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Fixed Capital Adjustment: Is Latin America Different? Evidence from the Colombian and Mexican Manufacturing Sectors

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Abstract

This paper examines capital adjustment patterns using two large and largely novel data sets from the manufacturing sectors of Colombia and Mexico. The findings show that investment patterns in these countries resemble those reported for the United States to a surprising extent. Capital adjustments beyond maintenance investment occur only rarely, but large spikes account for a significant fraction of total investment. Although duration models do not provide strong evidence for the presence of substantial fixed costs, nonparametric adjustment function estimates reveal the presence of irreversibilities in investment. These irreversibilities are important for understanding aggregate investment behavior.

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I. Introduction

Modern macroeconomic models attempt to explain the evolution of aggregate variables from the optimizing behavior of individual consumers and firms. In order to make these models analytically tractable, researchers normally assume that it is possible to represent the behavior of all microeconomic units in the economy by a single representative agent. But this representation depends among other things on the usually implicit and often neglected condition that the response to changes in the relevant variables is linear at the individual level.[2] In the case of investment, there is mounting evidence that this assumption is not empirically supported (Haltiwanger, 1997).

The traditional model of investment assumes that changes in the capital stock of the representative firm are subject to adjustment costs that can be represented by a strictly convex, everywhere continuous and twice differentiable function of gross investment. This formulation leads to a gradual adjustment of the capital stock in response to any shock to the marginal productivity of capital. In the usual case of quadratic adjustment costs, for example, capital adjusts smoothly and linearly as a fraction of the difference between desired and current capital—the so-called partial adjustment model (Hamermesh and Pfann, 1996).

Because of its analytical appeal and straightforward empirical implementation, representative agent models of investment under strictly convex adjustment costs have dominated the investment literature. However, there are good reasons to believe that the adjustment cost function may not be strictly convex, and it may be discontinuous and non-differentiable at zero. For example, Rothschild (1971) argued that adjustment costs are likely to grow less than proportionately with the level of investment (e.g. workers training) and that some adjustment costs are fixed (e.g. stopping the operations of a plant in order to install new equipment). Arrow (1968) posited that investment usually has a large irreversible component due to de-installation costs and the narrow markets for very specialized machinery. More recently, Dixit and Pindyck (1994) devoted an entire book to the analysis of a variety of irreversible investment models.

The presence of indivisibilities, irreversibilities, and/or non-convexities in the adjustment cost function may lead to optimal microeconomic investment paths characterized by infrequent episodes of large capital adjustments (investment spikes) surrounded by long periods of inaction. If the investment spikes of different firms are not perfectly synchronized, aggregate investment behavior cannot be modeled by the use of a representative firm. Under such circumstances, knowledge about the mean gap between target and actual capital stocks would be insufficient to make inferences about the effects

[2]For example, in the case of the representative consumer, the utility function needs to be homothetic for consumption to be linear in income. See Kirman (1992) for a discussion.

of policies and external shocks on aggregate investment. We would also need information about higher moments of the cross-sectional distribution of shocks to individual firms.[3]

To what extent do adjustment costs in the real world depart from the assumptions of the traditional model of aggregate investment? How important are nonlinearities for understanding aggregate investment? In order to answer these questions, macro-economists started to explore large microeconomic data sets. Recent studies by Doms and Dunne (1998), Cooper, Haltiwanger and Power (1997), and Caballero, Engel and Haltiwanger (1995) provide evidence from the United States manufacturing sector that plant-level investment is "lumpy", i.e. that adjustment occurs at discrete times and that long spells of inactivity are followed by bursts in capital expenditures. Nilsen and Schiantarelli (1998) report similar findings for the Norwegian manufacturing sector[4]. These findings suggest the existence of indivisibilities, irreversibilities, or non-convexities in the microeconomic adjustment cost technologies[5]. In addition, these studies find that aggregate investment is positively correlated with the number of plants experiencing investment spikes.

However, the empirical documentation on capital adjustment patterns is still very limited, and in particular there is hardly any reported evidence for developing countries. It is likely that, given the absence of well-functioning secondary markets for capital goods, irreversibilities are more important in developing economies (Caballero, 1993). Obtaining a better picture of the patterns of capital adjustments is a significant first step on the way to improving predictions about the likely effects of policies and macroeconomic shocks on investment behavior in developing economies. This appears particularly relevant since reviving investment in developing countries after macroeconomic adjustment often proved to be a slow endeavor.[6]

This study examines two unique large data sets from the manufacturing sectors of two important Latin American economies: Colombia and Mexico. The study of the aforementioned issues is particularly relevant for Latin America, given the size of macroeconomic shocks in the region, and the often surprisingly slow response of investment to adjustment policies. In addition, we hope that our work will be helpful to assess the robustness of existing results on the patterns of capital adjustment at the plant level in the United States and Norway.

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[3]See Bertola and Caballero (1994) and Caballero and Engel (1998) for, respectively, a pioneer and a recent study of the aggregate implications of irreversible investment. Dixit and Pindick (1994), Caballero (1997), and Hitsch (1997) survey the literature on irreversible and lumpy investment. Hammermesh and Pfann (1996) and Haltiwanger (1997) provide more general surveys on non-convex adjustment costs and heterogeneous patterns of micro adjustment.

[4]Goolsbee and Gross obtain similar results studying the U.S. airline industry.

[5]An alternative explanation for this pattern of capital adjustment is that the stochastic process for the marginal profitability of capital is subject to sporadic jumps. However, such explanation cannot easily account for the very infrequent occurrence of downward adjustments of the capital stock.

[6]See, for example, Goldsbrough et al. (1996) and Servén and Solimano (1993).

We find that, similarly to the United States and Norway, plants adjust their capital stocks only infrequently and in a lumpy fashion. Downward adjustments are rare. Investment spikes above 20 percent account for a large fraction of total investment in the two samples, and there is a close link between the concentration of investment spikes and movements in aggregate investment. Concerning within-plant patterns of investment, we find little evidence for the hypothesis that the probability of an investment spike is increasing on the occurrence of spikes in previous years. Estimates of the average adjustment function provide strong support for the importance of irreversibilities. While some of the evidence is indicative of the presence of fixed costs, the adjustment function estimates provide little supportive evidence in this regard. This last result is similar to what has been found for the U.S.

The paper is organized as follows. After a brief description of the data, in Section III we characterize the distribution of investment rates and evaluate the importance of investment spikes in shaping aggregate investment. In Section IV, we estimate a duration model for investment spikes. Section V presents nonparametric estimates of the average capital adjustment functions. Section VI concludes.

II. Data

The data from Mexico are from the Annual Industrial Survey, conducted by the National Institute of Statistics, Geography, and Information (INEGI). The survey covers 3,199 manufacturing establishments from 1984-94. The database constitutes a balanced panel: exiting plants were discarded from the sample by the collecting agency. However, according to INEGI, the number of exiting plants was very small. This can be explained partly by the fact that the survey tries to cover roughly 80 percent of value added in manufacturing, having therefore a bias towards larger and more successful firms. Nevertheless, the sample includes a substantial number of small establishments.

The data from Colombia are from the Annual Manufacturing Surveys (AMS) for the period 1975-91. These surveys are conducted by the National Administrative Directorate of Statistics (DANE) and include all the manufacturing establishments that employ ten or more workers. The data contain a core of mainly large or medium plants that appear in every survey plus a much larger group of smaller plants that enter or exit during the period under study. In order to exploit as much as possible the information in the data while trying to make the results comparable with those for Mexico, we work with two samples for Colombia. The first one is a large unbalanced panel that comprises all the plants with at least five consecutive annual observations, and the second one is a balanced subpanel with all the plants that appear in each of the seventeen surveys between 1975 and 1991.

These unusually rich databases comprise a large number of variables about the plant's production, input use, labor force, sales, inventories, investment expenditures, and capital stocks. Data on capital expenditures are grouped into five categories: machinery, transport equipment, land, buildings, and other (office equipment in the Colombian case). This differentiation is particularly useful when investigating the nature of adjustment costs.

Investment is defined as purchases minus sales of assets plus improvements. After the elimination of extreme outliers and plants with incomplete and inconsistent data, the Mexican panel contains 2,575 establishments. For Colombia, the unbalanced panel contains 9,304 plants and the balanced subpanel contains 2,032 plants. Details of the construction of capital stocks and investment rates as well as for the criteria used for the elimination of outliers are given in the Appendix.

It is worth emphasizing that the Colombian database includes a much larger number of small establishments. This is even true when examining the balanced Colombian sample, as shown in Table 1. For example, in the Mexican case, approximately 76 percent of all plants employ on average more than 50 people, whereas this is only true for approximately 54 percent of the plants in the Colombian balanced panel and only 26 percent of the establishments in the unbalanced panel. We will discuss later how these differences might affect our comparisons of investment patterns.

