Irreversibilities in fixed capital adjustment:
Evidence from Mexican and Colombian plants

R. Gaston Gelos [a*], Alberto Isgut [b]

[a]*Research Department, International Monetary Fund, 700 19th St., N.W., Washington, D.C. 20431, USA*
[b]*Department of Economics, Wesleyan University, Middletown, CT 06549, USA*

Abstract

Using two largely novel datasets, we examine how Mexican and Colombian plants invest in response to imbalances between actual and "desired" levels of capital stocks. Nonparametric estimates of the average adjustment function provide strong support for the presence of irreversibilities.

Keywords: adjustment costs; investment; irreversibilities; plant-level evidence

JEL classification: D24; E22; O12; O16

1. Introduction

In recent years, research on aggregate investment has focused on understanding behavior at the microeconomic level. A main finding of this literature is that plant-level investment level is not only infrequent but also asymmetric, as episodes of disinvestment occur much less often than episodes of positive investment. Capital adjustment also tends to be lumpy (see Cooper, Haltiwanger, and Power, 1999, Doms and Dunne, 1998, and Nilsen and Schiantarelli, 1997). This behavior is explained by characteristics of the adjustment cost technology. While under the

*Corresponding author. Tel.: +1-202-623-9427; fax : +1-202-623-4352
E-mail address: ggelos@imf.org (R.G. Gelos)

standard assumption of strictly convex and continuously differentiable adjustment costs it is always optimal to change the capital stock in response to profitability shocks, higher marginal costs of disinvestment than of positive investment (partial irreversibilities) give rise to periods of inaction and rare disinvestment. Similarly, nonconvexities in the adjustment cost function, such as fixed costs, yield lumpy investment at the plant level.

We contribute to this literature by examining fixed capital adjustments using largely novel plant data from the manufacturing sectors of two important developing countries, Colombia and Mexico. Our approach is inspired by the work of Caballero, Engel, and Haltiwanger (1995), henceforth CEH, who proposed to estimate a function that relates the investment rate to a measure of "mandated investment". We find strong support for the presence of irreversibilities, but no clear evidence for nonconvexities.

2. The capital adjustment function

Following CEH, define mandated investment at time t for plant i (x_{it}) as the difference between the log of desired capital (k_{it}^d) and the log of last period's capital stock (k_{it-1}):

$$x_{it} \equiv k_{it}^d - k_{it-1}. \tag{1}$$

Desired capital is the optimal stock of capital that the plant would wish to hold at time t if adjustment costs were *momentarily* removed. On the other hand, *frictionless* capital is defined as the capital stock that would maximize plant profits if changes in the capital stock were not subject to adjustment costs *at any time*. Consistent with a wide range of models, we assume that the desired capital stock is proportional to the frictionless stock of capital:

$$k_{it}^d = k_{it}^f + d_i, \tag{2}$$

Here, k_{it}^f denotes the log of frictionless capital d_i is a plant-specific constant. We let the data determine the value of this constant for each plant. If the production function is CES, frictionless capital is given by

$$K_{it}^f = aC_t^{-q}Y_{it},\qquad(3)$$

where K_{it}^f, C_t, and Y_{it} denote, respectively, frictionless capital, the real user cost of capital, and output, while the parameters α and θ represent the capital share of output and the elasticity of substitution between capital and labor.

When firms differ in their access to credit, the aggregate interest rate is unlikely to convey much information about the interest rate faced by each firm, an important component of the user cost of capital. There is evidence that financial constraints were important in Mexico and Colombia throughout the period examined (Gelos and Werner, 1999). Fortunately, we have information on another key component of the user cost of capital: the relative price of capital (machinery and equipment) to the producer price index. This variable is particularly informative given the large swings in the real exchange rate for these two countries in the period studied, and the fact that most machinery and equipment are imported.

