3.961	0.29703	1.58399
D	0.67260	3.95373	0.54518	2.80695	0.86932	1.55013	0.45569	2.9258	0.43663	2.50088	−0.40788	−0.64676
F	0.60011	1.37261	0.82739	1.67031	−0.00188	−2.16141	−0.61882	−1.23564	−0.44978	−0.80148	0.00069	1.07466
LR	−0.0007	−2.62139	−0.00126	−2.48127	−0.58515	−0.50375	0.00014	0.67633	0.00022	0.58817	0.1647	0.17563
DU	0.74026	0.66619					0.69279	0.81816				
DT	−2.7784	−3.15398					0.48218	0.51042				
DU-1			–0.70641	–0.62162					−0.13708	−0.14876		
DT-1			0.01114	0.19090					−0.01072	−0.2771		
DU-2					0.04304	0.71746					0.01851	0.47977
DT-2					12.3933	6.27925					15.5332	7.94757
Adj. R^2	0.2131		0.15799		0.1311		0.6789		0.66016		0.6741	
Log Lr	−703.43		−647.51		−585.539		−590.903		−543.15		−484.37	

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*			*Lag = 2*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.	LM test	d.f.	Prob.
	337.56	1	0.0000	353.10	1	0.0000	344.24	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	9.86	6	0.13	9.34	6	0.1553	6.58	6	0.361

Note: Dependent variable is private investment. *t*-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

Table 5.7 Effects of PPI on Private Investment (Model 2)

	Pooled data case				*Panel data case (random)*			
	Unlagged		*Lag = 1*		*Unlagged*		*Lag = 1*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	11.8566	7.89852	12.1531	7.17573	15.0516	8.14836	15.1976	7.9948
TIME	0.28293	2.42325	0.32373	2.36962	0.48999	5.68235	0.53941	5.47164
D	0.57704	3.49916	0.52336	2.80214	0.54424	3.45748	0.55977	3.23
F	0.78758	1.76644	0.77469	1.54584	−0.96090	−1.79418	−1.12983	−1.89907
LR	−0.0007	−2.57747	−0.00123	−2.41655	0.00016	0.77739	0.00037	1.00481
DIVDU	−0.0347	−0.28951			0.05864	0.48231		
GPDU	0.05293	0.27260			−0.30279	−1.91108		
CONCDU	−0.1222	−0.19009			0.10866	0.25257		
DIVDT	2.06112	0.34429			1.75513	0.45052		
GPDT	6.08447	1.2658			1.52561	0.49100		
CONCDT	−0.9697	−1.27965			0.12912	0.23612		
DIVDU-1			−0.04318	−0.28148			−0.04177	−0.26587
GPDU-1			−0.07583	−0.36051			−0.50265	−2.8282
CONCDU-1			−0.25176	−0.34985			−0.35248	−0.71361
DIVDT-1			3.20066	0.51858			1.59119	0.39855
GPDT-1			0.14229	0.01056			−18.8736	−1.99786
CONCDT-1			−0.13469	−0.0807			2.77924	2.22362

Adj. R^2	0.1757	0.1453	0.6785	0.6787
Log Lr	−706.64	−646.96	−588.73	−535.99

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.
	376.60	1	0.0000	364.74	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	7.73	10	0.655	11.67	10	0.3079

Note: Dependent variable is private investment. *t*-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

Table 5.8 Effects of PPI on Private Investment Defined as Gross Domestic Investment Minus Public Investment (Model 1)

	Pooled data case						*Panel data case (random)*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	8.52524	5.90699	12.0482	7.60141	8.56549	4.64182	11.9965	7.70941	8.18617	5.11725	12.717	7.2551
TIME	0.38858	3.33634	0.38012	4.13288	0.42191	2.74017	0.33188	3.94077	0.42688	3.25328	0.36512	3.4953
D	0.48252	2.88952	0.41659	2.91702	0.38643	1.88699	0.37075	2.77623	0.46902	2.59491	0.31643	2.0644
F	0.35229	0.83851	–1.06257	–2.25479	0.37264	0.71691	–1.07941	–2.46355	0.43905	0.96630	–1.1380	–2.104
LR	–0.0006	–2.26562	6.10905	0.19924	–0.0015	–2.01302	0.00010	0.55941	–0.0010	–2.34242	0.0004	0.8560
DU	–2.3802	–2.24367					–0.56833	–0.78091				
DT	–0.05089	–0.05994					1.0974	1.35159				
DU-1			–1.13005	–1.4864					–2.7763	–2.67919		
DT-1			–0.00707	–0.22991					0.03528	0.67958		
DU-2					–2.1426	–2.02563					–0.130	–0.167
DT-2					0.0391	0.72729					–0.002	–0.084
Adj. R^2	0.1353		0.1322		0.1008		0.720		0.720		0.7365	
Log Lr	–624.24		–574.47		–522.14		–497.00		–456.39		–407.24	

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*			*Lag = 2*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.	LM test	d.f.	Prob.
	411.83	1	0.0000	372.38	1	0.0000	341.30	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	8.14	6	0.22	10.14	6	0.1188	6.79	6	0.3402

Note: Dependent variable is private investment defined as GDI-public investment.
Source: Authors' computations.

data estimates—score slightly better, particularly the institutional variables (which exhibited the same signs as in tables 5.4 and 5.5) and the utilities PPI dummy, but again the overall significance of the model is not as good as had been hoped. The estimates do suggest, however, that a lagged *crowding-out* was taking place during the 1980s and 1990s as a result of the increased presence of private sector participation in utilities.

Effects of Infrastructure PPIs on Public Investment

The estimates in table 5.9 summarize the effects of PPI policies on public investment. The overall statistical results are similar to those of previous tables (and particularly, again, panel data are preferred and political stability is the strongest institutional explanatory variable).

The coefficients of the policy variables reveal several notable differences. First, the unlagged PPI dummies are significant and have the strongest statistical significance, but the impact of PPI is still strong with a one-year lag. Second, and much more interesting, the PPI in utilities and transport infrastructures has a different sign (positive and negative, respectively). PPI in utilities complement or *crowd in* public investments, whereas PPI in transport substitutes for or *crowds out* public investment. What this may reflect is that reforms in the utilities sector are used by governments to raise matching resources from private operators for the sector, whereas for transport, private investments allow governments to reduce their commitments to the sector—in terms of expansion, at least. These results hold, however, only at the aggregate level because it is not possible to draw similar, if more subtle, conclusions from a disaggregation of contract types.

Table 5.10, where Model 2 estimates are presented, suggests that disaggregating the PPI dummies by contract type (*DIV, CONC, GP*) not only reduces the overall significance of the panel data model but also eliminates the validity of individual coefficients in all cases.

Effects of Infrastructure PPIs on Recurrent Public Expenditures

The effects of PPI on recurrent public expenditures summarized in tables 5.11 and 5.12 (pages 164 and 166, respectively) follow a particularly interesting pattern, especially when contrasted with the pattern seen for the effect of PPI on public investment. From an overall statistical viewpoint, the unlagged panel case with fixed effects provides the best results according to the values of the comparison tests; as usual,

Table 5.9 Effects of PPI on Public Investment (Model 1)

	Pooled data case						*Panel data case (random effects)*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	3.66962	3.94788	3.9936	3.75475	4.06308	3.38307	4.44897	4.20102	4.83884	4.1948	5.20166	4.32134
TIME	–0.07364	–0.98179	–0.0624	–0.7266	–0.0049	–0.05000	–0.05740	–1.38683	–0.0541	–1.24162	–0.0266	–0.60620
D	0.02823	0.26252	–0.01665	–0.13596	–0.11209	–0.8315	0.14989	2.27065	0.10937	1.61114	0.06459	1.01417
F	0.44421	1.64164	0.44173	1.44382	0.61026	1.77114	0.01922	0.08736	0.02644	0.11457	0.11744	0.49584
DU	2.28888	3.35006					0.97727	2.75014				
DT	–1.50248	–2.74791					–0.75619	–1.85432				
DU-1			2.23534	3.14047					0.85183	2.41344		
DT-1			–1.28836	–2.14511					–0.65454	–1.57607		
DU-2					1.73967	2.40797					0.31974	0.98976
DT-2					–0.95966	–1.45039					–0.55866	–1.33359
Adj. R^2	0.079		0.0603		0.0393		0.8314		0.8560		0.8888	
Log Lr	–533.17		–486.19		–435.03		–347.08		–300.381		–244.885	

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*			*Lag = 2*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.	Likelihood Ratio Test	d.f.	Prob.
	479.3	1	0.0000	395.18	1	0.0000	341.15	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	3.33	6	0.7664	3.20	6	0.7838	4.15	6	0.6563

Note: Dependent variable is public investment. *t*-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

political stability matters. The time trend has been eliminated because there was a multicollinearity problem with the institutional variable.

The coefficients of the policy variables reveal several new elements. First, both dummies are statistically significant, which implies that there is an interaction between public expenditures and privatization. Second, the PPI dummies for utilities suggest that private investment in telecoms, energy and water, and sanitation has a declining impact over time on recurrent public expenditures (as seen in the declining *t*-ratios for the lagged variables), whereas the positive sign on the transport dummy suggests that as the private sector starts investing in transport, recurrent public expenditures in the sector increase. Third, the longer the lag with which the investment is accounted for, the lower the impact of private participation in utilities on these public expenditures. However, the longer the lag for transport, the higher the impact.

