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Private Costs and Public Infrastructure: The Mexican Case

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Abstract

One objective of government investment is to develop public infrastructure which may reduce private sector costs. In a developing economy, the scope for payoffs to investments of this sort may be particularly large. A major concern related to the recent fiscal adjustment in Mexico is that it has been carried out, in part, by depleting public infrastructure stocks.

We estimate the effects of public infrastructure on private sector costs in Mexico and calculate the implied optimal infrastructure stocks. Our estimates indicate that previous results suggesting a large productive role of public infrastructure capital are not robust. There is little evidence that public infrastructure plays a large role in reducing private sector costs.

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Keywords: Mexico, public infrastructure

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I Introduction

Over the past several decades, public expenditure has been evaluated primarily in two roles: enhancing macroeconomic stability and mitigating market failure. A no less important role concerns the ability of public investments in infrastructure capital to reduce the costs of private firms. The literature has primarily focused on the United States: (Aschauer 1989), (Munnell 1990), and (Nadiri and Mamuneas 1994), although Berndt and Hansson (1992) look at Sweden and Feltenstein and Ha (1995) provide an initial look at the Mexican experience. A major concern related to the recent fiscal adjustment in Mexico is that it has been carried out, in part, by depleting public infrastructure stocks. This depletion could significantly retard future growth by imposing an additional drag on private sector costs and output.

In this paper we consider the role that public infrastructure plays in improving the efficiency of the private sector. In particular, we focus on the short-run, static, gains which accrue to private firms as a result of government investments in electric, transportation, and communications infrastructure. We also provide estimates of the potential (partial equilibrium) payoffs from increased investment in public infrastructure and calculate the optimal infrastructure stocks implied by various elasticity estimates.

The existing literature generally supports the notion that public infrastructure capital is productive; one might expect, furthermore, that infrastructure in a developing economy such as Mexico's would be even more productive. Our estimates,however, suggest that infrastructure has negligible effects on private sector costs in Mexico. Although OLS estimates indicate apparent cost savings, these prospective savings effectively vanish when one accounts for sector specific effects. This is consistent with the evidence of Holtz-Eakin (1994), who finds that panel estimates (using US states) of the productivity enhancing effects of public sector capital are much smaller than estimates which neglect state specific effects. Our panel estimates are based on industries, rather than Holtz-Eakin (1994)'s geographic areas, but ours also suggest that ignoring sector specific effects overstates the aggregate effects of public sector capital.

Our base case estimates of the elasticity of private sector costs with respect to infrastructure suggest mean values of -0.019, -0.005, and +0.069 for electric, transport, and communications infrastructure across 14 sectors of the economy. On the basis of the most optimistic (-0.019) figure, increasing public infrastructure investment by 50% would reduce private sector costs by no more than 0.95%. The traditional OLS estimates (ignoring sector specific effects) suggest larger responses of private sector costs to public infrastructure. This leads us to conclude that estimates of significant productivity enhancing effects are likely due to mis-specification. Large potential benefits to public infrastructure, if available, should have been clearer in the data. The estimates suggest a modest role, at best, for public sector infrastructure capital in reducing private sector costs. These results represent improvements over the existing literature in several respects, including

- the role of industry specific effects
- evaluation of cost function characteristics such as returns to scale
- estimates of the precision of the elasticity figures rather than just point estimates.
- consideratio of cross-sector heteroskedasticity and autoregression
- calculation of the optimal infrastructure levels implied by the elasticity estimates

The paper is organized as follows. Section II briefly discusses the relevant policy environment. Section III introduces the basic model. Section IV briefly considers the data used for analysis, Section V presents the empirical results, and Section VII concludes.

II Background

GDP, or *Producto Interno Bruto* (PIB) grew strongly over the 1960-1993 period.[2] Average growth in real terms was 0.049 annually from 1960-1993 and only 1982, 1983, and 1986 saw real declines in aggregate output (INEGI 1997). Furthermore, this growth was experienced across the economy (Table 1). If anything, infrastructure growth has been more impressive; over the 1960-1993 period the Electricity and Communications stocks (total net capital stock, in real 1980 pesos, see Appendix B) grew by 0.137 and 0.255 annually (compound annual rates, see Table 2). Physical infrastructure stocks in Mexico have increased at rates comparable to, or perhaps a little higher than, rates in several other Latin American countries (Table 3[3]). The table presents averages of annual growth rates for several periods; the first column is for the whole period; the last column is for the most recent ten years. In recent years, growth of infrastructure stocks in Mexico has slowed in both absolute and relative terms.

Our financial measures are more convenient for analysis, and are reasonable approximations to the measures of physical infrastructure reported by (Canning 1998). Figure 1 shows changes in (log) electric, transport, and communications infrastructures over past several decades. The physical and financial measures of electric infrastructure, with the exception of the early 1960s, moved pretty much in tandem over the past few decades. The transportation measures also move

[2]Our dataset is confined to the period 1960-1993; unfortunately we have to neglect the most recent years of the Mexican experience. This is necessitated by our need to construct a data set from several sources, not all of which are currently available in the forms needed (see Appendix B).

[3]Based on data from (Canning 1998), which also include measures of telephones, unpaved roads, and rail lines. The main lines data (communications) and paved roads data (transportation) are of most interest here since they present the best opportunities for spillover effects which would appear in the national accounts data.

Sector (our numbering)		*Gran Division*	Sector GDP Growth
1	Mining	2	0.048
2	Food and tobacco	3	0.043
3	Textiles	3	0.029
4	Wood products	3	0.034
5	Paper	3	0.051
6	Chemicals	3	0.070
7	Nonmetallic minerals	3	0.055
8	Basic metals	3	0.052
9	Machinery	3	0.068
10	Other manufacturing	3	0.028
11	Construction	4	0.048
12	Commerce, hotels	6	0.051
13	Financial services	8	0.047
14	Medicine	9	0.048

Table 1: Compound annual growth rates 1960-1993, real 1980 pesos

	1960-1993	1983-1993
Electricity	0.137	-0.003
Transport	0.063	0.029
Communications	0.255	0.075

Table 2: Infrastructure compound annual growth rates, real 1980 pesos

	1950-1995	1950-1970	1970-1990	1980-1995	1985-1995
Electric					
Mexico	*0.120*	*0.176*	*0.071*	*0.068*	*0.065*
Argentina	0.057	0.072	0.049	0.034	0.021
Brazil	0.081	0.096	0.082	0.038	0.030
Chile	0.048	0.053	0.036	0.033	0.060
Colombia	0.084	0.119	0.064	0.056	0.070
Venezuela	0.098	0.121	0.096	0.057	0.053
Telephone main lines					
Mexico	*0.087*	*0.074*	*0.096*	*0.082*	*0.091*
Argentina	0.053	0.035	0.046	0.077	0.076
Brazil	0.093	NA	0.099	0.068	0.064
Chile	0.087	0.081	0.068	0.120	0.138
Colombia	0.079	0.081	0.073	0.090	0.086
Venezuela	0.092	0.094	0.088	0.079	0.074
Paved roads					
Mexico	*0.020*	*0.058*	*-0.045*	*0.019*	*0.019*
Argentina	0.045	0.086	0.031	0.014	0.012
Brazil	0.123	0.212	0.067	0.051	0.039
Chile	0.041	0.091	0.021	0.018	0.038
Colombia	0.052	0.077	0.038	0.021	0.024
Venezuela	0.042	0.086	0.018	0.027	0.033

Table 3: Physical infrastructure (average annual growth rates)

similarly, although there is a substantial jump in (financial) value in the late 1970s. Prior to, and after, this two year jump, the measures move in similar ways. The value of communications infrastructure also makes a substantial jump in the late 1970s; an increase which we do not see in the telephone main lines data. This, like the jump in transport infrastructure, may be due to quality changes which the physical measures do not capture. An advantage of the financial measures we use, relative to their physical measure counterparts, is their potential ability to capture changes in infrastructure quality as well as quantity.

Table 4 shows correlations between the physical and financial measures; the correlations between the logs of financial and physical measures is over 90%; the correlations between growth rates are lower, but with the exception of the transport measures, even the growth rates of financial and physical measures are positively correlated.

Infrastructure	ln(Levels)	Growth rates
Electric		
(*generating capacity*)	0.9152	0.4766
Transport		
(*paved roads*)	0.9855	0.0638
Communications		
(*main lines*)	0.9774	0.3594

Table 4: Correlations: physical and financial infrastructure measures

Clearly, however, investment has slowed significantly in recent years (Table 2). This recent decline is even more noticeable in the post-sample (1994-1998) period (Estados Unidos Mexicanos 1998). It prompts the concern that, while necessary for short-term budgetary reasons, these reductions in public infrastructure will ultimately prove to be cost increasing in the private sector.

III Model

We consider private sector costs in the Mexican economy in the context of a translog cost model: an approximation of a general private sector cost function from a first-order Taylor series expansion in logs of a transcendental function[4]. In the presentation below, the data dimensions of interest (and their associated indices) are: private inputs of labor and capital (indexed by $i \in \{L, K\}$), government infrastructures (indexed by m), sectors such as mining and textiles (indexed by j), and time (indexed by t). For brevity, the time index is ordinarily suppressed. In each sector j, the basic specification relates production costs $\mathbf{c}$ to input prices ($\mathbf{w}$), technical progress ($\mathbf{t}$), and output

[4]See (Takayama 1990) and (Berndt 1991), chapter 9 and the references cited therein.

