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PRODUCTIVITY DYNAMICS OF THE COLOMBIAN MANUFACTURING SECTOR

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Abstract

This paper analyzes the effects on Colombian manufacturing productivity of tax and foreign trade policy changes during the 1990s. Our results indicate that between 1977 and 1999, aggregate manufacturing productivity largely stagnates and even declines in some of the larger industries. There is little entry and exit of plants or reallocation of labor. The productivity stagnation can be explained by this lack of liquidation of unproductive plants combined with slow technological advance. Dynamics vary significantly across sub-sectors, however, and our findings attribute this variation primarily to within-sector output reallocation. The importance of industrial policy is large. Sector-level productivity declines coincide with protectionist policies in the form of import tariffs or beneficial tax treatments, while higher productivity levels are correlated with sectors' increasing foreign exposure. Our finding of small productivity effects of preferential treatments further points to the insignificant role played by output reallocation across plants in stimulating productivity growth.

Key words**:** Productivity dynamics, manufacturing sector, preferential treatments, tax exemptions.

JEL Classification: C14, C23, D24, F13, H3, L6.

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I. Introduction

The 1990s have seen the liberalization of foreign trade in a large number of countries, including most Latin American countries. These liberalization programs provide ideal settings for assessing the impact of such policy reforms on industry productivity to answer the question of whether – and if so why – openness to trade leads to productivity growth.[1] The theoretical literature suggests several avenues through which trade liberalization may affect productivity. Increased access to imported materials and equipment may allow firms to raise efficiency through technological improvements. The removal of barriers to trade may furthermore increase product market competition due to the market interaction of domestic products with foreign imports. Increased competition could affect firms' productivity in two ways. On the one hand, competition may spur firm innovation to enable domestic producers to compete on equal grounds with potentially higher-quality or cheaper imports. Increased competition could also lead to a reallocation of output from less to more productive firms by forcing the least productive firms to exit the industry.

The first two channels lead to productivity growth by affecting technological change, in the form of technological progress, learning by doing, or product and process innovation. Technological progress raises firm productivity indiscriminately and, consequently, industry-level productivity increases. The last channel leads to industry-level productivity increases without intra-firm efficiency increases, but through a selection effect that allows more productive firms to survive and grow in open markets, while the less productive firms contract. Regardless of channel, though, not only is industry productivity affected, there are also potentially serious implications for factor markets. Industry productivity growth due to technological improvements across firms may lead to the partial displacement of labor within firms, in particular if growth arises from skill-biased or labor-augmenting technological progress. Productivity growth

[1] Work that studies the link between trade liberalization and productivity growth includes cross-country comparisons (Sachs and Warner 1995), sector-level studies such as Keller (2000) and Kim (2000), and plant-level analyses that will be discussed in greater detail below. For a review of the latter branch of the literature, see Tybout (2001).

through exit of less productive firms entails the displacement of the entire workforce of the exiting plants. Isolating the sources of productivity growth is therefore also of importance in assessing the broader welfare effects of trade reforms.

This paper analyzes the role of policy reforms in shaping industry productivity using the case of the Colombian manufacturing industry over the time period from 1977 to 1999. We estimate plant-level total factor productivity for 21 three-digit manufacturing industries using the estimation framework suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2002).[2] We then provide empirical evidence about the role of industrial policy in contributing to the characterization of productivity growth in the Colombian manufacturing sector.

The sample period covers various policy regimes, including a tightening of foreign trade policies in the mid 1980s, followed by extensive trade liberalization in the early 1990s, which was partially reversed beginning in 1995. The data thus allows us to not only study the immediate effect of trade liberalization, but also the extent to which productivity effects are sustained in the face of reform reversal. In recognizing that exposure to foreign competition is but one aspect of firm competition that government policies affect, we depart from prior work in this area (among others, Pavcnik 2002, Fernandes 2002, and Muendler 2002) in assessing the effect of targeted tax cuts and other preferential tax treatments implemented during the later part of our data set on productivity evolution. The productivity effects of governmental tax reform packages are ambiguous. On the one hand, preferential tax treatments may stimulate investment or provide protection to industries that are susceptible to dynamic learning-by-doing effects. On the other hand, to the extent that such policies reduce competition and the incentive to innovate, industry productivity may stagnate or fall if inefficient firms are sheltered from market forces.

[2] Olley and Pakes (1996) examine productivity dynamics in the U.S. telecommunications equipment industry and analyze the effect of deregulation and technological change on productivity. Based on Chilean data, Levinsohn and Petrin (2002) investigate the role in Chilean productivity dynamics of intra-firm productivity improvements relative to productivity gains caused by firm turnover.

The empirical evidence on the importance of the various trade policy channels is mixed. A number of studies have pointed to the importance of foreign competition in generating intra-firm efficiency gains. In looking at the trade liberalization measures put in place in Chile during the late 1970s, Pavcnik (2002) finds significant productivity improvements in import-competing sectors by up to 10.4% in response to liberalized trade. Furthermore, these productivity differentials become more pronounced over time, suggesting persistent consequences for liberalization programs. Tybout and Westbrook (1995) and Muendler (2002) find similarly strong effects of foreign competition on productivity for Mexico during 1986 to 1990 and Brazil from 1986 to 1998. Only Muendler finds that firm turnover significantly contributes to industry productivity gains in the long run through an increased likelihood of exit by less efficient plants. Lopez-Cordova (2003), a study of the productivity effects of NAFTA on Mexican manufacturing from 1993 to 2000, is a second example where plant turnover is found to significantly contribute to productivity gains. He presents evidence that suggests that increased investment exposure and reduced barriers to trade with the United States channel these productivity gains.

The Colombian manufacturing sector is the subject of several studies using earlier waves of the plant-level database employed in this paper. Lui and Tybout (1996) examine Colombian plant-level productivity during 1981 to 1989 and find that exiting plants are, on average, significantly less productive than incumbents. The productivity of an exiting plant furthermore deteriorates several years before the plant actually exits.

Fernandes (2002) explores whether increased exposure to foreign competition generates gains in Colombian plant-level productivity for the period 1977 to 1991. She finds a strong, negative relationship between lagged nominal tariffs and plant productivity that is more pronounced for larger plants or those in more concentrated industries. Most of the important labor market, financial, tax, and trade reforms that were undertaken by Colombia in recent years are unfortunately not covered by her data.

The impact of the wide-ranging policy reforms of the 1990s on firm productivity and reallocation of output and inputs has, so far, received less attention. A series of papers by Kugler (1999) and Kugler and Kugler (2002) presents a notable exception. Based on a rich panel data set for the period 1982 to 96, the authors investigate the effect of both gradual and sudden increases in pay-roll taxation during the sample period on the composition of firms' labor forces and wages. Their findings indicate that payroll taxes are only partially shifted to workers in the form of lower wages. We build on their work, but focus on different aspects of the Colombian policy reforms, namely the impact of foreign trade and tax reforms.

Section II introduces the data, while section III summarizes the empirical methodology used to estimate productivity. Section IV summarizes the production function estimation results. Section V relates the estimated productivity measures to trade and tax reforms that went into effect during the sample period. Lastly, section VI concludes. Appendix A contains a summary of the data used in the study, whereas Appendix B contains the supporting tables.

