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The Role of Public Infrastructure Capital in Mexican Economic Growth

David Alan Aschauer*

Abstract: This paper develops and empirically implements a neoclassical growth model in which output depends on private capital and human capital as well as the quantity, means of financing, and efficiency of use of public capital. The empirical analysis is based on a cross section of 46 developing countries over the period from 1970 to 1990. In general, the paper finds empirical support for the importance of each of the three dimensions of public capital —quantity, financing, and efficiency— for long run standards of living and for transitional growth rates. The empirical results are applied to the recent performance of the Mexican economy.

Resumen: En este artículo se elabora y pone en práctica empíricamente un modelo neoclásico de desarrollo en el cual el producto depende tanto del capital privado y del capital humano como de la cantidad, los medios de financiamiento y la eficiencia del uso del capital público. El análisis empírico se basa en un estudio comparativo de 46 países en desarrollo a lo largo de un periodo que va de 1970 a 1990. En general, los resultados empíricos del modelo apoyan la importancia que tienen para el nivel de vida en el largo plazo y las tasas de crecimiento del periodo de transición todas y cada una de las tres dimensiones del capital público: magnitud, financiamiento y eficiencia. Los resultados empíricos se aplican al desempeño reciente de la economía mexicana.

Mexico, like nearly all countries, invests heavily in its stock of public infrastructure capital —transportation systems, water supply and water treatment plants, electrical supply, and communications. At a basic level, such investment is needed for a strong, flexible, and vibrant economy. Workers need to be able to use transport to get to their workplaces; companies need to use fresh water and dispose of waste as well as to have access to electrical power and communication facilities.

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Table 1. Growth rates of public capital 1970-1990
(percent per year)

	1970-1975	*1975-1980*	*1980-1985*	*1985-1990*
Electrical power	14.8	10.9	1.8	–1.2
Transportation	6.2	11.3	3.8	3.1
Communications	56.9	49.2	8.1	0.1

Source: Feltenstein and Ha (1995).

Yet, in recent years, investment in infrastructure in Mexico has slid and, in certain cases, even turned negative. As table 1 indicates, the estimated growth rates of each of the national stocks of electrical, transportation, and communications capital have plummeted from very high levels attained in the 1970's to –1.2%, 3.1%, and 0.1% per year, respectively.[1] Figure 1 shows the evolution of each of these types of infrastructure capital from 1970 to 1990. As the three separate panels of the figure indicate, by 1990 each type of infrastructure capital was to be found somewhat below its previous high: electrical infrastructure [panel (a)] peaked in 1982 at 73 963 millions of constant (1970) pesos; transportation infrastructure [panel (b)] crested in 1988 at 31 786 millions of pesos; and communications infrastructure [panel (c)] topped out in 1988 at 13 410 millions of pesos.[2]

There is, of course, legitimate concern that the monetary value of public capital is a rather poor indicator of the true public capital stock. For example, Pritchett (1996) argues that "the cost of public investment is not the value of public capital" and provides calculations to show that in a typical developing country less than 50 cents of capital is created for each public dollar invested. This would seem to imply that the use of the perpetual inventory approach to constructing capital stock data series such as those depicted in figure 1 would vastly overstate the true public capital stock.

Figure 2 shows, however, that there is a fairly close correspondence between physical measures of public capital (*e.g.*, kilowatt hours of electrical production) and the perpetual inventory based monetary measures of public capital. In each case, the monetary measures capture the substantial growth in physical capital which occurred from

1 Feltenstein and Ha (1995), p. 289.
2 *Ibid.*, pp. 289-291.

Figure 1a. Public capital stocks
(electrical power)

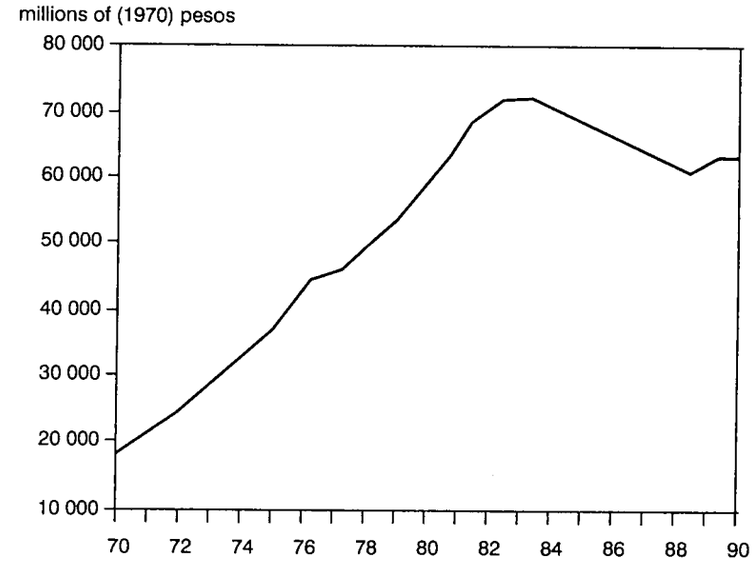


Figure 1b. Public capital stocks
(transportation)

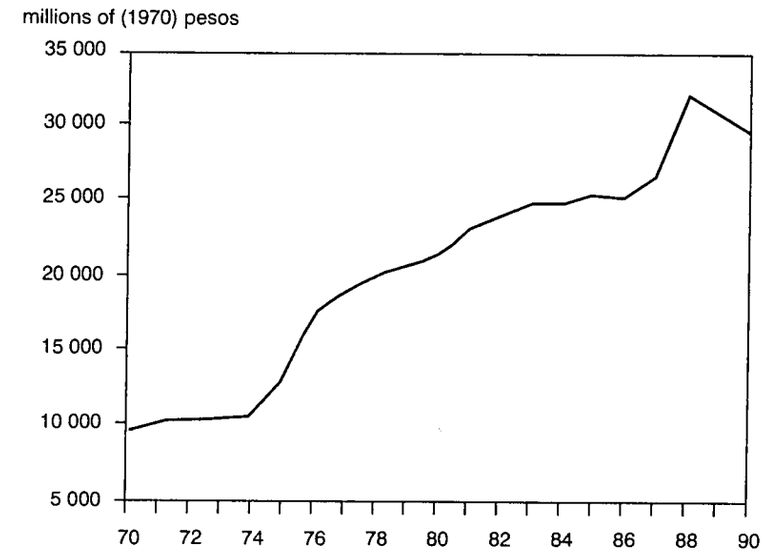


Figure 1c. Public capital stocks (communications)

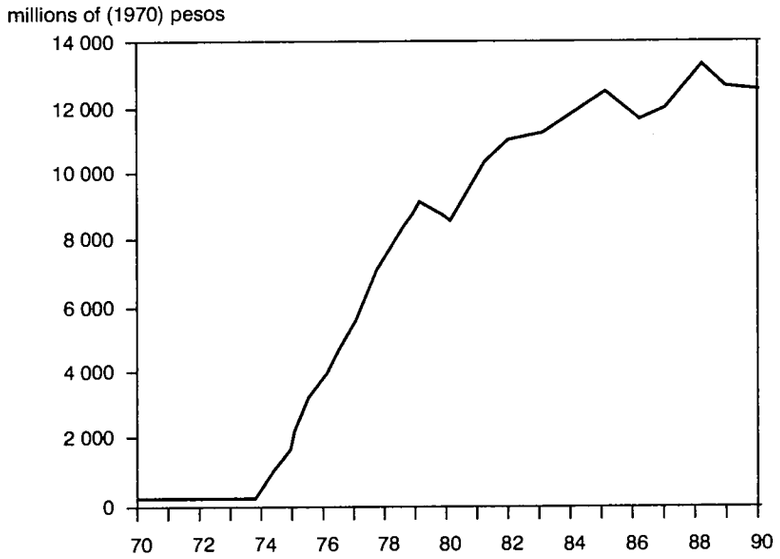


Figure 2a. Physical and monetary public capital stocks (electrical power)

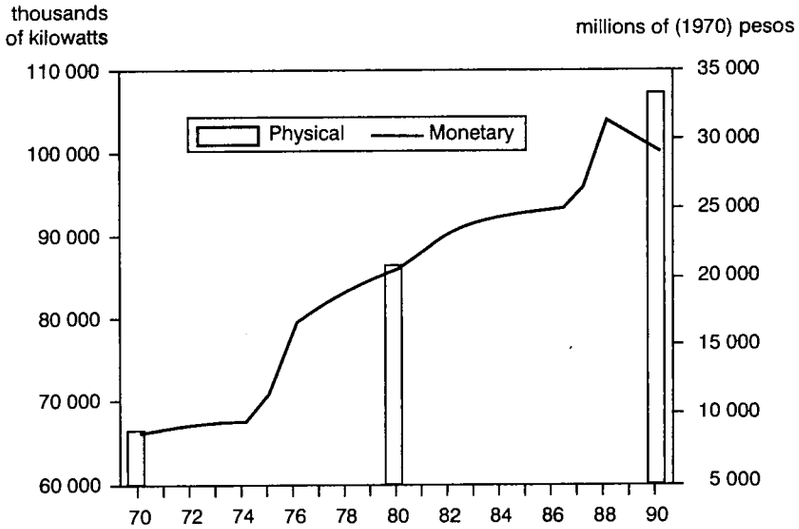


Figure 2b. Physical and monetary public capital stocks (transportation)