Table 1. Distribution of Total Mean Employment in Samples

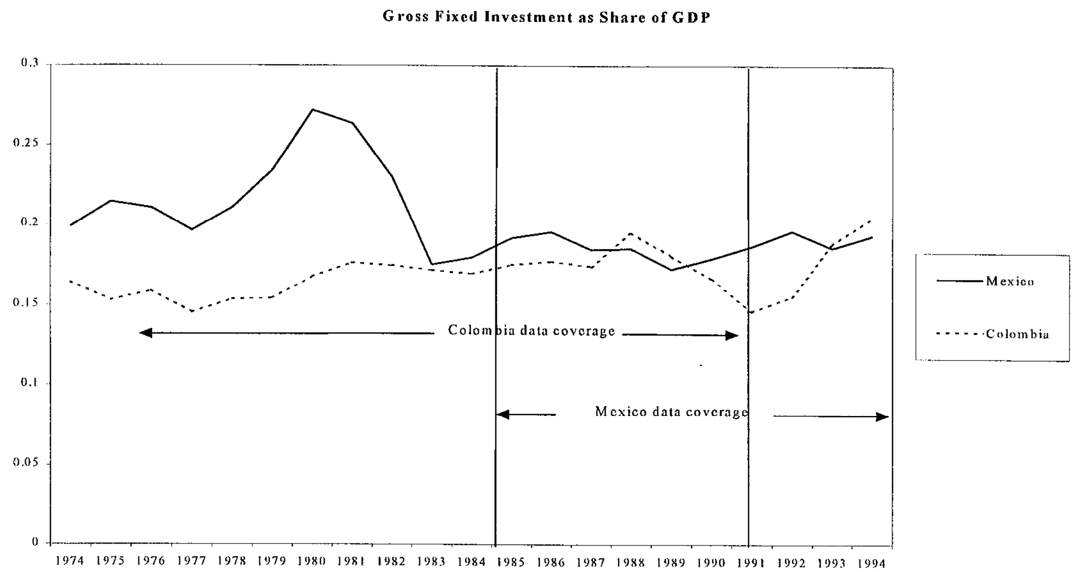
Number of employed persons	<=10	10-50	50-500	500-1000	>1000
Mexico	3.8 %	20.1 %	60.0 %	10.9 %	4.9 %
Colombia (balanced)	1.0 %	45.5 %	47.9 %	4.3 %	1.5 %
Colombia (unbalanced)	10.1 %	63.6 %	24.7 %	1.1 %	0.0 %

Source: Authors' calculations based on data from INEGI and DANE.

Another noteworthy difference is that the Mexican sample covers a much shorter period, which however was characterized largely by depressed aggregate investment levels. After the outset of the Mexican crisis in 1982, investment dropped sharply and only started to recover slowly in the early nineties. Despite slowdowns in economic growth during 1975 and 1981-83, Colombia's economy did not undergo such a dramatic fall in investment activity during the period studied. Figure 1 visualizes some of the differences; note, however, that, particularly in the Mexican case, investment shares as percentage of GDP only provide an incomplete picture given the contraction of GDP after the crisis.[7]

[7]Notice that Figure 1 depicts the aggregate level of investment in the economy. In our work, we focus on manufacturing investment only.

Figure 1. Colombia and Mexico: Aggregate Investment Activity and Sample Coverage



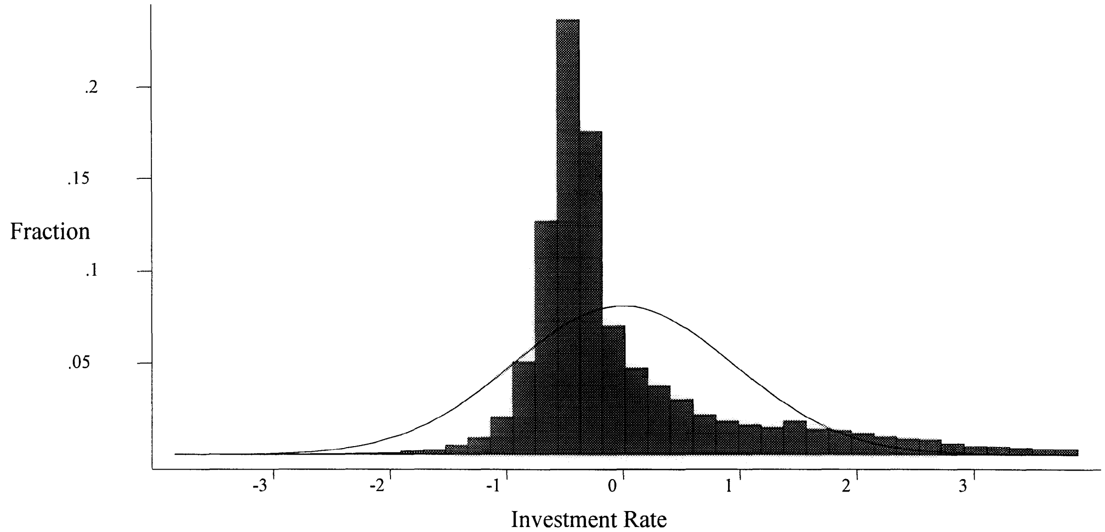
Source: IFS

III. The Distribution Of Investment Rates And The Importance Of Investment Spikes

In order to obtain a first picture of the salient features of the data, and to allow for immediate comparability with the evidence presented in Caballero, Engel, and Haltiwanger (1995) (hereafter CEH), Figures 2 and 3 show histograms of standardized investment-to-capital ratios for equipment investment[8] (machinery, transport equipment, and other). In the case of Colombia, the distribution is based on the unbalanced panel. CEH report a high degree of skewness and kurtosis, a feature that is indicative of non-convex or at least asymmetric adjustment costs. For reference, standard normal distributions are superimposed on the graphs. Such shapes would be expected in a standard quadratic adjustment cost model with normally distributed shocks, where investment-to-capital ratios are linear combinations of previous shocks. The distributions for Mexico and Colombia are surprisingly similar. Similarly to the picture in CEH, in both cases they display high skewness and kurtosis, but to a much stronger degree than in their sample.

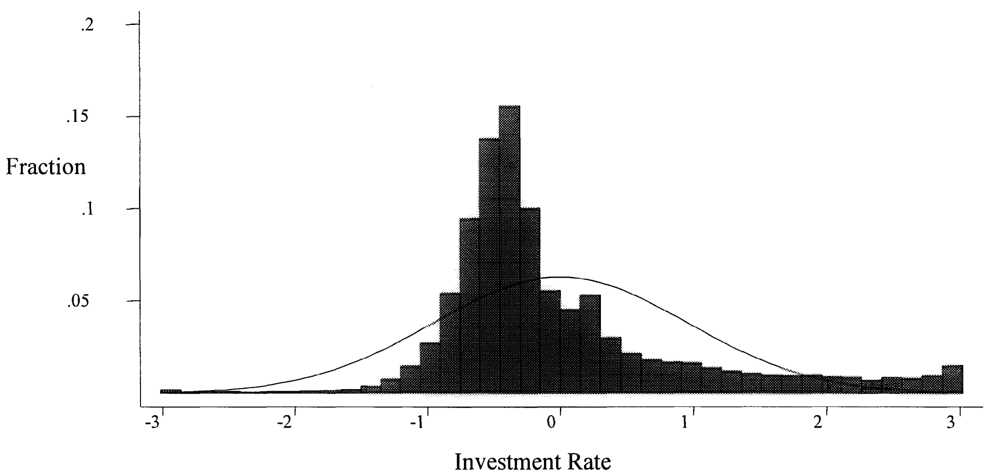
[8] The standardized investment rates are obtained by subtracting the mean investment rate for each plant and dividing by the plant-level standard deviation of investment rates. The following discussion draws on Gelos (1998) and Isgut (1997).

Figure 2. Colombia: Distribution of Standardized Equipment Investment Rates



Source: Authors' calculation based on data from DANE.

Figure 3. Mexico: Distribution of Standardized Equipment Investment Rates



Source: Authors' calculation based on data from INEGI.

Tables 2 and 3 provide information on the distribution of gross investment rates for different assets and the share of each interval in the total sum of positive real investment of that category. Three (and, in the case of Colombia, four) intervals of positive investment are considered:[9] maintenance investment, with investment rates of less than seven percent (four percent for buildings[10]), moderate investment (investment rates between seven -four for buildings- and twenty percent), and large investment rates (above twenty percent). For example, the entries in the fourth column and first row of Table 2 show that of all the recorded investment episodes in machinery equipment, 12.1 percent were characterized by investment rates between 0.07 and 0.20. These episodes accounted for 30 percent of the sum of all machinery investment in the sample.

Table 2. Mexico: Distribution of Fixed Gross Investment Rates and Share in Total Investment

Category	**$i<0$**	**$i=0$**	**$0<i<0.07^{*}$**	**$0.07^{*}<i<0.2$**	**$0.2<i<2$**
(1) Machinery	3.2 %	39.0 %	35.4 % (30.6 %)	12.1 % (30.0 %)	10.3 % (39.4 %)
(2) Transport Equipment	8.9 %	43.5 %	15.0 % (14.4 %)	15.0 % (30.9 %)	17.6 % (54.7 %)
(3) Other	2.4 %	43.0 %	22.7 % (10.3 %)	16.6 % (22.3 %)	15.3 % (67.4 %)
(4) Total Equipment [1) +2) +3)]	4.3 %	28.4 %	38.8 % (29.2 %)	17.4 % (32. 0 %)	11.1 % (38.8 %)
(5) Buildings	1.9 %	65.7 %	21.4 % (29.4 %)	5.9 % (27.9 %)	5.0 % (42.7 %)
(6) Land	1.9 %	94.8 %	1.5 % (14.6 %)	1.0 % (20.9 %)	1.2 % (64.5 %)

Source: Authors' calculations based on data from INEGI.
*0.04 for buildings. Shares in total positive investment in parentheses.

Four main common features of the distributions are apparent. First, the frequency of negative investment episodes is very low in both countries. This is surprising, given the major structural changes that took place in Mexico and an important recession in Colombia during the periods analyzed here. A possible explanation is the existence of some form of irreversibility that makes it costly for firms to sell capital goods.[11] Second, the share of zero investment episodes is very high in both Mexico and Colombia. As one would expect, zeroes occur much more often in the case of real estate than in the other

[9]In the Mexican sample, rates above 200 percent were very rare and consisted mainly of extreme outliers. This is different in the Colombian case and partly due to the larger fraction of small establishments in that sample. This will be discussed again below.
[10] These are the assumed depreciation rates for equipment and buildings, respectively.
[11] Irreversibility of investment is a good approximation to reality when secondary markets for specialized equipment are very thin. This seems to be verified by the fact that the item with a higher proportion of negative investment episodes is transportation equipment, whose demand is not limited to specialized manufacturers.

asset categories. In the Colombian sample, which contains a larger number of smaller plants, the proportion of zero investment episodes is also very large for transportation equipment. Although there is probably an upward bias in these numbers, given that in some cases it appears as if non-responses were registered as zeroes, this finding is similar to, but more extreme than, the ones reported for the United States and Norway. Third, a significant fraction of investment may be characterized as maintenance investment, but its contribution to total capital expenditures is only modest. Fourth, the largest contribution to total investment comes from investment rates that are above 20 percent. These investment "spikes" represent a larger share of total investment in the Colombian sample, probably because of its larger proportion of small plants. In all, these features are very similar to the ones reported by CEH and Doms and Dunne (1998).