II. Data Sources and Summary Statistics

Our primary data source is the Annual Manufacturing Survey of Colombia ("*Encuesta Annual Manufacturera*," henceforth EAM) collected by the Colombian Statistical Office DANE.[3] The available data from the Annual Manufacturing Survey extends from 1977 to 1999. The survey represents a complete Census of the manufacturing sector, which accounts for approximately 15% of Colombian GDP. According to the EAM, the largest sectors, Textiles and Food Processing, together comprise 45% of manufacturing plants and employment. From 1977 to 1999, the manufacturing sector overall has doubled its real output; however, as measured in terms of either plant count or employment, it has grown in size only by approximately 18% implying significantly rising labor productivity.

[3] DANE granted access to the data under an Inter-Institutional Cooperation Agreement between DANE and CEDE at the Universidad de los Andes.

The later analysis investigates the sources of this output growth to determine whether it is driven by rising (total factor) productivity or simply by a reallocation of resources away from labor towards other inputs into production.

The EAM has several limitations for empirical analyses. First, not all surveyed plants enter DANE's official database. To be included in the official database, a manufacturing plant must report either an employment level at or above 10 employees or a production level that exceeds a cutoff value set by DANE.[4] This selection procedure entails difficulties in defining plant entry and exit since the (dis-) appearance of a plant in the official database does not necessarily correspond to the formation (liquidation) of a plant. For plants with close to 10 employees, entry and exit rates are thus likely to be overestimated. To correct for this possible overstatement of plant turnover, we use only those plants with a workforce of 15 or more employees in at least one of two adjacent years, either at time *t* or time *t*-1.

A second shortcoming of the data's value for panel analyses is caused by difficulties in uniquely identifying plants across survey years due to the introduction of a new plant identification method in 1992.[5] A large fraction of plants have been traced manually across years. Table 1 illustrates, however, that the data continues to exhibit unnaturally large amounts of exit in 1991 paired with excess entry in 1992, introducing noise into the statistics for these two years. It presents a breakdown of the manufacturing sector into entering, exiting and continuing plants. Overall, the manufacturing sector remains relatively stable over time, with a high percentage of continuing plants each year. These plants hold more than 90% of total employment over the time period. After 1995, the number of exiting plants systematically exceeds the number of entrants; at the extreme is 1998 where only 263 entrants replace 649 exiting plants.

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[4] One exception to this selection rule has been in place since 1992 whereby all plants belonging to a multi-plant firm are included in the official database, regardless of size or production levels.

[5] In 1992 and again in 1993, the classification system that is used to assign plant identifiers and the rules by which a plant is included in the official database change significantly. These methodological changes make the tracking of each plant over time difficult. By manually tracing plants through the survey waves, most plants' histories have been successfully identified, however.

Table 2 further explores the characteristics of entrant and exiting plants in relation to incumbents. Entry and exit rates follow a pattern similar to that of overall economic activity, with higher entry and lower exit rates during periods of economic growth and the opposite during periods of economic slowdown. Average entry and exit rates over the period are very similar amounting to 9.1 and 9.2%, respectively. Measured both in terms of output and employment, entering and exiting plants are, on average, smaller than incumbents, however, so that based on size measures, they account for significantly less than 9% of sector activity. Relative to incumbents, entrants contribute on average 2.7% of annual output and 4.2% of employment. Exiting firms contribute on average a similar proportion of output during the year before exit and represent only a slightly higher fraction of incumbent employment with 4.7%.

The final data set consists of an unbalanced panel of 12,084 manufacturing plants amounting to 97,346 plant-year observations. Only 926 plants survive from the first survey in 1977 until the end of the data in 1999. For each plant-year observation, various additional plant characteristics, such as the plant's manufacturing sub-sector, its incorporation status, and its age, are available in addition to input choices and output. Appendix A contains a more detailed description of the data set construction.

III. Productivity Estimation

Since total factor productivity (TFP) is not directly observable, a variety of frameworks have been developed to infer a firm's underlying productivity level from observable input and output data. The various ways of estimating total factor productivity as the residual in the production function differ vastly in approach and, potentially, outcome. In its simplest form, the production function can be estimated using OLS or panel fixed effects techniques. Since input choices are likely to be correlated with unobserved productivity, however, a simultaneity bias is introduced into the OLS estimates that can be addressed by using an instrumental variables estimator. In the case of plant-level data, valid instruments are scarce. As an alternative to instrumental variables, the recent literature has put forth semi-parametric estimation techniques that rely directly on the dynamic nature of the underlying plant decision problem, which drives revealed input and output outcomes. The estimation procedure employed in this paper applies this framework suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2002) in estimating the production function coefficients and subsequently deriving estimates of the underlying TFP series. As a comparison, we also present results from alternative estimation procedures. We begin with a brief summary of the main estimation framework.

We assume that the industry produces a homogeneous product with Cobb-Douglas technology and that the factors underlying profitability differences among plants are Hicks-neutral efficiency differences. The plant's decision problem is one of intertemporal profit maximization where profits depend on the plant's state variables, here the capital stock K_t and the plant's productivity ω_t; prices; and the plant's input choices. Output is thus determined according to the following logarithmic production function:

$$\begin{aligned} y_t &= \beta_0 + \beta_k k_t + \beta_l l_t + \beta_e e_t + \beta_m m_t + u_t \\ u_t &= \omega_t + \varepsilon_t \end{aligned} \qquad \mathbf{1}$$

where y_t denotes the log of output, k_t represents the log of capital, l_t is the log of the number of employees, e_t is the log of electric energy consumption, and m_t denotes the log of intermediate input consumption. The econometric error, u_t, accounts for differences between predicted and actual production levels. It consists of two components, the unobserved productivity index ω_t and a mean-zero error ε_t representing measurement error or unexpected productivity shocks.

The plant's inter-temporal maximization problem yields demand functions for investment and intermediate inputs as a function of unobserved productivity.[6] The innovation of this approach lies in using either of these demand functions as a proxy for ω_t in the plant's

[6] See Olley and Pakes (1996) and Levinsohn and Petrin (2002) for more detail on the dynamic maximization problem.

production function. We follow Levinsohn and Petrin (2002) in working with the intermediate input demand function,

$$m_t = m_t(\omega_t, k_t). \qquad 2$$

For positive intermediate input choices, the intermediate input demand function can be inverted to yield:[7]

$$\omega_t = g_t(m_t, k_t)$$

and

$$y_t = \beta_0 + \beta_k k_t + \beta_l l_t + \beta_e e_t + \beta_m m_t + g_t(m_t, k_t) + \varepsilon_t \qquad 3$$

The economic intuition behind the intermediate input demand function and its inversion, equations 2 and 3, is the following. Consider a plant with a high productivity in the current period. For price-taking plants, a higher level of productivity implies a higher marginal product of capital. In response, the plant produces more output until the marginal product of capital falls to the point where it again equals its rental rate. To increase output, the plant increases all inputs including intermediate inputs. A high intermediate input usage thus reveals a more productive plant.

If the functional form of g_t were known, the coefficients could be estimated via OLS. Instead, estimation proceeds in two steps. In the first step, consistent estimates for the variable input coefficients are derived from the partially linear model in equation 3. We initially estimate the conditional expectations $\mathrm{E}[y_t \mid k_t, m_t]$, $\mathrm{E}[l_t \mid k_t, m_t]$, and $\mathrm{E}[e_t \mid k_t, m_t]$. Subtracting these expected output and variable input measures from equation 3 results in:

$$y_t - \mathrm{E}[y_t \mid k_t, m_t] = \beta_l(l_t - \mathrm{E}[l_t \mid k_t, m_t]) + \beta_e(e_t - \mathrm{E}[e_t \mid k_t, m_t]) + \varepsilon_t \qquad 4$$

[7] The main empirical advantage of using intermediate inputs rather than investment as a proxy for productivity is that most plants consume positive amounts of intermediate inputs, whereas a large fraction of the plants in our data does not make strictly positive investment choices.