The fact that the PPI in utilities and transport infrastructures has a different sign (negative and positive, respectively) is quite a significant result. For transport, this reflects the common wisdom among practitioners that investments in the sector are only viable when the operation of the services allowed by the investment is subsidized. In other words, there is a complementarity between recurrent public expenditures and private investment expenditures in transport. For utilities, the observation that PPI reduces recurrent public expenditures in utilities may reflect the fact that PPI often leads to significant cost reductions and that subsidy levels tend to decline once private operators take over operations. It may also suggest that during the 1990s, at least, public and private expenditures in the sector were substitutes. Table 5.12, however, suggests that this result does not hold for all types of private sector participation. For divestitures in the utilities sector, it seems that when PPI takes place with that type of privatization contract, recurrent expenditures increase.

Conclusion

This chapter provides empirical evidence on the impact that private participation in infrastructure has had on key macroeconomic variables in a sample of 21 Latin American countries during the 1985–98 period. The effects on GDP per capita, current public expenditures, public investment, and private investment were examined, controlling for country effects and institutional factors. The most interesting initial conclusions focus on the sign of the average macro effects of these micro reforms as estimated from Model 1. Table 5.13 (page 168)

Table 5.10 Effects of PPI on Public Investment (Model 2)

	Pooled data case				*Panel data case (random)*			
	Unlagged		*Lag = 1*		*Unlagged*		*Lag = 1*	
Variable	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*
Constant	3.00518	3.17881	3.05074	2.83953	4.38753	3.86902	4.81907	3.85598
TIME	0.070658	0.972953	0.086508	1.02017	−0.00185	−0.04831	0.004202	0.102901
D	0.084315	0.833599	0.049902	0.435871	0.177649	2.61672	0.159847	2.28561
F	0.579541	2.12111	0.579349	1.88307	−0.00192	−0.00797	−0.08577	−0.33593
DIVDU	−0.10843	−1.40861			−0.00826	−0.15074		
GPDU	−0.03527	−0.29531			−0.05281	−0.76188		
CONCDU	−0.30248	−0.78691			0.008682	0.046816		
DIVDT	−0.41943	−0.11882			−0.34932	−0.21648		
GPDT	−1.08498	−0.38211			−0.1971	−0.15255		
CONCDT	−0.40700	−0.90236			−0.14526	−0.62068		
DIVDU-1			−0.08516	−0.91265			−0.03976	−0.54395
GPDU-1			0.011500	0.091964			−0.07574	−1.06111
CONCDU-1			−0.15569	−0.30543			−0.01017	−0.04515
DIVDT-1			−0.50780	−0.14025			−0.24170	−0.15809
GPDT-1			6.09788	0.769687			−1.61612	−0.44201
CONCDT-1			−1.18086	−1.19824			0.091974	0.186214

Adj. R^2	0.0525	0.03386	0.5199	0.5475
Log Lr	−534.039	−486.68	−352.592	−303.393

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*		
Panel vs. pooled	LM test	d.f.	Prob.	LM test	d.f.	Prob.
	490.14	1	0.0000	413.20	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	5.12	10	0.8829	4.34	10	0.9306

Note: Dependent variable is public investment. t-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

Table 5.11 Effects of PPI on Recurrent Public Expenditures (Model 1)

	Pooled data case						*Panel data case (fixed effects)*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*	*Coefficient*	*t-ratio*
Constant	11.3039	10.7462	10.9635	9.89115	10.3882	9.28352						
D	−0.1788	−1.34699	−0.21252	−1.53208	−0.21873	−1.58207	−0.53505	−4.72158	−0.60036	−5.10504	−0.55101	−4.79349
F	1.76807	5.82027	1.69406	5.34853	1.67279	5.18957	0.37483	1.02608	0.46611	1.23573	0.55759	1.48251
DU	−2.3251	−2.88953					−1.90985	−3.45204				
DT	−0.4033	−0.49698					1.60745	1.91227				
DU-1			−1.5276	−1.84674					−1.03453	−1.78406		
DT-1			−0.33347	−0.39110					1.7084	1.86185		
DU-2					−1.04329	−1.27273					−0.60165	−1.03656
DT-2					−0.11565	−0.1333					2.22864	2.32731
Adj. R^2	0.128		0.1040		0.0933		0.676		0.6648		0.6687	
Log Lr	−886.74		−821.45		−746.58		−731.53		−677.59		−610.06	

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*			*Lag = 2*		
Panel vs. pooled	LM Test	d.f.	Prob.	LM Test	d.f.	Prob.	LM Test	d.f.	Prob.
	492.75	1	0.0000	432.92	1	0.0000	386.69	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	22.12	5	0.0004	19	5	0.0019	16.48	5	0.0055

Note: Dependent variable is public expenditure. *t*-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

summarizes the main results with respect to the statistically significant signs that could be identified.

The first obvious fact to emerge from table 5.13 is that transport and utilities privatization should not be expected to have the same macroeconomic effects. Transport has a significant positive effect on per capita income; utilities have no observable effect. Second, PPI, at best, leaves private investment constant but in the case of utilities tends to crowd investment out, which is the opposite of the effect it has on public investment. Indeed, the third result to emerge is from a public sector perspective. Utilities investment leads to increases in public investments but reduces recurrent expenditures. The opposite holds for transport. In other words, there is *crowding in* of public investment for PPI in utilities and *crowding out* for transport. Also, although private transport investments require a matching commitment to operational subsidies, the arrival of private utility operators reduces the burden of these operational subsidies.

The results generated by Model 2 are in general less interesting. The disaggregation of PPI per contract type yielded few statistically significant results. The most interesting ones are that divestitures, the strongest form of commitment to the private sector, have clear positive effects on GDP per capita. The second interesting result is that concession contracts and greenfield projects in transport have significant payoffs in future investments. Finally, divestitures in utilities and transport concessions tend to increase recurrent expenditures.

These results, however limited, provide the first econometric evidence on the macro effects of micro reforms for the region in which PPI policies have been the most active. Much better data is needed to draw more specific and more robust policy conclusions. Much more ambitious econometric analysis is also needed. In particular, causality has not been tested and an optimal lag structure has not been identified because of data limitations.

As the PPI experience progresses and more and better data become available, it should be possible to refine these results. But for now, these results already provide enough reasons to be concerned about a good assessment of the macro effects and in particular the fiscal effects of private participation in infrastructure. The fact that the effects on GDP per capita are neutral at worst and most probably positive is good news, but privatization comes at a risk with respect to its effects on the public sector accounts. The revelation of this risk may be the main contribution of this chapter because it is inconsistent with the fiscal gains expected by many policymakers as they engage in infrastructure privatization programs.

Table 5.12 Effects of PPI on Public Expenditures (Model 2)

	Pooled data case						*Panel data case*					
	Unlagged		*Lag = 1*		*Lag = 2*		*Unlagged*		*Lag = 1*		*Lag = 2*	
Variable	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*	*Coefficient*	t-*ratio*
Constant	11.8751	11.0155	11.5392	10.3069	10.8341	9.75749					13.4454	7.97494
D	−0.3618	−2.879	−0.33320	−2.56723	−0.29091	−2.27076	−0.69229	−6.24888	−0.70928	−6.18977	−0.55700	−5.19081
F	1.59759	5.24564	1.58883	5.06543	1.64259	5.21548	0.31248	0.84395	0.56458	1.48095	0.62041	1.75473
DIVDU	0.10125	0.95671					0.16150	2.10343				
GPDU	0.02751	0.18406					0.04272	0.36408				
CONCDU	−0.0648	−0.11170					0.44645	1.24778				
DIVDT	−2.8262	−0.51358					−1.82768	−0.53024				
GPDT	4.98035	1.16415					−1.97114	−0.7388				
CONCDT	0.16325	0.2677					0.32307	0.84723				
DIVDU-1			0.03432	0.27820					0.18662	2.02477		
GPDU-1			0.03225	0.22135					0.10929	0.92870		
CONCDU-1			−0.24189	−0.4143					0.44321	1.22012		
DIVDT-1			−3.16602	−0.58592					−2.00054	−0.5856		
GPDT-1			−0.31654	−0.03476					2.97191	0.50511		
CONCDT-1			1.00619	0.96937					0.52354	0.945324		
DIVDU-2					−0.04841	−0.43473					0.10595	1.25544
GPDU-2					0.03067	0.22158					0.15917	1.48609
CONCDU-2					−0.37117	−0.64509					0.32673	0.90769
DIVDT-2					−3.90711	−0.76645					−1.82049	−0.56524
GPDT-2					−10.1595	−1.13554					−3.7521	−0.6523
CONCDT-2					2.32176	2.25521					0.78765	1.14032

Adj. R^2	0.091	0.0895	0.1064	0.672	0.6683	0.6724
Log Lr	−890.77	−821.57	−742.71	−731.29	−673.94	−606.39

Comparison tests

Estimation method	*Unlagged*			*Lag = 1*			*Lag = 2*		
Panel vs. pooled	LM Test	d.f.	Prob.	LM Test	d.f.	Prob.	LM Test	d.f.	Prob.
	566.59	1	0.0000	493.99	1	0.0000	419.37	1	0.0000
Fixed vs. random	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.	Hausman test	d.f.	Prob.
	21.30	9	0.0113	18.96	9	0.0255	12.7	9	0.1767

Note: Dependent variable is public expenditure. *t*-ratios are calculated at 95 percent level of confidence.
Source: Authors' computations.

Table 5.13 Summary of Signs of Average Macroeconomic Effects of PPI

Variable	*PPI in utilities*	*PPI in transport*
GDP/capita	Not significant	+
Private investment	−	Not significant
Public investment	+	−
Recurrent public expenditures	−	+

Note: + = positive impact on the microeconomic variable; − = negative impact on the microeconomic variable.

Notes

1. Siniscalco, Bortolotti, and Fantini (2001) provided a similar study for countries of the Organisation for Economic Co-operation and Development.

2. The recent literature on regulation theory explicitly acknowledges that the term *private participation* is much more general than *privatization*. The former encompasses many different forms that include divestures, concessions, management contracts, leases, and so on (see Laffont and Tirole 1998).