In our empirical specification we allow the exponent on output to differ from one. Letting P_{mt} and P_t denote the producer price index for machinery and the manufacturing producer price index, taking logs in (3), substituting into (2), and adding an iid error term e_{it}, our equation for desired capital is

$$k_{it}^d = b_0 + b_1 \log(Y_{it}) + b_2 \log\left(\frac{P_{mt}}{P_t}\right) + d_i + e_{it},\qquad(4)$$

The log of desired capital is not observable. However, deviations between actual and desired capital are likely to be stationary. Therefore, we can substitute k_{it}^d with k_{it} in the left-hand side of equation (4) and interpret it as a cointegrating equation for the long-run determinants of desired capital.[1] After obtaining estimates of the parameters of equation (4), we compute the following estimates of mandated investment:

$$\hat{x}_{it} = \hat{b}_0 + \hat{b}_1 \log(Y_{it}) + \hat{b}_2 \log\left(\frac{P_{mt}}{P_t}\right) + \hat{d}_i - k_{it-1}. \tag{5}$$

Finally, we estimate our capital adjustment function nonparametrically as the average investment rate i_{it}/k_{it-1} corresponding to each level of mandated investment $\hat{x}_{it}$.[2] If irreversibilities are important, we should observe very little disinvestment for negative mandated investment rates. Similarly, with nonconvexities in the adjustment cost function, we would expect to see on average a larger-than-proportional investment response to high positive mandated investment rates than for low positive mandated investment. By contrast, when adjustment costs are strictly convex and continuously differentiable, the capital adjustment function should be linear.

3. Data and estimation results

---

[1] Concerning the estimation of the cointegrating equation, CEH use a procedure suggested by Stock and Watson to overcome small-sample biases, which amounts to the inclusion of lagged differences of the right-hand side-variable. We experimented with such a procedure, without altering the main qualitative results. To avoid extreme movements in predicted capital stocks due to outliers in the output variable, those plants with the top and bottom three percentiles of capital-output ratios were discarded from the sample.

[2] This function differs slightly from the used by CEH, who use the ratio of actual to mandated investment as their left-hand-side variable.

The data are from the Annual Manufacturing Surveys of Mexico and Colombia. The panel for Mexico covers the period 1984-94 and the one for Colombia covers 1975-91. Both panels are balanced. Investment is defined as purchases minus sales of machinery and equipment and the capital stock is constructed using a variant of the permanent inventory method. After the elimination of extreme outliers and plants with incomplete and inconsistent data, the Mexican and Colombian panels contain, respectively, 2,575 and 2,032 establishments. See Gelos and Isgut (1999) for more details on the data sets.

The results of estimating equation (4) (not shown) display a clear relationship between the log of output, the relative price index, and the log of machinery and equipment. The coefficient on the log of output was 0.33 in the Mexican case and 0.42 for Colombia, with t-statistics of 45.9 and 157.0, respectively. The coefficients for the log of the relative price index were –0.23 with a t-statistic of –13.7 for Mexico, and –0.45 with a t-statistic of –29.3 for Colombia. The R^2 were 0.79 and 0.96, respectively.

To estimate the average capital adjustment function in a nonparametric way for Colombia and Mexico, we use a Nadarya-Watson kernel estimator with an Epachenikov kernel.[3] This regression puts almost no restrictions on the shape of the adjustment function. For any mandated investment rate, this estimator computes a weighted average of the observed investment rates in its neighborhood, with weights given by the kernel. In order to calculate confidence bands, a bootstrap method was used with 250 draws in each case.

---

[3] See Goolsbee and Gross (1997) for a related approach. To calculate the optimal bandwidth h, Goolsbee and Gross modify a simple rule given in Silverman (1986). Here, this gives bandwidths of 0.057 for Mexico and 0.061 for Colombia. The shape of the estimated function is not sensitive to the choice of the kernel.

The estimated functions provide strong support for the presence of irreversibilities, but not for the existence of nonconvexities (Figures 1 and 2). As predicted by models with irreversibilities, negative mandated investment rates do not coincide with negative actual investment. In that range, plants seem to reduce their capital stocks by keeping gross investment levels below depreciation.[4] In the range for positive mandated investment rates, the shapes of the estimated adjustment functions are approximately linear. Overall, the estimated functions are clearly different from the ones implied by the quadratic adjustment costs, where the adjustment function would be a straight line passing through the origin.