Estimating equation 4 via OLS yields consistent estimates of β_l and β_e.[8]

In the second step, the estimated variable input coefficients are substituted into the production function,

$$y_t - \hat{\beta}_l l_t - \hat{\beta}_e e_t - \beta_k k_t - \beta_m m_t - \mathrm{E}[\omega_t \mid \omega_{t-1}] = \xi_t + \varepsilon_t \,, \qquad 5$$

assuming that ω_t evolves according to a first-order Markov process, $\omega_t = \mathrm{E}[\omega_t \mid \omega_{t-1}] + \xi_t$, with a mean-zero innovation ξ_t. The components of the conditional expectation $\mathrm{E}[\omega_t \mid \omega_{t-1}]$, which equals $\mathrm{E}[\omega_t + \varepsilon_t \mid \omega_{t-1}]$, can be approximated by:

$$\omega_t + \varepsilon_t = y_t - \hat{\beta}_l l_t - \hat{\beta}_e e_t - \beta_k k_t - \beta_m m_t$$

and

$$\omega_{t-1} = \hat{\phi}_{t-1}(m_{t-1}, k_{t-1}) - \beta_k k_{t-1} - \beta_m m_{t-1}.^{9} \qquad 6$$

The function $\hat{\phi}_{t-1}(m_{t-1}, k_{t-1})$ equals $\mathrm{E}[y_{t-1} - \hat{\beta}_l l_{t-1} - \hat{\beta}_e e_{t-1} \mid k_{t-1}, m_{t-1}]$. It is estimated separately in the first step for the two time periods 1977-91 and 1992-99 to account for the exogenous variation in the capital series brought about by methodological changes in the EAM in 1992 (see discussion below) and to acknowledge structural changes in the economy that may have affected the performance of the manufacturing sector.

Finally, equation 5 is estimated via Generalized Method of Moments, using as moment conditions the requirements that $\mathrm{E}(\xi_t + \varepsilon_t \mid k_t) = 0$ and $\mathrm{E}(\xi_t + \varepsilon_t \mid m_{t-1}) = 0$. The moment conditions rely on ξ_t being mean-independent of variables known at the beginning of the period, that is the capital stock, k_t, and the choice of intermediate inputs in the previous

[8] Various alternative semi-parametric estimators could be employed to estimate β_l and β_e.
[9] An estimate of $\mathrm{E}[\omega_t \mid \omega_{t-1}]$ can then be derived by regressing $\omega_t + \varepsilon_t$ on ω_{t-1}.

period, m_{t-1}.[10] Estimates of β_k and β_m are obtained by minimizing the GMM criterion function $Q(\beta_k, \beta_m)$:

$$Q(\hat{\beta}) = \min_{\hat{\beta}} \left(\xi(\hat{\beta}) + \varepsilon(\hat{\beta})\right)' Z\, (Z' \Sigma Z)^{-1} Z' \left(\xi(\hat{\beta}) + \varepsilon(\hat{\beta})\right) \qquad 7$$

where the error vectors $\xi(\hat{\beta})$ and $\varepsilon(\hat{\beta})$ are stacked over plant and year observations from the second to the last year in which a plant is observed in the data, Z denotes the instrument matrix of lagged intermediate inputs and current period capital values, and Σ is the estimated variance-covariance matrix of $(\xi(\hat{\beta}) + \varepsilon(\hat{\beta}))$.

IV. Estimation Results

We estimate production function parameters at the three-digit ISIC level to analyze as homogenous a sample of producers as possible given that the underlying theoretical model applies to homogeneous product industries. The unit of observation is a plant-year combination. We use the plant's annual value of production measured in millions of peso as our output variable.[11] Inputs into production are specified to be the plant's total number of employees, its annual electric energy consumption measured in kilowatt, total annual expenditures on raw materials measured in millions of peso, and the plant's capital stock in millions of peso. The EAM explicitly asks each plant to report the market value of its capital stock, allowing us to circumvent the perpetual inventory method or related approaches to construct plant-level capital stocks. We correct the reported capital stock measures for inflation adjustments that are added to each plant's capital stock beginning in 1994.[12] Nominal variables in current peso are converted to 1999

[10] We obtain starting values for β_k and β_m by estimating the production function via OLS, substituting the consistently estimated first-stage estimates for β_l and β_e . Throughout the estimation routine, all conditional expectations are estimated via locally weighted least squares. Levinsohn and Petrin (2002) contains a step-by-step outline of the estimation.

[11] We follow the literature in estimating an output-based production function instead of its value-added counterpart since using value added as the measure of the plant's production imposes the separability of intermediate inputs from total production.

[12] The methodological changes introduced to the EAM in 1992 and 1993 affect the reported capital series in other dimensions as well. From 1994 onwards, a plant's reported capital stock includes inflation

peso using corresponding price deflators. Appendix A contains a more detailed definition of individual variables.

Table 3 presents summary statistics for the variables used in estimation, aggregated to the two-digit ISIC sector level. The largest sectors in terms of number of plants are the Food Processing, Textiles, and Machinery sectors. Inputs and output differ systematically across sectors, justifying the division of the sample into sector-level sub-samples during estimation. Food Processing, for example, continues to be among the largest sectors in terms of average annual output and employment, similar to the Chemicals sector that, however, exhibits a less skewed distribution of average plant employment at higher employment levels. Sectors differ most significantly in their energy consumption ranging from energy-intensive sectors such as the Basic Metals sector to labor-intensive sectors such as Textiles and Leather. Across inputs, median input consumption falls short of mean input levels, indicating the presence of a large number of smaller plants operating in sectors with fewer large plants.

Table 4 contains the parameter estimates for the two-stage estimation procedure outlined above using material inputs as a proxy for unobserved productivity. Coefficients are precisely estimated at standard levels of statistical significance with the exception of the capital coefficient that is frequently insignificant under the Levinsohn-and-Petrin estimator. The insignificance of the capital coefficient may be due to artificial variation in the capital series introduced by the methodological changes in the EAM after 1992.[13]

Across industries there is significant variation in the partial elasticity of output with respect to each of the inputs. The average output elasticity with respect to labor equals 0.30, with respect to energy consumption 0.08, with respect to materials 0.55, and with

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adjustments and investment is recorded at book value to more closely reflect accounting standards of investment rather than representing actual investment outlays. The EAM does not retain the difference between book and market values as a separate variable and we consequently cannot adjust for it in the empirical analysis. Applying the perpetual inventory method to the capital stock beginning in 1994 is infeasible since it frequently yields negative values for the capital stock.

[13] Note that we acknowledge the structural change in the capital series in the first stage of the estimation procedure by allowing for a break in the estimated residual output contribution of capital and materials in 1992. This may not be sufficient, however, to fully remove all artificial capital fluctuations.

respect to capital 0.08. In comparison to the average share of capital in total production cost depicted in Table 4,[14] the estimated capital coefficients are thus low. They are in line, however, with production function estimates found in Fernandes (2002) who studies Colombian productivity over the period 1977-1991. Similar to our results, she finds capital coefficients ranging from 0.03 to 0.11 using OLS and from 0.01 to 0.13 using the Levinsohn-and-Petrin estimator. The most variation in elasticities across sectors occurs for materials, as measured by the standard deviation normalized by the mean of the input's estimated elasticity across sectors.