Table 3. Colombia: Distribution of Fixed Gross Investment Rates and Share in Total Investment - Unbalanced Panel

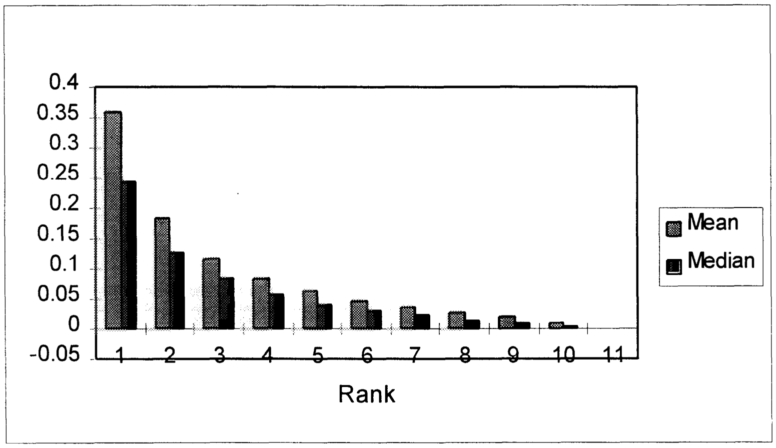
Category	**i<0**	**i=0**	**0<I<0.07***	**0.07*<i<0.2**	**0.2<i<2**	**i>2**
(1) Machinery	4.6%	38.1%	22.9% (12.2%)	14.9% (27.8%)	18.5% (56.3%)	0.9% (3.7%)
(2) Transport Equipment	7.8%	61.0%	5.9% (9.0%)	7.2% (24.7%)	15.4% (57.9%)	2.7% (8.4%)
(3) Other	2.8%	45.8%	14.9% (6.2%)	15.0% (26.6%)	20.0% (62.3%)	1.5% (4.9%)
(4) Total Equipment [1) + 2) + 3)]	5.6%	29.8%	25.2% (12.3%)	18.2% (31.6%)	21.7% (54.2%)	0.4% (1.8%)
(5) Buildings	4.4%	65.4%	10.2% (5.7%)	9.7% (31.3%)	8.9% (52.7%)	1.4% (10.4%)
(6) Land	5.6%	83.2%	3.6% (7.7%)	2.0% (14.6%)	4.4% (50.3%)	1.2% (27.4%)

Source: Authors' calculations based on data from DANE.
*0.04 for buildings. Shares in total positive investment in parentheses.

The relatively high frequency of maintenance investment suggests that fixed costs play an important role only for large, expansion investment and for negative investment. Repairing and improving an existing machine does not entail as much cost in terms of foregone output as adding a new machine or replacing an old one, a distinction that is rarely made in the theoretical literature. Improvements in existing capital stocks, which are included in our investment measure, may partly account for the relatively high frequency of low investment rates. An additional reason for this phenomenon is the existence of credit constraints. Firms may have sufficient internal funds to carry out maintenance investments, but financial restrictions may often prevent them from expanding their capital stocks. This possibility is supported by the fact that the frequency of zero investment episodes is much higher for small plants,[12] which are more likely to be financially constrained, than for large plants (Nilsen and Schiantarelli, 1997).[13]

To further characterize the nature of capital adjustment, we rank the investment rates for each plant from highest to lowest.[14] Given that there are eleven years of available data in the Mexican case, this means assigning numbers between 1 and 11 to the firm's investment episodes. For Colombia, we used the balanced subpanel of plants operating continuously between 1975 and 1991, allowing for 17 rankings. In Figures 4 and 5, the means and medians of the ranked equipment investment rates are depicted. Similarly to findings for the United States and Norway, the rank-1 investment rates in Mexico and Colombia (35.9 percent and 91.2 percent), are many times higher than the overall mean investment rates (7.8 percent in Mexico and 14.8 percent in Colombia[15])

Figure 4. Mexico: Mean and Median Investment Rates by Rank



Source: Authors' calculation based on data from INEGI.

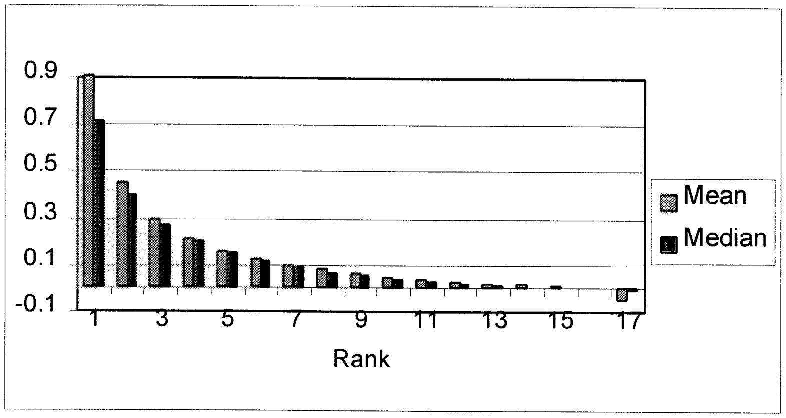
[12] In the balanced Colombian subpanel, which includes larger plants, the frequency of zero investment episodes drops considerably (for example from 29.8–20.3 percent for equipment investment).

[13] There are two other possible reasons why larger plants experience less episodes of zero investment: (a) within-plant aggregation over production lines and processes (Nilsen and Schiantarelli, 1997), and (b) higher diversification of product lines, implying less variable sales and investment plans (Doms and Dunne, 1998). See also Isgut (1997).

[14] See Doms and Dunne (1998).

[15] The lower mean investment rate for Mexico is due to two facts. First, as mentioned earlier, investment levels were depressed in Mexico throughout the eighties. The second reason relates to the larger number of small establishments in the Colombian sample. Small firms will in general tend to grow faster and report higher investment rates.

Figure 5. Colombia: Mean and Median Investment Rates by Rank
(Balanced Subpanel)



Source: Authors' calculation based on data from DANE.

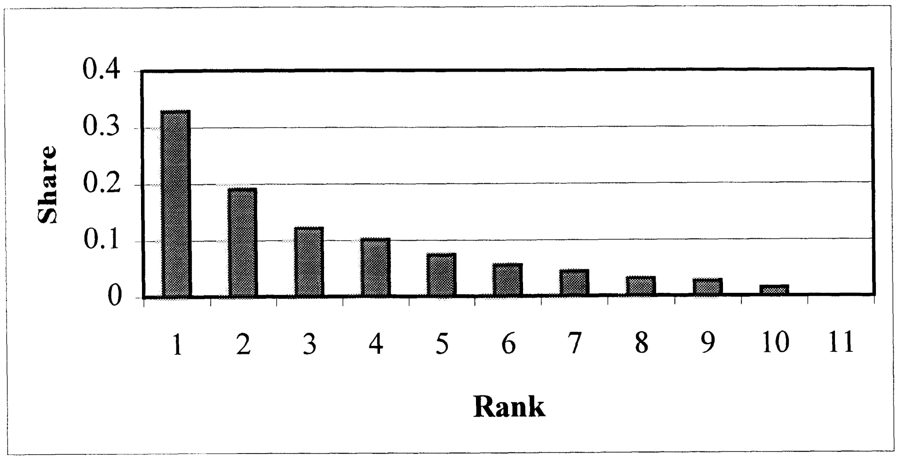
and significantly higher than the rank-2 rates (21.6 percent and 45.6 percent). The rank-1 investment rate is much higher in Colombia because of the larger proportion of small establishments and the longer time period covered by the sample.[16]

Figures 6 and 7 show the contribution of each investment rank to total equipment investment. The contribution of rank-1 investment to total equipment investment is approximately 33 percent in the case of Mexico and 20 percent in the Colombian case. Investment episodes in the three highest ranks account for 64 and 45 percent of total investment in the Mexican and Colombian samples, respectively.[17]

[16] The longer the permanence of a plant in the sample, the more likely we are going to observe a very large investment episode.

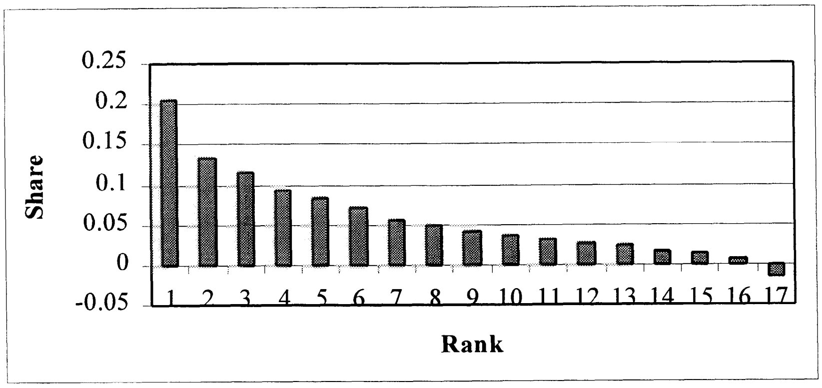
[17] These figures cannot be compared because of the different number of years in both samples. However, if we divide them by 1/T (where T is the total number of years of each sample), we obtain a measure of how different ranked investment episodes deviate from a constant level of investment. The normalized figures are around 3.5 for rank-1 investment and 2.4 for the three highest investment episodes for both countries.