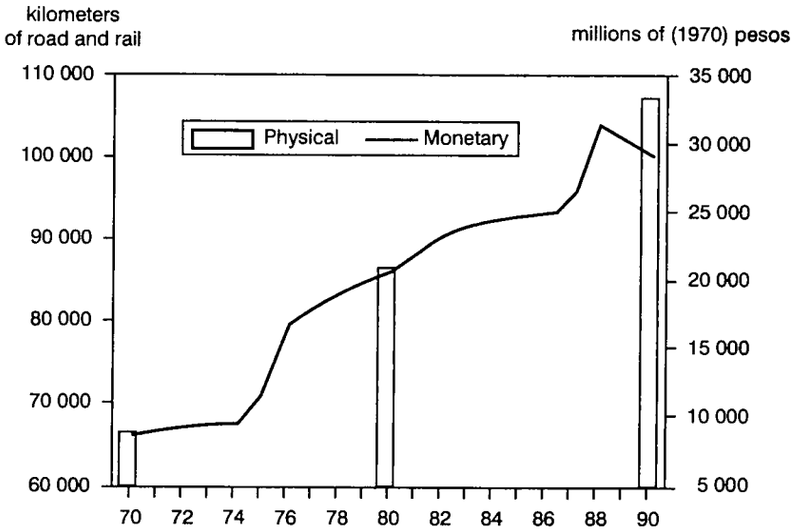


Figure 2c. Physical and monetary public capital stocks (communications)

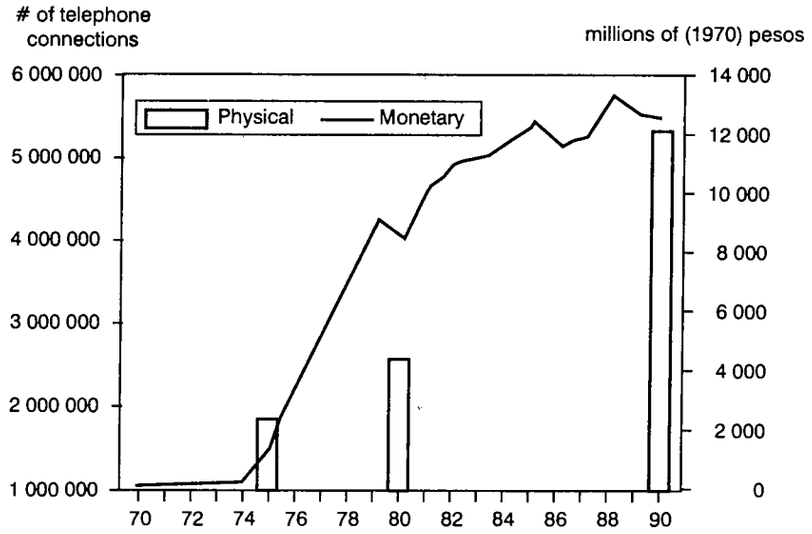


Table 2. Growth rates of output and employment 1970-1990
(percent per year)

	1970-1975	*1975-1980*	*1980-1985*	*1985-1990*
Output	6.5	6.6	1.9	1.3
Employment	3.5	4.2	3.6	0.4

Source: Feltenstein and Ha (1995).

1970 to 1990 (or, in the case of telecommunications, from 1975 to 1990). Coupled with the fact that the monetary measures include expenditures on capital items which are not directly represented by the particular physical measures (*e.g.,* transportation capital is more inclusive than mere kilometers of road and rail), it seems safe to say that the monetary measures are acceptable proxies for the true public capital stock in Mexico.

The focus of this paper is on the relationship between public capital and economic performance — where the latter is measured in terms of output growth and/or employment growth. Table 2 shows that at roughly the same time that investment and growth in the stocks of economic infrastructure were turning negative, the growth rates of output, measured as Gross Domestic Product, and total employment were also falling, if not plummeting. In the 1985 to 1990 period, for example, the growth rates of output and employment were averaging 1.3% and 0.4% per year, respectively, down from highs of 6.6% and 4.2% per year in the period from 1975 to 1980.

While this association is hardly convincing evidence of a causal relationship between infrastructure and output and employment growth, it does evoke the *possibility* that the public capital stock is an important determinant of Mexican economic performance. The remainder of this paper evaluates this possibility by

- presenting new estimates of the effects of the level and efficiency of public capital on economic growth;
- applying the analysis to the Mexican economy.

The paper ends by offering some tentative policy conclusions on the general importance of infrastructure capital to the prospects for future Mexican economic performance.

Public Capital and Economic Growth: Some New Estimates

We follow work by Mankiw, Romer, and Weil (1992) and Hulten (1996) to capture the separate growth effects of private tangible capital, public capital, the efficiency of public capital, and human capital. Consider an economy with a production function for private output given by

$$y = f(k, kg, eff, h) = a_c + a_k \cdot k + a_{kg} \cdot kg + a_{eff} \cdot eff + a_h \cdot h$$

where *kp* denotes the natural logarithm of private tangible capital per capita, *eff* represents the efficiency of use of public capital, and *h* stands for the natural logarithm of human capital per capita. In the framework of the neoclassical growth model, this production structure implies the corresponding growth expression[3]

$$y(T) - y(0) = b_c + b_y \cdot y(0) + b_{kp} \cdot kp^* + b_{kg} \cdot kg^* + b_{eff} \cdot eff + b_h \cdot h^*$$

where $y(T)$ and $y(0)$ represent the level of output per capita in the terminal and initial years chosen for the empirical analysis and "*" denote long run (or steady state) values of the various capital stocks. These long run capital stocks are related to savings/investment rates by the formula

$$z^* = iz - d \qquad z = kp, kg, h$$

where *iz* denotes the natural logarithm of investment (as a percent of output) and *d* represents the natural logarithm of an effective depreciation rate [the sum of the rate of population growth, the (exogenous) rate of technological progress, and the physical depreciation rate of capital].

As the growth expression is derived from the production function, the growth elasticities (*i.e.,* the *b*'s) are related to the output elasticities (*e.g.,* the *a*'s) by the formula

$$b_z = \frac{a_z}{a_{kp} + a_{kg} + a_h - a_y} \qquad z = kp, kg, h.$$

3 For details on the derivations of the equations in this section, the reader is referred to Mankiw, Romer, and Weil (1992), and Hulten (1996).

Similarly, the convergence rate — the rate at which the economy moves from one to another long run equilibrium given a shock such as an increase in the public capital stock — is determined from the coefficient on the initial level of output per capita.

We now estimate the growth expression using data for 46 developing countries over the period from 1970 to 1990. The basic data set comes from Easterly and Rebelo (1993) and various issues of the World Bank annual publication *World Development Report.* Private and public capital investment rates — expressed as fractions of output — are averaged over the period 1970 to 1990 and then, following Mankiw, Romer, and Weil (1992), deflated by the effective depreciation rate over the period 1970 to 1990 to generate proxies for private and public capital stocks. We note that in this data set the definition of *public capital* need not correspond directly with the definition of *infrastructure capital*; specifically, in certain countries the bulk of transportation, power, and other infrastructure facilities are publicly owned while in other countries many of these same facilities are privately owned. Human capital is proxied by secondary education enrollment rates averaged over the period 1970 to 1990.[4] The data set represents an augmentation of the data set utilized by Hulten (1996) to study the relative importance of the *quantity* and *efficiency of use* of public capital in developing countries. In particular, the data set used in the current paper (a) presents a continuous, rather than dichotomous, measure of the efficiency of public capital and (b) includes other variables in order to gain a deeper understanding of the importance of public capital to growth in developing countries.

Table 3 presents the basic estimates of the expression linking growth in per capita output to the various capital stocks and the efficiency of use of public capital. The first equation considers the relative importance of tangible and intangible capital. The growth elasticity of tangible capital equals 0.67 while the growth elasticity of intangible (human) capital equals 0.27, and both coefficient estimates are significantly different from zero at conventional measurement levels. The corresponding output elasticity of tangible capital equals 0.50 while the output elasticity of human capital equals 0.20. These output elasticities

4 There is a concern in the literature that school enrollment rates are poor proxies for human capital. Nevertheless, this paper uses the secondary school enrollment rate in order to compare results to Mankiw, Romer, and Weil (1992), and Hulten (1996). Future research might make use of other educational attainment measures as proxies for human capital.

Table 3. Growth and public capital
Dependent variable: $y(90) - y(70)$

	(1)	(2)	(3)	(4)
constant	0.88	1.20	1.42	1.53
	(0.57)	(1.42)	(0.56)	(1.41)
$y(70)$	–0.38	–0.38	–0.36	–0.36
	(0.10)	(0.10)	(0.10)	(0.10)
k	0.67	0.68	—	—
	(0.18)	(0.18)		
kp	—	—	0.31	0.31
			(0.08)	(0.08)
kg	—	—	0.30	0.30
			(0.11)	(0.11)
h	0.27	0.28	0.25	0.25
	(0.07)	(0.07)	(0.07)	(0.07)
d	—	0.13	—	0.04
		(0.24)		(0.53)
adj. R^2	0.43	0.42	0.45	0.44
S.E.R.	0.31	0.31	0.31	0.31

Note: Standard errors in parentheses.

are only somewhat larger than previous estimates in the literature — for instance, Mankiw, Romer, and Weil (1992) contains output elasticities of 0.44 and 0.23 for tangible and intangible capital. As these output elasticities of tangible and intangible capital sum to 0.70, the estimates imply diminishing returns to total capital and, thereby, the appropriateness of the neoclassical growth model framework for this set of countries. Finally, the convergence rate can be calculated using the coefficient on initial output and is equal to 2.5% per year which, in turn, implies that the *half life* of a shock to long run output is approximately 28 years. This, too, is directly in line with the available estimates from the literature.