To justify the use of raw material expenditures as a proxy for unobserved productivity ω, we verify that the estimated productivity series, $\hat{\omega}$, satisfies the properties of a valid proxy assumed by the underlying economic model. In particular, the plant's inter-temporal profit maximization problem yields a monotone policy function with productivity being increasing in the materials proxy for a given level of the capital stock. This property holds across sectors for the empirical relationship between plant-level ω and raw material expenditures. In 18 out of the 21 sectors, a regression of $\hat{\omega}$ on m and k indicates on average a positive relationship between productivity and raw materials usage, controlling for the plant's capital stock, thereby validating the use of the materials proxy.[15,16]

Table 4 furthermore compares the production function coefficients generated by the nonparametric estimator to those obtained from alternative production function estimation methods. We estimate sector-level production functions using ordinary least squares and plant-level fixed effects. Both regressions include an indicator variable to control for the structural break in the capital series after 1992. The results allow us to investigate the extent to which simultaneity present in plants' input choices affects the

[14] The input shares shown in Table 4 represent average cost shares for the period 1981-'93 since DANE collected electricity expenditures (as opposed to electricity usage in kilowatt) for this smaller sub-sample of the data only. The cost shares may therefore not accurately reflect average input shares for the full sample.

[15] The relationship does not hold for the Tobacco, Petroleum, and Transport Equipment sectors.

[16] Levinsohn and Petrin (2002) suggest further specification tests of the intermediate input proxy for productivity.

production function parameters under traditional estimation methods. Simultaneity biases may arise if plants' input choices are responsive to unobserved productivity shocks. Andrews and Marschak (1944) suggest that simultaneity biases may be most severe for inputs that adjust rapidly. Under OLS, estimates of the coefficients on variable inputs are then likely to be biased upwards. If capital as a quasi-fixed input is uncorrelated or only weakly correlated with the unobserved productivity shock, the OLS estimate of the capital coefficient is furthermore likely to be biased downward. The estimated variable-input coefficients are largely consistent with this intuition. The OLS coefficient exceeds its semi-parametric counterpart in 16 out of 21 sectors for labor, in 17 out of 21 sectors for energy, and in 13 out of 21 sectors for material inputs. The OLS estimate of the capital coefficient, however, is smaller than the Levinsohn-and-Petrin estimate in only 8 out of 21 sectors. This is not surprising in light of the imprecisely estimated capital coefficient using the Levinsohn-and-Petrin estimator. Future work will compare the distributions of the capital coefficient under the two estimators in more detail, using bootstrapping techniques to generate an empirical distribution for the capital coefficient.

Given production function estimates, a measure of total factor productivity at the plant level can be inferred as

$$T\hat{F}P_{it} = \exp(y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_e e_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_k k_{it}) \qquad \mathbf{8}$$

Annual sector-level productivity $T\hat{F}P_t$ can then be constructed as a weighted average of each plant's productivity measure, using output shares as weights. Table 5 summarizes the manufacturing sector productivity index derived from the Levinsohn-and-Petrin estimation methodology. The first column contains an output-weighted average of productivity aggregated across industries that is normalized to one in 1977. Normalization allows us to more clearly track the path followed by productivity with respect to a fixed point in time and across sectors.

During the twenty-year period of our sample, manufacturing productivity has remained fairly stable. The early 1980s see a fall in productivity relative to 1977, which is reversed during the second half of the 1980s and early 1990s, the period of wide-ranging foreign trade reforms. By the end of the 1990s, however, productivity returns to its earlier levels, possibly caused by the economic slowdown during that period. By the end of the data set in 1999, aggregate manufacturing productivity has fallen below its 1977 level.

This pattern holds for both output-weighted average productivity and un-weighted average productivity displayed in the table’s second column. Un-weighted productivity is smaller than output-weighted productivity, indicating the higher productivity of larger plants. In general, the productivity distribution is highly skewed as shown by a below-average median productivity and a large standard deviation. Changes in un-weighted average productivity reflect primarily the effect of technological change. Relative to 1977, un-weighted average productivity declines more steeply than output-weighted productivity and fails to return to its 1977 level throughout the sample period. Productivity stagnation arises therefore in part from a slow-down of technological change.

Last, Table 5 compares the evolution of total factor productivity to real labor productivity. Labor productivity increases dramatically and continuously over the entire sample period. By 1999, it has increased by 71.1% relative to 1977. A significant fraction of the gains in labor productivity arise during the economic slow-down of the 1990s, a period of shrinking employment, but constant or slowly increasing output. The starkly different picture that results from the TFP measures suggests a substitution away from labor to other inputs allowing output and TFP to remain virtually unchanged, while labor productivity increases.

A breakdown of productivity levels by two-digit ISIC industry reveals more nuanced productivity dynamics across manufacturing industries. Figure 1 depicts 2-digit sector level productivity growth rates obtained from the three alternative productivity estimation methods in Table 4, as well as labor productivity. The figure illustrates that across sectors, annual productivity growth rates fluctuate significantly.[17] The productivity growth paths derived from OLS are very similar to those based on the Levinsohn-and-Petrin estimator. The correlation between the two growth series ranges from 0.91 to 0.99 across sectors. In contrast, the labor productivity growth paths differ most significantly from the TFP-based productivity growth series. The correlation coefficient between the labor productivity growth series and the Levinsohn-and-Petrin TFP growth series, for example, ranges from 0.23 to 0.66 in the 2-digit sectors, and similar correlation coefficient ranges obtain when comparing labor productivity to OLS-based and fixed effects-based total factor productivity.[18]

To understand differences in productivity dynamics across sectors, we decompose productivity changes following Foster, Haltiwanger, and Krizan (2001) into the contribution of continuing, entering, and exiting plants:

$$\begin{aligned}\Delta T\hat{F}P_t = & \sum_{i\in \text{Cont}} \theta_{i,t-1}\Delta T\hat{F}P_{it} + \sum_{i\in \text{Cont}} \Delta\theta_{it}(T\hat{F}P_{i,t-1} - T\hat{F}P_{t-1}) + \sum_{i\in \text{Cont}} \Delta\theta_{it}\Delta T\hat{F}P_{it} \\ & + \sum_{i\in \text{Ent}} \theta_{it}(T\hat{F}P_{i,t} - T\hat{F}P_{t-1}) + \sum_{i\in \text{Exit}} \theta_{i,t-1}(T\hat{F}P_{i,t-1} - T\hat{F}P_{t-1})\end{aligned} \qquad 9$$

The first or within term measures the contribution to total productivity change of within plant productivity changes, weighted by the plant's output share of the previous year, $\theta_{i,t-1}$.

[17] We find that high variations in the pattern followed by the productivity indices of some sectors often respond to the atypical behavior of a single large plant in a specific year. This is true in particular for the Textiles sector. While this may be due to misreported information, we have chosen to keep such plants in the database unless the data error is completely evident.

[18] Syverson (2001) points out that productivity measures may be biased if the production function estimation does not account for the possibility of demand shocks that induce cross-plant variation in investment or materials demand. These would manifest themselves in significant dispersion in the productivity residuals even for homogeneous sectors. To gauge the size of the potential bias due to unexplained demand variation, we compare the observed residual dispersion across industries that vary in the degree of heterogeneity of their products, using one of the internally less homogeneous 2-digit sectors, the Food Processing sector, as a case study. We derive TFP estimates for each of the 4-digit industries based on separate estimations and compare the resulting dispersion in productivity residuals across industries. On average, more heterogeneous industries display higher degrees of dispersion in TFP than homogeneous food industries. These dispersion statistics are more consistent with differing degrees of product differentiation across industries than with the presence of plant-specific demand variation, alleviating some of the concerns about potential biases in the TFP measures. Results are available from the authors upon request.