3. The new growth theory literature is the most likely place to find such a model (see, for example, Aghion, Caroli, and García-Peñalosa 1999). In addition, political economy models may help explain under what circumstances privatization policies can be a success or a failure (see Alesina and Perotti 1996).

4. See Chamberlain (1984) for a survey and examples on the use of macroeconomic panel data.

5. For a review on how different types of infrastructures affect macroeconomic fundamentals, see, for example, Munnell 1992 or Gillen 1996.

6. As usual, a strong misspecification risk is always present in this sort of ad hoc model. However, because our idea is to isolate partial correlations among the privatization variables and the macroeconomic one, the use of the time trend and the institutional variables is the easiest way of minimizing that risk in this kind of heterogeneous sample. A lagged dependent variable (tried at preliminary stages of the work) would have done something similar, but at the cost of one degree of freedom and lower significance levels.

7. Nonlinear specifications were also discarded in preliminary estimations.

8. This argument has been widely discussed in the panel data literature. For example, Arellano (1993) insists on the fact that in the fixed effects model investigators make inferences conditional on the effects that are in the sample, whereas in the random effects model inferences are based on the population. But there is really no distinction in the nature of the effect: it is up to the investigator to decide whether to make one type of inference or the other.

9. However, this can easily be handled in the econometrics (Greene 1995).

10. Although initially tried, the models on the effects on the public deficit were rejected because the variable was not sufficiently reliable. For the interested reader, PPI in utilities tends to be associated with an immediate increase in the deficit whereas PPI in transport is associated with a delayed increase in the deficit.

11. This modeling strategy has been used before. See Fosu 2001, for example.

12. Goodness of fit measures in GLS models should be taken with caution. In particular, R^2 has no clear interpretation in such context.

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6

Regulation and Private Sector Participation in Infrastructure

Sheoli Pargal

THIS CHAPTER ASSESSES THE IMPORTANCE of the regulatory framework as a determinant of private sector investment in infrastructure, using recently compiled data on private and public sector investment in the water, power, telecommunications, roads, and railways sectors in nine large countries in Latin America.[1] Controlling for standard determinants of investment, the impact of variables that represent different aspects of the prevailing regulatory regime on a country's ability to attract private investment in infrastructure is analyzed.

During the last decades of the 20th century many countries in Latin America undertook public sector reform and introduced private participation in formerly state-dominated sections of their economies through management contracts, concessions, or outright privatizations. In the infrastructure sectors this was motivated by a desire to improve performance and increase efficiency in service provision, as well as by the fact that governments were constrained in increasing service coverage or improving public utility performance by limited fiscal resources and a multitude of competing claims on these resources. But investment in infrastructure is characterized by large, up-front, usually sunk costs that lead to a high risk of expropriation, long gestation lags before revenues are generated, and revenues that are usually generated in local currency. These aspects lead to a need for both long-term commitment and long-term financing in local currencies. However, the limited depth of nascent capital markets is rarely able to generate funding of the maturity and volume necessary to finance private infrastructure investment in Latin America. As a result, governments have made a concerted effort to attract foreign capital.

Analysts agree that an environment of macroeconomic and political stability and policy credibility and the existence of a sound regulatory framework are necessary for lowering the perceived risk of expropriation and thus for attracting private capital. In particular, the character of the entities entrusted with regulation determines confidence in the integrity of the system as a whole (see, for example, Kerf and others 1998). In this chapter, the amount of private investment attracted in each infrastructure sector in the countries studied is related to a set of independent variables that includes the characteristics of regulatory entities. This is a first attempt to test the assertion that the lack of independent regulation can be a major hindrance to attracting private sector investment in infrastructure in developing countries.

The study is of particular relevance for reforming countries because the Latin America and Caribbean region is, among the developing regions in the world, farthest along the road to deregulation of basic infrastructure services. It faces second-generation issues of appropriate regulation that others have yet to encounter. By characterizing regimes in terms of their ability to attract private investment in infrastructure, the analysis provides an empirical foundation for policy choices related to institutional structure and regulatory frameworks. In accord with intuition, the results are consistent with the idea that government action to increase regulatory certainty and to minimize the perceived risk of expropriation through the establishment of independent regulatory bodies is a critical determinant of the volume of private investment flows.

This chapter is organized as follows. The next sections provide background on the broad experience of the countries being studied and the approach taken here to assess the quality of the regulatory environment. The data are then discussed and, in the final sections, the estimation strategy and empirical findings of the analysis are described and conclusions presented.

Private Investment in Infrastructure in Latin America

The study covers Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Mexico, Peru, and República Bolivariana de Venezuela between, roughly, 1980 and 1998. Average annual public and private investment levels by sector and country before and after the passage of legislation permitting private entry are shown in appendix table 6A.5. The figures in the chapter display the evolution of private and public investment by sector and country over the period studied.

Almost all the countries in the sample had passed reform legislation by the mid-1990s in the telecommunications, power, and roads sectors.

The year in which legislation was passed in these countries varies widely, with Argentina and Chile being the earliest movers—the first infrastructure regulatory agency in Chile (Subtel or Subsecretaría de Telecomunicaciones) was established in 1977. Liberalization (through the introduction of competition and private sector participation) has also been deepest and most wide ranging in Argentina and Chile. For example, these are the only countries to enact legislation opening the water sector to private investment.

A point of interest is that the passage of legislation permitting private entry has not always been necessary for the private sector to invest in different sectors in this region. In Bolivia, for instance, three railway concessions were granted in 1996 although the relevant legislation was enacted only in 1998. In general, however, enacting legislation formalizes the sector liberalization and makes it less likely that the opening up will be reversed.

The striking increase in average annual investment in telecommunications and electricity and the large jump in the share of private sector investment in these sectors and in the roads sector following liberalization are illustrated in figures 6.1 and 6.2. In telecommunications and power the average annual share of public spending in total investment spending after liberalization declined to significantly less than 50 percent almost across the board. Prior to the opening of the sector, private investment in telecommunications was negligible or actually zero. Following liberalization, private investment increased and public investment declined, so that by 1998 private investment exceeded public spending in the sector in almost all the countries studied. Most countries in the sample granted initial exclusivity periods to privatized telecommunications firms or set limits on entry into the sector.[2] In general, the liberalization of access and tariffs came later. Similarly, between 1980 and 1998, public investment in the power sector generally declined whereas private investment increased, ultimately exceeding public spending in that sector. Liberalization in the power sector was usually accompanied by the restructuring of vertically integrated utilities.

Although legislation permitting private entry into the roads sector had been approved in five of the nine countries by 1993, the role of the state continued to be substantial even after 1993. With the striking exception of Mexico, where an ambitious toll-road program was launched in the late 1980s, annual public investment in roads far surpassed private investment in most Latin American countries. Private investment in roads increased slowly—the share of the private sector in total investment after liberalization typically remained below 50 percent. Public investment in the water sector also greatly exceeded private investment throughout the period, reflecting the limited liberalization

Figure 6.1 Annual Average Share of Private Investment in Total Infrastructure Investment in Selected Latin American Countries, by Sector