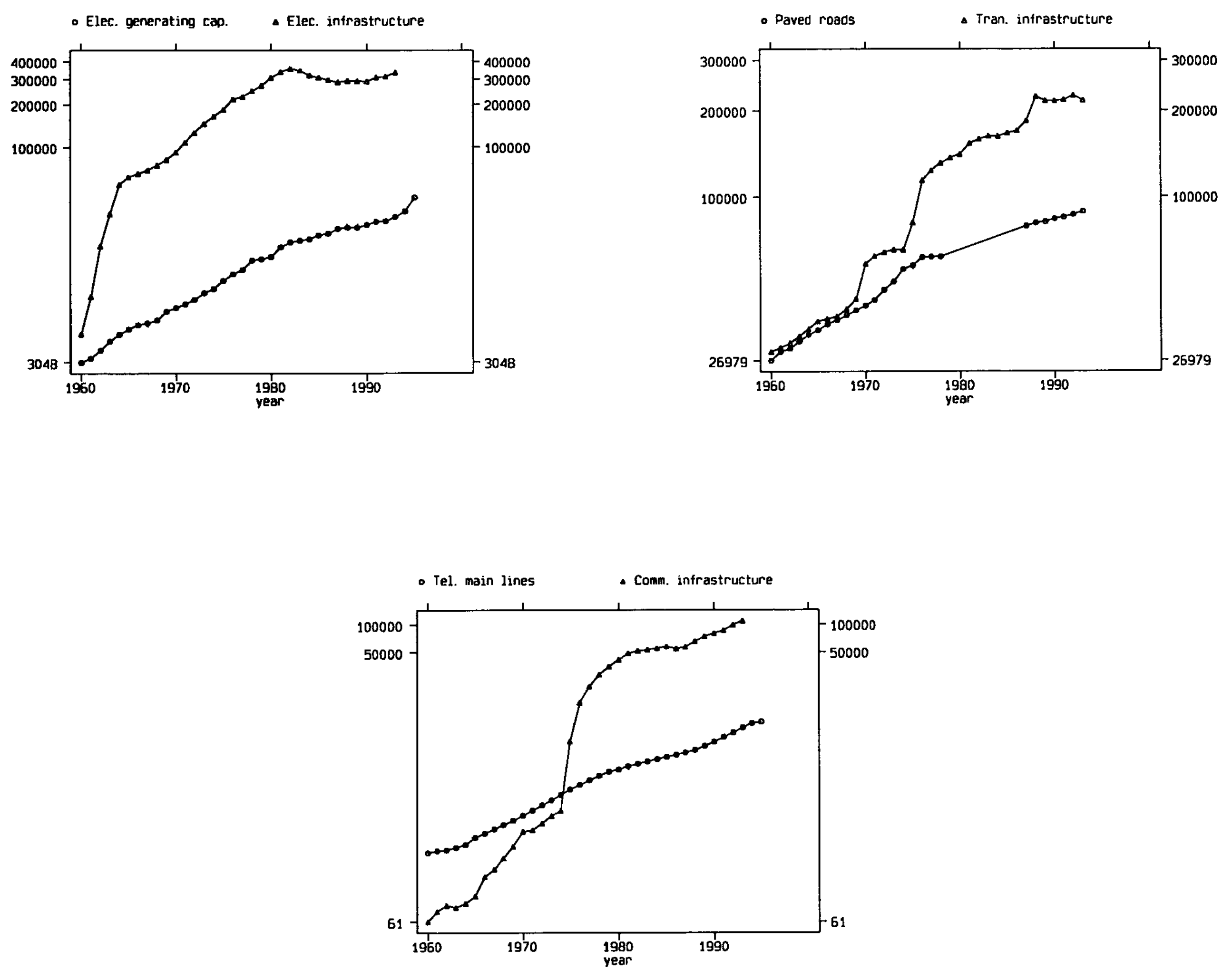

Figure 1: Physical (○) and financial (△) infrastructure (ln scales)

levels ($\mathbf{y}$)[5]:

$$\begin{aligned}\mathbf{c}_j = \alpha_{0j} + \alpha_{Lj}\mathbf{w_{Lj}} + \alpha_{Kj}\mathbf{w_{Kj}} + \beta_{LLj}\mathbf{w^2_{Lj}} + \beta_{LKj}\mathbf{w_L w_{Kj}} + \beta_{KKj}\mathbf{w^2_{Kj}} \\ + \sum_i \mathbf{w_{ij} t}\beta_{iTj} + \sum_i \mathbf{w_{ij} y_j}\beta_{Yij} + \mathbf{y_j t}\beta_{TYj} \\ + \alpha_{Yj}\mathbf{y}_j + \beta_{YYj}\mathbf{y^2_j} + \beta_{YLj}\mathbf{y w_{Lj}} + \beta_{YKj}\mathbf{y w_{Kj}} + \boldsymbol{u}_j\end{aligned} \tag{1}$$

Given the limited data available (see Section IV) we exploit assumed commonalities between the different sectors of the economy by estimating a single model which treats each sector-year combination as a separate observation of a single production cost function. Our primary interest here is not the simple private cost function (1), but the effects that government infrastructure investments have on private sector costs, so we augment (1) with stocks of government infrastructure (see (Nadiri and Mamuneas 1994) and (Feltenstein and Ha 1995)):

$$\begin{aligned}\mathbf{c} = \alpha_0 + \alpha_L\mathbf{w}_L + \alpha_K\mathbf{w}_K + \beta_{LL}\mathbf{w^2_L} + \beta_{LK}\mathbf{w_L w_K} + \beta_{KK}\mathbf{w^2_K} \\ + \sum_i \mathbf{w_i t}\beta_{iT} + \sum_i \mathbf{w_i y}\beta_{Yi} + \mathbf{yt}\beta_{TY} \\ + \alpha_Y\mathbf{y} + \beta_{YY}\mathbf{y^2} + \beta_{YL}\mathbf{y w_L} + \beta_{YK}\mathbf{y w_K} \\ + \sum_m \gamma_m\mathbf{g}_m + \sum_m\sum_i \gamma_{im}\mathbf{g_m w_i} + \sum_m \gamma_{Ym}\mathbf{g_m y} + \boldsymbol{u}\end{aligned} \tag{2}$$

Sectors of the economy will not be similar in all respects. We allow for differences in intercepts, in the marginal effects of input prices ($\mathbf{w}$), output levels ($\mathbf{y}$), and government infrastructure ($\mathbf{g}$). The translog specification is particularly convenient in that the elasticities of private sector costs with respect to public infrastructure stocks are directly obtained from estimates of (2). In sector j, the elasticity with respect to infrastructure m is:

$$\eta_{jm} = \gamma_m + \sum_i \gamma_{im} w_i + \gamma_{Ym} y \tag{3}$$

The estimated elasticities are linear combinations of estimated coefficients, so if $\mathbf{A} = [1 \;\; w_L \;\; w_K \;\; y]$ and $\mathbf{b} = [\hat{\gamma}_m \;\; \hat{\gamma}_{Lm} \;\; \hat{\gamma}_{Km} \;\; \hat{\gamma}_{Ym}]'$, $\eta_{jm} = \mathbf{Ab}$ and $\hat{V}(\eta_{jm}) = \mathbf{A\hat{V}(b)A'}$. In the elasticity calculations below, we construct values for $\mathbf{A}$ from the average (over the relevant sample horizon) values of $\mathbf{w}$ and $\mathbf{y}$; we treat those values as constants.

[5]Vectors are denoted by bold type and variables in logs (natural) by lower case.

A Estimation issues

There are two issues related to the role of input prices. The first is that for the economy as a whole, the prices of capital and labor are arguably endogenous. If so, our estimates will be inconsistent. Ideally, we would instrument for factor prices. We argue that factor prices in Mexico are determined in the world market and so for our purposes, private factor prices are exogenous. For a (relatively) small economy bordering the United States, this may be a reasonable approximation.

A second objection is that instead of government infrastructure *stocks*, one would preferably use *prices* (much as we use private factor prices). If infrastructure is acquired and utilized in the same fashion as other inputs, this objection is appropriate. Here, the use of stocks may not be problematic. Recall that our interest is in the spillover effects of publicly provided infrastructure; we estimate those spillovers through the translog model. The translog specification is appropriate not because our priors (based on, e.g., engineering data) suggest that costs vary as in (11), but because (11) is a good approximation to an *arbitrary* cost function. We allow the data to tell us how costs are affected by the inputs. Use of private inputs such as capital and labor, from standard cost theory, are determined by factor prices; therefore **r** and **w** are crucial regressors. By extension, this is why one would want to include infrastructure usage costs in (11). However, in the case of infrastructure, utilization would be more desirable than prices. Presumably private sector costs vary with the utilization of infrastructure, ϕ:

$$C \approx \Phi G U \tag{4}$$

or in logs:

$$c \approx \phi + g + u \tag{5}$$

The problem is an omitted variable one; we estimate $c \approx g+u$ rather than $c \approx \phi+g+u$. The effects of utilization on private sector costs will be, in our formulation, attributed to the disturbance term $\mathbf{u}$. If $\text{cov}(\phi, g) \neq 0$, the estimates of the effect of government infrastructure, g, on private costs c will be inconsistent. However, if utilization is uncorrelated with infrastructure levels, the estimates of the cost reducing effects of infrastructure will *not* be adversely affected by the omission of utilization from (11). This seems to be a plausible conjecture; for instance, there is little evidence that miles traveled and road capacity in the United States are correlated.[6] A sufficient, but not necessary,

[6]Based on data for 1975-1995 from the US Federal Highway Administration, the estimated relationship between annual vehicle miles, public road length, and time is:

$$\text{miles} = \underset{(0.275)}{0.012}\ \text{roads} + \underset{(4.395)}{51.837}\ \text{t} \tag{6}$$

The model includes autoregressive lags to two periods; most alternative specifications, including more or fewer lags,

Variable	Description
pb	Gross sectoral output in real 1980 pesos
pib	Sectoral value added in real 1980 pesos
labor	Workers employed in the sector (millions)
gwage	Mean annual sectoral wages in real 1980 pesos
lmpts	Sectoral payments to labor in real 1980 pesos
cap	Total sectoral net capital stock in real 1980 pesos
tbill	Treasury bill rate (Mexico)
cmpts	Sectoral payments to capital in real 1980 pesos
ielec	Electricity infrastructure (total net capital stock of Sector 61 of the *SCNM*)
itran	Transport infrastructure (Sector 64 of the *SCNM*)
icomm	Communications infrastructure (Sector 65 of the *SCNM*)

Table 5: Variable definitions

condition for consistent estimates is that government infrastructure is utilized at the same rate each period. But, a weaker condition, that utilization is not correlated with infrastructure levels, is also sufficient. This assumption is more plausible and is the one that we make.