The between plant component of productivity changes captures changing output shares of firms, weighted by the deviation of plant productivity from industry productivity. An increase in a plant's output share will thus only contribute positively to the industry's overall productivity evolution if the plant's productivity exceeds the industry average. The third term measures the covariance between plants' output share changes and productivity changes. The final components of the decomposition are the productivity contributions of entering and exiting plants.

Table 6 contains the results of the above decomposition for the manufacturing sector as a whole as well as for 2-digit industries, broken into sub-periods. The sub-periods correspond to the regime of high trade protection from 1977 to 1984, followed by a prolonged period of liberalization from 1985 to 1995 that accelerates during the early 1990s, and finally a partial reversal of reforms from 1996 to 1999. Across sectors, the initial period is marked by negative or very small positive annual growth rates, with the exception of the Glass sector, the only sector that displays sustained productivity growth throughout the sample period. The period of policy reforms is, on average, associated with positive growth rates, in particular for the Textiles, Paper, Basic Metals, and Machinery sectors. Finally, the most recent experience of the manufacturing sector indicates a renewed drop in productivity growth rates, frequently to negative levels. This trend is particularly strong in the Textiles and Machinery sectors, whereas the Wood, Chemicals and Glass sectors experience only a slight fall in annual productivity growth rates. Averaged over the period, the Textiles, Glass, and Basic Metals sectors exhibit large, positive growth rates, while in particular the productivity of the Food Processing sector shrinks steadily.

The productivity decomposition indicates that at the aggregate level, the evolution of productivity derives primarily from a continued erosion of within-plant productivity by continuing firms, indicating a lack of technological advance at the plant level. Both the within and between components of productivity change are negative for the manufacturing sector as a whole, while the covariance between productivity and output changes is positive indicating that the drop in within-plant productivity is countered by the reallocation of resources and output to more productive plants. Relative to the contributions to productivity growth by continuing plants, the effect of entry and exit on overall productivity growth is quite significant, in particular during the early and late periods of tighter international trade policy.

A significant fraction of the overall entry and exit contributions is attributable to the behavior of the Food Processing sector, one of the largest manufacturing sectors. The continued negative growth experienced by the Food Processing sector arises due to the exit of plants that contribute positively to the evolution of productivity, while less productive plants enter. The experience of the Food Processing sector is unusual, however, and the following section analyzes the degree to which it can be explained by preferential tax treatments in place for the sector.

V. The Effect of Preferential Treatments on Productivity

V.1. Preferential Treatments through Tariffs and Tax Benefits in Colombia, 1979-1999

V.1.1 *Protection through Tariffs*

Prior to 1990, Colombian trade policy is directed at protecting the economy to promote growth through import substitution and to diversify exports away from primary goods. Import quotas in particular drive up domestic prices during this period. Both the implicit tariff levied on imports (the implicit import cost in the form of security deposits with the Colombian Central Bank) and price levels in heavily protected sectors peak in the beginning of the 1970s and again in the second half of the 1980s. Subsequent dramatic trade liberalization measures in the early 1990s cause import restrictions at the aggregate manufacturing sector level to fall to their lowest values over the last 25 years.

The liberalization of the early 1990s does not, however, apply uniformly to all manufacturing sectors. Table 7 compares average effectively paid tariff rates at the three-digit ISIC level in the pre-1990 period to the equivalent measure during the post-1990 period of liberalization. The tariff rates are constructed from three-digit ISIC level data obtained from DANE on the monetary value of imports and the corresponding effective tariff payments for the sample period from 1977 to 1999. Tariff rates averaged across sectors fall by 8.6 percentage points from an average of 18.7% over the period 1977-89 to on average 10.2% over the period 1990-99. Some of the more heavily protected industries include the Glass and Machinery sectors (two-digit ISIC sectors 36 and 38 respectively) with a majority of three-digit ISIC sub-sector tariff rates exceeding 25% between 1977-89. The Machinery sector subsequently experiences one of the highest degrees of liberalization with a decrease in tariff rates within the sector of on average 60.7%.

Figure 2 displays the time series of tariff rates aggregated to the two-digit ISIC level. The figure underlines the stark decline in tariff rates in the early 1990s. It also emphasizes, however, that for a number of sectors, the significant tariff reduction of the early 1990s is later reversed through renewed tariff rate hikes. In most cases, however, tariff rates do not return to their pre-1990 levels by 1999.

V.1.2 *Tax Benefits*

The Colombian tax structure includes a significant number of exceptions for specific plants and industries, such as tax exemptions, discounts, and deductions, which not only make the tax system complex and administratively burdensome, but also lead to the erosion of important sources of fiscal income.[19] Despite efforts towards expanding the Colombian taxable base over the last two decades, it remains a small proportion of GDP compared to other Latin American countries.[20]

[19] In 1999, exemptions amounted to approximately ten percentage points of Colombian GDP.

[20] A 1994 IMF study of 20 countries found, for instance, that Colombia had the least value-added tax coverage as a percent of GDP of 33%, compared to an average of 50% for the entire sample.

The adoption of exceptions to the tax code has been justified as a corrective mechanism to reduce market imperfections. A tax exemption may be beneficial, for example, if it renders the tax structure more equal or if it promotes (discourages) the production of goods with positive (negative) externalities. Similarly, in industries that rely heavily on learning-by-doing, an infant-industry argument would suggest that tax shelters or protectionist policies more generally have positive long-run implications for sector productivity. The Colombian government in particular has used tax instruments as development tools for specific sectors or to promote social and regional equality. These potential benefits have to be weighed against efficiency losses that may result from such fiscal instruments. Exceptions to the tax code may, for example, distort investments that would have taken place in their absence or induce firms to attempt to qualify for them at all cost, even if they are not among the original benefactors. Evidence shows that the fiscal cost of tax exemptions is often greater than the direct benefits they generate. Empirically it is difficult, however, to quantify the level of rent transfers, in particular because lobbying pressures play a significant role in instigating tax exemptions in addition to efficiency and welfare concerns.[21]

To assess the extent of exemptions at the sector-level, we build a tax benefit measure in the form of an effectively paid tax rate based on data from the Colombian Ministry of Finance that is available for the 1993-99 sub-period of our sample. A firm's income tax burden can decrease either due to exemptions that reduce the firm's taxable income directly or due to explicit reductions in the income tax payable. Combining these two measures, an estimate of a firm's effectively paid income tax can be calculated as:

$$\text{Effectively Paid Income Tax} = \tau_{\text{effective}} * TB$$
$$\tau_{\text{effective}} = (1 - \alpha_{\text{pre-tax}}) * \alpha_{\text{tax}} * \tau_{\text{nominal}} \qquad \textbf{10}$$

[21] For a detailed comparison of Latin American tax policy reforms, see Bird (1992) and Bird and Chen (1999). Soto and Steiner (1999) provide an excellent comparison of the numerous Colombian tax reforms of the last two decades, while Hernandez, Prada, Ramirez, and Soto (2000) quantify the fiscal costs of the tax exemptions in place as of 2000. Table 8 summarizes the recent Colombian tax history from 1979 to 1999, including tax exemptions and benefits, as well as foreign trade taxes.