Figure 6. Mexico: Shares of Ranked Equipment Investment in Total



Source: Authors' calculation based on data from INEGI.

Figure 7. Colombia: Shares of Ranked Equipment Investment in Total (Balanced Subpanel)



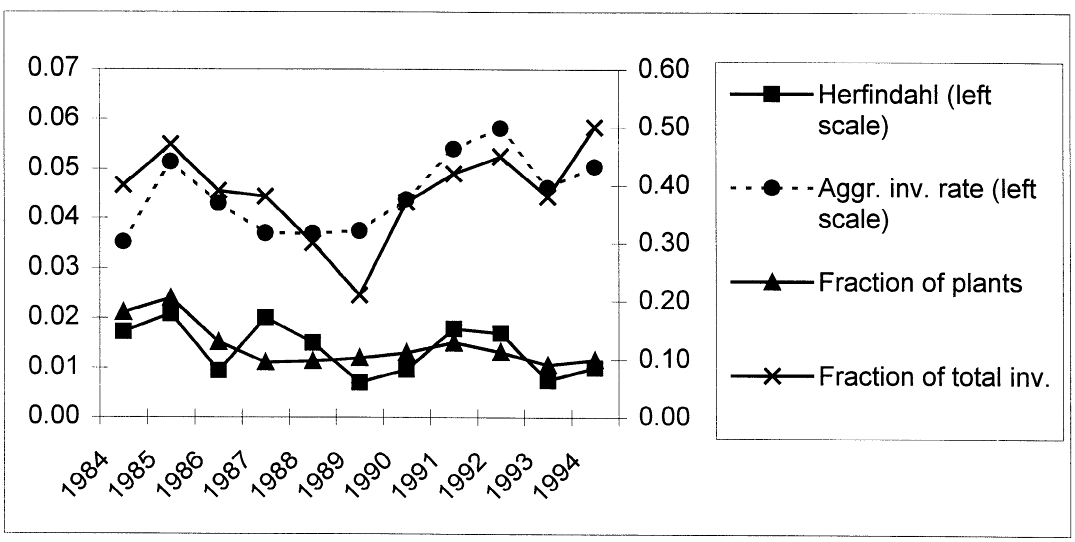
Source: Authors' calculation based on data from DANE.

To conclude this section, we investigate the relationship between the number of firms experiencing investment spikes and aggregate investment fluctuations. We relate the fraction of plants experiencing investment rates of more than 20 percent and the fraction of total investment accounted for by these spikes to the aggregate investment rate, defined as total equipment investment over total equipment capital at the beginning of the period. We also compute the Herfindahl index for investment for each year as a way of investigating whether investment is more concentrated on fewer plants in high investment periods, as found by Doms and Dunne (1998). The Herfindahl index is the sum of each plant's squared investment share in total investment at time t. If all the investment in a given period is due to one plant, the index takes the value of 1, while it becomes very small if investment shares across firms are similar.

As can be seen from Figures 8 and 9, the Herfindahl indices move together with the aggregate investment rate, although the comovements are more pronounced for Colombia (again using the balanced subpanel): the correlation is 0.71 for Colombia and 0.17 for Mexico. The correlation between the aggregate investment rate and the fraction of plants experiencing spikes is also larger for Colombia (0.78) than for Mexico (0.10). Finally, the fraction of total equipment investment accounted for by plants recording spikes is highly correlated with the aggregate investment rate in both countries (0.62 for Colombia and 0.68 for Mexico).

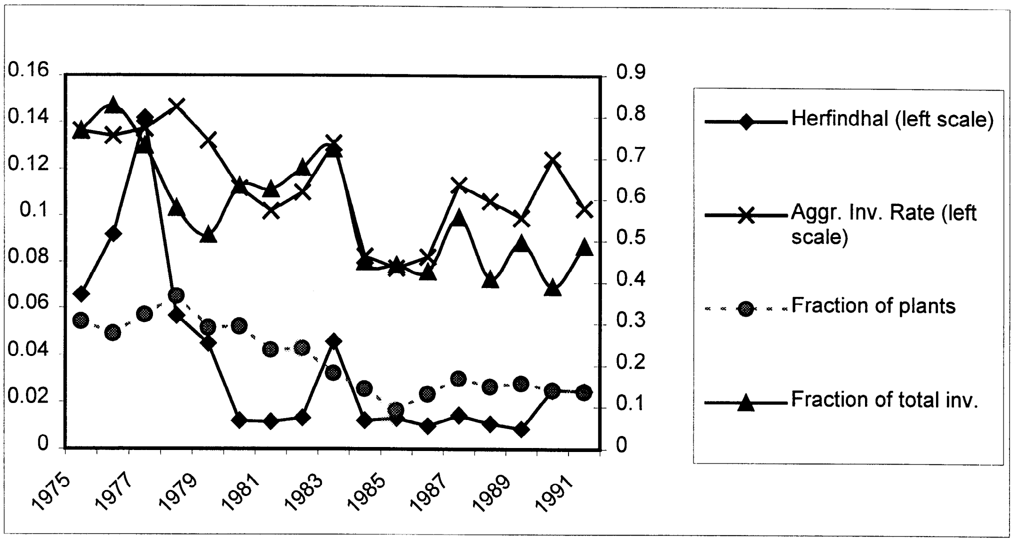
As an additional piece of information that will be relevant for the analysis in the following section, we find that the occurrence of investment spikes at the plant level is procyclical. In fixed-effects regressions of a dummy variable with value one when the plant's investment rate is greater than 20 percent on aggregate GDP growth, we find coefficients of 0.17 (with a t-statistic of 2.04) for Mexico and 0.01 (with a t-statistic of 8.7) for Colombia.

Figure 8. Mexico: Herfindahl Indices, Fraction of Plants and Fraction of Investment Accounted for by Plants Experiencing Investment Spikes



Source: Authors' calculation based on data from INEGI.

Figure 9. Colombia: Herfindahl Indices, Fraction of Plants and Fraction of Investment Accounted for by Plants Experiencing High Spikes



Source: Authors' calculation based on data from DANE.

IV. The Shape Of The Hazard

While the evidence presented so far is indicative of the existence of some sort of nonconvexities, it can also be accounted for by a skewed distribution of idiosyncratic shocks. Another way of exploring capital adjustment patterns is to examine whether the likelihood of an investment episode increases or decreases with the time elapsed since the last investment episode, by estimating an investment hazard function.

In general, it is difficult to make very precise statements about the shape of the hazard function without specifying the details of the model, including assumptions about the form of depreciation, the composition of capital goods and the properties of shocks. Therefore, the following discussion will be based on the predictions of a model developed by Cooper, Haltiwanger and Power (1997) (hereafter CHP). Their model allows for fixed costs of adjustment, a proportional cost component, and indivisibilities. Each period, firms can replace their existing machines by newer ones with leading technology and higher productivity. CHP represent the solution to their dynamic programming problem in terms of a hazard function which depends on the firm's current capital stock and the aggregate state of productivity.[18] They derive the result that, with

[18] The actual hazard obviously also depends on idiosyncratic shocks to productivity, which are assumed by CHP to be unobservable to the econometrician. The hazard that conditions on aggregate shocks only is the integral of the hazard that also conditions on idiosyncratic shocks over the fixed distribution of the latter. CHP assume that the idiosyncratic shocks are iid, so that their distribution is independent on the distribution of the current capital stock.

serially correlated profitability shocks and under some additional assumptions, the probability of investment increases with the time elapsed since the last investment episode. On the other hand, if adjustment costs are convex, the hazard is flat or, with serially correlated profitability shocks, downward sloping. Thus, explaining an upward sloping hazard without nonconvex adjustment costs would require assuming a very particular distribution of idiosyncratic shocks.

Since the interest here is not in maintenance investment, we will focus on investment spikes. Two definitions of investment spikes will be used: a high spike is defined as an episode in which the investment rate exceeds 20 percent, while a low spike denotes an investment occurrence above the assumed depreciation rate of seven percent. Using the notation of Nilsen and Schiantarelli (1997) (hereafter NS), let t denote calendar time, and T_{ij} the time at which firm i has its j-th investment spike. The hazard rate can then be written as:

$$p_{ijt} = \Pr\left[T_{ij} = t \mid T_{ij} \geq t, t - \left(T_{ij-1} + 1\right), x_{it}\right], \qquad (1)$$

where $t-(T_{ij-1}+1)$ is the interval since the last spike and the vector x_{it} represents additional variables such as fixed firm effects. To model the hazard, various avenues can be taken. The Kaplan-Meier estimator calculates the probability of a spike conditional on the fact that the firm has not experienced a spike over a period of a given length. It is computed by dividing the number of spikes in the sample by the number of firms "at risk", for every zero-spike period length. Define D_{kit} as a dummy variable that takes a value of one if the last investment spike was recorded k periods ago. Estimation of the Kaplan-Meier hazard is then equivalent to an OLS regression of the following form:

$$S_{it} = \sum_k \alpha_k D_{kit} + \varepsilon_{it}, \qquad (2)$$

where S_{it}=1 if plant i has an investment spike in period t, zero otherwise. This estimator, however, has two shortcomings. First, it may be desirable to smooth the estimated hazard function by assuming an explicit functional form. More importantly, this specification does not control for unobserved heterogeneity. It is well known that in general, neglecting heterogeneity leads to downward-biased estimates of duration dependence.[19] However, in the present setting, controlling for unobserved heterogeneity is not an easy task. One possibility is to estimate a model with fixed effects. For example, one could add plant-specific effects to equation (2) or estimate a logit model with fixed effects. However, the estimates of equation (2) with fixed effects would yield results that are affected by small-sample bias, given the limited number of time periods. Estimating a logit model with fixed effects by maximizing the unconditional likelihood is subject to similar problems, and maximizing the conditional likelihood following Chamberlain (1980) is not adequate in the presence of right-hand side variables representing the timing of past spikes.[20]

[19] See, for example, Neumann (1997).

