Electricity, Highways and Manufacturing Growth: A Cost Based Estimate

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Abstract: This paper studies the role of electricity and highways on the Mexican manufacturing sector. The paper uses a weighted aggregate input of labor and capital (with weights equal to their share in costs) and a weighted measure of infrastructure to estimate jointly the elasticity of infrastructure and the degree of internal returns to scale. I pool two-digit industries to obtain the estimates for the whole manufacturing sector. This paper follows the first order tradition initiated by Solow (1957) and Hall (1988a, b). For the entire manufacturing sector, I find that a weighted average index of both types of infrastructure has a significant effect on manufacturing growth. At the sectoral level the evidence is mixed.

Keywords: infrastructure, returns to scale, external effects.

Resumen: Este trabajo estudia el efecto de la electricidad y carreteras en el sector manufacturero mexicano. Se utiliza como insumo agregado un ponderado de trabajo y capital (con ponderaciones iguales a la participación en costos) y una medida ponderada de infraestructura para estimar de manera conjunta la elasticidad de la infraestructura y el nivel de retornos a escala. Se agrupan industrias en un nivel de dos dígitos para obtener las estimaciones de todo el sector manufacturero. El trabajo se enmarca dentro de la tradición de "primer orden" iniciada por Solow (1957) y Hall (1988a, b). Para todo el sector manufacturero, se encuentra que un promedio ponderado de ambos tipos de infraestructura tiene un efecto significativo en el crecimiento manufacturero. A nivel sectorial la infraestructura afecta algunos sectores.

Palabras clave: infraestructura, rendimientos a escala, efectos externos.

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I. Introduction

This paper estimates the elasticity of manufacturing output with respect to infrastructure and the degree of returns to scale. Several papers in the economic literature study the impact of infrastructure. The papers by Aschauer (1989) and Holtz-Eaking (1988) estimate the role of infrastructure for the whole economy. At the industrial level, Nadiri and Mamuneas (1994) calculated the impact of infrastructure on industrial factor productivity using data on two-digit industries.[1] These authors quantify the contribution of output demand, relative input prices, technical change and publicly financed capital on total factor productivity growth. The procedure used by these authors required an estimation process for output demand and cost functions, that imposes a lot of restrictions into the problem. Also, they imposed an assumption of constant returns to scale in private inputs. Castañeda, Cotler and Gutiérrez (2000b) used a framework that simultaneously estimated the impact of infrastructure on industrial growth, the degree of market power and the returns to scale parameter. They used the share of labor on total income to generate the estimates.

This paper calculates the share of labor on total costs to estimate the impact of infrastructure on industrial growth. The technique allows me to estimate simultaneously the impact of infrastructure and the degree of returns to scale. The paper follows the first order approach first envisioned by Solow (1957) and continued by the seminal contributions of Hall (1988a, b). The first order approach used in this paper allows me to proceed in my estimation without the need to assume constant returns to scale in private inputs, and without the need to use an extensively parameterized approach which requires a rather well specified model (Nadiri and Mamuneas, 1994). As Basu and Fernald (1998) have suggested, if the problem is correctly specified and all necessary data are available, the Nadiri and Mamuneas (1994) approach is theoretically superior to study the behavior of productivity and the factors that affect it. However, the likelihood of misspecification is larger with this approach and it needs far more requirements on the data to achieve a real superiority over the first order approach.

[1] Feltenstein and Ha (1995) estimate (using a translog function) the role of infrastructure on several two-digit industries. However, their statistical fit was quite unsatisfactory. The reasons for their failure may have to deal with the issue of factor prices reflecting their allocative properties. See the discussion on methodology.

Hall (1988b) estimates the degree of returns to scale for the U.S. manufacturing sector. His identification technique assumes that the Solow residual follows a random walk with drift. To estimate the degree of returns to scale, he uses a two stage procedure that projects (in the first stage) the weighted aggregate input of labor and capital (weighted by their share on costs) on the space spanned by instruments correlated with business fluctuations not known to be correlated with productivity shocks. Caballero and Lyons (1989) modified Hall's original approach by including an externality factor in the production function. These latter authors use both instrumental variable and SUR techniques to calculate its estimates.