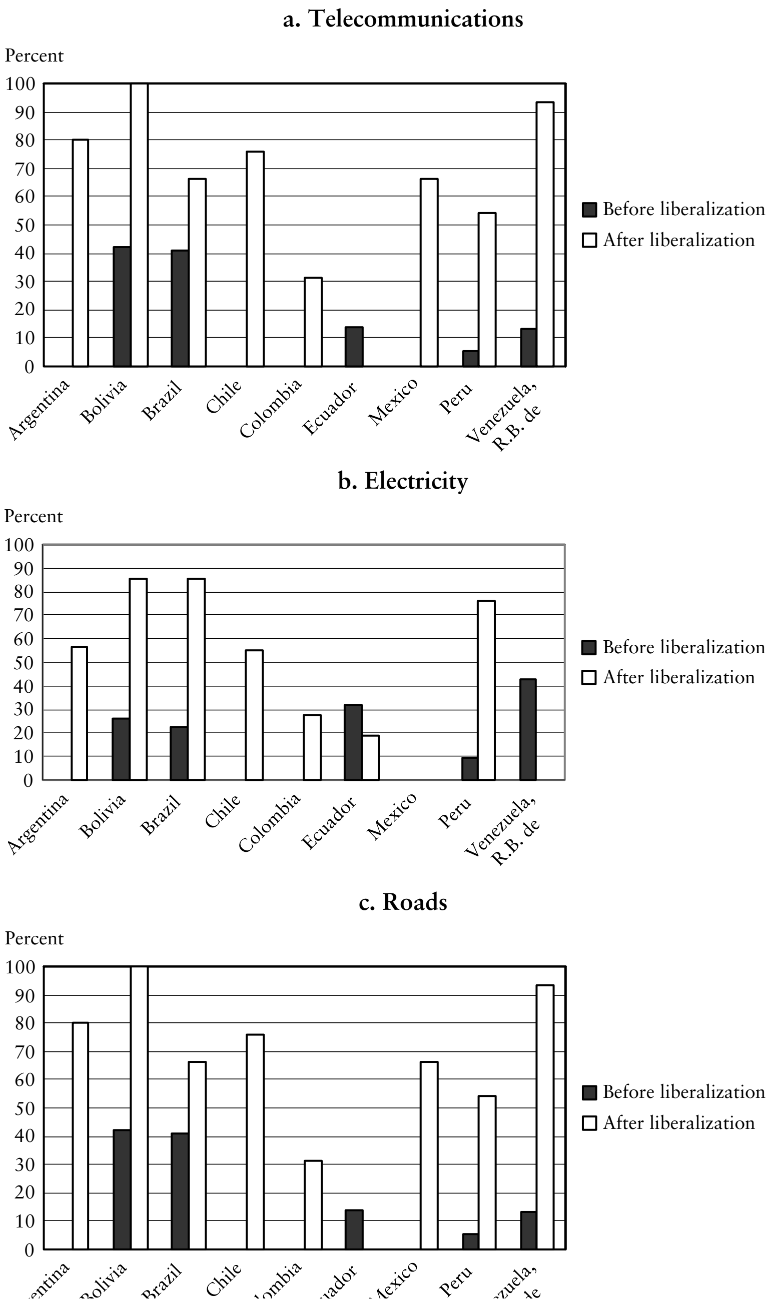
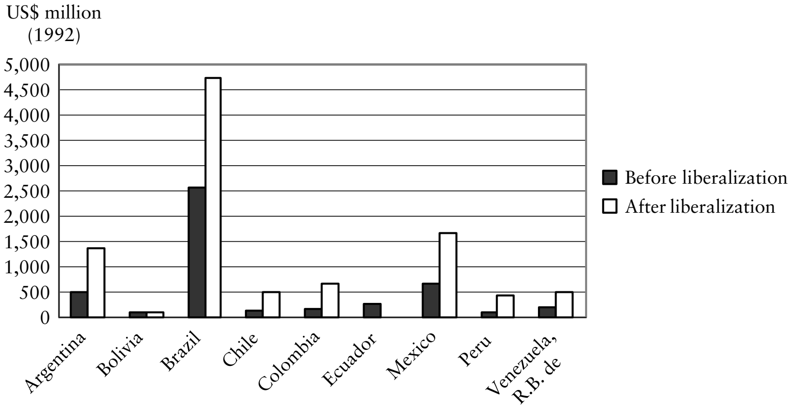
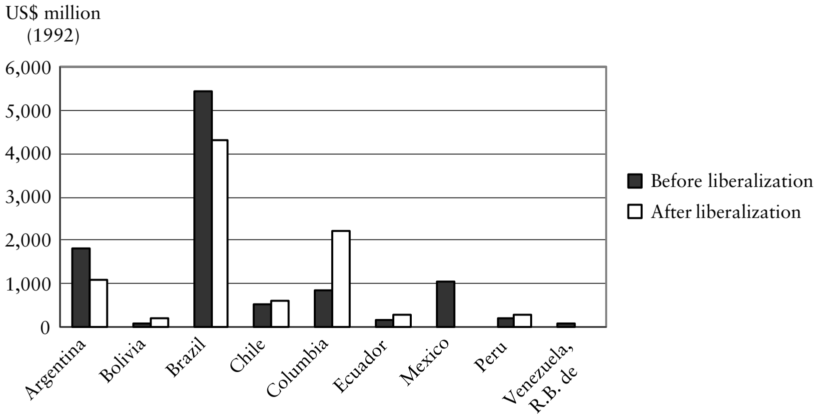


Figure 6.2 Average Annual Investment in Infrastructure in Selected Latin American Countries, by Sector

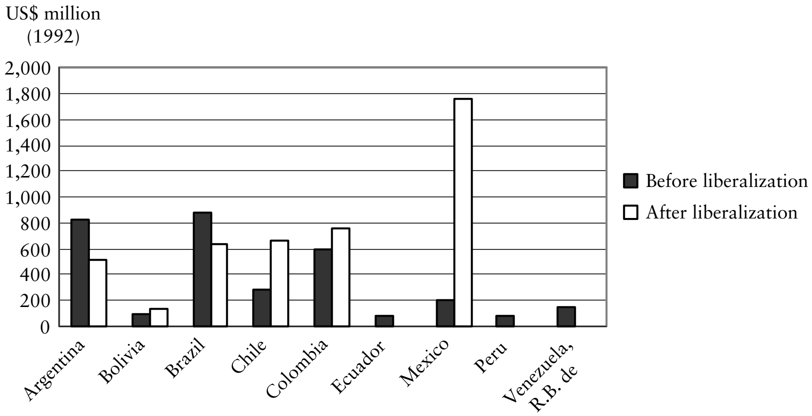
a. Telecommunications



b. Electricity



c. Roads



of the sector in Latin America. This was true for private investment in Chile as well. However, driven largely by the concession contract for Buenos Aires, private investment in water in Argentina grew to exceed public spending during the 1990s. Private investment in Bolivia's water sector also rose to substantially exceed public spending, particularly after 1991—even in the absence of enabling legislation.

A possible explanation for the difference in the average share of private investment in roads and water compared with power and telecommunications may lie in the natural monopoly elements of the road and water sectors. The low traffic density of rural and secondary road networks means that they are less amenable to cost-covering tariffs and thus less attractive to private concessions. As a result the need for public spending on roads is likely to continue.

A similar argument relating to the cost of provision and scale economies has been applied to rural water systems. It is also often politically difficult to auction off the responsibility to ensure road access or the responsibility for basic water service to the private sector because of the perception that these are core infrastructure services that the state should provide. Finally, water and power are the sectors in which the need for tariff adjustment is usually most pressing. This makes the political economy of private entry especially relevant in these sectors. Particularly in the case of water, where the general public (and not a small group) is often affected, anecdotal evidence points to the political difficulty of raising tariffs to cover costs. In fact, such tariff increases led to the failure of several concession contracts in the late 1990s.

Analytical Approach

Although there is a large body of empirical literature on the determinants of investment, including investment in infrastructure, this literature has focused mainly on testing traditional economic theories of investment behavior (see Everhart and Sumlinksi 2001 for a recent overview) rather than on assessing the contribution of the regulatory framework to the investment environment.

Recent empirical work, however, has demonstrated the critical role of the institutional environment in determining the magnitude of investment flows. For instance, the option approach to investment reviewed by Servén (1996) underlined the deterrent effect of uncertainty on private investment, especially when investment is sunk. Investor perceptions about the probability of reform reversal are often a key determinant of their willingness to invest. Lack of sustainability and credibility of reform can thus be a self-fulfilling expectation leaving countries in a low-level investment equilibrium. The general lesson from this analytical and empirical literature is that the stability and predictability of the incentive framework may be even more important than the level of investment incentives in determining the level of investor confidence.

Econometric work by Wallsten (2001a, 2002) on telecommunications reform in developing countries is relevant to the analysis described in this chapter. Wallsten (2001a) found that country-level telecommunications performance is positively related to regulation, as measured by a dummy indicating whether the country had established a separate telecommunications agency not directly under the control of a ministry. That study used a fixed effects approach to explore the impact of privatization, competition, and regulation on telecommunications performance in Africa and Latin America between 1984 and 1997. Wallsten (2002) showed that countries that established separate regulatory authorities prior to privatization saw increased telecommunications investment compared with countries that did not and that investors are willing to pay more for telecommunications firms in such countries.

These findings are consistent with the hypothesis that investors require a risk premium to invest where regulatory rules remain unclear. The analysis conducted for this book contributes to the literature on the role of regulation in private sector development. Detailed data on measures of regulatory independence were used in addition to data on both private and public investment in five sectors across the major economies of Latin America. This level of analysis allowed a more thorough assessment of the importance of independent regulatory institutions on the climate for private investment.

The effectiveness of regulatory institutions depends on the structure and process of regulation, key aspects of which are the independence, competence, and clarity of mandate of the regulatory agency; the transparency and openness of the regulatory process; and the existence of formal oversight and timely judicial review.[3] Smith (1997a, 1997b), discussing the desirable attributes of utility regulators, considered independence from the regulated firm, customers, and political authorities essential. He underlined the important tradeoff between the need to limit regulatory discretion (as, for example, through regulation by contract) to reduce the risk of expropriation and the need to retain the flexibility to respond to new environmental and market conditions (for example, in rapidly changing sectors like telecommunications). The openness and transparency of the regulatory process lessen the probability of capture by different interest groups. An important additional consideration is the country's stability and reputation for respecting private property rights—which can go a long way in assuaging investor concerns and thus allowing the regulator to retain substantial discretion without significantly increasing the cost of capital. But the ultimate accountability of the regulator is critical.

In this chapter the regulatory environment in the countries and periods under study are described in terms of the following four dimensions:

- The passage of legislation that permits private investment in sectors traditionally reserved for the public sector, and the existence of a regulatory body. The passage of enabling legislation is particularly important because Latin American regulatory frameworks are rooted in civil law.
- The autonomy of the regulator. Autonomy or independence is captured by its attributes—the location of the regulatory body outside the government; a separate source of funding (that is, independent of the vagaries of annual budgetary appropriations); and popular support, involving both the legislative and executive branches in the appointment process. Lacking data, it was impossible to assess the importance of aspects of independence such as security and length of tenure of regulators (with staggered terms that are not coincident with the electoral cycle).
- The size of the regulatory agency, with a larger body limiting the probability of capture by different interest groups (as well as the government). Whether the prospect of being able to capture the agency would make a smaller agency more attractive to private investors is an empirical question. A larger size would allow for a range of professional expertise and diversity of opinion (see, for example, Smith 1997a, 1997b, and 1997c), both critical to the competence of the agency. Commentators have argued, however, that a smaller agency could be more efficient in decisionmaking and more predictable, and that individual regulators might be more accountable than those in large commissions, which would make a smaller agency more attractive from the investor point of view. All these factors would suggest a positive relationship between size and private investment flows.
- The degree of risk borne by the investor as measured by whether the tariff regime is rate of return or price cap. Rate-of-return tariff regulation limits the risk taken by the investor vis-à-vis a price-cap regime and thus might be positively related to private investment in infrastructure. Also, Alexander and Irwin (1996) have presented evidence

that price-cap regulation, by subjecting firms to greater risk, increases the cost of capital.