Figure 1. MEXICO: Estimated Adjustment Function with 95 Percent Confidence Bands

---
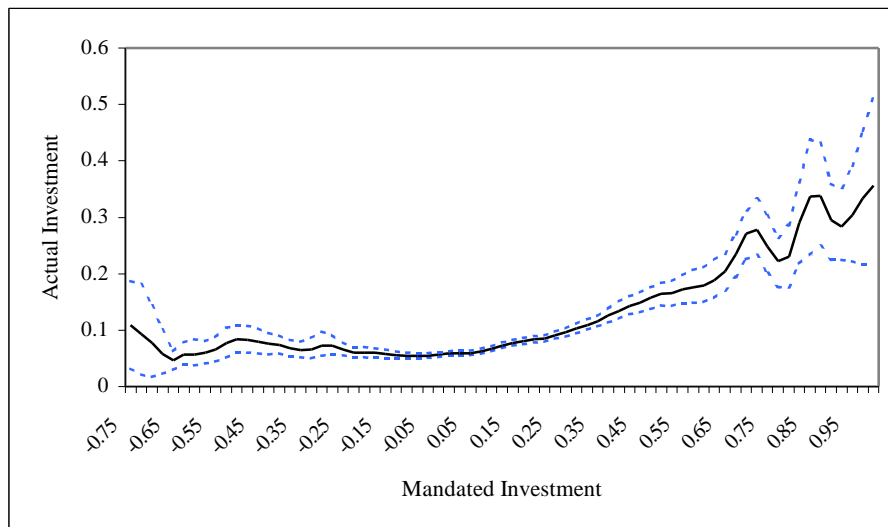
[4]One might argue that adjustment costs apply for gross, rather than net adjustment. We considered this possibility by relating only purchases to the desired investment ratios, obtaining the same qualitative picture. In Gelos and Isgut (1999), we also show histograms of investment rates conditional on high and low mandated investment rates that are consistent with the interpretation provided here.

Figure 2. COLOMBIA: Estimated Adjustment Function with 95 Percent Confidence Bands
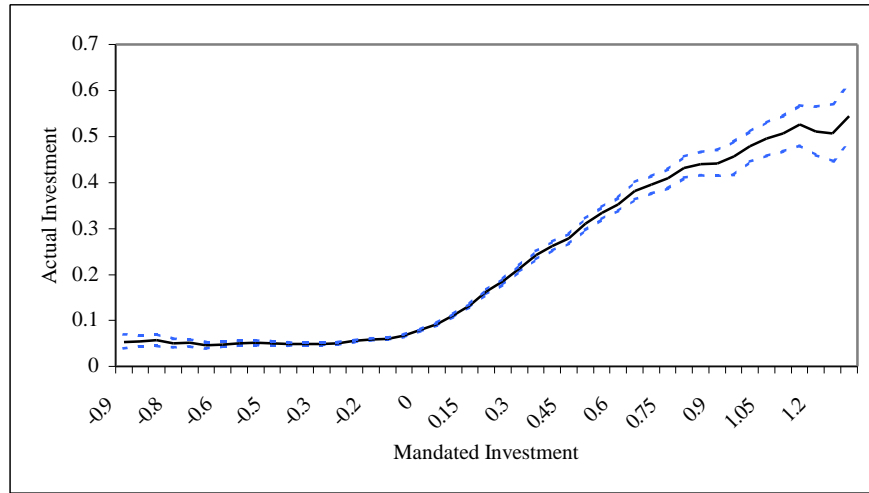
Acknowledgements

The authors wish to thank William Brainard, Gerry Helleiner, Stefan Krieger, Mike Lovell, and Giuseppe Moscarini for helpful comments. They are grateful to Günter Hitsch for his help with constructing the confidence intervals for the capital adjustment function estimates.

References

Caballero, R.J., E.M.R.A. Engel and J.C. Haltiwanger, 1995. Plant-level adjustment and aggregate investment dynamics, Brookings Papers on Economic Activity 2, 1-39.

Cooper, R., J.C. Haltiwanger, and L. Power, 1999. Machine replacement and the business cycle: Lumps and bumps, American Economic Review 89, 921-46.

Doms, M. and T. Dunne (1998), "Capital adjustment patterns in manufacturing plants," Review of Economic Dynamics 1, 409-29.

Gelos, R.G. and A. Isgut, 1999. Fixed capital adjustment: Is Latin America different? Evidence from the Colombian and Mexican manufacturing sectors, IMF Working Paper No. 99/59.

Gelos R.G. and A. Werner, 1999. Financial liberalization, credit constraints, and collateral: Investment in the Mexican manufacturing sector, IMF Working Paper No. 99/25.

Goolsbee, A. and D.B. Gross, 1997. Estimating adjustment costs with data on heterogeneous capital goods, NBER working paper No. 6342.

Nilsen, Ø.A. and F. Schiantarelli, 1997. Zeroes and lumps in investment: Empirical evidence on irreversibilities and non-convexities, mimeo, Boston College.

Silverman, B.W., 1986. Density estimation for statistics and data analysis. Chapman and Hall, London.