IV Data

The data derive from official Mexican government sources. The two primary sources are INEGI (1997) and Banco de Mexico (1995). For the 1980-1993 period, the data are taken from the government sources with little adjustment. For earlier periods (1970-1980 and 1960-1970), data series were typically constructed from multiple sources. These procedures are described in Appendix B. The sectors we use are determined by the national income accounts of Mexico, the *Sistema de Cuentas Nacionales de Mexico* (*SCNM*). Our basic delineation of the Mexican economy includes 17 sectors; one, agriculture, is dropped for a lack of capital stock data. Two others, Electricity (*Gran Division* 5) and Transport and Communications (*Gran Division* 7) are used to construct our estimates of public infrastructure. This leaves us with 14 sectors for analysis (see Table 1 for a list). The variable definitions are shown in Table 5 and the variables of interest and their sample means and standard deviations are presented in Table 6.

A Infrastructure

The data include measures of public infrastructure in: Electricity, Transportation, and Communications. We consider total net capital (consisting of the sum of net capital in buildings and

including or not including moving average terms, and varying the sample horizon did not appreciably change the results. The estimated coefficient on the roads variable was almost always less than 1.5 times the standard error.

	1960-1993	1960-1969	1970-1979	1980-1993
pb	333,788	156,940	298,529	485,294
	(349,484)	(131,115)	(250,968)	(440,396)
pib	209,708	98,471	186,757	305,555
	(283,186)	(116,221)	(221,609)	(363,613)
labor	0.777	0.414	0.735	1.067
	(1.347)	(0.645)	(1.160)	(1.727)
gwage	114.0	85.0	134.4	120.2
	(52.3)	(35.5)	(47.7)	(56.5)
lpmts	71,277	37,780	74,411	92,964
	(110,401)	(52,010)	(103,922)	(137,032)
cap	38,963	17,308	39,159	54,292
	(34,646)	(15,939)	(29,598)	(39,312)
tbill	0.150	0.039	0.070	0.288
	(0.136)	(0.012)	(0.025)	(0.108)
cpmts	117,082	40,467	104,317	180,925
	(164,152)	(47,853)	(134,742)	(206,483)
ielec	195,837	47,624	178,566	314,041
	(117,121)	(26,934)	(58,108)	(21,461)
itran	114,124	35,558	90,504	187,115
	(69,499)	(4,729)	(30,611)	(29,910)
icomm	30,784	163	10,817	66,917
	(33,718)	(106)	(12,535)	(19,640)

Table 6: Primary data: means (standard deviations); millions of 1980 pesos

construction, machinery, transportation equipment, and office equipment) as our measure of infrastructure. Typically, these stocks are measured in real 1980 pesos.

B Sample horizon

Our dataset covers the period from 1960-1993. Because of the significant changes in the Mexican economy over this period, we estimate models for several sub-samples of this period. In particular, we consider models of the periods 1960-1979, 1974-1993, and 1960-1993. Our base case is the 1974-1993 sub-sample since this period should most closely reflect the modern Mexican economy.

V Results

Our primary interest is in the effects of public infrastructure on private sector costs. Our summary measures of these effects are the elasticities of private sector costs with respect to the various infrastructure measures. Our basic model includes:

- sample period 1974-1993
- electricity, transport, and communications infrastructure stocks (but not education)
- constant degree of homogeneity in output

We consider, in turn, OLS estimates comparable to the prior US literature, and then estimates which account for the panel structure of the data.

A Overview

Tables 7-8 present the estimated elasticities and their standard errors for four different OLS specifications of the basic translog model.[7] The first, which we call "Basic OLS," is based on the three infrastructure stocks: electricity, transport, and communications. The basic OLS estimates are calculated imposing the constraint that costs are homogeneous of degree one in output (doubling output doubles private sector costs). The Basic OLS model generates estimates of (14), subject to the constraints (16).

The cost elasticity estimates are generally plausible; the magnitudes are not overly large and most have appropriate signs (Tables 7-8). Of the 14 Basic OLS elasticity estimates for electricity, 10 are negative with values of roughly -0.20. The estimated standard errors are in the range of 0.10-0.16; the smaller (in absolute value) elasticity estimates are, by conventional standards, insignificantly different from zero. The larger values (e.g. sectors 2, 4, and 5), on the other hand,

[7] Detailed coefficient estimates are shown in Table 15 of Appendix C.

do tend to be several times the size of their standard errors. The transportation estimates are fairly similar; 12 of the 14 are negative and again, many take on values around -0.15 or -0.35. Again, the standard errors are roughly 0.15. The communications elasticities however, are generally quite small (roughly 0.05), the "wrong" sign (9 of the 14 are positive), and imprecisely estimated (standard errors of 11 of the 14 are larger than their corresponding coefficients). Aside from Communications, results from the Basic OLS model suggest, on average, moderate levels of private sector cost savings from public infrastructure: elasticities of roughly -17%. This is broadly consistent with results from the US.

1 Communications

The small, positive, and insignificant estimates of the elasticity of private sector costs with respect to investments in communications infrastructure are similar to the estimates of the productivity enhancing effects of high technology investments in the United States (Stiroh 1998). Communications infrastructure (measured in terms of "main lines" per capita) have been found to be productive in some studies (Canning 1998), but in general the productivity enhancing effects of high technology are often not immediately apparent in aggregate data. One possible explanation is that reduced technology costs induce firms to factor substitute, but do not lead to significantly lower costs. In the US, there are indications, even from the micro data, that although technology use and lower costs are associated, firms which are productive in other ways ("good" performers) tend to be the ones which use technology, rather than technology use leading to lower costs among all firms (McGuckin, Streitwieser, and Doms 1996). This is similar to the argument of Hulten (1996), who argues, "How well you use it may be more important than how much you have".

2 Constraints

The No Restrictions specification considers how the estimated effects of infrastructure change if we impose fewer constraints on the basic translog model (11). The estimated Basic OLS is (14), subject to the constraints (16); the No Restrictions case considers estimates of (14), but *not* subject to the constraints (16). The only constraints imposed on the basic translog specification (11) are those necessary for homogeneity of degree one in input prices (13). The estimates, overall, are not too different from the Basic OLS estimates. The no restrictions estimates of the effects of electric infrastructure are slightly more negative, while the estimated effects of transport infrastructure are less so. The estimated communications effects are quite similar.

The constant returns to scale model is similar to the Basic OLS, but an additional constraint is imposed: the scale of operations does not change marginal costs (17). Imposing the constant returns to scale constraint generates larger (more negative) estimated effects of electric infrastructure, but smaller (more positive) estimated effects of transport and communications infrastructure. A test of (17) rejects the null hypothesis that costs are characterized by CRS.

B Sector effects

There are several econometric specification issues to consider. A major concern is that due to the panel nature of the data (14 sectors of the economy over 34 years), the disturbance terms in the empirical models may be characterized by heteroskedasticity, autoregression, or both.

We estimate the basic model (cost equation only) for several alternative specifications. Below (Tables 9-10) are elasticity estimates[8] for three of these:

1. Ordinary least squares (OLS) with robust standard errors (Table 9)
2. OLS with random effects (Table 9)
3. Feasible generalized least squares (FGLS) with cross-panel heteroskedasticity and within panel one period autoregression (Table 10)

If the relationship between private sector costs and public infrastructure is adequately described by (14) except for the error term having a sector specific variance, then the OLS with robust standard errors model will generate consistent estimates of the elasticities and their standard errors.

The random effects estimates allow for sector specific and common error components. That is, we allow the error term to take the form $\mathbf{v}_i + \mathbf{u}_{it}$; $\mathbf{v}_i$ is a sector specific disturbance term, while $\mathbf{u}_{it}$ is a sector and period specific term. A Breusch-Pagan test of whether or not the sector specific terms are 0 rejects the null hypothesis that they are, suggesting that the random effects specification is to be preferred ($p -$ value $= 0.00$). A Hausman test of the appropriateness of the random effects model relative to a fixed effects alternative (are the subset of coefficients common to the random effects and related fixed effects models systematically different when they should not be) does not lead us to reject the null hypothesis (p-value $= 1.00$) that the random effects model *is* appropriate or that the subset of coefficients does not differ systematically (see (Greene 2000) for a discussion of these tests). The random effects estimates are similar, in magnitude and sign, to the OLS panel estimates, although somewhat smaller in magnitude.

The FGLS estimates allow for cross-sector heteroskedasticity and within sector one period autoregression (common across sectors). Assuming that our sector specific variance and cross-sector one period auto-correlation specification is correct, the FGLS estimates should provide efficient estimates of the standard errors. Think of the FGLS estimates as allowing for (some) sectoral and

[8] Detailed coefficient estimates are shown in Table 16 of Appendix C.