Data

Data sources are described in table 6.1. Macroeconomic data are taken from the World Bank's *World Development Indicators* database and the International Monetary Fund's *International Financial Statistics (IFS)*. Investment data by sector were obtained from the database described in chapter 2 (appendix 2A). Data on regulatory variables (see table 6A.6) were obtained from Guasch (2001).

A physical measure of the infrastructure capital stock each year by sector is used as a control variable. This consists of the following: for roads, total road length and paved road length; for railroads, total length of the rail network; for telecommunications, the number of telephone main lines; for energy, the electric generating capacity in kilowatts; and for water, the growth in the percentage of the population with access to clean water. Pritchett (2000) has pointed out that standard expenditure-based units of capital, particularly public capital, are often inaccurate in what they measure. Especially when it comes to the public sector and in countries where the government is a large investor, the divergence between investment effort and public sector capital stock is very high.[4] This divergence renders suspect analyses that equate public spending on infrastructure with the value of infrastructure capital. With that caveat in mind, physical measures of capital stock were chosen for use as controls, even though they are not comparable across sectors.

The regressions include a dummy that takes on the value 1 in years following the passage of legislation permitting private investment in

Table 6.1 Data Sources

Variable	*Data source*
Real gross domestic product (GDP)	WB *World Development Indicators*
Investment deflator	WB *World Development Indicators*
GDP deflator	WB *World Development Indicators*
Interest rate	IMF *IFS*
Real public investment	See appendix 2A, chapter 2
Real private investment	See appendix 2A, chapter 2
Regulatory variables	Guasch 2001
Physical capital stock	See appendix 2A, chapter 2

utilities (because these sectors were often considered the prerogative of the state). Even though private entry had begun prior to the passage of relevant legislation or the setting-up of formal legal and judicial frameworks for private participation in some countries, the passage of legislation (rather than the earliest private entry into the sector in each country) is used as the measure of liberalization because there is greater certainty implied by the existence of a formal legal basis for private investment.

Summary descriptive statistics for the entire data set and for the set of variables measuring regulatory structure are included in appendix tables 6A.1 and 6A.2. Because, for the most part, liberalization and the development of regulatory frameworks started only in the 1990s, there are substantially fewer observations on the regulatory variables.

Appendix table 6A.3 is the correlation matrix for the complete data set and indicates how different determinants of private investment flows in infrastructure hang together. Public investment and private investment are significantly negatively correlated, supporting the idea that they are overall substitutes. Private investment is also significantly positively correlated with the dummy for the passage of reform legislation and with the existence of a regulatory body. The passage of reform legislation and the existence of a regulatory body are highly positively correlated but not perfectly so—reform legislation had been passed in only 40 percent of sector-country combinations prior to the establishment of a regulatory authority. Appendix table 6A.4 is the correlation matrix for the set of variables measuring aspects of the regulatory regime. The correlation between private investment levels and the passage of legislation opening the sector to private investment is significantly more positive in this subset of the data.

Estimation

In the two basic models examined in this chapter, fixed effects regressions are used to explore the relationship between different groups of independent variables and private infrastructure investment. In all models the dependent variable is the log of real private sector investment by country, year, and infrastructure subsector.

The first model examines the determinants of private infrastructure investment using a dummy for whether a regulatory body existed that year and a dummy for whether enabling legislation had been passed by that year as the only indicators of the regulatory environment. This model is also estimated for the four major sectors separately—telecommunications, roads, electricity, and water—to capture sector-specific idiosyncrasies. The second model is estimated for the years during which a regulatory body exists. This permits the inclusion of characteristics of the regulatory regime as explanatory variables in the analysis and provides an opportunity to assess the impact of the type of regulatory regime on private investment flows to infrastructure.

The reduced form equation being estimated, for each country *i*, sector *j*, and year *t* is

$$\mathrm{Ip}_{ijt} = \mathrm{f}\ (\mathrm{Ig}_{ijt}, \mathrm{GDP}_{it-1}, \mathrm{r}_{ijt}, \mathrm{p}_{ijt}, \mathrm{K}_{ijt-1}, \mathrm{R}_{ij}, \mathrm{D}_{ijt})$$

where Ip_{ijt} = private sector investment, Ig_{ijt} = public sector investment, GDP_{it-1} = gross domestic product lagged, r_{ijt} = real rate of interest, p_{ijt} = price of investment goods, K_{ijt-1} = previous period physical capital stock in the sector, R_{ij} = regulatory regime, and D_{ijt} = dummy for whether a reform law had been passed.

An agnostic stance is taken about whether public sector investment is complementary to or a substitute for private investment in the sector, noting the lack of consensus on this issue in the literature. Lagged capital stock would be expected to be negatively related to investment based on standard accelerator theories as well as on marginal productivity and cost of capital arguments. The sign on lagged GDP is expected to be positive because higher income should lead to greater capacity to invest, and more investment should also lead to an increase in incomes over time. The real rate of interest is included to capture the impact of the cost of financing on investment decisions, and a measure of overall investment goods prices is included to account for the actual cost of investment.[5] Both these price variables reflect the opportunity cost of capital and are expected to have a negative relationship with the amount of private investment attracted to a particular sector.

The existence of a regulatory body and the passage of reform legislation would both be expected to be positively related to the volume of private investment flows because both represent government commitment to constraints on its own power. This results in less scope for discretionary or arbitrary action (for example, against investor interests) and thus would imply a more certain business environment. The notion that investors require a risk premium to invest when regulatory rules remain unclear is supported by Wallsten (2002), who found greater investor willingness to pay for telecommunications firms in countries that have established regulatory authorities.

In the second set of regressions the dummy for the passage of reform legislation is augmented by the following regulatory indicators: whether regulatory decisions involve ministerial participation or the regulatory body is part of a ministry, whether the appointment of regulators involves both the legislature and the executive branch or only the executive branch, the size of the regulatory body, whether the regulatory body is funded solely by the government, and whether the tariff regime is rate of return. Most of these variables capture the degree of autonomy of the regulator from the executive branch and the susceptibility of the regulatory regime to government control or subversion by capture (for example, by regulated entities).

One would expect that a regulatory body being housed in a ministry or any ministerial involvement in decisionmaking would be negatively related to private sector confidence because an arm's-length relationship between the regulator and the government is generally desired. Likewise, regulators who are appointed by the executive branch of the government and those who are entirely dependent on the government for funding are unlikely to be independent. Low autonomy is expected to be negatively related to investor confidence and private investment flows. The expected sign on the coefficient of agency size is ambiguous. To the extent that a larger agency is likely to be more balanced and competent and less likely to be captured, a positive relationship between the size of the regulatory body and private investment might be expected, with the caveat that ease of capture might be attractive in some governance contexts.

Empirical Findings

Exploring the determinants of private investment over time uses the log of annual private sector investment (in millions of 1992 U.S. dollars) in each sector and country (for example, telecommunications in Argentina in 1995) as the dependent variable. Economy-wide control variables are the log of public investment in the sector and country each year, real GDP lagged one year, one-period-lagged physical capital stock in the sector in the country, the real price of investment goods, the real rate of interest, whether a law permitting private entry has been passed, and whether a regulatory body for the sector exists in the country. A time trend and sector dummies (omitted sectors are railways and gas) are included and the data are pooled over all years, sectors, and countries covered. The estimation accounts for the panel structure of the data by putting in country fixed effects.

The results of regressions are reported in which both the investment price and the real rate of interest are included, although including the real rate of interest leads to the loss of some 200 observations. This is because comparable real interest rate data were not available for some countries during the earliest years covered in this analysis.[6]

Determinants of Private Sector Investment

The results of the base regressions are presented in Models 1 and 2 in table 6.2. Model 1 is largely consistent with expectations. The overall relationship of private investment and public investment is one of substitutability. As might be expected, private investment is positively

Table 6.2 Country Fixed Effects Estimation

	Model 1		*Model 2*	
Control variable	*Coefficient*	t-*statistic*	*Coefficient*	t-*statistic*
Log of real public investment (ln_pub)	−0.1201513	−2.033**	−0.3324242	−3.109**
Log of lagged real GDP (ln_lgdp)	4.607274	6.695**	6.830853	2.893**
Trend	−0.2715046	5.483**	−0.3513241	2.157**
Lagged capital stock (lag_k)	2.94e–07	2.488**	−1.80e–07	−0.482
Regulatory body in place (Rbexist)	0.2573572	0.497		
Real rate of interest (Rroi)	−0.0118967	−3.775**	−0.0131696	−0.420
Investment price (Invprice)	−0.131716	−0.112	0.7038148	0.145
Dummy: passage of legislation opening the sector (Dreform)	3.640372	7.026**	6.087679	5.717**
Dummy: telecommunications	0.5296759	0.819	6.806443	3.200**
Dummy: roads	0.6889568	1.258	1.643749	1.179
Dummy: water	−2.344596	−4.135**	1.604541	0.982
Dummy: electricity	0.9701421	1.789*	1.725853	1.181
Regulatory body inside the ministry (Rbminis)			4.018742	2.858**
Dummy: appointment of regulator approved by legislature (Drbelec)			−5.512656	−2.370**
Number of members of regulatory commission (Rbnum)			0.2788061	1.556
Dummy: regulator's budget solely from government (Rbudgov)			−5.512654	−3.489**
Dummy: rate-of-return legislation (D_ror)			−0.9717241	−0.472
Constant	−55.26021	−6.700**	−86.95147	−3.107**
Number of observations	693		183	
R^2 within	0.5122		0.6469	

Note: The dependent variable is the log of real private investment.
* Significant at 10 percent.
** Significant at 5 percent.
Source: Data set used for the analysis (appendix 2A).

related to past period real GDP, indicating that richer economies generate greater private investment flows. A 1 percent increase in previous period real GDP is associated with an increase of 4.6 percent in private investment levels. Lagged real GDP was used as the explanatory variable to reflect the potential causal relationship between GDP and private investment.[7]

Investment volume is negatively related to the real rate of interest and the price of investment goods but significantly positively related to whether legislation enabling private entry has been passed—the mere act of passing legislation liberalizing private entry into a sector increases private investment by 3.6 percent. The dummy for passage of such legislation absorbs a fair amount of the effect of having a regulatory body in place, and indicates that in many cases the legal basis for private entry is probably more important than the actual institutional framework governing private sector participation.[8] Using a dummy to capture the opening of the sector is limiting in that it does not capture critical elements of the post-opening and post-privatization competitive environment, which would affect incentives to invest.