The second equation in table 3 allows for a separate influence of effective depreciation (which includes the population growth rate) on economic growth. The assumption of constant returns to scale over *all* productive inputs — raw labor as well as tangible and intangible capital — implies a zero coefficient on the effective depreciation rate; consequently, the assumption of constant returns to scale cannot be

rejected if the coefficient on the effective depreciation variable is not statistically significant at conventional levels. In the second equation, the point estimate of the coefficient on d equal to 0.13 carries a standard error of 0.24 — and so we cannot reject constant returns over all factors.

The third equation of table 3 decomposes the tangible capital stock into private and public capital in order to assess the relative importance of these two types of capital to economic growth. Evidently, the growth elasticities of private and public capital are nearly equivalent at 0.31 and 0.30, respectively, and are both statistically significant at usual levels. The growth elasticity of human capital is somewhat smaller, at 0.25, and of a similar level of statistical significance. The corresponding output elasticities of 0.25, 0.25, and 0.20 for private capital, public capital, and human capital are all reasonable and consistent with overall decreasing returns to scale to capital inputs.

The fourth equation of table 3 allows the test of the hypothesis of constant returns to scale over all productive inputs. The coefficient estimate of 0.04 on the effective depreciation variable is not statistically different from zero and, as a consequence, there is little basis to reject the assumption of constant returns over raw labor and capital inputs.

Recently, Hulten (1996) has presented estimates of the effects of public capital on growth in a framework which also takes into account the efficiency with which the public capital stock is employed in production. He argues that the effective public capital stock — the relevant argument in the production function — is itself a function of both the quantity of public capital as well as the average effectiveness of public capital as in

$$kg^e = l(kg, eff)$$

where *eff* is an observable measure of the efficiency of use of public capital.[5] In Hulten (1996), the basic efficiency variable is composed of various performance indicators for public capital: mainline faults per

5 Hulten (1996) assumes the particular functional form

$$kg^e = \ln(eff) + kg$$

which is rejected by the data. Here, we assume that

$$kg^e = eff + kg$$

which, it turns out, is not rejected by the data.

100 telephone calls for telecommunications; electricity generation losses as a percent of total system output for electricity; the percentage of paved roads in good condition and diesel locomotive utilization as a percentage of the total rolling stock for road and rail transportation. As these performance measures are in different units, Hulten sees "no natural way of adding up the indicators in this form to arrive at a total." His solution is to sort the various indicators into quartiles, assigning values of 0.25, 0.50, 0.75, and 1.00, and then adding up across the quartile rankings to obtain a unit free aggregate index. This results, however, in a dichotomous variable which detracts from the ability to make efficiency comparisons across countries.

In the present paper, we take a different approach which leads to a continuous measure of efficiency across countries and, thereby, facilitates inter-country comparisons. Here, we first normalize each of the indicators so that performance in a particular category — say, telecommunications — is measured in terms of standard deviations from the average level of performance. Then we take the simple average across performance indicators to obtain an aggregate performance index for each country.

Figure 3 presents the public capital efficiency index for the full set of 46 developing countries in the sample. Mauritius ranks the highest, and Nigeria the lowest in efficiency of use of public capital. Mexico ranks second in public capital efficiency, some one and one-half standard deviations above the average level of efficiency. Looking inside the public capital efficiency index, we see that in Mexico, as of 1990

- 13% of total output is lost in the generation of electrical power;
- 85% of paved roads are in good condition; and
- 64% of the diesel inventory is in use.

The equations presented in table 4 show the impact of adding the efficiency variable to the basic growth expression. The coefficient estimate on the efficiency variable lies in the range of 0.30 and is highly statistically significant. This coefficient estimate implies that a one standard deviation increase in public capital efficiency (*i.e.*, an amount equal to 0.66 efficiency units) will induce a one-half deviation increase (*i.e.*, 1%) in the average annual rate of economic growth over the 20 year sample period. The introduction of the efficiency variable also has the effects of

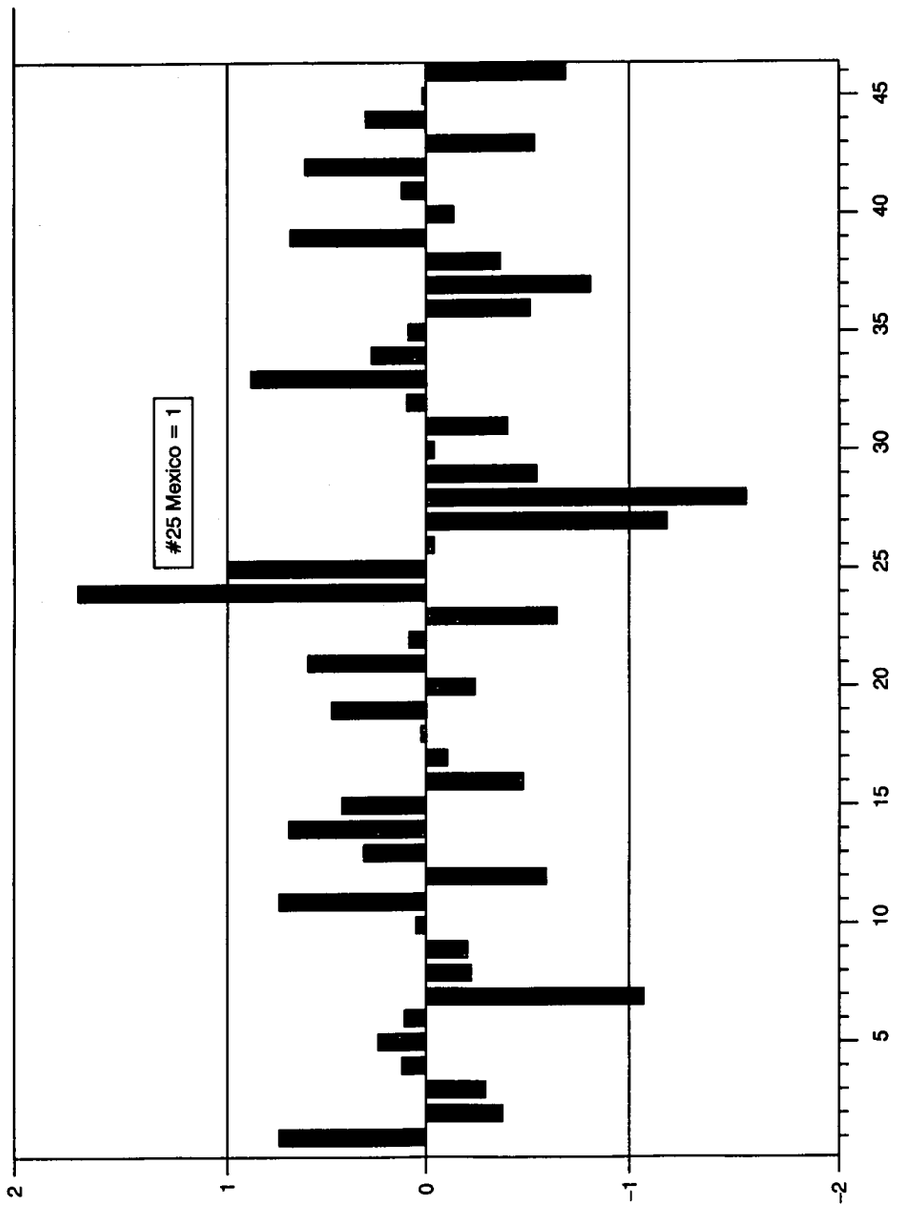


Figure 3. Public capital efficiency

- reducing the magnitude and statistical significance of the growth elasticities of tangible and human capital;
- eroding, rather substantially, the statistical significance of the relationship between the quantity of public capital and economic growth; and
- shrinking the coefficient on the initial level of output and, thereby, the convergence rate (from 2.5% per year to 2.0% per year).

Similar results led Hulten (1996) to state that, from the perspective of economic research "just as early studies of the sources of international growth inappropriately ignored infrastructure capital, it is no longer appropriate to ignore the efficiency with which this capital is used." Indeed, from a policy perspective, it is Hulten's belief that "programs aimed only at new infrastructure construction may have a limited impact on economic growth, and may have a perverse effect if they divert scarce resources away from the maintenance and operation of existing infrastructure stocks."

A close reading of Hulten's paper, as well as the above results, suggests that Hulten is being fairly generous to the notion that new public capital will have an important positive impact on economic growth. In particular, the coefficient on public capital in the equations listed in table 3, while positive, is quite small and of a low level of statistical significance. One could argue on the basis of these results that public capital shows *no* statistical association with economic growth.

Yet this model is lacking, for at least one important reason: it ignores the means of financing public capital. Following Barro (1990), Aschauer (1997a, b, c) shows how an increase in public capital has both a positive and negative effect on long run output and transitional growth rates. The positive effect comes from the direct role of public capital in the production of goods and services. The negative effect arises from the adverse effect of public debt which, ultimately, requires an increase in distortional taxation on labor and/or private capital. If — and only if — the former, positive effect dominates the latter, negative effect, then an increase in public capital stimulates growth. So an alternative interpretation of the lack of statistical significance of the public capital variable in the equations in table 4 is that this coefficient is capturing the *net* (of financing) rather than the *gross* effect of public capital on growth.