Similarly to the briefly reviewed literature in the last paragraph, this paper uses a production function framework. The difference lies in that an infrastructure stock is added to private inputs in the production function. The addition of infrastructure stock as an input generates an estimating equation that allows me to estimate simultaneously the degree of returns to scale and the impact of infrastructure. The approach followed in this paper implies that previous work, aimed at estimating the degree of the returns to scale (Hall, 1988b), may have yield biased estimates of this index, since infrastructure stocks may be correlated with the instruments used for obtaining the estimates.[2]

II. Empirical Implementation

I assume a technology with degree of homogeneity r in labor and capital and no intermediate inputs:

$$Y(t) = A(t)F(L(t), K(t), I(t)) \tag{1}$$

$L(t)$ is labor input, $K(t)$ is the stock of capital, $A(t)$ represents Hicks neutral technical progress, $I(t)$ is the stock of public infrastructure, and $Y(t)$ is output. Differentiating with respect to time the last equation and rearranging:

[2] Using Mexican data, Jarque (1988) ran several regressions of the Solow residuals on infrastructure stocks. However, he used a different data set, he obtained the Solow residuals by calculating the share of labor on income, whereas in this paper I use data that calculates the share of labor on total costs. Also, he did not control for market power effects or returns to scale.

$$\frac{\dot{Y}}{Y}=\left(\frac{F_K K}{Y}\right)\frac{\dot{K}}{K}+\left(\frac{F_L L}{Y}\right)\frac{\dot{L}}{L}+\left(\frac{F_I I}{Y}\right)\frac{\dot{I}}{I}+\frac{\dot{A}}{A} \tag{2}$$

The dots over the letters indicate a derivative with respect to time, the sub indexes represent partial derivatives. By using Euler's theorem, and given the homogeneity of degree r in labor and capital:

$$\left(\frac{F_K K}{Y}+\frac{F_L L}{Y}\right)=r$$

Using this last expression, I can express condition (2) as follows:

$$\frac{\dot{Y}}{Y}=r\frac{\dot{K}}{K}+\left(\frac{F_L L}{Y}\right)\left(\frac{\dot{L}}{L}-\frac{\dot{K}}{K}\right)+\left(\frac{F_I I}{Y}\right)\frac{\dot{I}}{I}+\frac{\dot{A}}{A} \tag{3}$$

If firms maximize profits and hold some degree of market power, the term multiplying the rate of growth of labor in (2) (the elasticity with respect to labor) can be expressed in the following way:

$$(F_L L)/(Y)=\beta\,(wL)/(pY)$$

With w representing nominal wage, p the price of output and β the markup (price over marginal cost). Using this last expression, equation (3) can be written in the following way:

$$\frac{\dot{Y}}{Y}=r\frac{\dot{K}}{K}+\beta\frac{wL}{pY}\left(\frac{\dot{L}}{L}-\frac{\dot{K}}{K}\right)+\left(\frac{F_I I}{Y}\right)\frac{\dot{I}}{I}+\frac{\dot{A}}{A} \tag{4}$$

If infrastructure has no impact on growth and I assume constant returns to scale, equation (4) corresponds to Hall's formulation (1988a). Note that proceeding as in Jarque (1988) and imposing the assumptions of no market power and constant returns to scale will generate an erroneous measurement of the impact of infrastructure. Castañeda *et al.* (2000b) estimated the last equation.

By using the first order conditions for cost minimization and Euler's theorem, I find that $\beta\alpha = r\eta$, where α represents the share of labor in total income $\left(\frac{wL}{pY}\right)$ and η measures its share in total costs. By using the condition $\beta\alpha = r\eta$ in (4), I obtain my estimating equation:

$$\frac{\dot{Y}}{Y}=r\left((1-\eta)\frac{\dot{K}}{K}+(\eta)\left(\frac{\dot{L}}{L}\right)\right)+\left(\frac{F_I I}{Y}\right)\frac{\dot{I}}{I}+\frac{\dot{A}}{A} \tag{5}$$

Notice that the term multiplying the rate of growth of labor in (5), $r\eta$, represents an elasticity. If factor shares in total costs vary over time, then the elasticity changes too. However, if due to implicit labor contracts, the wage does not represent the shadow value to the firm, the share of labor in costs will only be correct on average, not at each moment in time. This rigidity in the labor market generates serious problems for the parameterized approach (Nadiri and Mamuneas, 1994) which requires factor prices to be allocative on each period. The parameterized approach requires the estimation of a very large number of parameters along with a multiple equation framework that imposes several cross equation restrictions, implying that the results are very sensitive to misspecification (Basu and Fernald, 1998). As has been argued in the literature, this rigidity does not affect the approach followed in this paper, since I am interested in estimating the average degree of returns to scale. Notice that this shortcoming of the parameterized approach is even more difficult to control for the Mexican data. This lack of quality data has affected other approaches with the parameterized methodology.[3]