Whether a firm facing competition is likely to invest more or less than a monopoly is an empirical question. In several cases Latin American state-owned infrastructure firms were privatized as monopolies or granted exclusivity periods of varying lengths, as in the telecommunications sector. As shown by Wallsten (2001b) in his study of telecommunications privatization in developing countries, granting a monopoly concession seriously reduces investment by the privatized firm relative to firms that face competition. Unfortunately such data were not available for most of the sectors and countries studied.[9]

The estimation includes previous period capital stock because the coefficient on it is highly significant, although it is a physical measure that varies by sector and is not easy to interpret. The coefficient on capital stock is positive, which is contrary to what theory would suggest. However, this appears to be an artifact of aggregation because it is uniformly negative in the regressions disaggregated by sector.[10] Controlling for other factors, the water sector received significantly less private investment than other sectors, whereas private investment in power was higher than in the other sectors.

Characteristics of the Regulatory System

Given that a regulatory body exists, what aspects of the regulatory structure are critical to attracting private investment in infrastructure? Model 2 in table 6.2 presents the results of the fixed effects regression restricted to the years after a regulatory body had been established. The passage of legislation opening the sector is still a significant and positive determinant of the volume of private investment flows, and public investment is clearly being replaced by private investment. Although the sign and significance of the other economy-wide variables are unchanged, the real rate of interest and the investment price index are no longer significantly different from zero. Also, after controlling for regulatory factors, the telecommunications sector attracts significantly more private investment than do the others.

For the regulatory variables, some results require further exploration. For instance, private investment volumes are significantly positively related to the regulatory body being located inside a ministry or to ministerial involvement in decisionmaking.[11] In addition, systems in which regulators are appointed by the executive branch are associated with greater private investment than if the selection of the regulatory body goes through both the legislature and the executive branch. On the face of it, both these aspects of the regulatory structure should militate against private investor interest because they imply lower constraints on the government's power to expropriate the value of an investment. On more reflection, however, it seems that these results may underline the critical need of investors for regulatory predictability and credibility. For instance, investors are likely to expect that decisions made by a regulator housed in a ministry will not be overturned. In addition, a regulatory body appointed by the executive may be considered stronger by virtue of having the full power of the executive branch behind it, and be perceived to speak with a clearer voice than a regulatory body whose appointees have to go through approval by the legislature.

A natural question is whether these considerations are specific to Latin America. They may result from the historical existence of generally strong executive branches on the continent. Such arrangements may thus increase investor certainty about government intentions and could result in more private investment than otherwise would occur.

It is particularly interesting that, consistent with intuition, private investment is positively associated with the regulator not being funded *solely* by the government. This is an important element of regulatory independence. In addition, the number of commissioners or regulators is positively related to investment volumes (significant at 12 percent), reflecting the possibly greater independence, broader expertise, and lower likelihood of capture of a larger commission.[12] Although not significant, investment volumes are negatively related to rate-of-return tariff regulation that limits both downside and upside risk. Alternative tariff regulatory mechanisms such as price caps would provide the opportunity to earn a higher rate than the fixed rate of return, which would compensate for the greater risk of investment in sectors like infrastructure.

Sector-Specific Results

Table 6.3 presents the results of the base regression for the telecommunications, roads, electricity, and water sectors separately. Multicollinearity among the indicators of regulatory structure and lack of variation of these variables over time within each country led to the decision not to run sector-specific models with regulatory variables included.

Public and private investment in telecommunications and power are strong substitutes. A somewhat weaker but still substitutable relationship is observed in the water sector. In roads the relationship is complementary but not significant. A complementary relationship between public and private investment in the roads sector would indeed be expected because of the difficulty of obtaining private financing for nonprimary highways.[13] In all cases higher lagged GDP is associated with higher private investment volumes and, in contrast to the findings of Models 1 and 2, lagged capital stock is negative and significant in all the sectoral regressions apart from the one for water.

The passage of legislation opening the sector to private entry is significantly positively related to private investment volumes in telecommunications and roads but less so in the power sector and virtually not at all in the water sector. The result on power is somewhat surprising because liberalizations of telecommunications and power have been deeper and wider than those of the other sectors, with a decline in the importance of government investment going hand in hand with the increase in private participation. The regulatory regime might also have been expected to be more critical for power than for telecommunications given the greater contestability of the latter. As in the regression on pooled data (Model 1), the existence of a regulatory body is not a significant determinant of private investment in any sector after controlling for the passage of enabling legislation.

This leads to the question of whether the water sector differs in some crucial respect from other infrastructure sectors. As mentioned earlier, the natural monopoly aspects of water distribution and transmission are stronger than in other utilities. Also, opening up the water sector to private investment, which may require an increase in tariffs to cover costs, tends to be politically more difficult than liberalization in *nonessential* sectors.[14] Investors may thus expect greater scrutiny for water sector investments.

Table 6.3 Fixed Effects Regressions by Sector

Log of real private	*Telecoms*		*Roads*		*Power*		*Water*	
investment	*Coefficient*	t-*stat*	*Coefficient*	t-*stat*	*Coefficient*	t-*stat*	*Coefficient*	t-*stat*
Log of real public investment	–0.2942	–3.189**	0.1825	0.409	–0.7662	–2.500**	–1.0194	–1.55
Log of lagged real GDP	5.8493	4.356**	5.7597	4.312**	4.0419	3.435**	6.4141	4.003**
Trend	0.4144	3.608**	0.3525	3.278**	0.5119	4.703**	0.3059	2.852**
Lagged capital stock	0.0000	–2.168**	0.0000	–4.703**	–0.0004	–4.101**	0.0018	0.000
Regulatory body in place	–1.0046	–1.077	–0.6995	–0.692	0.1993	0.202	0.3486	0.292
Investment price	1.3759	0.628	4.2064	1.815*	1.6965	0.783	1.7566	0.798
Real rate of interest	–0.0058	–0.967	–0.0059	–1.007	–0.0092	–1.620	–0.0205	–3.493**
Dummy: passage of legislation opening the sector	5.2836	5.6**	5.4172	5.148**	1.8347	1.780*	1.8979	1.476
Constant	–67.5412	–4.189**	–66.2719	–4.447**	–41.5051	–2.912**	–76.1823	–3.974**
Number of observations	159		142		159		109	
R^2 within	0.7068		0.6322		0.5499		0.5274	

* Significant at 10 percent.

** Significant at 5 percent.

Source: Data set used for the analysis (appendix 2A).

In view of the risks deriving from both the political sensitivities of privatizing water service provision and the huge sunk costs of investment in the sector, investors are likely to be less willing to invest in water simply because the necessary legislation permitting private entry into the sector has been passed. Investors may look for a better-developed regulatory framework and more detailed investor protections. Finally, it is worth noting that private entry into the sector has usually taken place through the award of large concession contracts, which may not be linked to the passage of legislation. All these factors would lead to the observed lack of correlation between private investment and the passage of legislation permitting private entry.

Conclusions

This chapter has presented findings on institutional factors that affect the investment climate for infrastructure using recent data from the nine largest Latin American countries. The most significant determinant of private investment volumes overall (after lagged GDP) was found to be the passage of legislation liberalizing the investment regime. This is important because it indicates that the legal basis for reform is probably more critical in determining the quality of the investment climate than are specific aspects of the institutional framework governing private sector participation. The general relationship of private to public investment was also found to be one of substitutability.

The results on regulatory structure underline investors' need for stability and predictability and reflect the historical existence of strong executive branches in most Latin American countries. A particularly intuitive result is that private investment is positively associated with the independence and credibility of the regulator, and chiefly its ability to commit.

Controlling for other factors, the water sector received significantly less private investment than did other sectors, whereas the level of private investment in power was higher than that in the other sectors. The sectoral analysis indicates that the water sector differs materially from the other three sectors: private investment in water is not significantly affected by the passage of reform legislation in the sector and public expenditure is very important and only mildly substitutable for private spending. Political economy considerations appear to make private investors more wary of entering the water sector than the other sectors analyzed.

Appendix 6A

Table 6A.1 Descriptive Statistics

Variable	*Observations*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
ln_pvt	1039	–1.508701	6.58633	–9.21034	8.642539
ln_pub	1039	4.353829	3.421206	–9.21034	9.1114
ln_lgdp	995	11.10819	1.305327	8.168795	13.53596
Trend	1039	6.180943	7.640273	–10	18
Year	1039	1986.181	7.640273	1970	1998
Lag_k	975	600168.2	1695603	–0.1339746	1.74e+07
Rbexist	966	0.2691511	0.4437484	0	1
Dreform	1039	0.201155	0.4010567	0	1
Rroi	796	10.59798	52.92596	–98.47225	388.1028
Invprice	1039	1.031041	0.2023544	0.6601342	2.1052

Note: See table 6.2 for full spelling of variables. Ln_pvt = log of real private investment.

Source: Data set used for analysis (appendix 2A).