Table 4. Growth, public capital, and efficiency
Dependent variable: $y(90) - y(70)$

	(1)	(2)	(3)	(4)
constant	1.07 (0.48)	1.04 (1.20)	1.35 (0.47)	1.24 (1.17)
$y(70)$	–0.30 (0.09)	–0.30 (0.09)	–0.30 (0.09)	–0.29 (0.09)
k	0.26 (0.18)	0.26 (0.18)	—	—
kp	—	—	0.17 (0.07)	0.17 (0.07)
kg	—	—	0.11 (0.11)	0.11 (0.11)
eff	0.35 (0.08)	0.35 (0.08)	0.34 (0.08)	0.34 (0.08)
h	0.20 (0.06)	0.20 (0.06)	0.18 (0.06)	0.18 (0.06)
d	—	–0.01 (0.45)	—	–0.04 (0.44)
adj. R^2	0.6	0.59	0.62	0.61
S.E.R.	0.26	0.27	0.26	0.26

Note: Standard errors in parentheses.

Figure 4 depicts the 1980 level of external public debt as a percent of output — a measure of the burden placed on the economy associated with the financing of public capital expenditures — for the developing countries in the sample. On average, external debt equaled some 30% of output. The maximum debt ratio, attained in Mauritania, reached 140% of output, while the minimum debt ratio, achieved in Mozambique, equaled 0.1% of output. Mexico's external debt ratio was somewhat below the sample average, and equaled 21 percent.

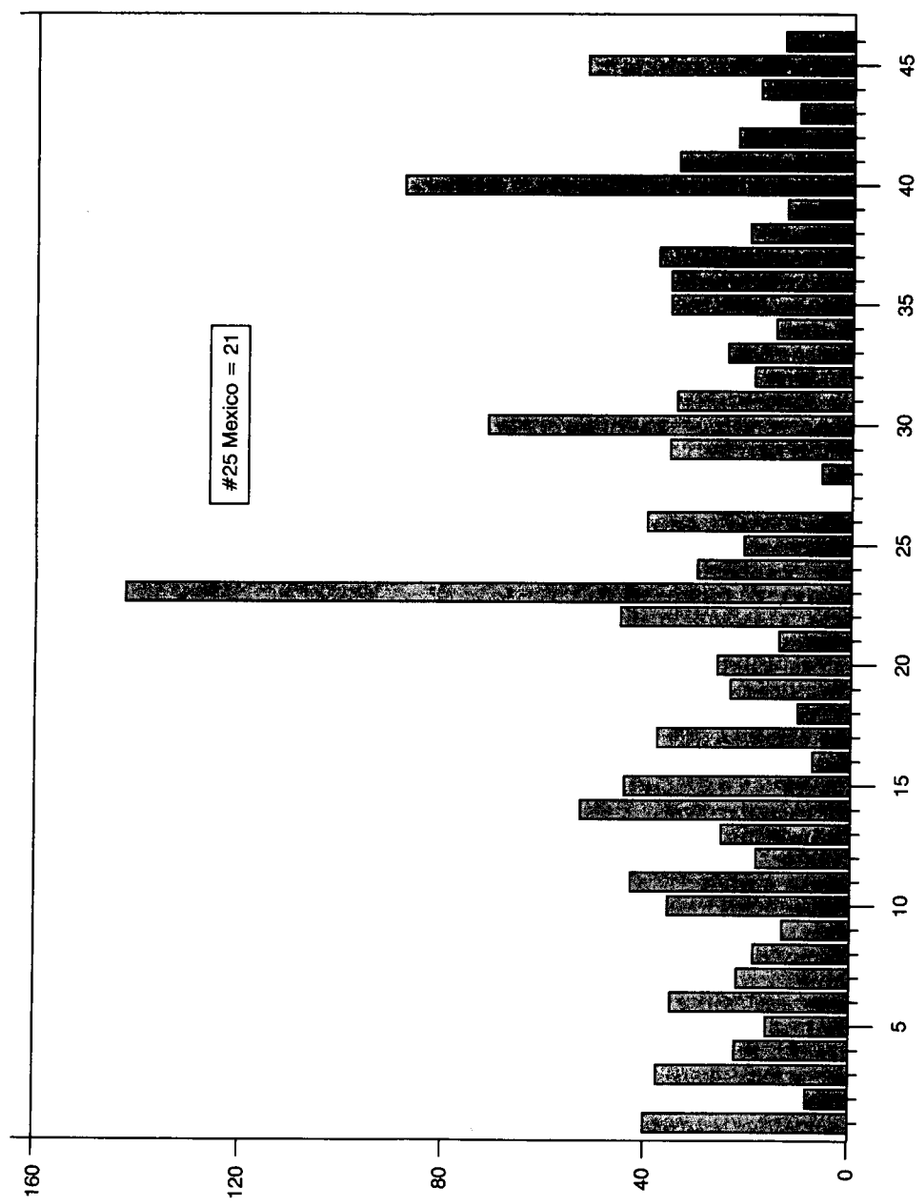


Figure 4. External public debt
(% of output)

Table 5. Growth, public capital, and external public debt
Dependent variable: $y(90) - y(70)$

	(1)	(2)	(3)	(4)
constant	1.25 (0.45)	1.57 (1.14)	1.71 (0.44)	1.98 (1.08)
$y(70)$	–0.31 (0.08)	–0.32 (0.08)	–0.31 (0.08)	–0.31 (0.08)
k	0.47 (0.18)	0.48 (0.19)	—	—
kp	—	—	0.26 (0.07)	0.26 (0.07)
kg	—	—	0.28 (0.11)	0.29 (0.11)
eff	0.32 (0.08)	0.31 (0.08)	0.29 (0.07)	0.29 (0.07)
h	0.18 (0.05)	0.18 (0.06)	0.15 (0.05)	0.16 (0.06)
$debt$	–0.46 (0.18)	–0.47 (0.18)	–0.57 (0.18)	–0.57 (0.18)
d	—	0.13 (0.43)	—	0.11 (0.40)
adj. R^2	0.65	0.64	0.69	0.68
S.E.R.	0.25	0.25	0.23	0.23

Note: Standard errors in parentheses.

The equations contained in table 5 explore the possibility of a trade-off between the productivity of capital and the burden of financing capital by including the total external debt ratio in the basic growth expression.[6] The coefficient estimate on external debt lies in the

6 It would be preferable to use total — internal plus external — public debt as a measure of the burden of financing public capital. However, total public debt is not available for many of the countries of the data sample, necessitating the use of external public debt as a reasonable proxy for the total debt public burden.

range of –0.50 and is highly statistically significant. This coefficient estimate implies that a one standard deviation increase in external debt (*i.e.*, an amount equal to 23% of output) will cause a one-third deviation increase (*i.e.*, 0.12%) in the average annual rate of economic growth over the 20 year sample period. The introduction of the external debt variable also has the effects of

- increasing the magnitude and statistical significance of the growth elasticities of tangible and human capital — to approximately the same levels as in table 3; and
- returning public capital to statistical significance, with an estimate of the growth elasticity of public capital centered on 0.2.

Overall, the empirical results contained in table 5 suggest that a proper extended analysis of the impact of public capital on economic growth should take into account not only the efficiency of use of public capital but also the means of financing public capital.

Figure 5 illustrates this point by showing the net effect on economic growth of an external debt financed increase in public capital. These impacts are calculated by the expression

$$\frac{d\,[y(90) - y(70)]}{d\,[\exp(kg)]} = \frac{b_{kg}}{\exp(kg)} + b_{debt} = \frac{0.28}{\exp(kg)} - 0.57$$

where we have imposed the condition $d[exp(kg)] - d[exp(debt)] = 0$. These net growth effects average –0.31 across the entire sample and range between a high value of –0.002 for Guatemala and a low value of –0.49 for Algeria.

Of course, another means of financing public capital is possible — namely, a reorientation of public spending priorities away from government *consumption* to government *investment*. Figure 6 shows that for many countries there is significant scope for such a financing mechanism. Over the period 1970 to 1990, the sample average level of government consumption equaled 18% for the entire sample of 46 countries. The high value of government consumption of 36% of output was reached in Zambia while the low value of 8% of output was achieved in Mexico.

Table 6 adds the natural logarithm of the government consumption ratio to the basic growth expression. The ratio of government consumption spending to output plays a significant, negative role in

Table 6. Growth, public capital, and government consumption
Dependent variable: $y(90) - y(70)$

	(1)	(2)	(3)	(4)
constant	1.29	1.54	1.63	1.89
	(0.43)	(1.07)	(0.42)	(1.04)
$y(70)$	–0.41	–0.41	–0.39	–0.39
	(0.09)	(0.09)	(0.08)	(0.09)
k	0.39	0.39	—	—
	(0.18)	(0.18)		
kp	—	—	0.20	0.20
			(0.08)	(0.08)
kg	—	—	0.22	0.29
			(0.10)	(0.11)
eff	0.28	0.28	0.26	0.26
	(0.07)	(0.08)	(0.07)	(0.07)
h	0.20	0.21	0.18	0.19
	(0.05)	(0.06)	(0.05)	(0.06)
debt	–0.28	–0.29	–0.41	–0.42
	(0.18)	(0.19)	(0.18)	(0.19)
gc	–0.33	–0.32	–0.29	–0.29
	(0.13)	(0.13)	(0.14)	(0.14)
d	—	0.10	—	0.10
		(0.41)		(0.39)
adj. R^2	0.69	0.68	0.71	0.71
S.E.R.	0.23	0.24	0.22	0.22

Note: Standard errors in parentheses.

the economic growth process. Specifically, a one standard deviation increase in government spending (*i.e.*, an amount equal to 7% of output) is estimated to cause a one-third standard deviation decrease (*i.e.*, 0.11%) in average economic growth over the period 1970 to 1990. The introduction of the government consumption variable also has the effect of

- decreasing the magnitude and statistical significance of the growth elasticities of tangible and intangible capital; and
- decreasing the magnitude of the effect of external public debt.