If infrastructure does not affect industrial growth, then equation (5) corresponds to Hall's (1988b) estimating equation. Caballero and Lyons (1989) used Hall's (1988b) formulation and included an externality index instrumented by a measurement of aggregate manufacturing input (labor and capital weighted by their shares in manufacturing total costs) to adjust the estimate of the index of returns to scale. My own results do not find significant evidence for the existence of an external economy index for the Mexican manufacturing sector. However, as I will later show, the inclusion of infrastructure in the production function appears to have an important impact on the Mexican manufacturing sector.

Castañeda *et al.* (2000b) used equation (4) to estimate the impact of infrastructure on manufacturing by using data on the share of labor on output (α). In this paper, I use a completely different set of data that calculates the share of labor on costs (η), this modification allows me to estimate a lower number of parameters (the degree of returns to

[3] See in Feltenstein and Ha (1995) that their statistical fit was not satisfactory.

scale, and the impact of infrastructure), thus increasing efficiency in the estimation process.

The change in the estimating equation and in the data set used leads to different results from those found by Castañeda *et al.* (2000b). Besides, the approach followed by these authors was not completely orthodox when they estimated the degree of returns and the degree of market power simultaneously. Hall (1988a) did not pretend the estimation of the returns to scale at the same time in which he estimated the degree of market power. In fact, he argues that some of his findings might be due to increasing returns to scale. The reasons for Castañeda *et al.* (2000b) for that approach was the lack of data for the rental price of capital, which forced them to use the share of labor on total income as a weight for the growth of the labor capital ratio. In that way they solve for the lack of data on the rental price. However, that approach had a cost both in terms of efficiency for the number of parameters to estimate and in the possibility of multicollinear regressors, specially the stock of capital and the rate of growth of the labor capital ratio.[4] I am not aware of any other paper that pretends the estimation of the returns to scale parameter, simultaneously with the degree of market power. The use of the rental price in this paper allows me to calculate the share of labor on total costs and leads me to a more confident statistical model.

A second difference with the approach followed by Castañeda *et al.* (2000b) is in the measurement of infrastructure used to estimate the paper, they used the assets of electricity and the assets of highways separately in their estimation procedure. In contrast, in this paper, I used the input-output matrix for several years and use the technical requirements of each industry with regard to these measures of infrastructure to make a weighted average measurement of the infrastructure input.

III. Results

I use data that belongs to 42 Mexican industries for the period 1970-1991.[5] The results are discussed in the following order. First, I pool all the manufacturing industries together and estimate the impact of

[4] See the discussion in Basu and Fernald (1998).

[5] I use this period span because I could not get data on infrastructure for later years. See the appendix for an explanation of the data.

public infrastructure and the index of returns to scale under the assumption of identical parameters across industrial sectors and fixed effects for each industry. Next, I assume a common effect of infrastructure and heterogeneous coefficients for the returns to scale index. Finally, I pool industries into sectors[6] and estimate the impact of infrastructure. For all the estimates, I assume fixed effects for each two-digits industry.

Hall (1988b) has implicitly assumed that the aggregate input of equation (5) (the weighted sum of capital and labor, with weights equal to the share of each in total costs) may be correlated with technical progress yielding a classical case of simultaneous equation bias. To solve the problem, Hall advocates the use of instrumental variable techniques. Caballero and Lyons (1989) agree with Hall but propose the inclusion of an externality index in Hall's regression equation and included in their results estimates for non-instrumental techniques. The case for estimating with non-instrumental techniques is supported on Nelson and Starz's (1988a, b) results. They have shown significant biases for small samples and poorly chosen instruments. The results of Nelson and Starz show me a trade-off in the choice of the estimation technique: if I choose instrumental variables, the results may be biased in small samples but are asymptotically correct. On the other hand, non-instrumental estimates are asymptotically biased but behave better for small samples. Shea (1997) has also shown that instrumental variables are not very appropriate if an equation has multiple parameters to estimate. Given these arguments, I report in Table 1, the results for least squares and two stage least squares estimates. The instruments used for the two stage procedure are: the current rate of growth of domestic product and its lagged value, the rate of growth of oil price and the rate of change of the terms of trade.