	Basic OLS		
Sector	Electric	Transportation	Communications
Mining	0.003	−0.086	−0.022
	(0.158)	(0.162)	(0.060)
Food and tobacco	−0.419	−0.179	0.043
	(0.123)	(0.151)	(0.047)
Textiles	−0.095	−0.495	0.063
	(0.122)	(0.143)	(0.040)
Wood products	−0.563	−0.433	0.071
	(0.127)	(0.132)	(0.047)
Paper	−0.382	−0.140	0.064
	(0.121)	(0.167)	(0.050)
Chemicals	0.001	−0.083	−0.061
	(0.130)	(0.169)	(0.067)
Non-metallic minerals	−0.200	−0.157	0.009
	(0.124)	(0.143)	(0.047)
Basic metals	0.225	−0.394	0.035
	(0.119)	(0.136)	(0.044)
Machinery	−0.021	−0.338	0.046
	(0.127)	(0.144)	(0.049)
Other manufacturing	−0.396	0.355	−0.030
	(0.121)	(0.143)	(0.041)
Construction	−0.283	0.019	0.020
	(0.166)	(0.137)	(0.048)
Commerce, hotels	−0.272	−0.003	−0.008
	(0.178)	(0.150)	(0.061)
Financial services	−0.085	−0.136	−0.009
	(0.124)	(0.166)	(0.055)
Medical services	0.098	−0.245	0.041
	(0.164)	(0.148)	(0.061)

Table 7: Estimated private sector cost elasticities with respect to public infrastructure stocks (SEs in ()'s)

	No restrictions			*CRS*		
Sector	Electric	Transportation	Communications	Electric	Transportation	Communications
Mining	−0.126	−0.028	−0.041	−0.574	−0.180	0.090
	(0.153)	(0.153)	(0.066)	(0.183)	(0.194)	(0.072)
Food and tobacco	−0.412	−0.109	0.038	−0.832	0.056	0.065
	(0.120)	(0.145)	(0.050)	(0.142)	(0.179)	(0.057)
Textiles	−0.187	−0.510	0.106	−0.288	−0.134	0.025
	(0.122)	(0.143)	(0.044)	(0.145)	(0.168)	(0.048)
Wood products	−0.625	−0.272	0.057	−0.751	−0.053	0.065
	(0.124)	(0.133)	(0.054)	(0.152)	(0.152)	(0.057)
Paper	−0.452	−0.038	0.050	−0.801	0.058	0.105
	(0.120)	(0.156)	(0.054)	(0.140)	(0.199)	(0.060)
Chemicals	−0.076	0.007	−0.131	−0.399	0.023	0.033
	(0.140)	(0.160)	(0.066)	(0.151)	(0.203)	(0.080)
Non-metallic minerals	−0.274	−0.074	0.008	−0.594	0.075	0.029
	(0.121)	(0.135)	(0.051)	(0.144)	(0.169)	(0.056)
Basic metals	0.172	−0.257	0.016	−0.240	−0.467	0.119
	(0.117)	(0.134)	(0.047)	(0.133)	(0.161)	(0.052)
Machinery	−0.100	−0.294	0.047	−0.473	−0.412	0.127
	(0.123)	(0.143)	(0.051)	(0.145)	(0.171)	(0.059)
Other manufacturing	−0.391	0.468	0.004	−0.711	0.930	−0.105
	(0.127)	(0.139)	(0.050)	(0.142)	(0.162)	(0.049)
Construction	−0.364	−0.050	0.051	−0.694	0.528	−0.014
	(0.162)	(0.141)	(0.053)	(0.198)	(0.154)	(0.057)
Commerce, hotels	−0.240	−0.023	−0.025	−0.803	0.307	0.027
	(0.184)	(0.150)	(0.062)	(0.211)	(0.177)	(0.074)
Financial services	−0.162	−0.091	−0.026	−0.495	−0.089	0.062
	(0.125)	(0.156)	(0.057)	(0.144)	(0.199)	(0.067)
Medical services	0.095	−0.205	0.010	−0.370	−0.115	0.110
	(0.168)	(0.144)	(0.065)	(0.193)	(0.176)	(0.074)

Table 8: Estimated private sector cost elasticities with respect to public infrastructure stocks (SEs in ()'s)

temporal variation in the disturbance terms. The FGLS estimates are similar in magnitude and sign to the prior panel estimates, but yet again smaller (on average) in magnitude.

All of these models attempt to more carefully construct estimates of the non-systematic part of the basic cost equation. We also considered several other models with various specifications of the way disturbance terms might be related across sectors and time (not reported here); none of these models provided compelling evidence that the reported estimates are significantly flawed.

In general these heteroskedasticity and autoregressive consistent estimates are larger (i.e., not as *negative*) than the Basic OLS estimates (Table 11). This lends further support to the conclusion that the role of public infrastructure in reducing private sector costs in Mexico is modest. In Table 11, the estimated infrastructure effects are generally largest for electric infrastructure and smallest for communications, with the effects of transportation capital falling somewhere in the middle. In fact, the effects of communications infrastructure appear to be consistently positive, literally implying that additional public sector communications infrastructure *increases* private sector costs.

Figures 2-4 present an overview of the elasticity estimates and their precision by infrastructure type (i.e. Electric, Transportation, and Communications). Each figure presents estimates for one infrastructure type over six models (i.e. Basic OLS, No restrictions, CRS, OLS panel, OLS RE, and FGLS); each model generates elasticity estimates for 14 sectors. The figures plotted are the estimated elasticities plus or minus two times the estimated standard errors. Although many of the bars are largely below the x-axis, in general either the two standard error range includes positive values, or the magnitude of the effect is quite small. And, what we might think of as more careful models (e.g. the panel estimates) tend to generate smaller (more positive) estimated elasticities.

VI Payoffs from infrastructure

Given the estimated effects, a policy maker might ask "What are the implied payoffs from public investments?" We consider two approaches to evaluating the importance of these estimates for policy makers. The first is to consider the estimated costs and benefits which would be associated with different increases in infrastructure stocks. These are static calculations; we ignore here the shadow cost of public funds, ignore firms' reactions to infrastructure increases, and ignore financing costs (such as increases in the real interest rate resulting from increases in government borrowing). Second, we use the elasticity definition and a convenient feature of our model formulation to calculate implied optimal infrastructure levels. Not surprisingly, given the small estimated elasticities, the estimated payoffs from additional investments are negligible.

For the illustrative calculations, consider three alternatives. The first is the result of a 1%

	OLS panel, robust SE			*OLS Random effects*		
Sector	Electric	Transportation	Communications	Electric	Transportation	Communications
Mining	0.160	0.006	0.062	0.211	-0.044	0.055
	(0.103)	(0.036)	(0.037)	(0.093)	(0.085)	(0.040)
Food and tobacco	-0.107	0.048	0.062	-0.084	0.019	0.049
	(0.075)	(0.042)	(0.022)	(0.071)	(0.078)	(0.029)
Textiles	-0.081	-0.147	0.110	-0.006	-0.131	0.066
	(0.101)	(0.072)	(0.027)	(0.072)	(0.074)	(0.025)
Wood products	-0.328	0.023	0.103	-0.297	-0.086	0.086
	(0.056)	(0.094)	(0.029)	(0.073)	(0.068)	(0.032)
Paper	-0.123	0.070	0.071	-0.082	-0.002	0.063
	(0.088)	(0.060)	(0.027)	(0.071)	(0.087)	(0.032)
Chemicals	-0.022	0.067	0.047	-0.050	-0.007	0.080
	(0.150)	(0.071)	(0.050)	(0.084)	(0.091)	(0.041)
Non-metallic minerals	-0.130	0.054	0.071	-0.088	-0.027	0.061
	(0.059)	(0.060)	(0.023)	(0.070)	(0.071)	(0.030)
Basic metals	0.160	0.105	0.023	0.195	0.082	0.007
	(0.089)	(0.099)	(0.027)	(0.069)	(0.070)	(0.028)
Machinery	0.056	-0.087	0.075	0.057	-0.101	0.064
	(0.053)	(0.105)	(0.020)	(0.072)	(0.077)	(0.030)
Other manufacturing	-0.093	0.000	0.116	-0.001	-0.046	0.064
	(0.103)	(0.092)	(0.034)	(0.075)	(0.074)	(0.029)
Construction	-0.096	0.062	0.067	-0.073	0.064	0.035
	(0.074)	(0.084)	(0.019)	(0.099)	(0.074)	(0.032)
Commerce, hotels	-0.075	0.011	0.082	-0.073	-0.025	0.081
	(0.123)	(0.092)	(0.034)	(0.114)	(0.082)	(0.038)
Financial services	-0.075	0.083	0.047	-0.072	0.047	0.052
	(0.089)	(0.041)	(0.031)	(0.073)	(0.087)	(0.035)
Medical services	-0.156	0.132	0.075	-0.140	0.095	0.080
	(0.139)	(0.057)	(0.040)	(0.103)	(0.078)	(0.040)

Table 9: Panel elasticity estimates (SEs in ()'s)

		FGLS - hetero, AR1	
Sector	Electric	Transportation	Communications
Mining	0.176	-0.039	0.070
	(0.145)	(0.140)	(0.042)
Food and tobacco	-0.069	0.006	0.059
	(0.041)	(0.043)	(0.017)
Textiles	0.073	-0.135	0.074
	(0.043)	(0.042)	(0.015)
Wood products	-0.249	-0.101	0.099
	(0.059)	(0.053)	(0.023)
Paper	-0.087	0.005	0.073
	(0.051)	(0.063)	(0.021)
Chemicals	-0.105	0.005	0.084
	(0.053)	(0.056)	(0.023)
Non-metallic minerals	-0.068	-0.013	0.069
	(0.050)	(0.050)	(0.020)
Basic metals	0.228	0.158	0.004
	(0.070)	(0.071)	(0.025)
Machinery	0.087	-0.037	0.061
	(0.050)	(0.052)	(0.019)
Other manufacturing	0.082	-0.028	0.070
	(0.066)	(0.063)	(0.023)
Construction	-0.012	0.031	0.049
	(0.059)	(0.043)	(0.018)
Commerce, hotels	-0.047	-0.040	0.091
	(0.076)	(0.054)	(0.023)
Financial services	-0.104	0.049	0.063
	(0.030)	(0.022)	(0.016)
Medical services	-0.165	0.068	0.095
	(0.073)	(0.055)	(0.025)

Table 10: Panel elasticity estimates (SEs in ()'s)

	Electric	Transportation	Communications
Basic OLS	-0.171	-0.165	0.019
OLS, robust	-0.065	0.031	0.072
OLS, random effects	-0.036	-0.012	0.060
FGLS, hetero, AR(1)	-0.019	-0.005	0.069

Table 11: Mean elasticities

increase in public infrastructure stocks. The second is the effect of an increase in infrastructure stocks of the same size of current *gross* investment (roughly 3% of GDP). Finally, we ask what the effects would be of increasing investment by 60% (to 5% of GDP). All of this additional investment is assumed to add to infrastructure stocks; that is, it is net of depreciation.