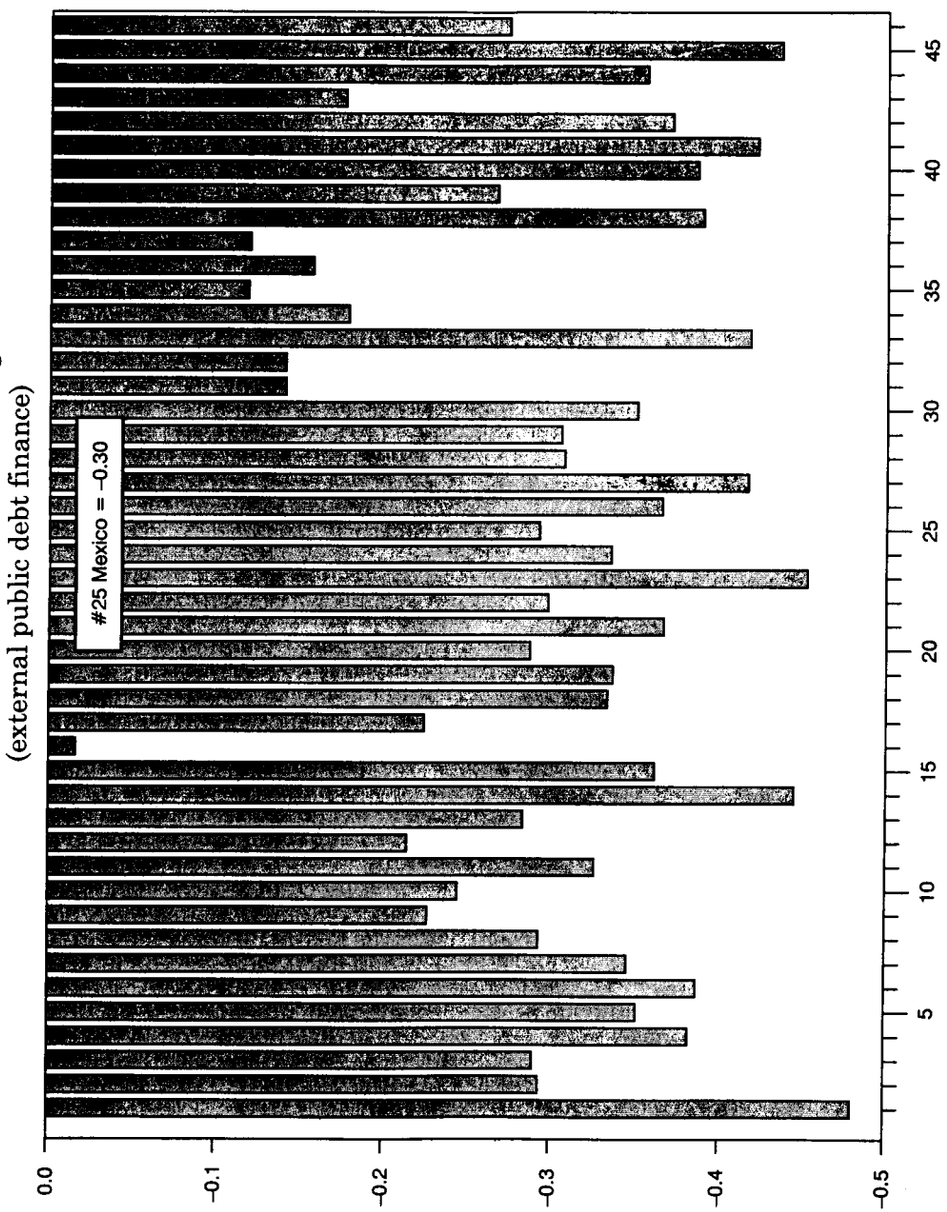


Figure 5. Public capital and economic growth (external public debt finance)

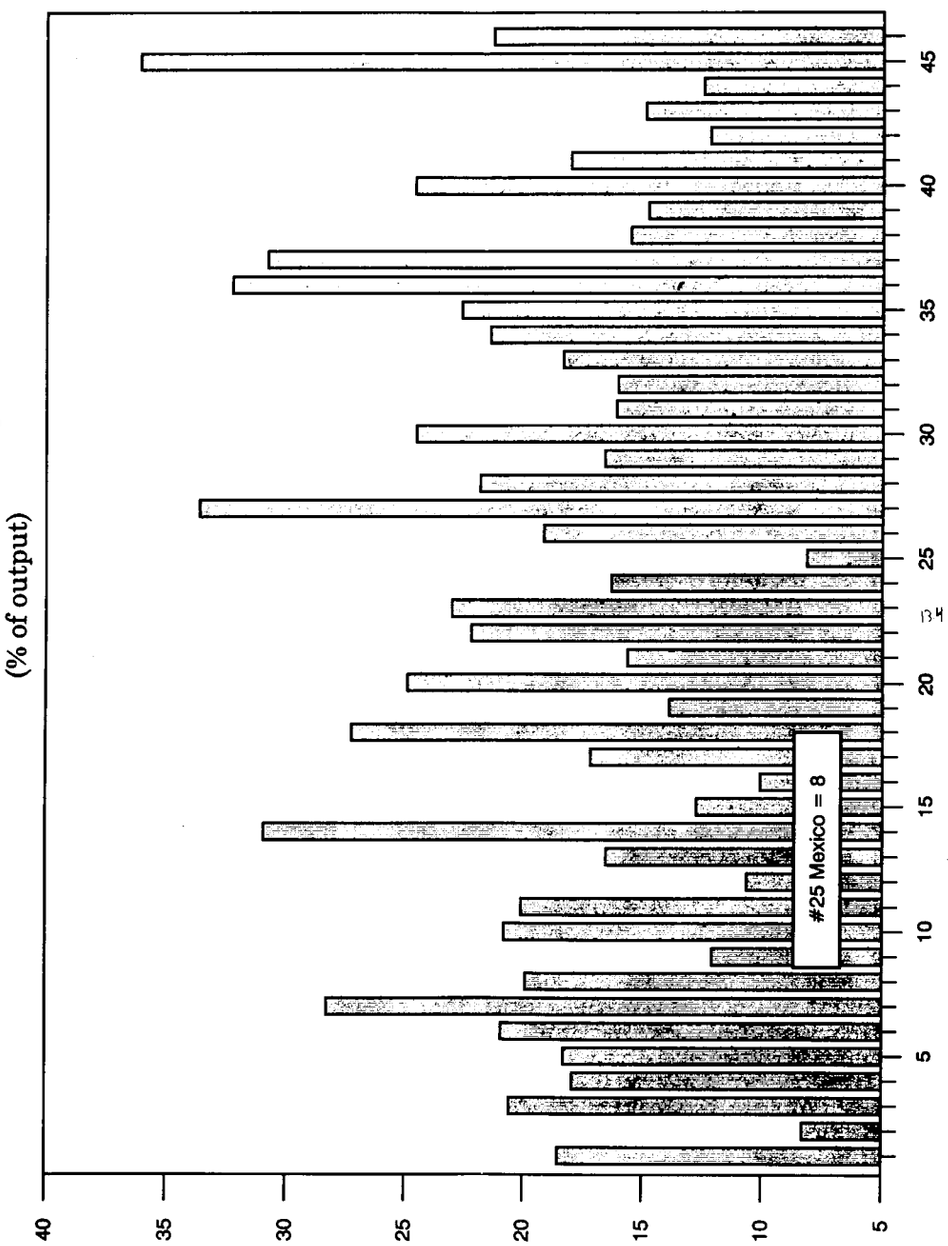


Figure 6. Government consumption (% of output)

Figure 7 shows the net effect on economic growth of an increase in public capital financed by a reduction in government consumption across the set of developing countries in the sample. This growth impact is calculated by use of

$$\frac{d\,[y(90) - y(70)]}{d\,[\exp(kg)]} = \frac{b_{kg}}{\exp(ig)} - \frac{b_{gc}}{\exp(gc)} = \frac{0.22}{\exp(ig)} - \frac{-0.29}{\exp(gc)}$$

where we have imposed the condition that $d[exp(ig)] + d[exp(gc)] = 0$. These effects average 1.93 over the entire sample of countries and reach a high of 3.86 in Mexico and a low of 0.93 in Algeria. Consequently, a potentially powerful means of financing public capital — and generating increased growth in per capita output — is through a scaling back of the amount of resources absorbed by government consumption activities.

Policy Implications for Mexico

A number of tentative conclusions pertinent to Mexican infrastructure policy can be drawn from the foregoing analysis of the relationship between public capital and economic growth in developing countries. These conclusions are based on the following fitted growth expression:

$$y(90) - y(70) = 1.63 - 0.39 \cdot y(70) + 0.20 \cdot kp + 0.28 \cdot kg + 0.26 \cdot eff + 0.18 \cdot h - 0.41 \cdot debt - 0.29 \cdot gc$$

and utilize sample average data as well as data for Mexico. Consequently, these policy conclusions are conditional on assumption that the specific process generating Mexican economic growth is closely captured by the average process estimated for the entire set of countries in the sample. A preferable approach would be to utilize separate time series for the Mexican economy — but, unfortunately, this is unfeasible due to limitations of data.