In the estimates shown in Table 1, I impose the assumption of common coefficients and fixed effects for each industry. The reader can notice that the estimates indicate no evidence of increasing returns. He can also note that the inclusion of public infrastructure provokes a statistically significant reduction in the size of the returns to scale parameter for both procedures (OLS and TSLS). Thus, if I exclude these variables from the regression, I may have an important bias in the procedure. A first order approach regression that intends to measure the index of returns to scale without considering other external inputs

[6] See the appendix for the definitions of sectors.

such as infrastructure may lead to erroneous measures of the index of returns. Regardless of techniques, my measure of infrastructure appears to have a significant impact on the manufacturing sector.

Table 1. Estimations for the Entire Manufacturing Sector (Dependent Variable: Output Growth)

	Least Squares	*Least Squares*	*Two Stage Least Squares*	*Two Stage Least Squares*
Degree of Returns (r)	0.226^{s}_{dr}	0.156^{s}_{dr}	0.485^{s}_{dr}	0.348^{s}_{dr}
	0.03	0.03	0.04	0.056
Elasticity of Infrastructure	—	0.204^{s}	—	0.159^{s}
		0.038		0.03

Note: I imposed as restriction that all industrial sectors had the same degree of returns and that infrastructure had an identical impact over industrial growth. I also assume fixed effects for individual industries. Numbers in small size are standard errors.
s means that the estimated parameter is statistically significant at 10% level.
cr denotes the rejection of the hypothesis of constant returns to scale.
dr means that I reject the hypothesis of constant returns in favor to the hypothesis of decreasing returns to scale.

According to the OLS estimates, a 10 percent increase in the aggregate input of infrastructure leads to an increase of manufacturing output of 2 percent. By the same token, the 2 TSLS results show that an increase of 10 percent in infrastructure gives a 1.6 percent increase in manufacturing output. The TSLS evidence indicates that the elasticity of a typical manufacturing industry with respect to its own input is .348. This elasticity increases to .507 when the stock of infrastructure rises with industry inputs in the same proportion. A similar interpretation can be constructed for the OLS estimates.

Now I turn to the results after relaxing the restriction that constraints all the coefficients of the degree of returns to scale to be constant across industries. Table 2 shows the estimates after imposing a common coefficient on infrastructure and individual estimates of r for each industry. According to the least square evidence, infrastructure has an important impact on manufacturing growth. Thus, these results suggest that a 10 percent increase in infrastructure will lead to an increase in manufacturing output of 1.87 percent. The 2SLS estimate also reports a statistically significant impact of infrastructure on manufacturing, a 10 per cent increase in this stock will give a 1.45 percent increase in manufacturing. Both, the instrumental variable

Table 2. Manufacturing (Dependent Variable: Output Growth)

	Non-Instrumental Variables	*Instrumental Variables*		*Non-Instrumental Variables*	*Instrumental Variables*
Infrastructure	0.187^{s}	0.145^{s}			
	0.039	0.045			
Industry	r	r	*Industry*	r	r
11	0.37^{s}_{dr}	0.48_{dr}	37	0.27_{dr}	0.26
	0.21	0.314		0.22	0.27
12	0.32_{dr}	0.35_{cr}	38	0.09_{dr}	0.13_{dr}
	0.27	0.49		0.22	0.36
13	0.057_{dr}	0.13_{dr}	39	0.22_{dr}	1.0_{cr}
	0.17	0.2		0.49	0.85
14	0.37_{cr}	1.31^{s}_{cr}	40	0.79_{dr}	1.60^{s}_{cr}
	0.41	0.76		0.49	0.83
15	0.075_{dr}	0.31_{cr}	41	0.33_{dr}	0.49_{cr}
	0.43	0.69		0.33	0.52
16	−0.185	−0.59	42	0.37_{dr}	0.55_{dr}
	0.16	0.58		0.24	0.32
17	0.18_{dr}	−0.138	43	−0.16	−0.037
	0.25	0.44		0.32	0.43
18	0.68^{s}_{cr}	1.03^{s}_{cr}	44	0.20_{dr}	0.39^{s}_{cr}
	0.35	0.46		0.19	0.26
19	−0.05	0.158_{dr}	45	1.09^{s}_{cr}	1.29^{s}_{cr}
	0.18	0.35		0.31	0.47
20	−0.03	−0.09	46	0.10_{cr}	−0.19
	0.38	0.56		0.16	0.42
21	0.04_{dr}	0.99_{cr}	47	−0.52	−1.68
	0.4	0.7		0.34	0.58
22	−0.05	0.48_{dr}	48	0.17_{dr}	0.41^{s}_{dr}
	0.19	0.3		0.16	0.21
24	0.199_{dr}	0.244_{dr}	49	0.42_{dr}	0.89_{dr}
	0.21	0.27		0.26	0.44
25	0.52^{s}_{dr}	0.58_{cr}	50	0.009_{dr}	0.01_{dr}
	0.26	0.36		0.37	0.57
26	0.36_{dr}	0.64^{s}_{cr}	51	0.25_{dr}	1.31^{s}_{cr}
	0.23	0.33		0.28	0.44
27	0.10_{dr}	0.35_{dr}	52	0.006_{dr}	0.42_{dr}
	0.22	0.36		0.16	0.26
28	0.49^{s}_{dr}	0.85^{s}_{cr}	54	0.01_{dr}	−0.85
	0.27	0.37		0.45	0.91
29	0.12_{dr}	0.21_{dr}	55	0.24_{dr}	0.37_{cr}
	0.13	0.25		0.37	0.53