The basic calculation is a simple comparison of the value of the estimated reductions in private sector costs following from an increase in public sector infrastructure stocks. The cost of a δ percentage increase in infrastructure stocks is:

$$\sum_m \delta g_m \tag{7}$$

while the estimated benefits across the sectors $1 \leq j \leq 14$ are:

$$\sum_j \sum_m \delta \eta_{jm} c_j \tag{8}$$

Using our Basic OLS estimates and the 1993 values for infrastructure stocks and sectoral costs, the estimated cost of a 1% increase in infrastructure would be 6.62 (billions of real 1980 pesos). The benefits in private sector cost reduction would, in total, be 12.35 (billions of real 1980 pesos). If these benefits were accrued over several years, the total would be larger; at depreciation and discount rates of 10%, the present value would be approximately 55.6 billion. The two scenarios based on larger expansions of public infrastructure stocks would be associated with similarly larger multi-period payoffs. Table 12 presents estimated costs and benefits for the three scenarios. Note, however, that the panel estimates imply an *increase* in private sector costs. Although some sectors have (small) negative elasticities, many estimates are actually positive (Table 10). This is a further indication of the likely weak effects of public infrastructure on private sector costs.

A second approach to evaluating appropriate levels of infrastructure stocks is to recognize that we estimate constant elasticities, but not constant peso cost changes. Therefore, our expression of infrastructure stocks in currency rather than physical terms allows a simple calculation which yields an estimate of "optimal" infrastructure stocks. For infrastructure stock m, by definition, the

	Investment cost	Private sector cost reduction (-) or increase (+) FGLS	Basic OLS
1% increase in infrastructure stocks	6.6	+1.2	-12.4
Increase by current gross spending amount (3% GDP)	186.9	+34.1	-348.7
Increase current amount by 60% (5% GDP)	311.5	+56.8	-581.1

Table 12: Costs and benefits of increased infrastructure (real 1980 pesos, billions)

elasticity of private sector costs with respect to stock m is:

$$\eta_m = \frac{dC/dG_m}{C/G_m} \tag{9}$$

A static notion of optimality would require that the marginal benefits of increases in infrastructure stocks ($-\frac{dC}{dG_m}$) be equal to the marginal costs of those increases. Infrastructure stocks are measured in pesos and we ignore potential infrastructure production nonlinearities. Therefore the marginal cost of infrastructure increases is -1 (it costs 1 peso to increase stocks by 1 peso).

Then, at the optimum level of infrastructure $-\frac{dC}{dG_m} - 1 = 0$ and

$$G_m^* = -\eta_m C \tag{10}$$

This calculation of the optimal stock implicitly assumes:

1. Total private sector cost remains constant (C is fixed).
2. Infrastructure *production* has constant returns to scale (marginal cost of producing infrastructure is constant).
3. Increasing infrastructure stocks does not affect the shadow cost of government funds (which is implicitly assumed to be zero: the cost of 1 peso is 1 peso).
4. Only current period benefits matter in calculating optimal levels.

The calculated optimal infrastructure stocks are shown in Table 13. The calculations are based on panel elasticity estimates (feasible GLS, heteroskedastic consistent, 1 period autoregressive structure; see Table 11) with the communications elasticity set to 0.00. The table also includes calculations using the mean Basic OLS elasticities for each infrastructure type with three different elasticity assumptions for communications: -0.019 (negative of Basic OLS), 0.00, and -0.010.

		η_m	Actual G_m	Optimal G^*_m	Ratio G^*_m/G_m
Panel (FGLS)	Electric	-0.019	335.0	91.9	0.27
	Transportation	-0.005	217.4	24.2	0.11
	Communications	0.000	110.0	0.0	-
Basic OLS	Electric	-0.171	335.0	826.8	2.47
	Transportation	-0.165	217.4	797.8	3.67
	Communications	-0.019	110.0	91.9	0.84

Table 13: Optimal infrastructure stocks (real 1980 pesos, billions)

Unfortunately, because the elasticity estimates are not particularly precise, neither are the calculated levels of optimal infrastructure stocks. If the Basic OLS estimates are accurate then current levels of electric and transportation infrastructure are too low; the optimal levels are 2-4 times larger. However, the panel estimates suggest much lower elasticities and hence optimal infrastructure levels. In fact, the FGLS panel estimates suggest that current (i.e. 1993) stocks are too *large*.

VII Conclusions

This paper provides estimates of the effects of public sector infrastructure stocks on private sector production costs. The significant effects that others have found for the US do not appear in the Mexican data; if anything, significant negative effects of public investments on private sector productivity appears likely to be an artifact of neglecting sector specific effects. There seems to be little evidence to suggest that additional public infrastructure investment would produce sizeable benefits in the form of private sector cost reduction.

Appendices

A Translog model

A sensible cost function will also satisfy conditions which are not inherent in (2), such as homogeneity of degree one in input prices. We impose homogeneity of degree one in private factor input prices *a priori*. We do not impose inequality constraints such as $\alpha_i > 0$ or $\gamma_m < 0$. We evaluate two further sets of restrictions on the estimated model: constant degree of homogeneity in output and constant returns to scale (in private inputs)[9]. The specific restrictions and the implications of the restrictions for estimation are discussed in more detail below. In general, we restrict our attention

[9]Unlike, for instance, Nadiri and Mamuneas (1994) who impose CRS restrictions a priori.