[20] This follows from results presented in Card and Sullivan (1988).

Heckman and Singer (1984) propose including a random effect in the hazard, whose distribution is not parameterized. Instead, it is assumed that the distribution is discrete with a limited number of support (mass) points. Here, we follow NS, who adopt this methodology for the estimation of a logit model with random effects.[21] If, in addition to duration dummies, one includes time-specific effects λ_t in the model, the probability of an investment spike can be written as

$$P(S_{it}=1)=\frac{e^{\sum_k \alpha_k D_{kit}+\lambda_t+v_i}}{1+e^{\sum_k \alpha_k D_{kit}+\lambda_t+v_i}}. \tag{3}$$

Treating the initial conditions as fixed, the log likelihood function is given by

$$\log L = \sum_{i=1}^{N} \log \sum_{\lambda=1}^{M} pr_\lambda \prod_{t=1}^{T} P_{it\lambda}^{S_{it}} (1-P_{it\lambda})^{(1-S_{it})}, \tag{4}$$

where N is the number of observations, M is the number of mass points, and pr_λ are the associated probabilities. Note that this approach is not free from potential drawbacks. One issue, as in any maximum-likelihood estimation of dynamic models, concerns the treatment of initial conditions. Another complication may arise from a correlation between the time-invariant effects and the explanatory variables, yielding inconsistency of the estimator[22]. Since the answer to these issues is not obvious, the results from various estimators will be discussed, and they all should be interpreted with caution.

Using the Heckman-Singer random effects logit specification for the case of equipment, NS obtain flat hazard estimates for the high spike definition, and a U-shaped hazard[23] for a spike definition based on the plant's median investment rate over time.[24] CHP also use the Heckman-Singer method, though with another functional specification, obtaining increasing hazard estimates.

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[21] Frank Windmeijer kindly provided us with a computer program to implement this estimator.

[22] Unfortunately, no Hausman test of fixed vs. random effects can be carried out here, since such a test requires an estimator that is consistent under the alternative hypothesis (i.e. correlation between effects and explanatory variables).

[23] The fact that, for U-shaped hazards, the probability of an investment spike is higher in the period immediately after one such burst of investment, i.e. that investment shows some persistence, is usually explained by time-to-build considerations or by serially correlated shocks. Acemoglu and Scott (1997), on the other hand, argue that learning-by-doing may give rise to persistence in investment.

[24] We also experimented with this spike definition, obtaining similar results to the ones presented below.

Tables 4 and 5 present results from the estimations of the simple Kaplan-Meier, simple logit, and logit with random effects estimations for equipment investment. When carrying out the estimations, we included completed spells and spells that were still ongoing after 10 (7) years in the Colombian (Mexican) sample. For Colombia, we use the balanced subpanel. In the random effects logit estimations, it turned out that allowing for two (and in the Colombian case of the low-spike definition, three) mass points was sufficient. The hazards estimated by the random-effect logit model are depicted in Figures 10, 11, 12, and 13 for the two different groups defined by the different mass points.

Table 4. Mexico: Hazard Estimates for Equipment Investment

Variable	OLS High Spike	OLS Low Spike	Logit High Spike	Logit Low Spike	Random Effects Logit High Spike	Random Effect Logit Low Spike
D1	0.48	0.65	4.60	5.04	4.60	5.04
	(43.32)	(105.56)	(19.25)	(23.27)	(19.25)	(23.27)
D2	0.36	0.50	4.30	4.46	4.30	4.47
	(23.71)	(47.83)	(17.61)	(20.39)	(17.61)	(20.41)
D3	0.33	0.48	4.10	4.36	4.10	4.37
	(17.57)	(32.79)	(16.42)	(19.51)	(16.42)	(19.55)
D4	0.36	0.42	4.07	3.97	4.07	3.98
	(15.53)	(20.88)	(15.82)	(17.17)	(15.82)	(17.23)
D5	0.35	0.40	3.81	3.76	3.81	3.77
	(11.92)	(14.94)	(14.10)	(15.39)	(14.10)	(15.45)
D6	0.38	0.37	3.74	3.54	3.74	3.56
	(10.62)	(10.79)	(13.14)	(13.43)	(13.14)	(13.49)
D7	0.58	0.51	4.40	3.88	4.40	3.90
	(12.84)	(11.71)	(14.19)	(13.63)	(14.19)	(13.69)
Const 1					-4.39	-4.21
[probability]					[0.71]	[0.72]
Const 2					-4.41	-4.43
[probability]					[0.29]	[0.28]
F-test	486.96	2202.8	-	-	-	-
	(7,4882)	(7,10992)				
χ^2	-	-	928.1	1747.4	-	-
			(16)	(16)		
# of observ.	4899	10999	4899	10999	4899	10999

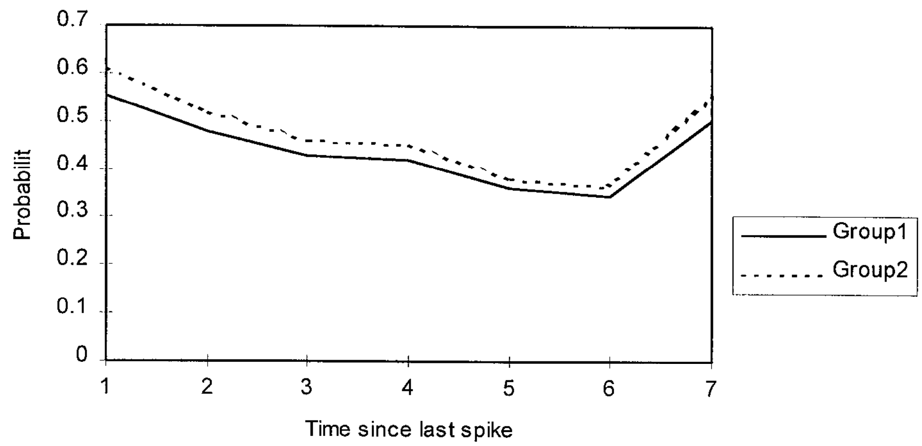
Source: Authors' calculation based on data from INEGI. Note: t-statistics in parentheses. Time dummies (not shown) included in logit and random effects logit regressions.

Table 5. Colombia: Hazard Estimates for Equipment Investment

Variable	OLS High Spike	OLS Low Spike	Logit High Spike	Logit Low Spike	Random Effects Logit High Spike	Random Effects Logit Low Spike
D1	0.40	0.64	3.59	4.70	3.59	4.56
	(64.20)	(152.58)	(22.29)	(19.80)	(22.29)	(18.97)
D2	0.35	0.51	3.39	4.17	3.39	4.18
	(43.03)	(72.37)	(20.84)	(17.51)	(20.84)	(17.34)
D3	0.32	0.45	3.31	3.96	3.31	4.08
	(31.87)	(45.00)	(20.11)	(16.52)	(20.11)	(16.76)
D4	0.28	0.38	3.17	3.73	3.17	3.92
	(22.69)	(28.56)	(18.82)	(15.32)	(18.82)	(15.88)
D5	0.30	0.35	3.26	3.59	3.27	3.83
	(20.49)	(20.61)	(18.96)	(14.49)	(18.95)	(15.24)
D6	0.27	0.35	3.11	3.57	3.11	3.86
	(15.73)	(16.44)	(17.37)	(14.02)	(17.37)	(14.94)
D7	0.31	0.36	3.26	3.54	3.26	3.88
	(15.24)	(13.64)	(17.64)	(13.44)	(17.65)	(14.49)
D8	0.33	0.43	3.27	3.70	3.27	4.07
	(13.72)	(12.96)	(16.82)	(13.37)	(16.82)	(14.49)
D9	0.35	0.41	3.16	3.53	3.16	3.92
	(11.84)	(9.50)	(15.09)	(11.58)	(15.10)	(12.68)
D10	0.42	0.38	3.39	3.22	3.39	3.63
	(11.47)	(6.57)	(14.72)	(9.08)	(14.72)	(10.08)
Const 1					-4.07	-4.13
[probability]					[0.83]	[0.62]
Const 2					-4.11	-4.77
[probability]					[0.17]	[0.20]
Const 3					-	-3.13
[probability]						[0.19]
F-test	886.3	3254.0	-	-	-	-
	(10,16389)	(10,24168)				
χ^2	-	-	1378.1	2670.3	-	-
			(25)	(25)		
# of observ.	16399	24178	16399	24178	16399	24178

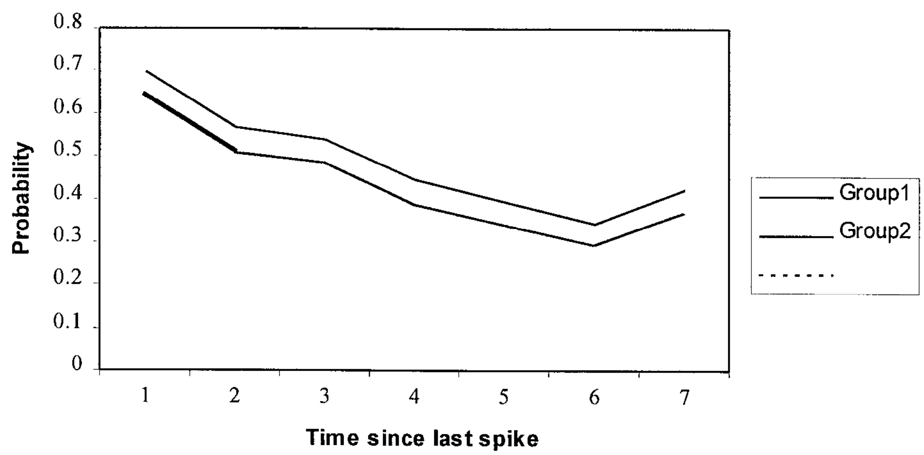
Source: Author's calculations based on data from DANE. Note: t-statistics in parentheses. Time dummies (not shown) included in logit and random effects logit regressions.