Table 2. Conclusion

Infrastructure Industry	Non-Instrumental Variables r	Instrumental Variables r	Industry	Non-Instrumental Variables r	Instrumental Variables r
30	0.09_{dr}	0.35_{dr}	56	–0.28	–0.05
	0.13	0.24		0.22	0.33
31	0.01_{dr}	0.1_{cr}	57	0.3_{dr}	0.43_{dr}
	0.37	0.9		0.21	0.26
32	0.09_{dr}	0.49_{cr}	58	0.92^{s}_{cr}	0.38_{cr}
	0.13	0.31		0.2	0.34
35	0.01_{dr}	0.16_{dr}			
	0.23	0.37			

Note: Numbers in small size are standard errors.
s means that the estimated parameter is statistically significant at 10% level.
cr means that I cannot reject the hypothesis of constant returns to scale.
dr means that I reject the hypothesis of constant returns in favor of the hypothesis of decreasing returns.

and the OLS results indicate that a given percentage increase in infrastructure stock, paired with a similar increase in private inputs, increases manufacturing output in a larger percentage than the increase that can be attained with the sole increase of private inputs.

The non-instrumental variable estimates of *r* show that 31 industries reject the hypothesis of constant returns in favor of the hypothesis of decreasing returns and I do not reject the hypothesis of constant returns in 5 industries. No single industry indicates evidence of increasing returns to scale. The instrumental variable results show that 18 industries have evidence of decreasing returns and 17 industries do not reject the hypothesis of constant returns.[7]

Next, I discuss the estimates of the pooled industries into sectors (see the appendix for the definitions of sectors). Because technical progress may be correlated with private inputs, I implemented specification tests to examine the endogeneity of the aggregate input (the weighted sum of capital and labor).

The chi-square statistics with its marginal significance are reported in Table 3. At the 10 percent level, I reject the hypothesis of no endogeneity in 30 industries and I do not reject the hypothesis in the 12 remaining industries. At the 5 percent level, I reject the hypothesis

[7] Caballero and Lyons found similar results with respect to the U.S. manufacturing industry. However, they used a different variable to measure the external effects to the industry.

of no endogeneity in 29 industries and I do not reject the hypothesis in the remaining 13. These results could be used to justify the use of instrumental variable models. However, the number of industries in which the non-instrumental variable technique can be used is large. For these reasons, I decided to report the three stage least squares results and the seemingly unrelated regression estimates.[8] The instruments used were the current rate of growth of gross domestic product and its lagged value, the rate of growth of oil price and the rate of growth of the terms of trade. The stock of infrastructure is treated as exogenous, since no single industry is able to control its availability.

I ran two procedures to test the constraint that restricts all industrial coefficients to be equal inside a sector. In the first procedure, I tested whether the infrastructure coefficients can be restricted to be equal inside the sector, leaving *r* unrestricted. In the second procedure, I tested whether the coefficients *r* can be restricted to be equal across all the industries contingent on assuming a common impact of infrastructure.[9] I followed this course of action for both sets of estimates (SUR and 3SLS). For most pooled sectors, I cannot reject the hypothesis of a common effect of infrastructure. For the coefficient of returns to scale, I reject the hypothesis of common coefficients in two sectors (food and beverages, and glass and cement). Thus, in Table 4, I report single industrial coefficients for those cases in which I rejected the hypothesis of a common index of returns to scale.