Here, $\tau_{\text{effective}}$ denotes the effectively paid tax rate and *TB* is the taxable income base. $\tau_{\text{effective}}$ is computed as the product of $\alpha_{\text{pre-tax}}$, the rate of reduction of pre-tax income due to exemptions, α_{tax} , the rate of reduction of the nominal income tax rate, and the nominal tax rate τ_{nominal}. The tax data provided by the Colombian Ministry of Finance allows us to calculate both $\alpha_{\text{pre-tax}}$ and α_{tax} at the four-digit ISIC level. Table 9 presents pre-tax exemption rates, $\alpha_{\text{pre-tax}}$, and effectively paid income tax rates, $\tau_{\text{effective}}$, aggregated to the three-digit ISIC manufacturing sector over the period 1993-1999.

While the nominal tax rate is set uniformly across all sectors at an average of 32.9% over the period, the effective income tax rate paid by the manufacturing sector amounts to only 27.5%. On average, $\alpha_{\text{pre-tax}}$ equals 4.5%, but the variance in exemption rates is large. For instance, the average exemption rate for the Printed Materials sector is close to 44%. The Food Products, Beverages and Other Non-Metallic Mineral Products sectors follow with average exemption rates of 9%, while some sectors like Leather Products receive no exemptions at all to reduce their taxable base. The overall monetary value of tax exemptions to the manufacturing sector amounts to approximately $259.4 million in 1999. Table 10 shows how these benefits have been distributed rather unevenly across sectors over time, with the Food Processing, Printed Materials and Chemicals sectors together capturing in excess of 55% of all benefits each year. All three of these sectors experienced negative average annual productivity growth during our sample period.

The producers' response to tax incentives is difficult to isolate, mainly because the role that tax incentives play in inducing investment cannot be easily separated from other determinants of firm investment decisions. Instead of focusing on the investment response, we therefore concentrate on the link between productivity growth and preferential tax treatments.

V.2. Policy Exercise

To provide evidence of the extent to which the evolution of sector-level preferential treatments, both in the form of protection from foreign competition and tax exemptions, has contributed to systematic changes in productivity within and across industries, we relate the estimated productivity to measures of tax and foreign policy. The setting is ideal for studying whether openness to trade induces productivity growth since the available data covers both the ten years before and after the largest Colombian trade liberalization in the early 1990s. The sample period furthermore covers a series of tax reforms that lead to significant variation, both within the cross-section and over time, in the available tax policy instruments. According to Bird and Chen (1999), fiscal needs and the pressures of strong lobbying groups drive most of the Colombian tax reforms during the sample period. The data allows us to investigate whether these tax policies have nevertheless provided microeconomic incentives that help to sustain productivity levels.

As measures of protection from foreign competition, we use the effectively paid tariff rates at the three-digit ISIC sector level discussed above. Ideally, a measure of effective protection would be preferable. Building such a measure, however, requires specific knowledge of the imported component of inputs at the sector-level. This data is currently not available. We assume furthermore that the trends in effectively paid tariff rates are representative of other trade policy instruments that affect a sector's protection from foreign competition, such as quotas.

To further control for the impact of foreign trade on productivity we construct a foreign markets' exposure measure and the rate of real devaluation at the sector-level. The foreign markets' exposure measure is defined as the ratio of one half of the sum of imports and exports to output. The sector-level real devaluation rate is constructed for two-digit ISIC industries, using data on the nominal Peso-Dollar exchange rate from the Central Bank of Colombia and sector-level inflation rates for both Colombia and the US, based on producer price indexes for the period 1990-1999 for Colombia and 1982-1999 for the US and manufacturing-sector producer price index for the earlier years.[22] The data were obtained from the Colombian Central Bank and the U.S. Department of Labor Statistics.

To measure preferential tax treatments across sectors, we use the difference between the nominal tax rate τ_{nominal} and the estimated effectively paid tax rate, $\tau_{\text{effective}}$. A larger value for the difference, $(\tau_{\text{nominal}} - \tau_{\text{effective}})$, corresponds to a larger tax benefit received by the particular manufacturing sector.

We estimate a series of panel regression models at the plant level of the following form:

$$\begin{aligned}\hat{\omega}_{ijt} = \alpha_0 + \sum_{k=1,\dots,3} \alpha_{1k} ET_{j(t-1)} s_{kt} + \alpha_{2k} (\tau_{\text{nominal}} - \tau_{\text{effective}})_{j(t-1)} s_{kt} + \alpha_{3k} DEV_{j(t-1)} s_{kt} + \beta_k s_{kt} \\ + \alpha_4 EXP_{j(t-1)} + \nu_i + \varsigma_t + \varepsilon_{ijt}\end{aligned} \quad \textbf{11}$$

Here, $\hat{\omega}$ denotes the (log) plant-level unobserved productivity resulting from our estimation in section III. *ET* is the lagged 3-digit sector-level effectively paid tariff rate, *DEV* denotes the lagged 2-digit sector-level real devaluation rate of the Colombian peso, and *EXP* the above described, 3-digit sector-level measure of exposure to foreign markets. The policy variables are interacted with three size-class indicators *s* to account for differential impacts across plant sizes.[23] We also include size dummies explicitly in the panel estimation.

Since the tax data is only available for the period 1993-99, we estimate four separate panel regressions. First, we estimate the relationship between log productivity and foreign trade measures only for the full period 1978-99. In addition to the above variables, we include a dummy variable that is set to one for all years subsequent to the 1990 regime shift in trade policy. The second and third regressions break the panel into

[22] We use real devaluation instead of the real exchange rate because data for the latter is unavailable at the sector level.
[23] The small-size dummy equals one if plant employment is less than 50. A medium-sized plant has employment larger than or equal to 50 and less than 200. The large-size dummy equals one if plant employment is greater than or equal than 200.

two periods, 1977-92 and 1993-99, to check the robustness of the results in comparison to the final regression for the period 1993-99 that includes the tax benefit measures. The sub-period regressions also allow us to increase our understanding about policy-induced productivity response patterns during the 1990s.

All panel models include plant-level fixed effects to control for individual plant drivers of efficiency and to reduce potential endogeneity between the policy measures and the average sector productivity levels. Finally, all panels include year dummies to account for exogenous macroeconomic shocks that may have affected manufacturing productivity. Since the policy variables are only at the sector level, standard errors are corrected for clustering at the four-digit ISIC level, the lowest level of disaggregation among the policy variables. Table 11 presents the estimation results.

The results indicate that the response patterns of plant productivity differ across time periods. Prior to the liberalization of the 1990s, higher devaluation rates are associated with higher plant level productivity. Devaluation may serve the purpose of making domestic products more competitive in the US market and thereby boosting productivity through exports. This result, consistent with productivity growth from learning-by-doing, is unexpectedly true for all plant sizes after controlling for exposure to foreign competition. Higher exposure to foreign competition has, as expected, a positive and statistically significant effect on productivity across regression models, higher in magnitude for the period 1993-99. The response to sector-level devaluation is very different for the later sub-period where the estimated effect of sector-level devaluation is negative for all plant sizes. Across the three sub-period panel models, a Wald test cannot reject that the devaluation effects are the same across plant sizes suggesting that relative price changes mitigated by devaluation have similar effects on plants of different sizes.[24]

[24] 1978-92: F-statistic = 0.22 and Pr(F > *F*(2, 40626)) = 0.81; 1994-99 (1): F-statistic = 0.29 and Pr(F > *F*(2, 19065)) = 0.75; 1994-99 (2): F-statistic = 0.20 and Pr(F > *F*(2, 19062)) = 0.82.