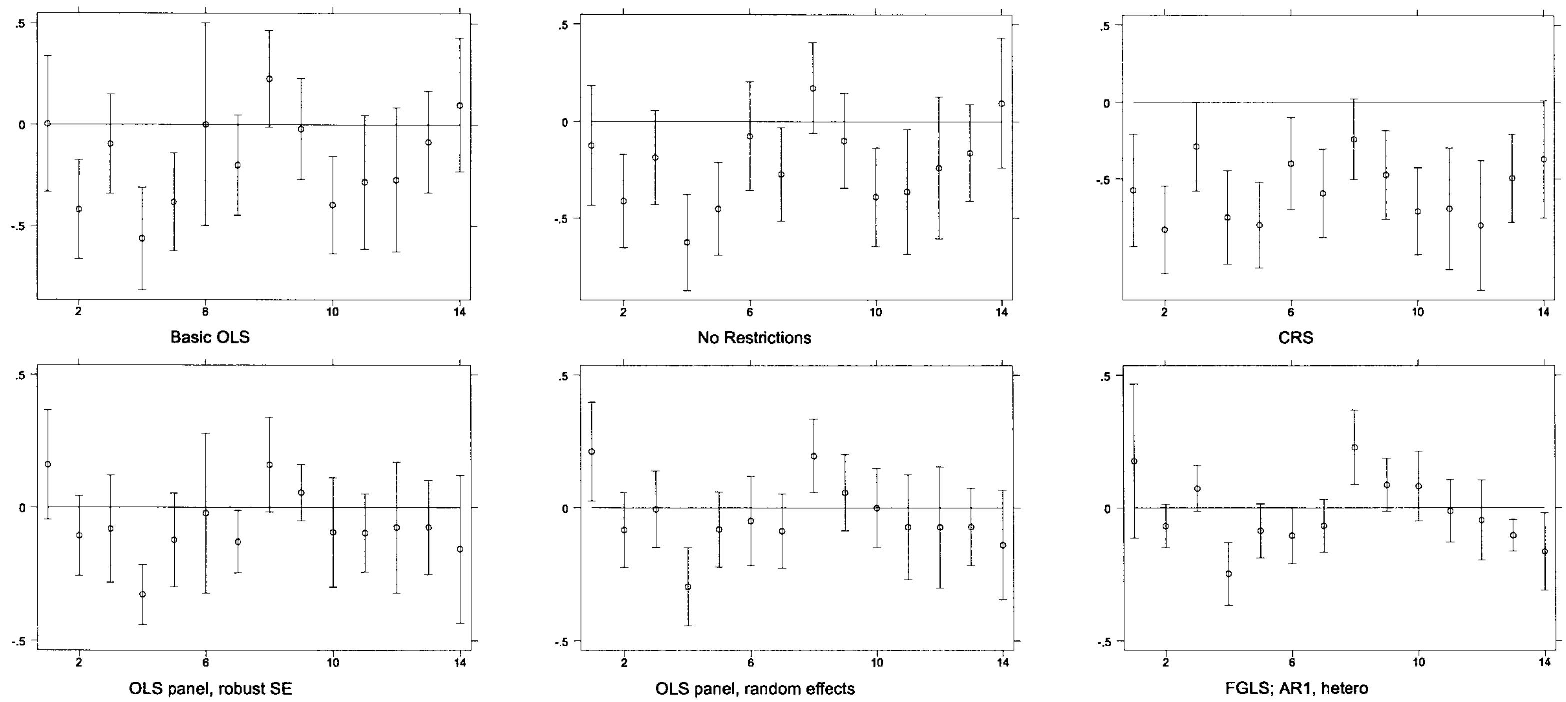

Figure 2: Electric: elasticity estimates $+/-2 \times \mathrm{SE}$

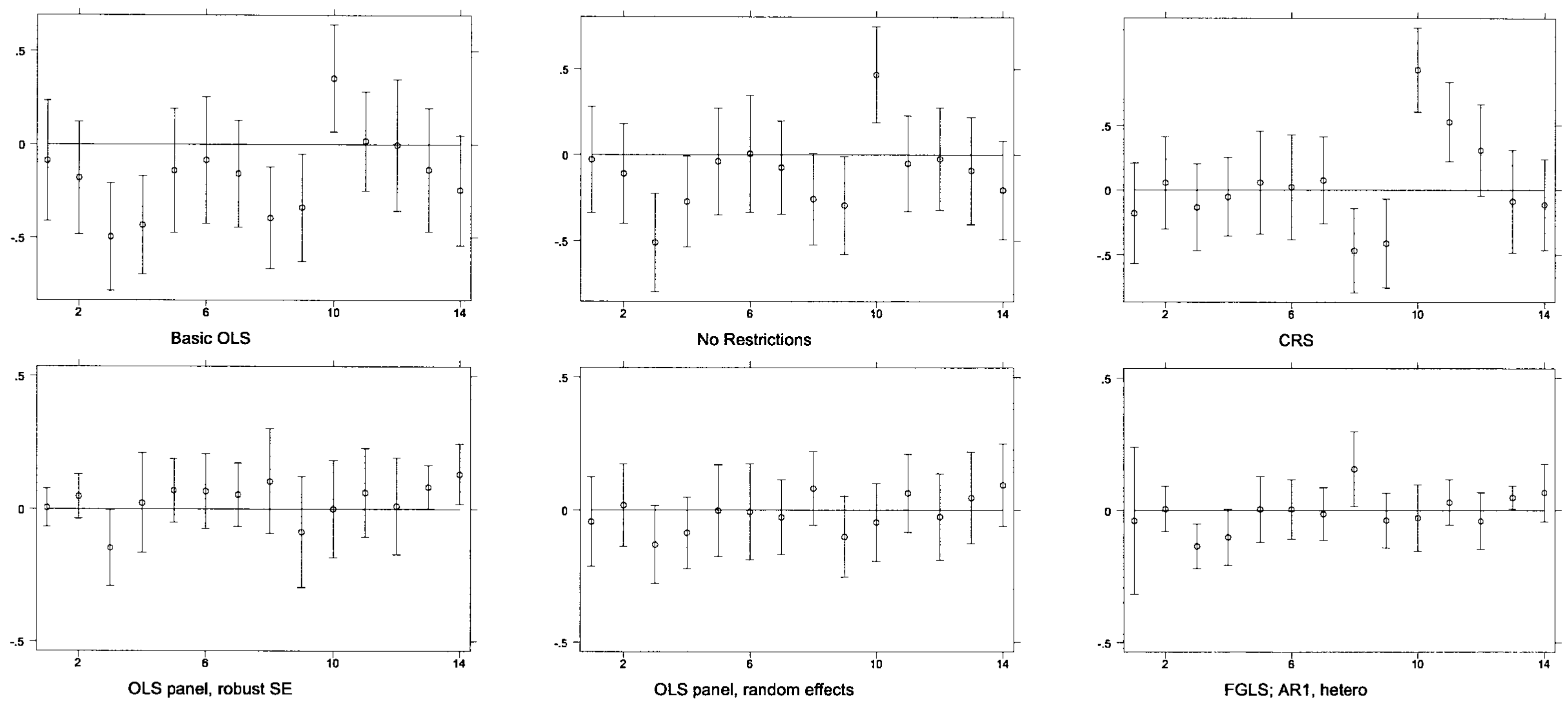

Figure 3: Transportation: elasticity estimates $+/-2 \times \mathrm{SE}$

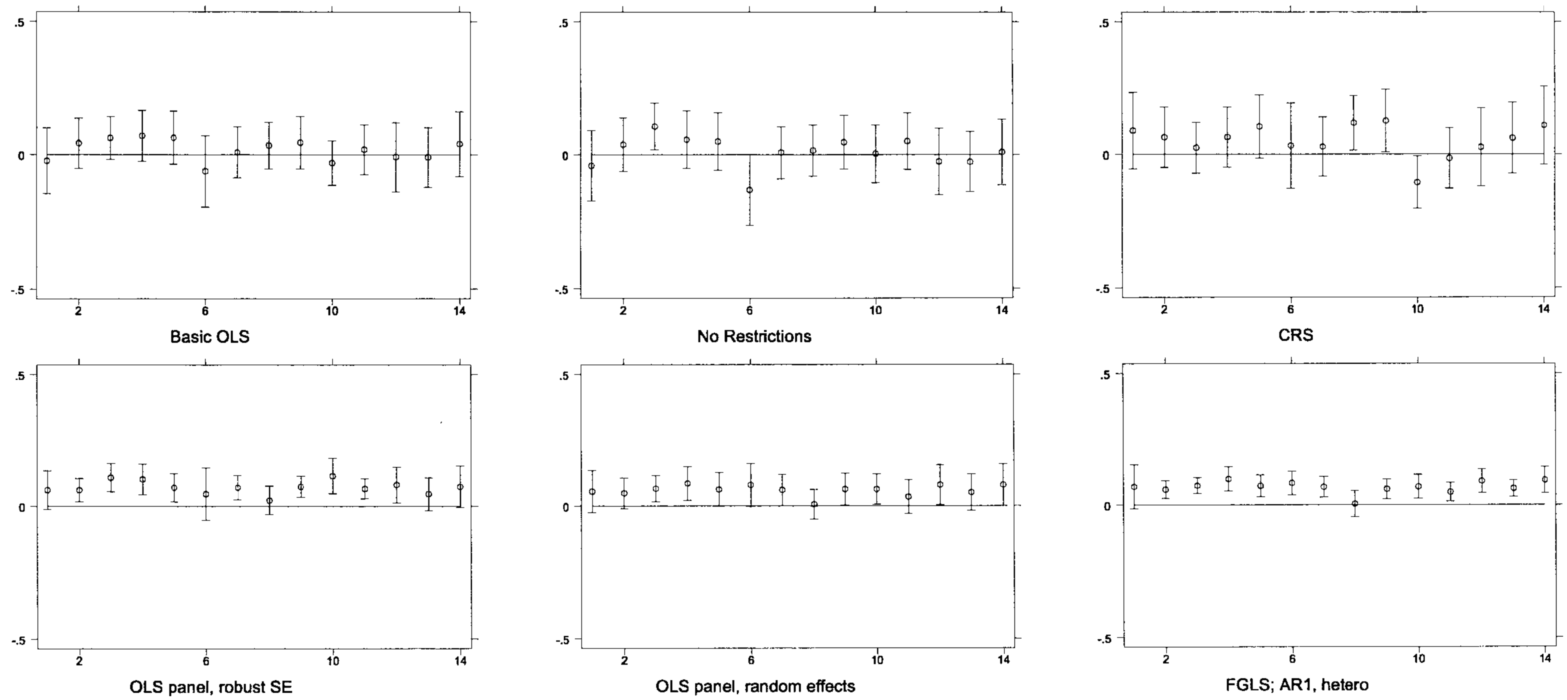

Figure 4: Communications: elasticity estimates $+/-2\times$ SE

to the constant degree of homogeneity in output case. Our estimates do lead us to reject the null hypothesis that the cost function describing the Mexican economy exhibits constant returns to scale, so the constant degree of homogeneity model is more appropriate.

A Constraints

Let the augmented translog model (from (2)) be given by:

$$\begin{aligned}\mathbf{c} = \boldsymbol{\alpha_0}^* + \boldsymbol{\alpha_L}^*\mathbf{w}_L + \boldsymbol{\alpha_K}^*\mathbf{w}_K + \beta_{LL}\mathbf{w_L^2} + \beta_{LK}\mathbf{w_L}\mathbf{w_K} + \beta_{KK}\mathbf{w_K^2} \\ + \sum_i \mathbf{w_i}\mathbf{t}\beta_{iT} + \sum_i \mathbf{w_i}\mathbf{y}\beta_{Yi} + \mathbf{yt}\beta_{TY} \\ + \boldsymbol{\alpha_Y}^*\mathbf{y} + \beta_{YY}\mathbf{y^2} + \beta_{YL}\mathbf{y}\mathbf{w_L} + \beta_{YK}\mathbf{y}\mathbf{w_K} \\ + \sum_m \boldsymbol{\gamma_m}^*\mathbf{g}_m + \sum_m\sum_i \gamma_{im}\mathbf{g_m}\mathbf{w_i} + \sum_m \gamma_{Ym}\mathbf{g_m}\mathbf{y} + \boldsymbol{u}\end{aligned} \tag{11}$$

where the *d coefficient vectors include sector specific effects. We gain some additional efficiency in our estimates by noting that the above specification implies, from Shepard's Lemma, that the share of total cost attributable to each private factor input is:

$$\begin{aligned}\mathbf{S_L} &= \boldsymbol{\alpha_L}^* + \beta_{LK}\mathbf{w_K} + \beta_{LL}\mathbf{w_L} + \beta_{LY}\mathbf{y} + \sum_m \gamma_{Lm}\mathbf{g}_m + \boldsymbol{u_L} \\ \mathbf{S_K} &= \boldsymbol{\alpha_K}^* + \beta_{KK}\mathbf{w_K} + \beta_{LK}\mathbf{w_L} + \beta_{KY}\mathbf{y} + \sum_m \gamma_{Km}\mathbf{g}_m + \boldsymbol{u_K}\end{aligned} \tag{12}$$