A look at Table 4 will show that the hypothesis of increasing returns to scale is rejected in all industries. This result contrasts with previous work that found evidence of increasing returns to scale. In those estimates, 21 industries were reported as having increasing returns.[10] These differences suggest that omitting infrastructure from the regression may create biases in the estimate of the index of returns to scale.[11]

According to the SUR results, infrastructure affects significantly food beverages and tobacco, chemicals, wood, metal products, basic metals and machinery and equipment. At the same time, the 3SLS evidence indicates significant effects of infrastructure on food beverages and tobacco, chemicals and basic metals. Putting together these

[8] For the whole manufacturing sector I was not able to obtain SUR and 3SLS estimates. For this reason, I report in Tables 1 and 2 the OLS and 2SLS estimates.
[9] I realized standard *F* and Wald tests.
[10] See Castañeda and Garduño (2000).
[11] It may also be due to the technique of estimation, previous work estimated the inverse of the index of returns to scale. It is not possible to follow that methodology in the context of this paper because of the multiplicity of independent variables in this context.

Table 3. Endogeneity tests

Industry Digit	*Chi-Square*	*Probab.*	*Industry Digit*	*Chi-Square*	*Probab.*
11	4.11	0.04	29,30	4.07	0.04
12	0.36	0.55	31, 32	4.93	0.03
13	3.79	0.05	35,37,38, 39,40, 41	5.68	0.02
14	8.46	0.003	43	1.41	0.24
15	0.021	0.88	44	12.83	0.00
16	0.001	0.97	45	1.44	0.23
17	4.79	0.03	46,47	10.9	0.00
18	7.98	0.005	48,49,50	2.5	0.11
19	12.39	0.00	51,52,54,55,	4.96	0.03
20	0.008	0.93	56	0.62	0.43
21	3.01	0.08	57	0.18	0.67
22	6.24	0.01	58	1.93	0.17
24,25,26, 27,28	17.33	0.00			

results, it can be argued that infrastructure impacts significantly the following sectors: food, beverages and tobacco, chemicals, wood, metal products, basic metals and machinery and equipment with the elasticity ranging between 0.131 and 0.586.[12] Using another data set and estimating simultaneously the degree of market power, Castañeda *et al.* (2000b) did not find the same sectors affected by infrastructure.[13] The output share of these industries with respect to total manufacturing output for 1991 is 64.9 percent. I omit the estimates of the degree of returns when the weighted infrastructure stock is not included as regressor. However, I must point out that, as in the results of Table 1, the estimates of returns to scale get reduced when I add the infrastructure stock as an explanatory variable. This is a rather robust result.

[12] I ran regressions that incorporate each stock of infrastructure (electricity and highways) as a single regressor. The results for electricity showed that some of the sectors with high requirements of electricity (according with the 1993 input-output matrix) were positively impacted by this type of infrastructure. With a weighted average of infrastructure, I was not able to gather systematic information from the input-output matrix.

[13] Those authors included the two measurements of infrastructure (electricity and highways) separately in their regression equations. In this paper, I constructed a weighted average of the two measurements. They found significant impact of highways on chemicals, textiles, paper, glass and cement, and metal products, and for electricity: wood, chemicals, and transport equipment. Clearly some do not coincide with the findings of this work.

Table 4. Dependent Variable: Output Growth

	SUR	*3SLS*		*SUR*	*3SLS*
Food, Beverage and Tobacco			*Textiles*		
Infrastructure	0.131^{s}	0.173^{s}	Infrastructure	0.095	–0.103
	0.043	0.046		0.102	0.132
Industry	*r*	*r*	Industry	*r*	*r*
11	0.267^{s}_{dr}	0.565^{s}_{dr}	24,25,26,27,28	0.212^{s}_{dr}	0.594^{s}_{dr}
	0.084	0.136		0.073	0.164
			Chemicals		
12	0.27^{s}_{dr}	0.63^{s}_{cr}	Infrastructure	0.215^{s}	0.15^{s}
	0.119	0.32		0.076	0.081
13	0.093^{s}_{dr}	0.14^{s}_{dr}			
	0.034	0.055			
14	0.12_{dr}	1.59^{s}_{cr}	Industry	*r*	*r*
	0.27	0.5	35,37,38,39,40, 41,42	0.135^{s}_{dr}	0.285^{s}_{dr}
				0.056	0.1
15	0.023_{dr}	–0.04			
	0.218	0.43			
			Glass and Cement		
16	–0.23	–0.25			
	0.086	0.37			
17	0.082_{dr}	–0.32	Infrastructure	0.195	0.095
	0.116	0.28		0.147	0.158
18	0.718^{s}_{dr}	0.799^{s}_{cr}			
	0.147	0.27			
19	0.007_{dr}	0.346^{s}_{dr}	Industry	*r*	*r*
	0.06	0.144	43	–0.17	0.088_{dr}
20	–0.007	–0.163		0.21	0.29
	0.23	0.374	44	0.197^{s}_{dr}	0.42^{s}_{dr}
21	0.173_{dr}	0.451_{cr}		0.102	0.148
	0.23	0.42	45	0.966^{s}_{cr}	1.22^{s}_{cr}
22	0.081_{dr}	0.36_{dr}		0.224	0.33
	0.137	0.25			
Wood			*Paper*		
Highways	0.132^{s}	0.142	Highways	0.104	0.109
	0.079	0.092		0.086	0.092
Electricity	0.427^{s}	0.213	Electricity	0.385	0.327
	0.249	0.344		0.275	0.3