The response in productivity to lagged effective tariff rates also changes across periods. In general, plants in industries with higher effective tariff protection exhibit lower productivity. In the pre-1990 period, however, the effect is statistically insignificant for large plants.[25] In the two regressions for the sub-period 1993-99, the estimated coefficients on effective tariff rates are larger in absolute value and statistically significant, indicating a negative relationship between productivity and tariff protection for all plant sizes. These differences in coefficients across time periods translate into sizable differences in the elasticity of productivity with respect to tariff rates. At mean tariff levels for the manufacturing sector of 15.2% for the period 1977-92, the estimated coefficients translate into productivity responses of -0.30%, -2.3%, and -1.72% to a 1% increase in tariff rates for large, medium, and small plants, respectively.[26] For the period 1993-99 with mean tariff rates of only 7.9%, however, a 1% increase in tariff rates from the mean would imply a decrease in productivity by 3.0%, 4.3%, and 4.5% for plants of the three size classes, respectively. The Wald test indicates that the coefficients are not statistically different across sizes for the later sub-period.[27]

The small-size dummy variable has a negative coefficient in all panels that is significant in particular for the first sub-period, confirming that smaller plants have on average lower productivity levels than medium-sized plants. The coefficient on the large size dummy is not significantly different from zero. This result possibly reflects the fact that the remaining included variables already capture the most salient features of larger plants of relevance to productivity, for example, their degree of foreign exposure. The change of regime dummy variable is positive and significant as expected, indicating that market liberalization during the 1990s contributes to higher manufacturing productivity levels.

[25] For this period, the Wald test rejects the hypothesis that coefficients across plant sizes are equal. F-statistic = 2.61, Pr(F > *F*(2, 40626)) = 0.07.

[26] The semi-logarithmic specification of the regression model implies that the elasticity of productivity (exp(□)) with respect to tariff rates equals $\square_{1k}$*tariff rate.

[27] 1994-99 (1): F-statistic = 0.48, Pr(F > *F*(2, 19065)) = 0.62; 1994-99 (2): F-statistic = 0.41, Pr(F > *F*(2, 19062)) = 0.67.

Turning to the effect of tax policy changes, the coefficient on the difference between nominal and effectively paid tax rates is negative and significant for all firm sizes, and not statistically different across sizes.[28] This result confirms that the special tax treatments put in place since 1993 have not enhanced productivity. One reason for this result may be that they apply to sectors that, while not particularly efficient, are large and powerful enough to exert the necessary lobbying pressure to divert preferential tax treatments in their direction.

In the estimation, we do not explicitly instrument for the tariff and tax rate variables. At the sector-level, policy measures may be endogenous to productivity measures if less efficient producers have high lobbying powers. To the extent that lobbying takes place, it is likely to be more prevalent among large sectors with strong organizations and political clout. This moderates the endogeneity concern since the average plant does not generally have the ability to enforce sector-level policy changes. The inclusion of plant-level fixed effects further helps mitigating possible endogeneity of this sort.

VI. Conclusions

Despite limitations in the available data, this paper provides a set of interesting results on productivity dynamics of the Colombian manufacturing sector. Our findings indicate that the economic slowdown of the second half of the 1990s has eroded productivity gains from opening the economy to foreign markets in the early 1990s, with overall manufacturing productivity in 1999 falling below the levels of two decades ago. This is caused, in particular, by a decline in within-plant productivity, likely due to a slow-down in technological progress. The decade associated with trade liberalization, 1985-95, sees productivity improvements due to both output reallocation towards more productive plants and positive net entry effects relative to the manufacturing sector's earlier performance. Both types of productivity gains have been partially reversed by 1999.

[28] F-statistic = 0.36 and $Pr(F > F(2,19062)) = 0.70$.

A breakdown of productivity levels by two-digit ISIC industry reveals significant differences in productivity dynamics across manufacturing industries. The only sector that displays sustained productivity growth relative to 1977 is the Glass sector, while the Textiles, Machinery and Basic Metals sectors experience only slight, but volatile productivity improvements during 1977-99. A productivity decline in some of the largest manufacturing sectors, including Chemicals, Food Processing, Paper, and Machinery, explains the drop in productivity at the aggregate level. These sectors are also the ones for whom the within-plant decrease in productivity is the most pronounced. For sectors that gain in productivity over the sample, such as the Glass and Textiles sectors, output reallocation over time towards more productive plants is central to productivity growth.

The paper then investigates the role of industrial policy, both as it relates to international trade and taxation, in affecting plant behavior by relating the estimated plant-level productivity to measures of preferential policy treatments. Our econometric analyses indicate that effective tariff rates are consistently negatively related to productivity, with significantly stronger impacts in the post-liberalization period. In light of the overall trends in productivity, the results underline that international exposure is only one of the factors that influence plants' productivity and that the positive effects of trade policy reforms have not been sufficiently large to date to counteract the overall stagnation in productivity levels. Similarly, we find that targeted tax exemptions do not enhance industry productivity over the sample period, suggesting that to the extent that they have been implemented to support the development and growth of specific sectors, their success is limited.

VII. Appendix A
Construction of Plant-Level Data Set

The initial data set contains 166,936 plant-year observations. For a plant to be included in the final database used in the empirical analysis, it has to satisfy the following criteria:

- Only plants with two or more observations during the period 1977-1999 remain in the database. The estimation methodology requires multiple annual observations per plant. Consequently, we drop 4,020 observations that correspond to plants that appear only once throughout the sample period.

- When a plant reports a sector change from a three-digit ISIC industry to another, this change is treated as the liquidation of the plant and the entry of a new plant. There are 1,481 3-digit sector changes.

- When there is a gap of one year during which a plant does not participate in the survey, the information for the missing year is obtained by linear interpolation. This applies to 3,570 cases. When the reporting gap is longer, as is the case for 1,777 observations, the plant's entire history is dropped from the database.

- The official DANE database consists of the universe of Colombian plants with a workforce in excess of 10 employees. To more accurately capture plant entry and exit by small plants around the 10-employee cut-off, the following procedure is adopted. We use data only for those plants that report an employment level at or above 15 employees in at least one of two consecutive years. By dropping plants with consistently between 10 and 15 employees, we eliminate the most likely plants that could shrink in employment below the 10-employee cutoff from one year to the next, but not actually exit the industry altogether. A firm with 15 employees or more that disappears from the database is thus treated as having exited under the assumption that it is unlikely for the plant to lose in excess of 40% of its workforce over a one-year period. We drop 37,493 plant-observations for which reported employment is less than 15 employees in consecutive years. This procedure generates 2,303 new instances in which a plant appears in only one year. These plants are dropped from the dataset.

- We drop 2,663 observations corresponding to 501 plants because of missing data. We furthermore exclude 5,274 observations, or 589 plants, from the final database because either their intermediate input usage or their energy consumption is less than or equal to zero.

- All monetary series measured in current Colombian Peso are converted to constant, 1999 Colombian Peso. To deflate the capital series, we use the Producer Price Index (PPI) for the formation of capital goods. For intermediate inputs, we employ the Producer Price Index for intermediate consumption. To deflate the personnel and other operational expenditures, we use the Consumer Price Index. Last, the industrial output series is deflated using a sector-level deflator constructed from the sector-level PPI for the period 1990-1999 and the industry-wide PPI for the initial years from 1977 to 1989. All price indices are obtained from the Central Bank of Colombia.