Furthermore, $\mathbf{S_L}$ and $\mathbf{S_K}$ must satisfy the adding up constraint: $\mathbf{S_L} + \mathbf{S_K} = 1.0$. We also know that a reasonable cost function must satisfy conditions such as homogeneity of degree one in input prices, which implies that:

$$\begin{aligned}&\alpha_L + \alpha_K = 1 \\ &\alpha_{LK} + \alpha_{LL} = 0 \\ &\alpha_{KK} + \alpha_{LK} = 0 \\ &\beta_{LY} + \beta_{KY} = 0\end{aligned} \tag{13}$$

We impose these conditions; letting $\mathbf{r} = \mathbf{w}_K$ and $\mathbf{w} = \mathbf{w}_L$ allows us to write (11) as:

$$\begin{aligned}\mathbf{c} - \mathbf{r} = \boldsymbol{\alpha_0}^* + \boldsymbol{\alpha_L}^*\frac{\mathbf{w}}{\mathbf{r}} + \beta_{LL}\mathbf{w}\frac{\mathbf{w}}{\mathbf{r}} + \beta_{KK}\mathbf{r^2} \\ + \alpha_T\mathbf{t} + \beta_{LT}\mathbf{t}\frac{\mathbf{w}}{\mathbf{r}} + \beta_{YT}\mathbf{yt} \\ + \boldsymbol{\alpha_Y}^*\mathbf{y} + \beta_{YY}\mathbf{y^2} + \beta_{LY}\mathbf{y}\frac{\mathbf{w}}{\mathbf{r}} \\ + \sum_m \boldsymbol{\gamma_m}^*\mathbf{g}_m + \sum_m \gamma_{Lm}\mathbf{g_m}\frac{\mathbf{w}}{\mathbf{r}} + \sum_m \gamma_{Ym}\mathbf{g_m}\mathbf{y} + \boldsymbol{u}\end{aligned} \tag{14}$$

Note that the above conditions also imply that (14) is subject to the constraint $\beta_{KK} = \beta_{LL}$. And:

$$\mathbf{S_L} = \boldsymbol{\alpha_L}^* + \beta_{LL}\frac{\mathbf{w}}{\mathbf{r}} + \beta_{LY}\mathbf{y} + \beta_{LT}\mathbf{t} + \sum_m \gamma_{Lm}\mathbf{g}_m + \boldsymbol{u_L} \tag{15}$$

A constant degree of homogeneity in output requires (in addition to the above):

$$\begin{aligned} \beta_{LY} =& \beta_{KY} = 0 \\ \beta_{YY} =& \beta_{YT} = 0 \\ \gamma_{YE} =& \gamma_{YR} = \gamma_{YC} = 0 \end{aligned} \tag{16}$$

(where the infrastructure subscripts are E - electricity, R - transportation, and C - communications). Finally, CRS further implies that marginal costs are unaffected by scale, or that:

$$\alpha_Y = 1 \tag{17}$$

In our estimation, we begin with (14) and (15), impose the appropriate conditions and estimate the model parameters in a SUR framework. This should provide reasonable statistical properties and the estimates should be invariant to the choice of which cost share equation is deleted (see (Berndt 1991), (Nadiri and Mamuneas 1994)).

B Data

The analysis requires several elements of data (all on an annual basis). The sources of these data are described below.

It should be noted that one of the primary sources for our data, INEGI (1997), presents, for some variables, two separate series of data, one for 1970-1984 and one for 1980-1993. Unfortunately, these series are not always consistent. Where the series are inconsistent the later series are ordinarily combined with the growth rates implied by the earlier series.

A Gross output

The needed measure of sectoral output is gross output; not value added. The (INEGI 1997) accounts do not include a consistent time-series of gross output for the 1960-1993 period. Therefore, the data used in this paper are constructed as follows.

1 1980-1993

For the 1980-1993 period, constant price (1980 new pesos) gross production figures and implicit price deflators (base 1980) are available for the nine major sectors of the economy as well as the major divisions of the manufacturing sector which are of interest. This gives us pb_t, $1980 \le t \le 1993$.

2 1970-1984

For the 1970-1984 period, constant price (1970 pesos) gross production figures and implicit price deflators (base 1970) are available for all the relevant sectors of the economy. There does not appear to be a ready conversion rate from 1970 pesos to 1980 pesos.

To calculate pb for 1970-1979 in 1980 new pesos, the data selected include gross output (pb) and value added (pib). These figures are used to calculate the ratio of gross product to value added; this ratio is then multiplied by pib in 1980 new pesos (see section B). For each year, gross product for each sector in 1980 new pesos is based on real (1980 new pesos) value added by sector and the ratio of pb to pib in 1970 pesos:

$$pb_{1980,t} = pib_{1980,t} \times \frac{pb_{1970,t}}{pib_{1970,t}} \qquad \text{for } 1970 \leq t \leq 1979 \tag{18}$$

This gives us $pb_t, 1970 \leq t \leq 1993$.

3 1960-1969

For the period 1960-1985, gross production (pb) is reported only for the nine major sectors of the economy (*Gran Divisions*) and only in 1970 pesos.

The pb figures in 1980 new pesos are calculated as follows:

1. We calculate the growth rates (real 1970 pesos) in pb by sector for each year 1960-1970.
2. Beginning with the 1970 constant peso (1980 new pesos) gross output figures calculated above (based on the ratio of pb to pib), we work back to 1960 using the growth rates for 1970 peso based figures. For the nine *Divisions* of the manufacturing sector (sectors 2-10, this paper), we use the overall manufacturing growth rate since the disaggregated *Division* data are not available.

In summary, the 1960-1993 gross output (pb) figures are derived as follows:

- 1980-1993: from (INEGI 1997) published tables
- 1970-1984: from pib in 1980 new pesos data and the ratio of pb to pib for 1970 peso data
- 1960-1969: from the calculated 1970 value of pb in 1980 pesos and the growth rates of 1970 peso pb figures

B Production cost

Production cost is measured by real (1980 prices) value-added, or *Producto Interno Bruto* (pib); INEGI (1997) reports these figures for 1960-1993. The data are copied (with some rearrangement) directly from the (INEGI 1997) files.

Value added is also reported for *Gran Division* 1: "Agropecuario, Silvicultura Y Pesca" which we ignore because there are no capital accounts for the agricultural sector (see section C below). To the extent that the agricultural sector is dominated by small-scale, local farming this will not materially change our results as long as these producers are unlikely to make much use of government provided infrastructure of the types we consider.

C Factor payments

The two private inputs are labor and capital. We take two approaches to calculating factor payments. First, we take sector specific factor prices (mean wages, Treasury bill rate) and multiple by sector specific factor usage (employment, net capital stock). Second, we use national income accounts estimates of wage payments and payments to owners of capital. Our preferred measures are those from the national income accounts.

1 Wage rates

For labor, INEGI (1997) reports mean nominal remuneration for 1980-1993 and 1970-1984 by sector (nine *Gran Divisions* and nine *Divisions* of manufacturing). The 1980-1993 figures are converted to real 1980 pesos using the implicit price deflators for gross output .

INEGI (1997) also reports nominal 1970 peso figures for 1970-1984; these are converted to real 1970 pesos using the appropriate implicit price deflators. The real 1970 figures are used to calculate growth rates which are then successively applied (beginning with real 1980 figures) to generate real mean wages back to 1970.

For 1960-1969, we construct three different series based on potential wage paths. In all cases, we work from our constructed 1970 figures and from 1970, we calculate the 1960-1969 values assuming that wages grew as follows:

- GDP growth: wages in all sectors grow at the same rate as the growth rate of the Mexican economy
- `pib` growth: wages in each sector grow at the same rate as value added in that sector
- No growth: $w_t = w_{t+1}, 1960 \leq t \leq 1969$

Our Basic OLS is that wages grow at the same rate as overall GDP.

2 Interest rate

The interest rate used is the Mexican Treasury Bill rate. This is admittedly crude, but since our primary concern (for purposes of estimation) is variation, it is not too bad. For 1978-1993, the rate used is the one reported in (IFS 1998). This series has a gap in 1986; for 1986, we estimate the T-bill rate based on a OLS regression of the T-bill rate on the Time Deposit rate (also reported in (IFS 1998)) for the period 1978-1993 (excluding 1986). The estimated relationship, which has an F-statistic of $F(1,13) = 2137.77$ $(p = 0.0000)$, is:

$$\hat{t} = \underset{(1.014)}{0.211} + \underset{(0.023)}{1.067d} \tag{19}$$

For the years prior to 1978, we estimate the Treasury Bill rate as follows. The 1977 rate is estimated using the 1977 Time Deposit Rate and the estimated equation (19). Nominal interest rates are converted to real by subtracting the annual growth in the consumer price index. Prior to 1977, we calculate the Mexican Treasury Bill rate based on an assumed parity between US and

Mexican rates:

$$r_{M,t} = x_{M,t} \times \frac{R_{US,t}}{I_{US,t}} \tag{20}$$

where the subscripts M and US refer to Mexico and the United States, respectively. Real interest rates are indicated by r, nominal interest rates by R, the nominal exchange rate with the US dollar by x, and price indices by I. All data are taken from (IFS 1998).

3 Employment

We use sectoral employment to calculate total labor costs. For 1980-1993, we use sector employment from (INEGI 1997). For 1970-1979, we use the growth rates of employment calculated from the employment data presented for 1970-1983 to extend the 1980 figures back annually to 1970.

For 1960-1969, we use the sector growth rates of `pib` or value-added to extend the 1970 figures back to 1960.

4 Private capital stocks

Private sector capital figures are from the `banco` data.

5 National income accounts

For the 1970-1993 period, INEGI (1997) reports the disposition of `pib` into: *Remuneracion De Asalariados*, *Impuestos Indirectos Menos Subsidios*, and *Excedente Bruto De Operacion.* We ignore taxes and indirect subsidies and calculate labor and capital shares on the basis of the wage and surplus flows only.