Figure 10. Mexico: Hazard for Equipment Investment
(High Spikes, Random Effects Logit Estimation)



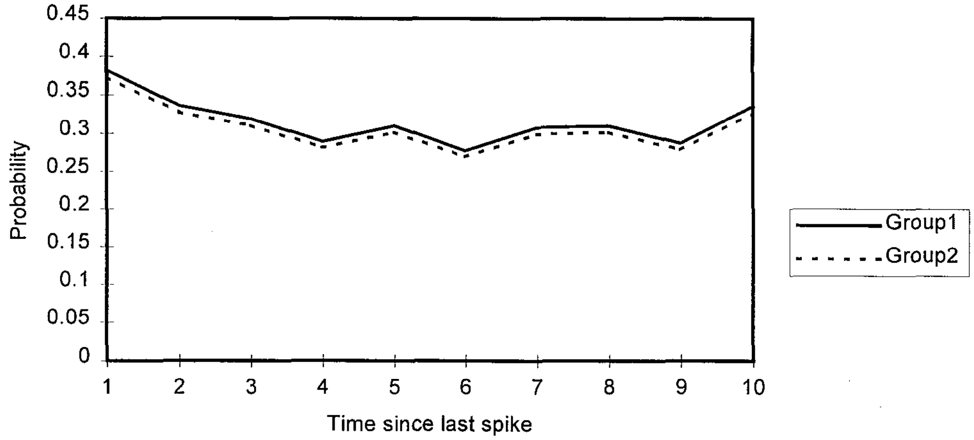
Source: Authors' calculation based on data from INEGI.

Figure 11. Mexico: Hazard Estimates for Equipment Investment
(Low Spikes, Random Effects Logit Estimation)



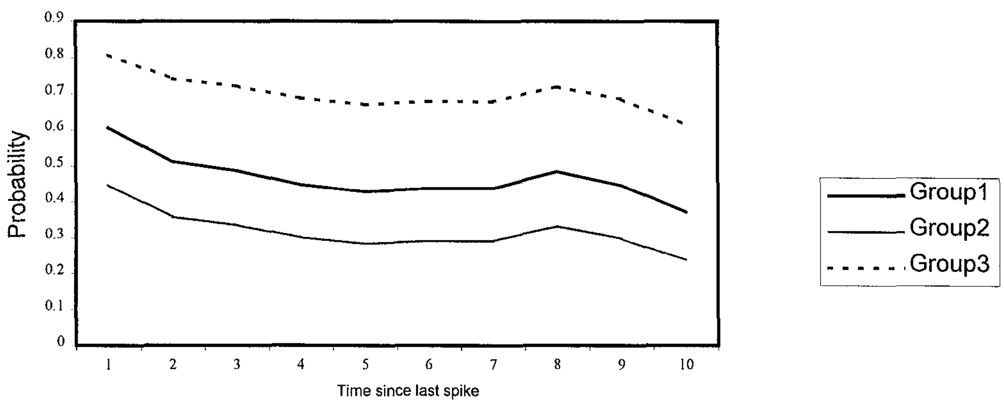
Source: Authors' calculation based on data from INEGI.

Figure 12. Colombia: Hazard Estimates for Equipment Investment
(High Spikes – Random Effects Logit Estimation)



Source: Authors' calculation based on data from DANE.

Figure 13. Colombia: Hazard for Equipment Investment
(Low Spikes, Random Effects Logit Estimation)



Source: Authors' calculation based on data from DANE.

The simple logit and the random effects logit provide very similar estimates; in the case of high spikes, they are virtually identical. This is somewhat surprising, since a-priori one would suspect heterogeneity to be important, given the variety of plants in the sample and the fact that no further plant-specific variables were included in the specification.[25] In the Mexican case, the simple Kaplan-Meier and the logit estimates

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[25] In additional regressions (not shown) we included additional plant-specific variables. Although several of these variables where statistically significant, their inclusion did not alter the shape of the estimated hazard functions.

both yield downward-sloping hazards; however, the spike probability increases again in the seventh year after the last spike. For Colombia, the hazards are essentially flat.

In an earlier version of their paper, CHP considered the possibility that firms are financially constrained. If investment must be financed internally, the ability of a firm to replace its machinery will depend on the firm's productivity and demand conditions. Low productivity plants that need to replace their machinery may be unable to do so if replacement involves substantial fixed costs. As a result, their productivity is further reduced in the next period, making it even more difficult that an investment will take place. If productivity shocks are serially correlated, this behavior may induce a negative slope in the hazard function. Although the presumption that Mexican and Colombian plants are to a large degree financially constrained is supported by evidence presented elsewhere[26], an attempt to control for this possibility by including the cash flow at the firm level did not yield substantially different hazard shapes.[27]

The results from the hazard function estimation do not seem to support the importance of nonconvex adjustment costs, at least for equipment. However, apart from the estimation problems mentioned earlier, in the Mexican case the number of time periods available may be too short to correctly detect a U-shaped hazard if this were the true shape. It should also be noted that both fixed effects logit and fixed effects OLS estimates (not shown in the paper) yielded upward sloping hazards.[28] Finally, it might be the case that the random-effects logit specification is insufficient to account for the heterogeneity in our samples. In an additional set of regressions we split the sample according to plant size and average growth rates. These regressions show for Colombia that smaller plants have U-shaped hazards, while the hazards for larger plants are downward sloping. In the Mexican case, the pattern is less clear.

Finally, it is worth mentioning again that investment spikes exhibit strong procyclicality, as discussed in the previous section. Within the context of the model developed by CHP, this suggests that the Mexican and Colombian samples examined here may be characterized by highly serially correlated aggregate shocks and fixed, as opposed to output-proportional, machine replacement costs. The intuition is the following. While the replacement of machines involves lower opportunity costs in periods of low productivity of inputs, the firm would like to buy a new machine when productivity is high if shocks are serially correlated. If adjustment costs are proportional to output, the opportunity cost aspect is more relevant and investment spikes are

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[26] See Gelos (1998) and Gelos and Werner (1999) for evidence for the Mexican case and Tybout (1983) for an analysis of Colombian firms.

[27] It should also be noted that, not surprisingly, cash flow helps to predict investment spikes. However, controlling for cash flow does not alter the shape of the hazards. The same is true for other control variables, such as the median size and output growth rates of individual plants.

[28] A limited Monte-Carlo simulation revealed that, while the fixed effects estimators showed a bias, the bias seemed to go in the opposite direction (i.e. in favor of finding a decreasing hazard when the true hazard was constant). More work is required in this area.

countercyclical. In contrast, if there are only fixed adjustment costs, the opportunity cost argument disappears and replacement is more likely during economic upturns.

V. The Average Adjustment Function

In this section, we go one step further in our attempt to provide a description of firms' capital adjustment behavior. We estimate the average adjustment function following a similar approach as CEH. Since our aim is to investigate how plants adjust their capital stocks in response to changes in some notion of their "optimal" capital stocks, the latter concept needs to be made precise and operational. CEH define the *desired capital stock* as the capital stock that the plant would hold if adjustment costs were temporarily removed and *frictionless capital* is the capital stock it would hold in the absence of frictions at any time. They then assume that the natural logarithm of the desired capital stock k_{it}^{d} is proportional to the frictionless capital, k_{it}^{*}:

$$k_{it}^{d} = k_{it}^{*} + d_i , \qquad (5)$$

where d_i is a plant-specific constant. This assumption is consistent with the predictions of a wide variety of models. For example, in the irreversible investment model firms are more reluctant to invest in good times because they are afraid of getting stuck with too much capital (see Caballero, 1983); therefore d_i is negative. In this model actual capital is larger than desired capital if the irreversibility constraint is binding. In the conventional partial adjustment model desired capital also differs from frictionless capital, since capital is adjusted gradually over time. In this model, d_i can be either negative (when the firm is investing) or positive (when the firm is disinvesting), and the actual capital stock is always equal to desired capital.

The estimation of the frictionless capital stock is problematic because it entails making assumptions about the technology, market structure, and behavior of individual firms. CEH derive their estimates from a simple neoclassical framework, and we follow a similar approach here. If the production function is CES, frictionless capital is given by

$$K_{it}^{*} = \alpha C_{it}^{-\theta} Y_{it} , \qquad (6)$$

where K_{it}^{*}, C and Y_{it} denote the levels of the frictionless equipment capital stock, 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.

We do not have a good aggregate series on the cost of capital.[29] Moreover, the aggregate series of ex-post real interest rates that are available contain negative values for various years, which precludes taking logs. On the other hand, there is reason to believe that the lack of a good aggregate series for interest rates is not a major drawback, given the evidence that financial constraints were important in Mexico and Colombia throughout the period examined. Different firms faced different premia in the cost of external and internal funds, so that aggregate interest rate data are unlikely to convey much information.[30] However, we have information on one key component of the user cost of capital, namely the relative price of capital goods (machinery) to the producer price index. This variable is particularly important given the large swings in the real exchange rate for these two countries in the period studied, combined with the fact that most capital goods are imported (see Isgut, 1997). In fact, the real exchange rate and the machinery-producer-price ratio are highly correlated.