1) The public capital stock is an important determinant of long run output per capita and of transitional growth rates. Figure 8a shows the relationship between public capital and economic growth for the entire cross country sample. *For Mexico, a 1% (or 33 billion pesos) increase in*

Figure 7. Public capital and economic growth
(government consumption finance)

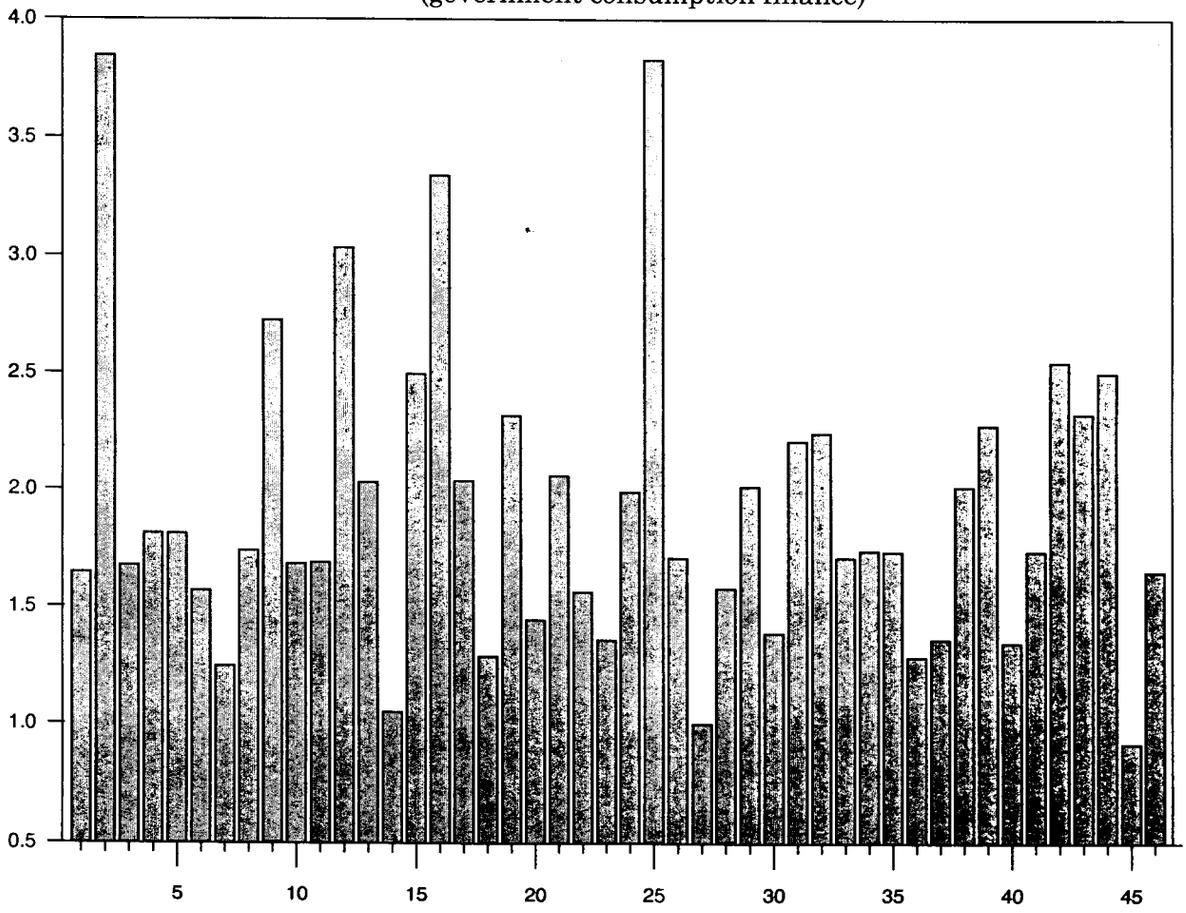
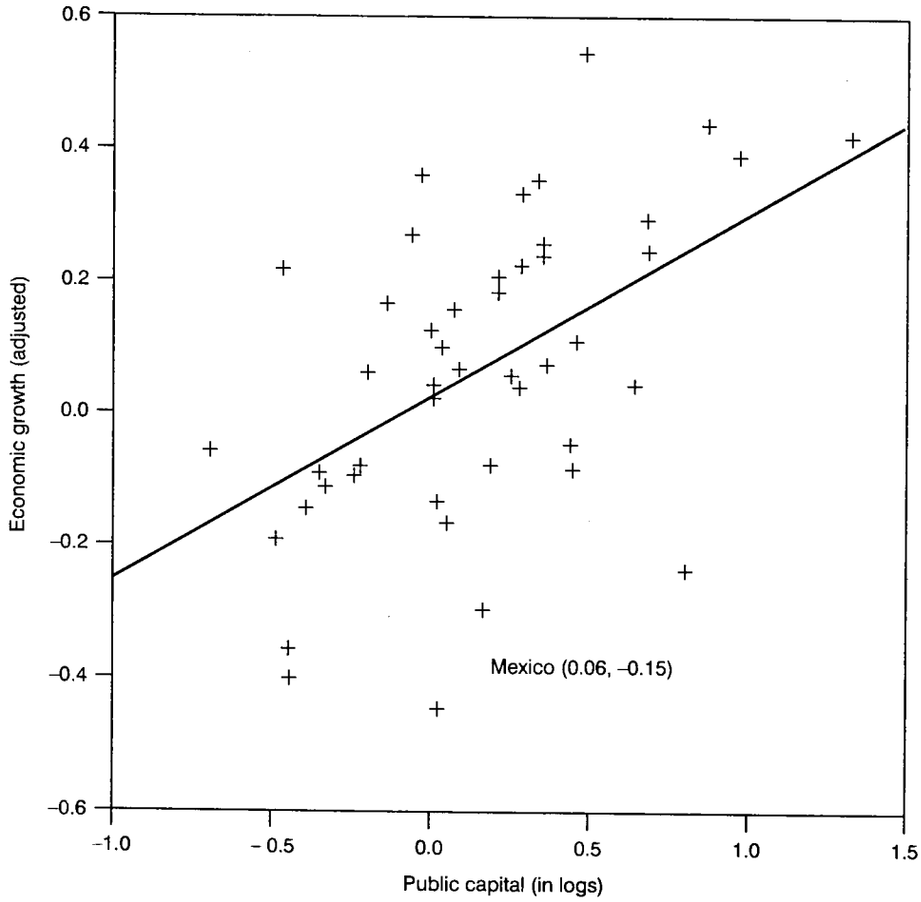


Figure 8a. Public capital and economic growth



public capital would lead to a 0.28% (or 88 pesos) increase in the long run level of output per capita — and an increase in the average growth rate of just over 0.01% per year.

2) The private capital stock also is an important determinant of long run output per capita and of transitional growth rates. Figure 8b shows the relationship between private capital and economic growth for the entire sample of developing countries. *For Mexico, a 1% (or 54 billion pesos) increase in private capital would lead to a 0.20% (or 63 pesos) increase in the long run level of output per capita — and an increase in the average growth rate of around 0.01% per year.*

3) For the typical country in the sample, a reallocation of the total capital stock from private to public capital would modestly increase the long run level of output per capita and the rate of economic growth. On average, therefore, the types of capital included in the private capital stock have been over-accumulated relative to the types of capital included in the public capital stock. *For Mexico, a 1% (or 54 billion pesos) reallocation of capital would increase the long run level of per capita output by 0.15% (or 47 pesos) — and the rate of economic growth by just under 0.01% per year. This relatively large impact arises because production in the Mexican economy is private (rather than public) capital intensive — at least relative to the entire set of developing countries in the sample. This does not imply that Mexico could expect to reap significant productivity and output gains by reversing the outcome of recent privatization efforts; rather, it implies that Mexico could experience economic improvement by investing somewhat more in the types of capital which, typically, are included in the public capital stock and somewhat less in the types of capital which are included in the private capital stock.*

4) The efficiency of use of the public capital stock is a key factor in explaining long run levels of output per capita and transitional growth. Figure 8c displays the overall relationship between efficiency and economic growth. *In Mexico, a 1% increase in public capital efficiency would result in a 0.26% (or 81 pesos) increase in long run output per capita — and an increase in the average growth rate of somewhat more than 0.01% per year.* We agree, then, with Hulten (1996) that the economic growth depends on the efficiency with which public capital is utilized just as much as on the size of the public capital stock.