Table 4. Conclusion

	SUR	3SLS		SUR	3SLS
	Wood			Paper	
Industry 29, 30	r	r	Industry 31, 32	r	r
	0.097^{s}_{dr}	0.234^{s}_{dr}		0.069_{dr}	0.121_{dr}
	0.056	0.135		0.084	0.114
	Metal Products			Basic Metals	
Highways	0.208^{s}	0.202	Highways	0.198^{s}	0.206
	0.119	0.125		0.118	0.138
Electricity	0.119	0.091	Electricity	0.356	0.634
	0.348	0.366		0.352	0.408
Industry 48,49,50	r	r	Industry 46,47	r	r
	0.141_{dr}	0.189_{dr}		0.089_{dr}	−1.079
	0.115	0.146		0.097	0.369
	Transport			Machinery and Equipment	
Highways	0.027	0.069	Highways	0.22	0.22
	0.144	0.154		0.154	0.159
Electricity	0.314	0.458	Electricity	0.787^{s}	0.567
	0.439	0.479		0.458	0.482
Industry 56, 57, 58	r	r	Industry 51,52,54, 55	r	r
	0.428^{s}_{dr}	0.228_{dr}		−0.142	0.137_{dr}
	0.162	0.223		0.102	0.207

Note: Numbers in small size are standard errors.
s means that the estimated parameter is statistically significant at 10% level.
cr means that I do not reject the hypothesis of constant returns to scale.
dr means that I reject the hypothesis of constant returns in favor of the hypothesis of decreasing returns.

The results on sectors that have a common estimate of the degree of returns (r) indicate that textiles, chemicals, metal products, transport equipment and paper, have decreasing returns to scale. This assertion is true for both the SUR and the 3SLS techniques. Basic metals shows evidence of decreasing returns only for the SUR method, and machinery and equipment has decreasing returns according to the 3SLS method.

For those sectors with a different estimate of r inside the sector, food, beverages and tobacco and glass and cement, the SUR technique indicates that 11 industries have an r statistically smaller than one. For one industry, the hypothesis of constant returns to scale cannot be

rejected. The 3SLS results show 6 industries with decreasing returns and 5 industries with constant returns.

There are several industries in the sectors studied that have a negative coefficient. A careful look at Table 4 will indicate that almost all of them are not statistically significant.

IV. Concluding remarks

The aim of this work was to estimate the effect of infrastructure on Mexican manufacturing sector growth by using data on cost shares. The results indicate that infrastructure has a significant impact on Mexican manufacturing growth. Also, the evidence on increasing returns is less evident than in previous work. Using the results of the sectoral estimates, I find no sector that shows evidence of increasing returns to scale. The estimates of returns to scale get reduced when I introduce the infrastructure stocks as regressors, this is a rather robust result which proves that an omission of the infrastructure stock from the estimating equation may lead to biases in the estimating procedure for returns to scale. This paper follows the appropriate econometric procedure to estimate the effect of infrastructure. The paper improves upon previous work (Castañeda *et al.*, 2000b) by calculating the rental price of capital and thereby estimating an equation that is free of potential collinear behavior in the regressors. Also, the paper uses a weighted measure of infrastructure that increases the efficiency of the estimating process.