Table 6A.2 Descriptive Statistics if Regulatory Body Exists

Variable	*Observations*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
ln_pvt	260	1.986591	6.069542	–9.21034	8.642539
ln_pub	260	3.5557	4.241931	–9.21034	7.889421
ln_lgdp	258	11.22734	1.275387	8.627512	13.53596
Trend	260	13.96923	3.958157	0	18
Year	260	1993.969	3.958157	1980	1998
Lag_k	244	784008.1	2054862	–0.1339746	1.74e+07
Dreform	260	0.6307692	0.4835273	0	1
Rroi	260	7.519959	15.01653	–68.56507	94.56563
Invprice	260	0.9823314	0.168972	0.7030305	1.479487
Rbminis	260	0.8961538	0.3056492	0	1
Drbelec	260	0.1115385	0.3154049	0	1
Rbnum	195	4.333333	2.553887	1	9
Rbudgov	255	0.4784314	0.5005169	0	1
D_ror	260	0.0884615	0.2845126	0	1

Note: See table 6.2 for full spelling of variables.

Source: Data set used for analysis (appendix 2A).

Table 6A.3 Correlation Matrix for Complete Data Set

Obs=646	*ln_pvt*	*ln_pub*	*ln_lgdp*	*Year*	*Lag_k*	*Rbexist*	*Dreform*	*Rroi*	*Invprice*
ln_pvt	1.0000								
ln_pub	–0.2141	1.0000							
ln_lgdp	0.0006	0.2294	1.0000						
Year	0.5117	–0.2134	0.0846	1.0000					
Lag_k	0.2445	0.0124	0.3014	0.1308	1.0000				
Rbexist	0.2978	–0.1864	0.0472	0.6419	0.0168	1.0000			
Dreform	0.3371	–0.1475	0.1640	0.5442	0.1849	0.5717	1.0000		
Rroi	–0.0319	0.1689	0.3266	0.0332	0.1213	–0.0779	–0.0093	1.0000	
Invprice	–0.1225	0.0498	–0.2828	–0.2159	–0.0607	–0.2123	–0.2536	–0.2069	1.0000

Note: See table 6.2 for full spelling of variables.
Source: Data set used for analysis (appendix 2A).

Table 6A.4 Correlation Matrix for Regulatory Variables

Obs=191	*Dreform*	*Rbminis*	*Drbelec*	*Rbnum*	*Rbudgov*	*D_ror*	*ln_pvt*
Dreform	1.0000						
Rbminis	–0.1293	1.0000					
Drbelec	0.0013	0.1538	1.0000				
Rbnum	0.2213	–0.1073	–0.1665	1.0000			
Rbudgov	–0.0455	0.1394	–0.3288	–0.0854	1.0000		
D_ror	–0.0006	0.1268	–0.1185	–0.2729	0.0632	1.0000	
ln_pvt	0.4604	–0.0763	0.1662	0.1997	–0.1691	–0.0708	1.0000

Note: See table 6.2 for full spelling of variables.
Source: Data set used for analysis (appendix 2A).

Table 6A.5 Public and Private Investment before and after the Passage of Reform Legislation

Country	*Sector*	*Investment source*	*Average investment per year in 1992 US$m—period before liberalization*	*Average investment per year in 1992 US$m—period after liberalization*
Argentina	Telecoms	Public	502.57	144.00
Argentina	Telecoms	Private	0.00	1,233.00
Argentina	Electricity	Public	1,814.00	437.00
Argentina	Electricity	Private	0.00	664.00
Argentina	Gas	Public	207.00	75.00
Argentina	Gas	Private	0.00	294.00
Argentina	Railways	Public	315.00	108.00
Argentina	Railways	Private	0.00	197.00
Argentina	Roads	Public	826.00	349.00
Argentina	Roads	Private	0.00	161.00

Table 6A.5 (continued)

Country	*Sector*	*Investment source*	*Average investment per year in 1992 US$m—period before liberalization*	*Average investment per year in 1992 US$m—period after liberalization*
Argentina	Water	Public	209.00	138.00
Argentina	Water	Private	0.00	110.00
Bolivia	Telecoms	Public	23.00	0.00
Bolivia	Telecoms	Private	56.00	103.00
Bolivia	Electricity	Public	57.00	28.00
Bolivia	Electricity	Private	25.00	157.00
Bolivia	Railways	Public	19.00	21.00
Bolivia	Railways	Private	9.00	3.00
Bolivia	Roads	Public	82.00	88.00
Bolivia	Roads	Private	11.00	51.00
Brazil	Telecoms	Public	1,427.00	1,601.00
Brazil	Telecoms	Private	1,121.00	3,132.00
Brazil	Electricity	Public	4,218.00	504.00
Brazil	Electricity	Private	1,229.00	3,806.00
Brazil	Railways	Public	887.00	73.00
Brazil	Railways	Private	912.00	259.00
Brazil	Roads	Public	747.00	311.00
Brazil	Roads	Private	131.00	326.00
Chile	Telecoms	Public	120.00	46.00
Chile	Telecoms	Private	0.00	463.00
Chile	Electricity	Public	515.00	217.00
Chile	Electricity	Private	0.00	400.00
Chile	Roads	Public	283.00	494.00
Chile	Roads	Private	0.00	165.00
Chile	Water	Public	72.00	140.00
Chile	Water	Private	0.00	20.00
Colombia	Telecoms	Public	164.00	378.00
Colombia	Telecoms	Private	0.00	298.00
Colombia	Electricity	Public	857.00	1,421.00
Colombia	Electricity	Private	0.00	776.21
Colombia	Roads	Public	598.19	632.52
Colombia	Roads	Private	0.00	123.21
Ecuador	Electricity	Public	120.09	231.29
Ecuador	Electricity	Private	49.77	49.07
Mexico	Telecoms	Public	659.00	538.00
Mexico	Telecoms	Private	0.00	1,116.00
Mexico	Roads	Public	207.97	696.26
Mexico	Roads	Private	0.00	1,059.93
Peru	Telecoms	Public	75.11	131.22
Peru	Telecoms	Private	2.58	312.48
Peru	Electricity	Public	190.30	40.12
Peru	Electricity	Private	3.00	243.49
Venezuela, R.B. de	Telecoms	Public	177.09	13.80
Venezuela, R.B. de	Telecoms	Private	23.42	484.93

Source: Author's calculations.

Table 6A.6 Aspects of Regulatory Structure, by Country and by Sector

Country	*Sector*	*Year established*	*Name*	*In ministry or minister involved in decisions*	*Regulator appointed by legislature and executive*	*Size*	*Tenure*	*Funded solely by government*	*Tariff regulation*
ARG	Electricity	1992	ENRE	0	0	5	5	0	Price cap
ARG	Railways	1996	CNRT	1	0	5	5	0	Price cap
ARG	Roads	1993	MEOSP/Ocraba	1	0	5	1	0	Price cap
ARG	Telecoms	1990	CNC	1	0	EP	5	0	Price cap
ARG	Water	1993	ETOSS	0	0	8	6	0	Price cap
BOL	Electricity	1994	Superintendencia de Electricidad	1	1	1	5	0	Price cap
BOL	Railways	1995	Superintendencia de Transporte	1	1	1	5	0	Price cap
BOL	Roads	1995	Superintendencia de Transporte	1	1	1	5	0	Price cap
BOL	Telecoms	1994	Superintendencia de Telecomunicaciones	1	1	—	5	—	Price cap
BOL	Water	1994	Superintendencia de Agua	1	0	1	5	0	Rate of return
BRA	Electricity	1996	ANEEL	1	1	5	4	0	Price cap
BRA	Railways	1996	Ministerio de Transportes	1	0	EP	EP	1	Price cap
BRA	Roads	1993	DNER	1	0	EP	1	1	Price cap
BRA	Telecoms	1997	Anatel	1	0	EP	EP	1	Price cap

BRA	Water	1995	Municipality	1	0	EP	EP	1	Price cap
CHL	Electricity	1978	CNE	1	0	6	EP	0	Price cap
CHL	Railways	1984	MOP	1	0	1	EP	0	Price cap
CHL	Roads	1984	MOP	1	0	1	EP	0	Price cap
CHL	Telecoms	1977	Subtel	1	0	7	5	1	Revenue cap
CHL	Water	1990	Superintendencia de Servicios Sanitarios	1	0	1	EP	1	Rate of return
COL	Electricity	1992	CREG	1	0	8	4	0	Price cap
COL	Railways	1992	Invias	1	0	1	EP	1	Price cap
COL	Roads	1992	Invias	1	0	1	EP	1	Price cap
COL	Telecoms	1994	CRT	1	0	3	2	1	Price cap
COL	Water	1994	CRA	1	0	9	EP	1	Price cap
ECU	Electricity	1996	CONELEC	1	0	7	4	0	Rate of return
ECU	Railways	—	—	—	—	—	—	—	—
ECU	Roads	—	Direccion de Concesiones	1	0	EP	EP	1	—
ECU	Telecoms	1992	CONATEL	1	0	6	EP	0	Price cap
ECU	Water	—	—	—	—	—	—	—	—
MEX	Electricity	1995	CRE	0	0	1	5	1	Price cap
MEX	Railways	1995	SCT	1	0	EP	EP	1	Price cap
MEX	Roads	1985	Caminos y Puentes Federales	1	0	5	EP	1	Price cap
MEX	Telecoms	1996	COFETEL	0	0	4	EP	1	None
MEX	Water	1989	CAN	1	0	1	EP	1	Price cap

(Table continues on the following page.)