5) The human capital stock also is an important determinant of long run per capita output and transitional growth. Figure 8d depicts the relationship between human capital and economic growth for the

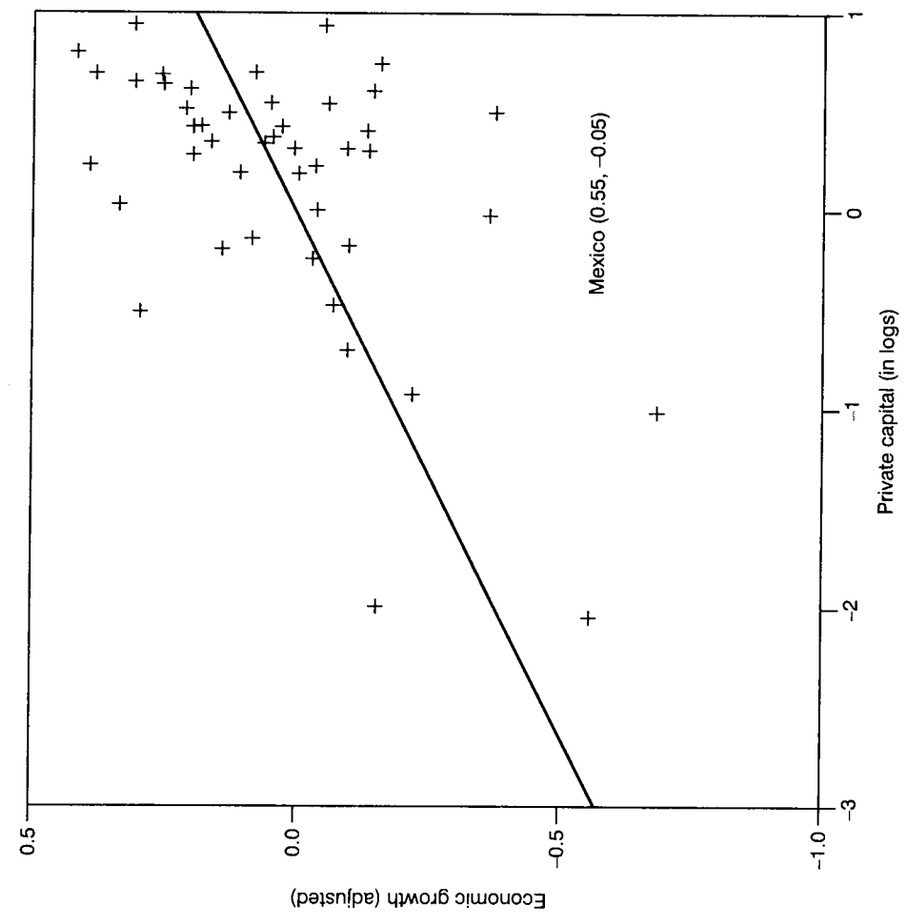


Figure 8b. Private capital and economic growth

Figure 8c. Public capital efficiency and economic growth

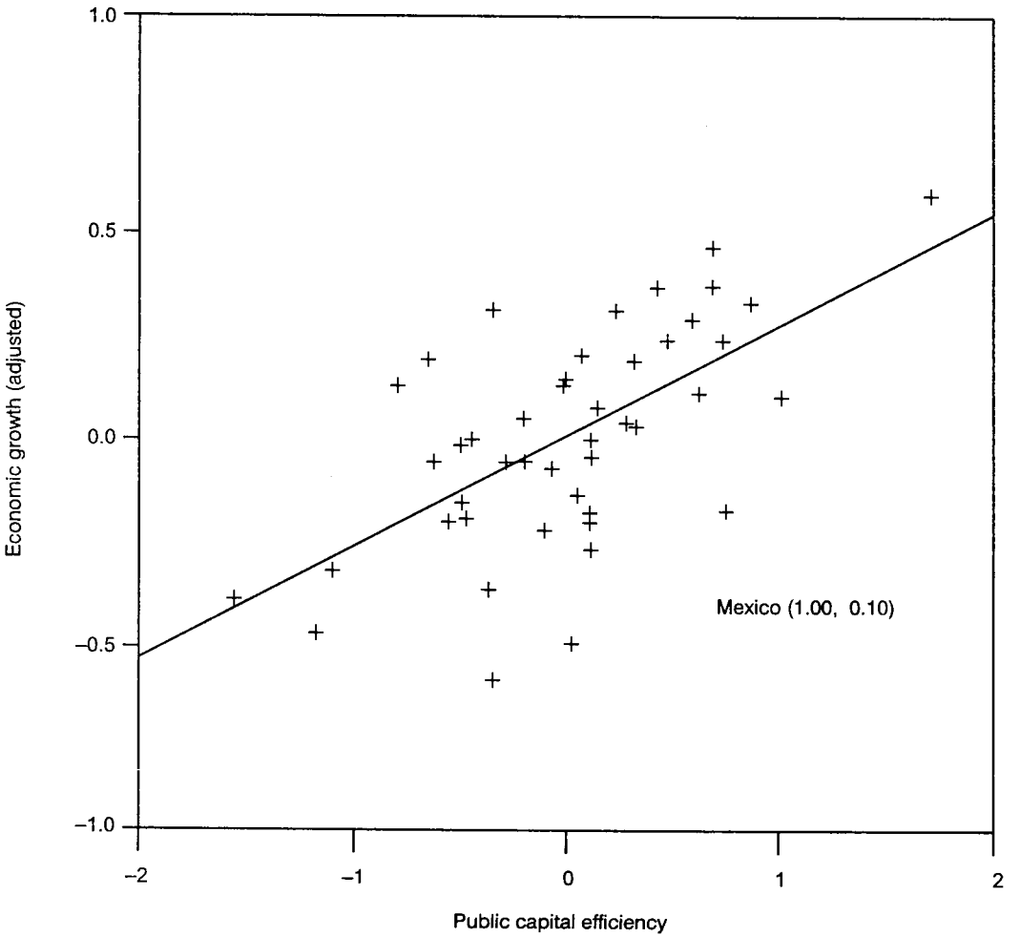
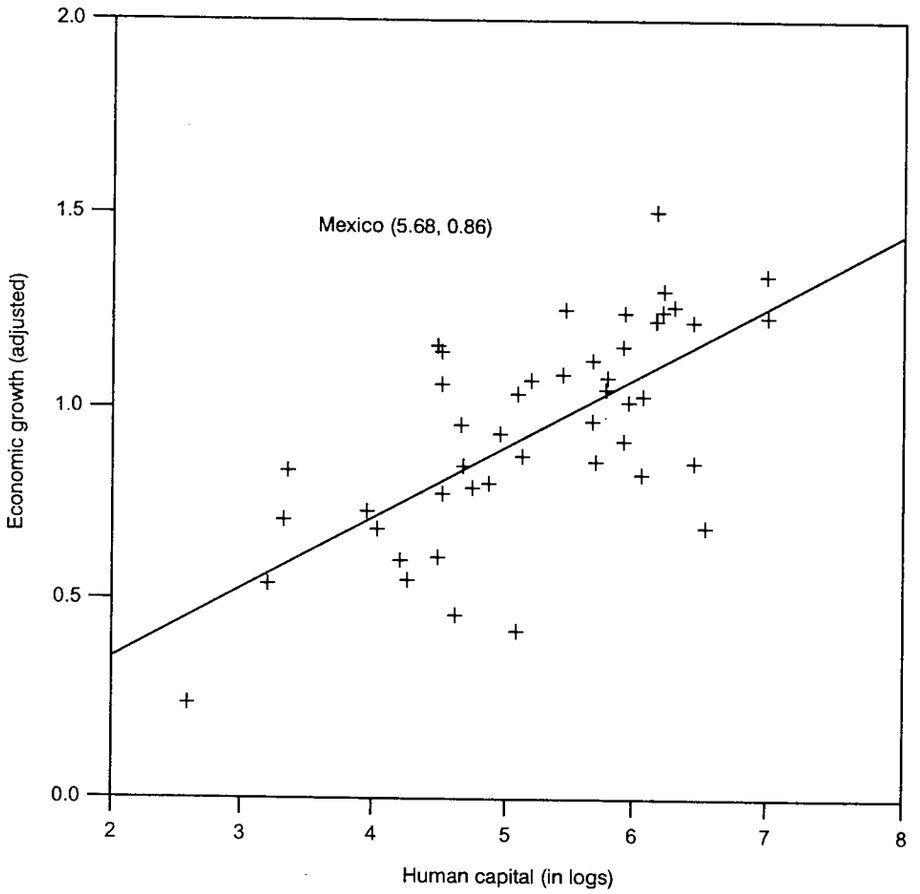


Figure 8d. Human capital and economic growth



broad set of developing countries. *For Mexico, a 1% increase in human capital would lead to a 0.18% (or 56 pesos) increase in long run per capita output — and an increase in the average growth rate of somewhat less than 0.01% per year.*

6) The level of external public debt is a critical factor determining the long run level of per capita output and the rate of economic growth. Figure 8e shows the relationship between external public debt, measured as a ratio to output, and economic growth. *In Mexico, a 1% (or 7 billion pesos) increase in external public debt would lead to a 0.09% (or 28 pesos) reduction in the long run level of per capita output — and an approximate 0.005% per year reduction in the rate of economic growth.*

7) The level of government consumption spending is a key determinant of the long run level of output per capita and economic growth. Figure 8f depicts the relationship between government consumption spending, as a ratio to output, and economic growth. *In Mexico, a 1% (or 2 billion pesos) increase in government consumption spending would result in a 0.29% (or 91 pesos) decrease in the long run level of per capita output — and a more than 0.01% per year decrease in the rate of economic growth.*

8) The means of financing capital, generally, and public capital, specifically, is important to long run per capita output levels and to rates of economic growth. *In Mexico, a 1% (or 33 billion pesos) increase in public capital would increase* ***or*** *decrease long run per capita output (and economic growth) — depending on how the public capital is financed. Specifically, if the rise in public capital is financed by a reduction in government consumption, economic growth will be stimulated and there will be a rise in long run per capita output equal to 178 pesos (or 0.57%) — and a rise in annual growth of some 0.02%. But if the rise in public capital is financed by an equal rise in external borrowing, economic growth will be depressed and there will be a drop in long run per capita output equal to 1.1% (or 341 pesos) — and a drop in annual growth of around 0.05 percent.*