For the whole manufacturing sector, the TSLS results indicate that the elasticity of a typical manufacturing industry with respect to its own input is .348. This elasticity increases to .507 when the stock of infrastructure rises with industry inputs in the same proportion. A similar result is found for the OLS estimates. A given percentage increase in the infrastructure stock, accompanied with a similar increase in private inputs, increases manufacturing output in a larger percentage than the increase that can be achieved with the increase of private inputs.

This work finds different sectors impacted by infrastructure from those found in previous work (Castañeda *et al.*, 2000b). However, both studies –this study and the previous one– show robust evidence of the influence of infrastructure for the whole (pooled) sector, in spite of the different model and data used. The sectoral results indicate that infrastructure affects significantly 65 percent of total manufacturing output for 1991.

The paper showed that there are external effects (the stock of infrastructure) to the industry that affects positively the rate of growth of the industrial sector. These external effects can be modified by economic policy. If the aim of government policy is the promotion of economic growth, the government must encourage the construction of infrastructure.

Appendix

- Food and Beverages are industries 11 to 22 in the National Account Systems of INEGI (Meat and Dairy, Fruit and Vegetables, Wheat Grinding, Corn Grinding, Coffee, Sugar, Oil and Fat, Animal Food, Other Food Products, Alcoholic Beverages, Beer and Beverages).
- Wood includes industries 29 and 30 (Wood and Wood Products).
- Machinery and Equipment includes industries 51, 52, 54 and 55 (Non-Electrical Machinery, Electrical Machinery, Electronic Instruments and Electric Instruments).
- Basic Metals includes industries 46 and 47 (Primary Iron Metals and Primary Non-iron Metals).
- Glass and Cement includes industries 43, 44 and 45 (Glass and Glass Products and Cement).
- Chemical includes industries 35, 37, 38, 39, 40, 41 and 42 (Basic Chemicals, Synthetic Resins, Pharmaceutical Products, Soaps and Detergents, Other Chemical Products, Rubber Products and Plastic Products).
- Paper includes industries 31 and 32 (Paper Products and Printing/Publishing).
- Textiles includes industries 24, 25, 26, 27 and 28 (Soft Fiber Textiles, Resilient Fiber Textiles, Other Textile Products and Apparel).
- Metal Products includes industries 48, 49 and 50 (Metal Furniture, Fabricated Metals and Other Metal Products).
- Transport Equipment includes industries 56, 57 and 58 (Automobiles, Autoparts and Transport Equipment).

Data

The sources for highways and electricity were the Presidential Report (several years), the Mexican Historic Statistics published by INEGI and the Federal Electricity Commission's annual report (several years). The electricity infrastructure measure was obtained from the Federal Electricity Commision's annual report, I used data defined as annual installed capacity. These data includes the annual installed capacity in generation, distribution and transmission. The highways infrastructure measure includes the total kilometers in federal and local highways considering rural highways and toll ways.

From these data I constructed a single measure of infrastructure by using the input-output matrix for several years. I looked at technical coefficients of each industry with regard to the infrastructure on use and constructed a weighted average measure of infrastructure based on these technical coefficients.

The costs are based on the following formula:

$$wL + r^* K$$

r^* corresponds to the rental price of capital, which was calculated following the methodology proposed by Hall and Jorgenson (1967):

$$\text{with } r^* = \frac{1}{(1-u)} q(r+d)\left(1 - \frac{u}{r\tau}\left(1 - e^{-r\tau}\right)\right)$$

representing the tax rate; q is the capital goods deflator which was obtained from the net investment of capital at nominal prices divided by net investment at constant prices, these data was obtained from the Banco de México; r is the rate of interest, which corresponds to the lending rate of the Banco de México; d is the depreciation rate calculated from the Banco de México publications; τ is the time span along which capital is depreciated for fiscal policies. For this analysis I consider 20 years.

Alpha is equal to the following formula:

$$\frac{wL}{wL + r^* K}$$

Output was obtained from the statistics for sectoral GDP published by INEGI in the National System Accounts. We used data at constant and nominal prices. These data were adjusted for indirect taxation and subsidies. The sectoral price deflator (*p*) was obtained by combining the real and nominal data. The sources for labor data were the statistics on employment published by INEGI. From the sectoral employment data I inferred the yearly hours by assuming that each worker would work 40 hours per week with two weeks of holidays per year. This methodology appears arbitrary, however it appears to be the only available methodology. Labor income was obtained from the National Accounts System published by INEGI. The average wage (*W*) is calculated from the ratio of labor income to yearly hours. The data on capital assets were taken from the publications by Banco de México.

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