Table 6A.6 (continued)

Country	*Sector*	*Year established*	*Name*	*In ministry or minister involved in decisions*	*Regulator appointed by legislature and executive*	*Size*	*Tenure*	*Funded solely by government*	*Tariff regulation*
PER	Electricity	1993	CTE/Osinerg	1	0	EP	EP	0	Rate of return
PER	Railways	1998	OSITRAN	1	0	4	5	0	Price cap
PER	Roads	1998	OSITRAN	1	0	4	5	0	Price cap
PER	Telecoms	1991	OSIPTEL	1	1	6	3	0	Price cap
PER	Water	1992	SUNASS	1	0	EP		1	Price cap
VEN., R.B. de	Electricity	1992	CREE	1	0	EP	EP	0	Price cap
VEN., R.B. de	Railways	1995	MTC	1	0	EP	EP	1	Price cap
VEN., R.B. de	Roads	1991	MTC	1	0	EP	EP	1	Price cap
VEN., R.B. de	Telecoms	1991	CONATEL	1	0	5	EP	1	Price cap
VEN., R.B. de	Water	—	—	—	—	—	—	—	—

— Not available

Note: See acronym list in book for full spelling of regulatory structures. EP = Discretion of executive power.

Source: Guasch 2001.

Notes

1. These data are summarized in chapter 2.

2. Colombia and Ecuador did not privatize. However, Colombia allowed *controlled competition* in long-distance service and free entry in fixed line local service.

3. See Noll (2000) for an exposition.

4. "(T)he potential contribution to current and future production of a capital stock is not the same as what happened to have been spent on it, especially when governments are the investors" (Pritchett 2000, p. 3).

5. Investment price is calculated as the ratio of the investment deflator to the GDP deflator.

6. Dropping the real rate of interest from the regressions and using only the investment price led to greater significance of the latter and no changes of note in the signs or significance of the coefficient estimates on the other variables.

7. Because the dependent variable is private investment in different infrastructure subsectors and not total investment in the economy, the issue of reverse causality from investment to income or GDP is less likely to be a problem. The effect *on* GDP of private investment is expected to be very attenuated and, given that infrastructure investment has long gestation lags, to act only over time.

8. When the regressions were run without including the reform dummy, higher significance was obtained on the existence of a regulatory body.

9. The empirical results reported in chapter 5 showed that infrastructure privatization has an impact on GDP per capita, with the effect dependent on whether privatization occurs in the transport or the utilities sector, and *varying by the form of privatization:* whether it is through greenfield investment, divestitures, or concessions. Because the investment data used in this study are not disaggregated by the form of private participation, the date for the passage of legislation opening up the sector was used rather than the date of first private entry (greenfield entry or concession, for instance) in the analysis.

10. Dropping this variable made no difference to the sign or significance of other variables.

11. Smith (1997a) noted that a dedicated regulatory unit set up within a ministry is often a first step in the transition from the traditional model of ministerial regulation to a fully autonomous agency. Such a unit coordinates regulatory activity and fosters development of the necessary technical skills and professional norms, often contracting with outside professionals for technical tasks. Alternatively, as in some agencies in Colombia, ministerial participation in the regulatory agency is observed, although the agency has most of the attributes of an independent entity.

12. It is likely that the true relationship is quadratic—reflecting the tradeoffs in speed of decisionmaking versus risk of capture between small and large regulatory bodies.

13. Consistent with this study's findings on roads, Dailami and Leipziger (1998), in an analysis of credit risk premiums in foreign currency private loans to greenfield infrastructure projects in developing countries, found that road projects commanded the highest risk premium in 1994–96.

14. Perhaps in view of the perceived greater political risk of investments in water, the number of large, private international operators is lower than in the other sectors.

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Acronyms and Abbreviations

ARDL	Autoregressive–distributive lag
ADF	Augmented Dickey-Fuller
Anatel	Agência Nacional de Telecomunicações (Brazil)
ANEEL	Agencia Nacional de Energia Eletrica (Brazil)
AYEE	Agua y Energía Eléctrica de Argentina
BOT	Build-Operate-Transfer
BROT	Build-Rehabilitate-Operate-Transfer
CADAFE	Compañia Anonima de Administracion y Fomento Electrico
CANTV	Compañía Anónima Nacional de Teléfonos de Venezuela
CCRD	Companhia Vale Rio Doce
CEPAL	Comisión Económica para América Latina
CFE	Comision Federal de Electricidad
CHILECTRA	Compañía Eléctrica de Chile
CNA	Comisión Nacional del Agua (Mexico)
CNC	Comisión Nacional de Comunicaciones (Argentina)
CNE	Comisión Nacional de Energía (Chile)

CNRT	Comisión Nacional de Regulación del Transporte de Argentina
COBEE	Corporación Boliviana de Energía Eléctrica
COFETEL	Comisión Federal de Telecomunicaciones (Mexico)
CONATEL	Comisión Nacional de Telecomunicaciones (Ecuador and Venezuela, R.B. de)
CONELEC	Consejo Nacional de Electricidad (Ecuador)
CORFO	Corporación de Fomento de la Producción (Chile)
CPT	Compañía Peruana de Teléfonos (Peru)
CRA	Comisión de Regulación de Agua Potable y Saneamiento Básico (Colombia)
CRE	Cooperativa Rural de Electrificación; Comisión Reguladora de Energía (Mexico)
CREE	Comisión Reguladora de Energía Eléctrica (Venezuela, R.B. de)
CREG	Comisión de Regulación de Energía y Gas (Colombia)
CRT	Comisión de Regulación de Telecomunicaciones (Colombia)
CTC	Compañía de Telecomunicaciones de Chile
CTE/OSINERG	Organismo Supervisor de la Inversión en Energía (Peru) (Before: Comisión de Tarifas de Energía)
CUDIE	Cumulated, depreciated, investment effort
CVRD	Companhia Vale Rio Doce
DNER	Departamento Nacional de Estradas de Rodagem (Brazil)
EAP	East Asia and Pacific
ECARES	European Center for Advanced Research in Economics and Statistics

EdC	Electricidad de Caracas (Venezuela, R.B. de)
EDELCA	Electrificación de Caroni (Venezuela, R.B. de)
Electrobras	Centrais Electricas Brasileiras S.A.
EMELEC	Empresa Eléctrica de Ecuador
EMETEL	Empresa Estatal de Telecomunicaciones (Ecuador)
ENDE	Empresa Nacional de Electricidad S.A.
ENDESA	Empresa Nacional de Energía S.A. (Chile)
ENRE	Ente Nacional Regulador de la Electricidad (Argentina)
ENTEL	Empresa Nacional de Telecomunicaciones
EP	Electricity power
ETOSS	Ente Regulador del Agua (Argentina)
EU	European Union
FEPASA	Ferrovias Paulistas
FE–SUR	Fixed effects–seemingly unrelated regressions
FNM	Ferrocarriles Nacionales de Mexico
GDI	Gross domestic investment
GDP	Gross domestic product
GG	General government (spending)
GLS	Generalized least-squares
GMM	Generalized method of moments
GP	Greenfield project
HYDRONOR S.A.	Hidroeléctrica Nor-Patagónica S.A. (Argentina)
IETEL	Instituto Ecuatoriano de Telecomunicaciones
IFI	International financial institution
IFS	*International Financial Statistics*
IPP	Independent power producer

IMF	International Monetary Fund
INICEL	Instituto Ecuatoriano de Electrificación
Invias	Instituto Nacional de Vías (Colombia)
IOU	Investor-owned utility
ITU	International Telecommunications Union
MA	Moving average
MEOSP/Ocraba	Ministerio de Economía, Obras y Servicios Públicos/Organo de control de la Red de Accesos a Buenos Aires (Argentina)
MOP	Ministerio de Obras Públicas (Chile)
MTC	Ministerio de Transportes y Comunicaciones (Venezuela, R.B. de)
NIC	Newly industrialized country
O&M	Operation and maintenance
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least-squares
Opc	Observations per country
OSIPTEL	Organismo Supervisor de Inversión Privada en Telecomunicaciones (Peru)
OSITRAN	Organismo Supervisor de la Inversión en Infraestructura de Transporte de Uso Público (Peru)
PE	Public enterprise
PPI	Private participation in infrastructure
PPP	Purchasing power parity
PTO	Plantas de Tratamiento
RFFSA	Rede Ferroviaria Federal
SCT	Secretaría de Comunicación y Transporte (Mexico)
SEGBA	Servicios Eléctricos del Gran Buenos Aires

SINTREL	Sistema Nacional de Transmissão de Energia Elétrica
SOE	State-owned enterprise
Subtel	Subsecretaría de Telecomunicaciones (Chile)
SUNASS	Superintendencia Nacional de Servicios de Saneamiento (Peru)
SUPTEL	Superintendencia de Telecomunicaciones
SUR	Seemingly unrelated regressions
TELMEX	Telecomunicaciones de México
TS	Time series
2SLS	Two-stage least-squares

Index

Latin America's macroeconomic crises of the 1980s and '90s forced a severe fiscal adjustment across the region. More often than not, however, fiscal stability was achieved at the cost of a drastic compression of public infrastructure spending, which in some countries amounted to half or more of the total budget deficit reduction. The retrenchment of the public sector from infrastructure construction and maintenance was accompanied by the opening up of such activities to the private sector, in the hope that it would take the leading role in infrastructure provision.

This book assesses the consequences of this changed public-private partnership from the perspective of economic growth, public finances, and the quantity and quality of infrastructure services. First, it documents the major trends in infrastructure provision in Latin America over the past two decades. Second, it evaluates the implications of these trends for economic growth and public deficits. Finally, it assesses the determinants and macroeconomic effects of the private sector response, and in particular whether private involvement has succeeded in making up for the public sector retrenchment. Valuable to anyone concerned with Latin America's development, this book will be of particular interest to those in the fields of infrastructure, fiscal policy, and economic growth.

"This fascinating book highlights a neglected cost of two decades of fiscal austerity in Latin America. The authors' careful analysis reveals that the decline in public investment in infrastructure may have been expensive not only for growth but for long-term fiscal solvency as well. Deserves to be read by every IMF economist (and many others besides)."

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John F. Kennedy School of Government, Harvard University

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