9) It is important to consider all three dimensions of public capital — how much there is, how efficiently it is utilized, and how it is financed — in assessing its impact on economic growth. *In Mexico, a 1% (or 33 billion pesos) debt financed increase in public capital* ***and*** *a corresponding 1% increase in the efficiency of use of public capital would cause a 0.10% (or 30 pesos) increase in long run per capita output — and a rise in annual growth of around 0.004 percent.*

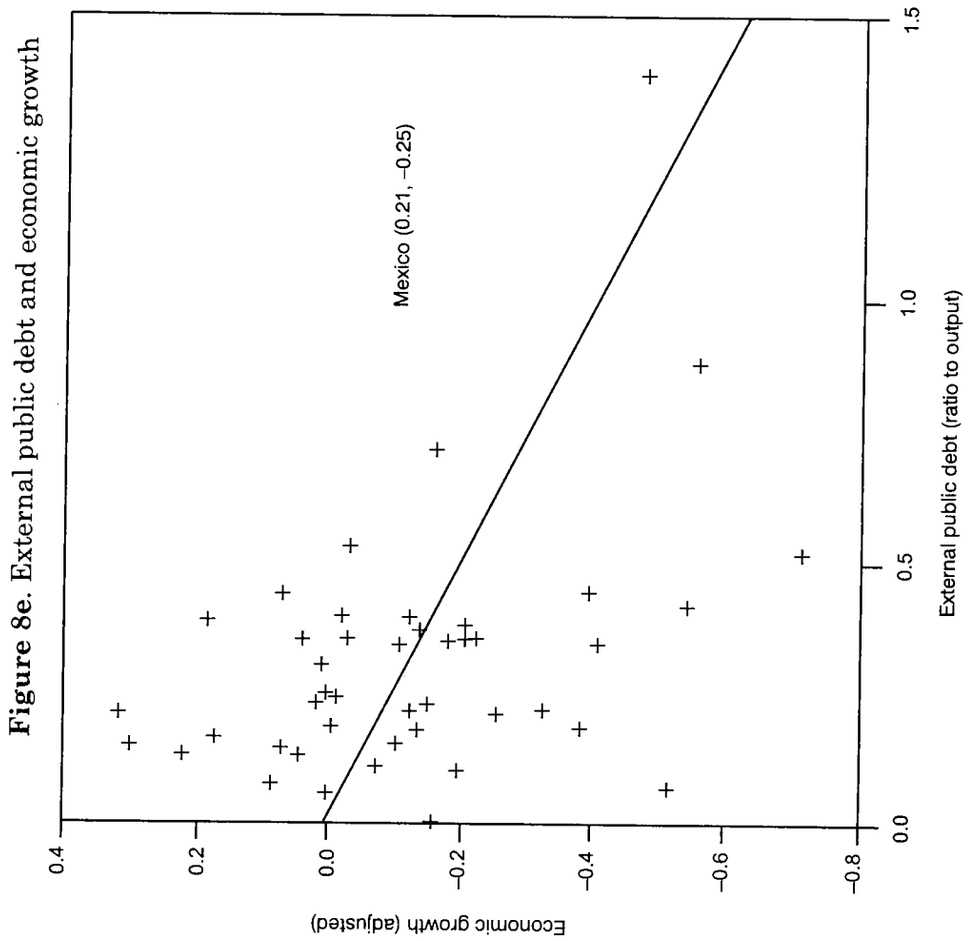


Figure 8e. External public debt and economic growth

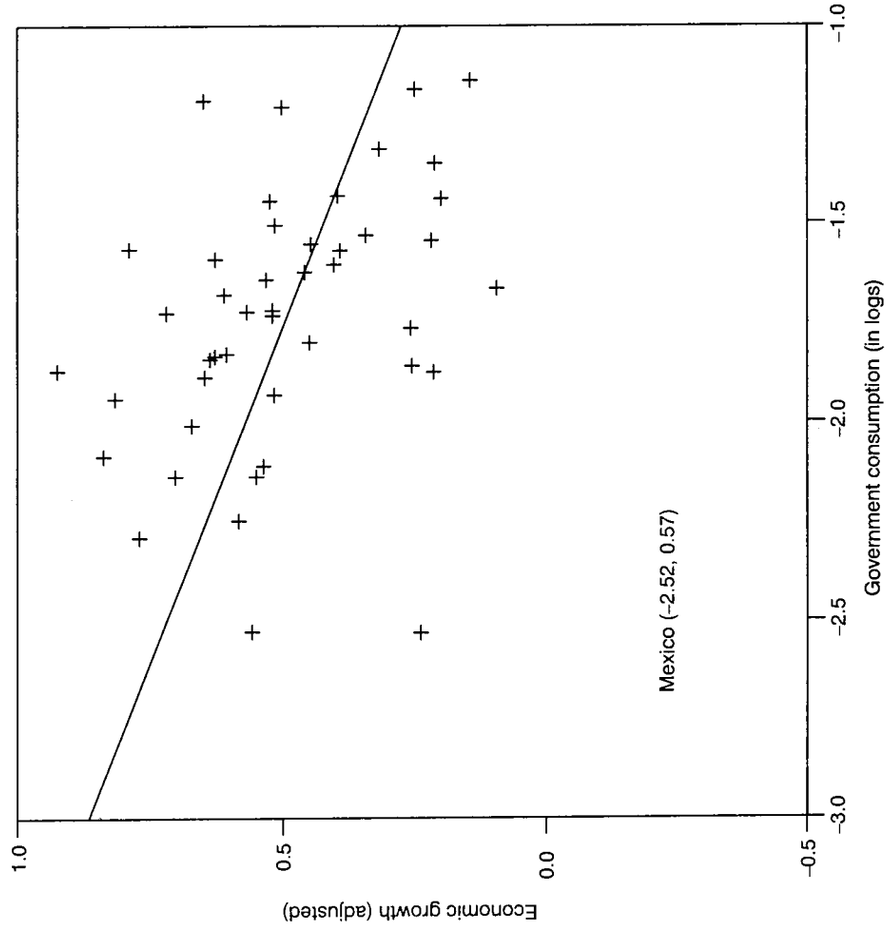


Figure 8f. Government consumption and economic growth

Consequently, for Mexico it appears that debt financed public capital investment may be a potential engine of long run growth. But a mere increase in the public capital stock is not likely to accomplish the goal of higher growth. Rather, what is needed is an increase in the ***efficient public capital stock*** *accomplished through* ***more*** *and* ***better*** *public capital investments.*

Conclusion

This paper develops and estimates a neoclassical growth model in which not only the quantity, but also the means of financing and efficiency of use of public capital are important determinants of output per capita levels and transitional growth rates. The empirical results indicate that government policymakers need to pay close attention to the costs involved in financing public capital — through a higher debt burden and associated taxes on labor and capital income — as well as to the way in which public capital is employed — efficiently or inefficiently. Briefly put, when it comes to infrastructure policy, a "large" public capital stock is not, by itself, a sufficient condition for economic growth, but must be augmented by appropriate financing and utilization policies.

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Productividad en grandes y pequeños establecimientos con distintas intensidades en la utilización de insumos

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y Lilia Domínguez Villalobos*

Resumen: La intención del presente trabajo es analizar los cambios en la productividad de la industria mexicana tomando como punto de partida las disparidades entre las empresas por su tamaño y por la intensidad en el uso de los insumos. Para analizar los determinantes de la productividad entre los distintos estratos se estimó un modelo econométrico. Los resultados de la estimación muestran que el comportamiento de la productividad es el resultado de un conjunto interrelacionado de variables de naturaleza micro-macroeconómica. Se muestra que hay una dualidad en el comportamiento entre empresas y, por ello, los efectos esperados de las variables micro-macroeconómicas sobre la dinámica de la productividad son disímiles. Por último, se analizan las repercusiones de los distintos efectos desde el punto de vista teórico y de política económica.

Abstract: The aim of this paper is to discuss productivity changes among the different sized firms and intensities in the use of inputs in Mexican manufacturing. In order to analyze the underlying factors causing productivity differences we estimated an econometric model. Our results demonstrate that the productivity determinants are the result of an interrelated set of micro and macroeconomic variables. We show that there is a duality in the behavior among firms and therefore, the expected impact from the

* Las autoras son profesoras-investigadoras de la Maestría en Ciencias Económicas de la Facultad de Economía de la Universidad Nacional Autónoma de México. Esta investigación es fruto de un trabajo realizado a lo largo de varios años con la colaboración y apoyo de numerosas personas. Agradecemos, en primer lugar, los comentarios de nuestros colegas de la Maestría en Ciencias Económicas, especialmente de Fidel Arroche, Julio López y Martín Puchet. En ese sentido, también nos fueron muy útiles las observaciones del doctor Eugenio Kuznetsov y del doctor Fernando Clavijo, así como de los dictaminadores anónimos. En el manejo de la información participaron con muy buena disposición los becarios del proyecto PAPIIT IN302795 Julio César Escalante y Vicente Mata. Asimismo, agradecemos al Banco Mundial el apoyo financiero en la última fase de este trabajo. Por último, nuestro reconocimiento de manera muy especial al licenciado Abigaíl Durán por el cálculo de los indicadores microeconómicos basados en la información de la Encuesta Industrial Anual, INEGI, así como por su amplia y generosa ayuda.