For 1970-1984, figures are available in 1970 pesos. To construct 1980 new peso equivalents, we calculate real (1970 peso) flows using the sectoral implicit price deflators and then calculate the real growth rates. Then, the 1970-1979 figures are estimated using the real 1980 (1980 new pesos basis) figures and the 1970-1980 growth rates in real 1970 peso terms.

For 1960-1969, we assume that labor payments grew at the rate of sectoral `pib`, while payments to capital grew at the rate of sectoral net capital stocks.

D Government infrastructure

We use the net capital stocks of three sectors of the economy, *Electricity* (Rama 61; contained in *Gran Division* 5), *Transportation* (Rama 64; contained in *Gran Division* 7), and *Communications* (Rama 65; contained in *Gran Division* 7) as our measures of government infrastructure. The *Transportation* and *Communications* figures are presented in (Banco de Mexico 1995). We use total net capital for each of these sectors as our measures of national infrastructure stocks.

Comparable figures have been previously been published for the electric sector, but are not currently available. We construct net capital stock series for electricity as described below. Banco de Mexico (1995) presents both real (1980 new pesos) and nominal capital stock figures.

1 Net capital stock: electricity

The real capital stock series is constructed in stages.

1. Previous Banco de Mexico publications present net capital for sector 61 in 1970 pesos for 1960-1990.
2. We calculate the ratio of real 1980 pesos to real 1970 pesos using implicit price deflators for *Gran Division* 5. INEGI (1997) presents 1970 denominated gross output pb for *Gran Division* 5 (which includes sector 61) for 1970-1984 and 1980 denominated gross output for 1980-1993.
3. These ratios are used to convert the 1970 denominated net capital figures for 1980-1984 to 1980 denominated net capital figures.
4. The growth rates in the 1970 denominated net capital figures are used to extend the 1980 figure back to 1960 and to extend the 1984 figure up through 1990.
5. Estados Unidos Mexicanos (1998) presents estimates of total infrastructure (in megawatts) in the electric industry for the years 1988-1998. The growth rates in these figures are used to extend the 1990 estimates calculated above forward until 1993.

Likewise, the nominal net capital stock series for the electric infrastructure is constructed in stages.

1. The real (1970 pesos) capital stocks for four types of capital (*Edificios, Construcciones E Instalaciones*, *Maquinaria Y Equipo De Operacion*, *Equipo De Transporte*, and *Mobiliario Y Equipo De Oficina*) in *Rama 61* are presented in the previous Banco tables. A separate file (`PRE4991.PRN`) presents implicit price deflators for these series; these deflators are used to generate nominal capital stock figures for each series, which are then summed to provided total net capital 1960-1990.
2. To convert the 1970 pesos to 1980 pesos, we calculate the ratio of nominal pb (1970 pesos) to nominal pb (1980 pesos) for *Rama 61* for 1980-1984 and use the average of the ratios for these five years as our conversion factor (1.325429).
3. For the years 1991-1993, we calculate real growth (see above) and price level growth for each year; the nominal figures are calculated as the product of the prior year's nominal figure times one plus the sum of real and price level growth. Price level growth is estimated by using the implicit price level changes of total net capital in *Rama 64* (Communications). The derived growth rates are shown in Table 14.

	Real	Price	Total
1991	0.0639	0.2014	0.2653
1992	0.0126	0.1467	0.1593
1993	0.0685	-0.0602	0.2633

Table 14: Growth rates used for nominal Electricity infrastructure

C Regression results

Table 15 reports coefficient estimates from various specifications (dual equation models):

- *Basic OLS*: 1974-1993 sample; electric, transport, and communications infrastructure stocks; restrictions: homogeneity of degree one in input prices and constant degree of homogeneity in output.
- *1960-1993*: Same as Basic OLS, but 1960-1993 sample.
- *No restrictions*: Same as Basic OLS, but restrictions only for homogeneity of degree one in input prices.
- *CRS*: Same as Basic OLS, but restrictions for homogeneity of degree one in input prices and constant returns to scale in output.

		Basic OLS	1960-1993	No restrictions	CRS
Cost	α_L	26.016	52.041	27.308	−0.218
		(2.369)	(2.498)	(4.748)	(1.183)
	β_{LL}	−0.095	−0.121	−0.102	−0.059
		(0.007)	(0.007)	(0.006)	(0.008)
	β_{KK}	−0.095	−0.121	−0.102	−0.059
		(0.007)	(0.007)	(0.006)	(0.008)
	α_Y	−15.608	3.265	−16.475	1.000
		(1.374)	(1.039)	(3.465)	(NA)
	β_{YY}			0.021	
				(0.157)	
	β_{LY}			0.011	
				(0.052)	
	α_T	0.100	0.188	0.060	0.002
		(0.008)	(0.009)	(0.024)	(0.002)
	β_{LT}	−0.012	−0.025	−0.013	0.001
		(0.001)	(0.001)	(0.003)	(0.001)
	β_{YT}			0.004	0.000
				(0.001)	(0.000)
	γ_E	−15.196	−1.254	−11.281	2.122
		(2.519)	(0.307)	(3.042)	(2.555)
	γ_{LE}			−0.162	0.000
				(0.066)	(0.000)
	γ_{YE}	1.241	0.108	0.999	−0.220
		(0.205)	(0.028)	(0.242)	(0.204)
	γ_R	−4.127	4.062	−2.507	−2.951
		(2.282)	(1.159)	(3.172)	(2.795)
	γ_{LR}			0.239	0.000

Table 15: Coefficient (SE) estimates; dummy variables excluded

		Basic OLS	1960-1993	No restrictions	CRS
				(0.056)	(0.000)
	γ_{YR}	0.330	−0.370	0.073	0.226
		(0.185)	(0.097)	(0.249)	(0.227)
	γ_C	3.190	−1.047	4.409	−.342
		(0.926)	(0.320)	(1.026)	(1.075)
	γ_{LC}			−0.083	0.000
				(0.036)	(0.000)
	γ_{YC}	−0.262	0.092	−0.318	0.035
		(0.079)	(0.027)	(0.085)	(0.092)
	α_0	(dropped)	−403.097	(dropped)	(dropped)
			(22.920)		
Labor share	β_{LL}	0.049	0.046	0.049	0.050
		(0.004)	(0.005)	(0.004)	(0.004)
	β_{LY}	−0.013	0.020	−0.012	−0.022
		(0.017)	(0.018)	(0.017)	(0.017)
	β_{LT}	−0.007	−0.007	−0.008	−0.006
		(0.001)	(0.002)	(0.001)	(0.001)
	γ_{LE}	0.066	−0.019	0.065	0.073
		(0.029)	(0.007)	(0.029)	(0.029)
	γ_{LR}	0.035	−0.025	0.040	−0.001
		(0.042)	(0.047)	(0.042)	(0.042)
	γ_{LC}	−0.001	0.019	−0.002	0.003
		(0.011)	(0.009)	(0.011)	(0.011)
	γ_{LD}				
	α_L	13.574	13.652	13.949	10.901
		(2.044)	(2.893)	(2.049)	(2.034)
cost	N	280	476	280	280
	k	96	96	96	96
	"R^2"	0.996	0.998	0.997	0.995
share	N	280	476	280	280
	k	19	19	19	19
	"R^2'	0.949	0.867	0.949	0.948

Table 15: Coefficient (SE) estimates; dummy variables excluded

Table 16 reports coefficient estimates from various panel specifications:

- *OLS panel*, 1974-1993 sample
- *OLS random effects*

- *FGLS*

		OLS panel	OLS Random effects	FGLS (hetero, AR(1))
Cost	α_L	−12.074	−3.186	−0.981
		(7.424)	3.000	(2.070)
	β_{LL}	−0.152	−0.150	−0.152
		(0.006)	(0.003)	(0.002)
	β_{KK}			
	α_Y	−7.633	2.269	1.613
		(6.734)	(2.162)	(1.494)
	β_{YY}	0.024	0.013	−0.049
		(0.243)	(0.101)	(0.066)
	β_{LY}	−0.003	−0.017	0.062
		(0.109)	(0.033)	(0.023)
	α_T	−0.070	−0.016	−0.005
		(0.042)	(0.015)	(0.011)
	β_{LT}	0.006	0.003	0.001
		(0.004)	(0.002)	(0.001)
	β_{YT}	0.002	0.000	0.000
		(0.002)	(0.001)	(0.001)
	γ_E	−7.841	−2.169	−3.988
		(4.966)	(1.886)	(1.268)
	γ_{LE}	0.130	−0.005	0.067
		(0.077)	(0.044)	(0.028)
	γ_{YE}	0.583	0.197	0.304
		(0.369)	(0.149)	(0.096)
	γ_R	3.605	5.830	5.360
		(3.823)	(2.019)	(1.230)
	γ_{LR}	0.030	−0.038	−0.004
		(0.084)	(0.036)	(0.024)
	γ_{YR}	−0.310	−0.459	−0.439
		(0.272)	(0.158)	(0.093)
	γ_C	1.217	−1.177	−0.691
		(1.862)	(0.656)	(0.426)
	γ_{LC}	−0.092	−0.021	−0.050
		(0.049)	(0.023)	(0.015)
	γ_{YC}	−0.044	0.112	0.089
		(0.129)	(0.055)	(0.034)
	α_0	182.478	*(dropped)*	*(dropped)*
		(96.577)		

Table 16: Coefficient (SE) estimates; dummy variables excluded

		OLS panel	OLS Random effects	FGLS (hetero, AR(1))
	AR(1) coef.			0.079
cost	N	280	280	280
	Est. coefficients	96	95	96
	Groups	14	14	14
	Periods	20	20	20
	F	1056.17		
	χ^2		1.09×10^6	4.10×10^8
	$p-$ value	0.000	0.000	0.000

Table 16: Coefficient (SE) estimates; dummy variables excluded

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