Departing slightly from (6), we do not restrict the exponent on output to be equal to one.[31] After taking logs and substituting into equation (5), our estimating equation for desired capital is

$$k_{it}^{d} = \alpha_i + \beta \log(Y_{it}) + \gamma \log\left(\frac{P_{mt}}{P_t}\right) + \varepsilon_{it}\,, \qquad (7)$$

where P_{mt} is the producer price index for machinery, P_t is the producer price index, and $\alpha_i \equiv d_i + \alpha$ is a fixed plant effect to be estimated. Of course, the log of desired capital is not observable. However, deviations between actual and desired capital are likely to be stationary. In other words, actual capital may differ from desired capital, but we should not expect these differences to widen without bound over time. Therefore, we can estimate equation (7) using actual capital in the left-hand side and interpret the estimated parameters as representing the long-run determinants of desired capital.[32]

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[29] Note that CEH rely on an essentially aggregate measure of the cost of capital, which has little cross-sectional variation. Moreover, they assume a constant real interest rate. Therefore, as Woodford (1995) notes, it is likely that most of the variation over time in their frictionless capital measure is due to "accelerator-effects".

[30] An interesting extension would be to derive the frictionless capital stock conditional on the availability of internal funds. However, the data set only contains a flow variable of internal funds (profits), which makes estimation of a meaningful relation difficult.

[31] By allowing for more flexibility, we are again following a similar avenue as CEH, who relax the equality in the elasticity of the capital stock to output and the costs of capital implied by the model.

[32] Concerning the estimation of the cointegrating equation, CEH use a procedure suggested by Stock and Watson (1993) 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.

The results (not shown) display a significant relationship between the logs of output, the relative price index, 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. CEH define mandated investment at time *t* as the difference between the log of desired capital and the log of last period's actual capital: $x_{it} = k_{it}^d - k_{it-1}$. Our measure of estimated mandated investment is obtained from the predicted desired investment from the above regression.

How can these estimates be used to infer anything about the nature of adjustment costs? If irreversibilities are important, we should observe very little disinvestment for negative mandated investment rates, i.e. one would observe a range of inaction. With nonconvexities in the adjustment cost function, due for example to the presence of fixed (stock) costs, we would expect to see on average a larger investment response to high positive mandated investment rates than for low positive mandated investment. In both cases, one is likely to observe *nonlinearities* in the relationship between the two variables at the plant level.

Our estimates can be used to estimate the average adjustment function, defined as the average response of actual investment to each level of mandated investment in the sample. This function will depend on the cross-sectional distribution of mandated investment across different plants. For example, in the case when plants follow a simple (S,s) policy, by which they invest only when mandated investment exceeds certain threshold, the shape of the average adjustment function will depend on the distribution of the investment threshold across plants. This shape will reflect the underlying nonlinearities at the plant level. For example, a large positive aggregate shock not only will increase mandated investment for each individual plant but also will induce more firms to adjust to their desired capital stock levels. As a result, the average investment response will be more than proportional to the shock to mandated investment.[33]

Figures 10 and 11 show nonparametric estimates of the average adjustment functions for equipment investment for Colombia and Mexico. We use a Nadarya-Watson kernel estimator with an Epachenikov kernel.[34] This regression puts almost no

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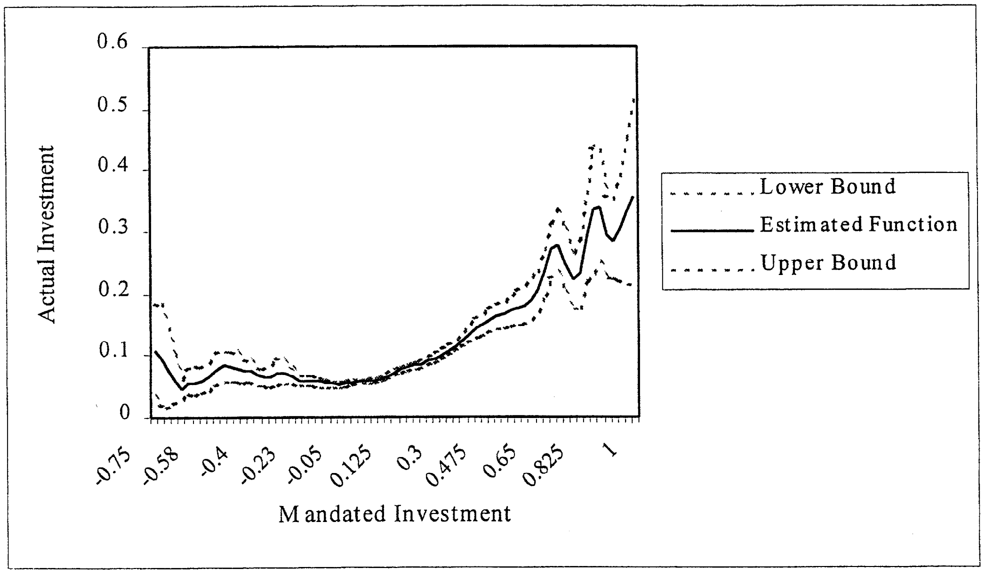
[33] Notice, however, that one cannot immediately deduce the presence of nonconvexities (e.g. fixed costs) at the micro level from the observation of such nonlinearities at the aggregate level. As Woodford (1995) points out, such a nonlinear pattern can be generated by a model with irreversibilities and convex adjustment costs if the marginal profit associated with an increase in the capital stock is sufficiently steep at low levels of the capital stock.

[34] 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), giving $h=2.347*\sigma*n^{-1/5}$, where σ is the standard deviation of the independent variable and n is the number of observations. Here, this gives bandwidths equal to 0.057 for Mexico and 0.061 for Colombia, which we use in the estimations. The shape of the estimated function is not sensitive to the choice of the kernel.

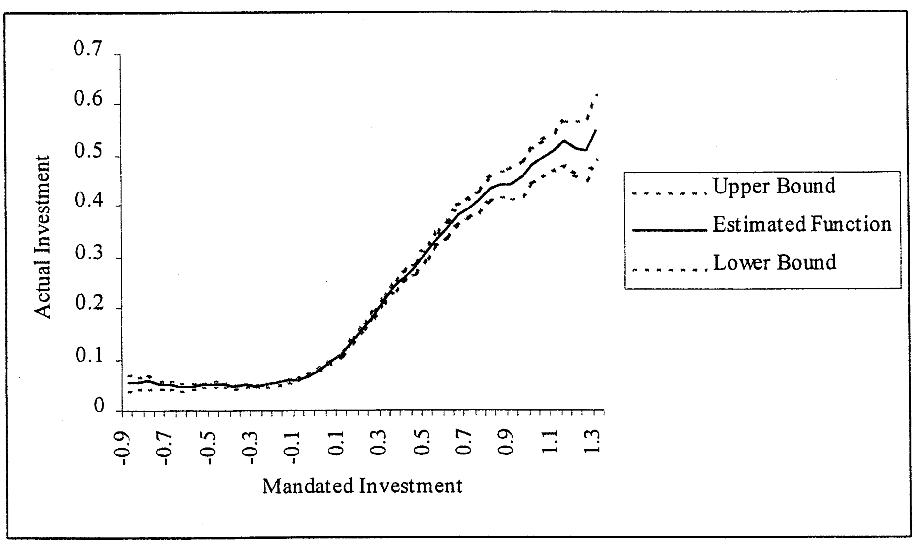
restrictions on the shape of the adjustment function. For any mandated investment rate, this estimator computes a weighted average of the observed investment rates in its neighborhood, with weights given by the kernel. In order to calculate confidence bands, a bootstrap method was used with 250 draws in each case[35].

Figure 14. Mexico: Estimated Adjustment Function with 95 Percent Confidence Bands



Source: Authors' calculation based on data from INEGI.

Figure 15. Colombia: Estimated Adjustment Function with 95 Percent Confid. Bands



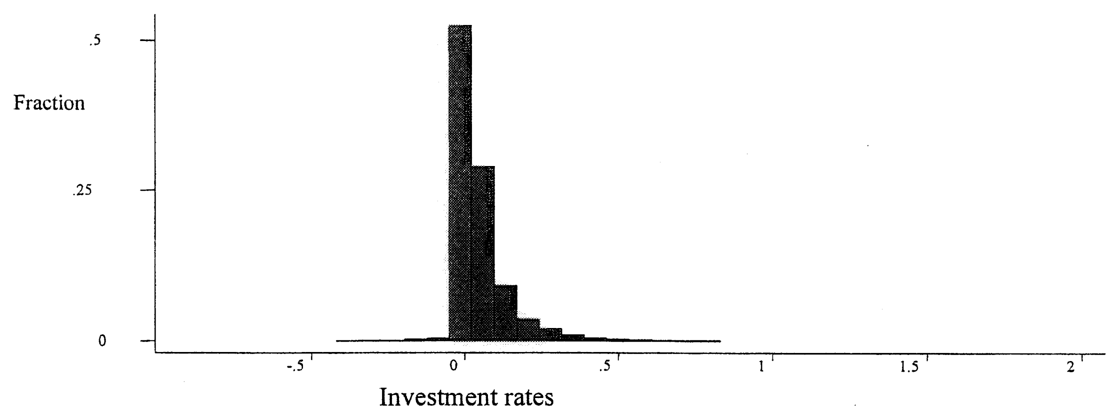
Source: Authors' calculation based on data from DANE.

[35] We are grateful to Günter Hitsch for his help in constructing the confidence intervals.

The pictures do not look very different from estimates for the United States (CEH, 1995; Goolsbee and Gross, 1997). 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.[36] In the range for positive mandated investment rates, the shapes of the estimated adjustment functions are approximately linear. Finally, the estimated functions are clearly different from the theoretical case of quadratic adjustment costs, where the adjustment function would be a straight line with a 45° slope passing through the origin.[37]

Figures 16, 17, 18, and 19 present conditional histograms of equipment investment. Figures 16 and 19 show investment rates for low mandated investment rates of less than seven percent, while Figures 17 and 19 show investment rates for high mandated investment rates of more than 20 percent. Actual investment rates are noticeably larger for the case of high mandated investment. The tails of the distribution are thicker, and a significant fraction of plants has investment rates of more than 30 percent, while such high rates are more rare in the graphs for low mandated adjustments. These differences between the histograms are stronger in the Colombian case. These types of histograms are not consistent with the predictions from simple continuous adjustment models (Woodford, 1995).

Figure 16. Mexico: Distribution of Actual Equipment Investment Rates for Low Mandated Investment



[36] One might argue that adjustment costs apply for gross, rather than net adjustment. A plant that sells three old machines and buys a new one for the same price records no net investment, but certainly incurs adjustment costs. We considered this possibility by relating only purchases to the desired investment ratios, similarly to Goolsbee and Gross (1997). The same qualitative picture obtains.

[37] This follows from the definition of mandated investment and the fact that in a quadratic adjustment cost model desired capital is always equal to actual capital.

Figure 17. Mexico: Distribution of Actual Equipment Investment Rates for High Mandated Investment Rates

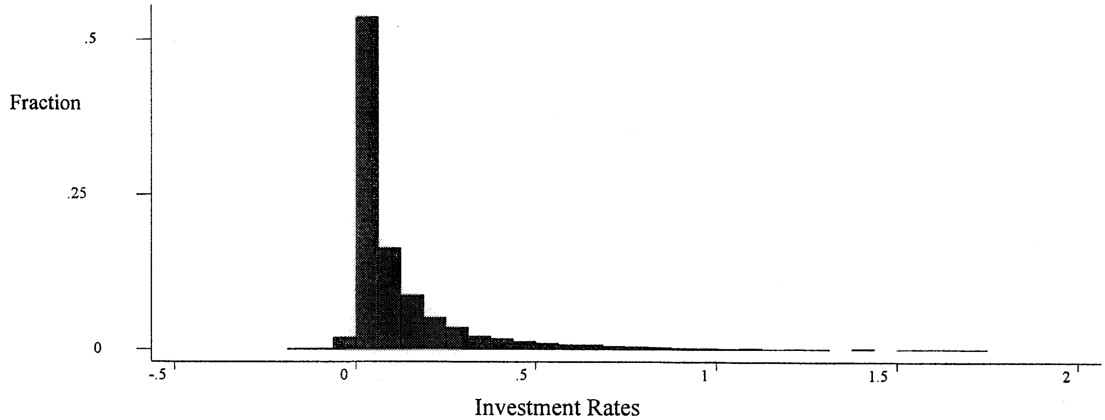


Figure 18. Colombia: Distribution of Actual Equipment Investment Rates for Low Mandated Investment Rates

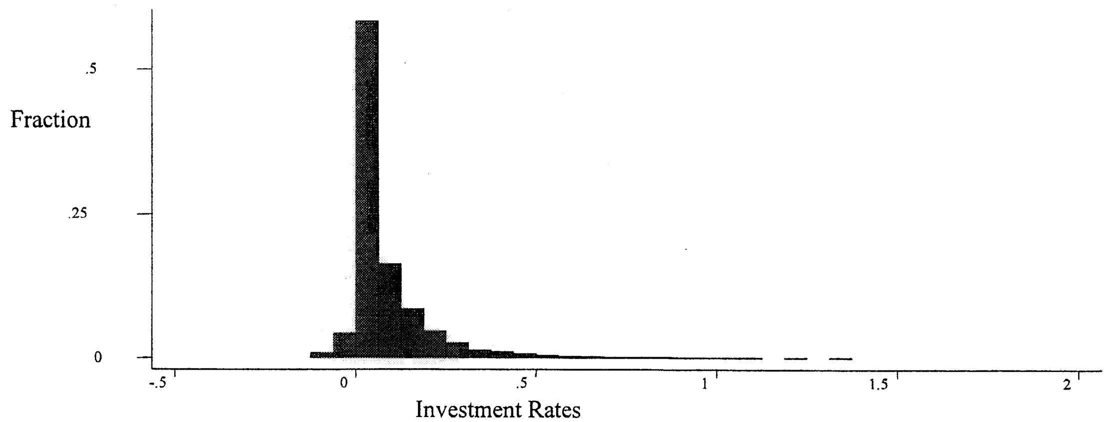
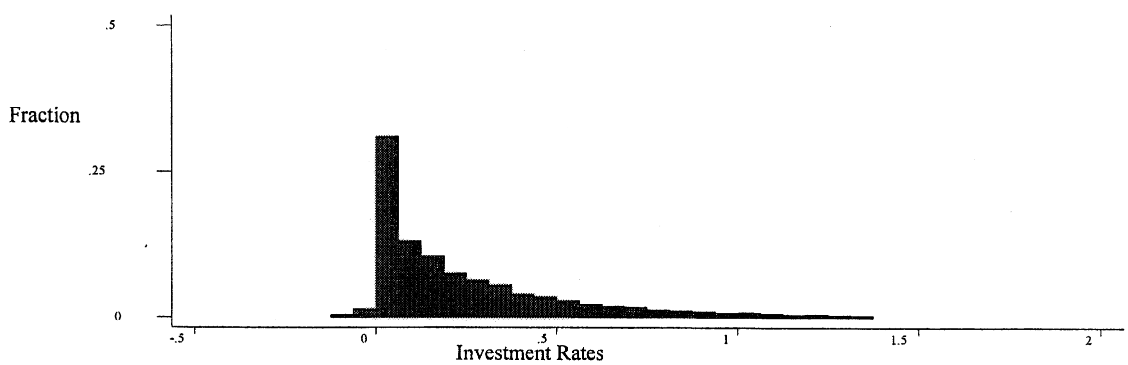


Figure 19. Colombia: Distribution of Actual Equipment Investment Rates for High Mandated Investment Rates



VI. Conclusion

Investment patterns in the Colombian and Mexican manufacturing sectors resemble each other and are in many respects surprisingly similar to those found in the United States and Norway. Capital expenditures are lumpy, with periods of inactivity followed by investment spikes. Plants sell fixed capital very rarely; instead, they reduce their capital stocks to lower desired levels only by letting them depreciate. In the Colombian case, and to a lesser extent in Mexico, the varying degree of concentration of such spikes is very important for explaining movements in aggregate sectoral investment.

Irreversibilities appear to be even more important in the two cases studied than in the United States. This finding is not surprising, given that secondary markets for capital goods are thinner in developing countries. While the evidence regarding the presence of irreversibilities is very strong, the results regarding the importance of nonconvexities such as fixed costs are less clear-cut. Estimates of the average adjustment function clearly point to the importance of irreversibilities, but it is not clear from this empirical exercise if fixed costs of investment are also relevant. On the other hand, whereas the estimated hazard functions are mostly flat or downward sloping, the procyclicality of investment spikes is consistent with the predictions of a model with fixed adjustment costs. Overall, the patterns reported for capital adjustments in United States manufacturing appear to represent, at least in this sector, general regularities of investment, and not features particular to a single country.

The evidence presented in this paper supports the notion that a disaggregated view of the economy is necessary to understand investment behavior. The nonlinearities revealed in the two countries analyzed here suggest that, in order to make predictions concerning the likely response of aggregate investment to economywide shocks, knowledge about the history of cross-sectional shocks is necessary. For example, it is likely that a series of bad shocks, such as experienced by Mexico during the eighties, affected the plant-level distribution of desired and actual capital stocks in such a way as to render the response to positive changes in macroeconomic conditions initially very weak. This may contribute to the explanation of the slow response of investment to the macroeoconomic adjustment program implemented in Mexico in the late eighties.

CONSTRUCTION OF THE VARIABLES

Capital Stock: Both the Mexican and the Colombian surveys include replacement cost values for five categories of fixed assets: machinery equipment, buildings, land, transport equipment and other (office equipment for Colombia). Because these values are affected by inflation a possibly large accounting depreciation rates, we decided to use a variant of the permanent inventory method to compute capital stocks. The usual perpetual inventory method takes an initial value of capital, usually, the book value of the first year of each plant in the survey, to construct all subsequent values. However, these book values could potentially yield estimates that are too low. For example, accounting depreciation may be faster than economic depreciation for tax purposes. Additionally, if the book value is not adjusted for inflation, the real book value will be reduced quickly in a context of high inflation. On the other hand, firms are often required to update their book values to the market value by law. Therefore, even if the initial book value can be a poor proxy for the actual capital stock, chances are that at least some subsequent book values may be a better proxy for the capital stock at a later date.

In order to exploit such information, and assuming that the book value at time *t* represents a lower bound for the actual capital stock ($BV_t \leq K_t \ \forall t$), we improve upon the traditional perpetual inventory method with the following two-step procedure:

1) Set $K^1_0 = BV_0$ and compute

2) Set $K_T = K^1_T$ (where T is the last year in the sample) and compute

The first recursion captures any possible update in the book value of capital during the sample period. The second recursion updates the values of the capital stock that preceded the update, so that the final series will be consistent with the standard permanent inventory method while including a better estimate for the initial capital stock.

While for land, zero depreciation was assumed, a rate of 4 percent was chosen for buildings and 7 percent for all other asset categories. For Mexico we used the following price deflators: producer price indices for machinery and construction, a land price index for Mexico City, and the wholesale price index for Mexico City. For Colombia we used implicit GDP prices for machinery, transportation equipment, and construction.

Investment: Investment is defined as purchases minus sales of used and new assets plus improvements on existing assets plus capital assets produced for own use. For Mexico, machinery and transport equipment investment were deflated by the mid-year machinery price index, other investment by the mid-year wholesale price index, purchases of land by the mid-year Mexico City Land Price Index, and expenditures on construction by a construction mid-year price index. For Colombia, machinery and office equipment were deflated with the machinery price index, transportation investment by the transportation price index, and construction and land investment by the construction price index.

Price indices: All price indices were obtained from Banco de México and Banco de la República (Colombia).

The following method was used to eliminate outliers: Establishments with zero or missing capital or that reported values for total investment of less than - 90 percent or larger than 200 percent were eliminated from the sample.

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