§ For internal consistency over time, we subtract inflation adjustments from the reported capital values beginning in 1992.

VIII. Appendix B

Table 1
Break-down of Manufacturing Sector into Entering, Exiting, and Continuing Plants, 1977-1999

Year (t)	Total Number of Plants	Entering Plants, (t-1) to (t)	Exiting Plants, (t) to (t+1)	Continuing Plants, (t-1) to (t)
1977	3,371	3,371	-	-
1978	3,763	392	334	3,037
1979	3,796	367	436	2,993
1980	3,743	383	353	3,007
1981	3,733	343	372	3,018
1982	3,754	393	356	3,005
1983	3,799	401	351	3,047
1984	3,790	342	345	3,103
1985	3,831	386	265	3,180
1986	4,027	461	262	3,304
1987	4,177	412	299	3,466
1988	4,287	409	328	3,550
1989	4,352	393	272	3,687
1990	4,329	249	373	3,707
1991	4,209	253	482	3,474
1992	*4,907*	*1,180*	*264*	*3,463*
1993	5,020	377	454	4,189
1994	4,951	385	461	4,105
1995	4,993	503	447	4,043
1996	4,977	431	457	4,089
1997	4,910	390	535	3,985
1998	4,638	263	649	3,726
1999	3,989	-	3,989	-

Notes:
(1) Plants remain in the database only if they appear for a minimum of two years, resulting in zero entering plants between 1998 and 1999 and zero exiting plants between 1977 and 1978.
(2) Entering plants denote plants that appear for the first time in the respective year's Census, similarly, exiting plants denote plants that appear for the last time in the respective year's Census.

Table 2

Entry and Exit in the Colombian Manufacturing Sector

	Plant Entry					Plant Exit				
Year	**Entry Rate**	**Output Share of Entrant Plants**	**Output relative to Incumbents**	**Employment relative to Incumbents**	**Real Labor Productivity relative to Incumbents**	**Exit Rate**	**Output Share of Exiting Plants**	**Output relative to Incumbents**	**Employment relative to Incumbents**	**Real Labor Productivity relative to Incumbents**
1978	11.63	2.82	2.97	5.26	56.33	8.88	2.21	2.32	4.76	48.83
1979	9.75	2.52	2.67	4.44	60.14	11.49	3.32	3.53	5.84	60.45
1980	10.09	3.47	3.70	4.91	75.43	9.43	2.74	2.92	5.32	54.92
1981	9.16	3.20	3.38	5.65	59.92	9.97	2.25	2.38	4.38	54.28
1982	10.53	2.33	2.44	4.44	55.02	9.48	2.13	2.23	4.66	47.80
1983	10.68	2.44	2.55	4.76	53.65	9.24	2.04	2.14	4.58	46.65
1984	9.00	1.72	1.79	4.11	43.67	9.10	2.39	2.49	4.38	56.86
1985	10.18	2.31	2.41	4.07	59.28	6.92	2.18	2.29	3.30	69.20
1986	12.03	2.29	2.39	4.61	51.77	6.51	1.88	1.96	3.47	56.56
1987	10.23	1.74	1.81	4.17	43.51	7.16	2.20	2.29	3.50	65.59
1988	9.79	2.80	2.92	4.55	64.19	7.65	1.25	1.30	3.53	36.88
1989	9.17	1.74	1.80	3.63	49.49	6.25	1.21	1.25	2.74	45.64
1990	5.72	1.28	1.32	2.25	58.62	8.62	1.91	1.97	3.89	50.70
1991	5.84	2.60	2.86	3.60	79.44	11.45	6.38	7.00	9.43	74.29
1992	*28.04*	*11.65*	*13.53*	*17.21*	*78.66*	*5.38*	*2.26*	*2.62*	*4.32*	*60.74*
1993	7.68	2.18	2.29	3.51	65.23	9.04	2.64	2.78	4.60	60.32
1994	7.67	3.37	3.62	4.10	88.31	9.31	3.41	3.66	5.30	69.09
1995	10.16	4.45	4.79	6.26	76.42	8.95	2.64	2.84	4.97	57.17
1996	8.63	3.54	3.76	4.68	80.46	9.18	2.28	2.42	4.62	52.43
1997	7.84	3.66	3.93	5.02	78.25	10.90	2.99	3.20	4.77	67.12
1998	5.36	1.87	1.98	2.86	69.14	13.99	3.78	4.01	5.81	68.97

Notes:

(1) Plant entry denotes plants that enter between the prior year (*t*-1) and the current year (t), while plant exit occurs between the current year (t) and the following year (t+1).

(2) Output is measured as the plant's real value of production in millions of peso and real labor productivity is measured as the plant's real value of production divided by total employment.

Table 3

Plant-level Input and Output Choices by 2-digit ISIC(2)

Variable	Food Processing	Textiles	Leather	Wood	Paper	Industrial & Other Chemicals	Rubber & Plastic Products	Glass	Basic Metals	Machinery	Manufac-turing
Employment											
Average	121.09	157.52	78.43	52.55	95.37	130.05	91.48	127.23	206.36	88.13	103.10
Median	49.00	51.00	37.00	32.00	38.00	56.00	43.00	46.00	51.00	40.00	42.00
Std. Dev.	212.07	384.23	147.50	80.20	193.37	191.84	156.33	202.54	619.87	149.21	208.90
Capital Stock (000000, 1999 peso)											
Average	3,390.08	2,739.91	359.35	602.06	2,981.92	3,934.77	2,009.89	5,120.27	11,431.12	1,079.65	2,294.78
Median	355.73	241.22	66.43	84.48	255.32	431.58	326.44	338.30	381.01	174.09	195.15
Std. Dev.	18,211.54	16,114.80	1,928.93	4,095.20	16,437.19	17,366.42	8,243.52	23,491.65	53,678.24	4,857.06	14,685.04
Energy Consumption (000 kw)											
Average	1,424.08	1,869.25	167.31	270.16	2,110.96	2,660.47	1,217.97	4,416.36	17,075.58	448.87	1,478.33
Median	290.76	168.88	38.40	56.60	73.06	176.27	309.61	223.22	383.60	84.76	106.16
Std. Dev.	4,150.86	8,222.57	688.41	1,520.56	12,820.75	11,704.85	3,289.83	14,863.31	68,749.31	1,325.57	10,808.51
Material Inputs (000000, 1999 peso)											
Average	6,514.27	2,899.89	933.67	588.78	3,003.81	6,549.95	2,594.79	1,850.48	7,104.68	2,560.91	3,380.13
Median	1,551.17	584.39	272.78	200.73	386.76	1,165.82	655.53	309.49	923.76	368.79	482.27
Std. Dev.	13,435.22	9,796.84	3,017.77	2,154.64	9,438.14	17,964.45	7,061.79	4,118.50	13,413.69	17,869.79	13,443.96
Output (000000, 1999 peso)											
Average	13,832.02	6,602.09	1,694.66	1,480.62	6,848.91	15,501.10	5,342.11	9,177.78	13,968.06	4,318.41	7,287.76
Median	3,108.89	1,194.27	505.41	501.42	1,036.79	3,181.49	1,319.01	1,351.61	1,543.88	782.53	1,075.30
Std. Dev.	30,415.91	24,945.34	5,038.83	5,704.59	20,288.69	37,690.94	16,895.41	21,436.61	30,904.42	23,563.10	24,849.04
Sector Size											
Number of Plants	828	830	198	206	317	302	270	222	60	884	4,118

Notes:
(1) All entries represent input and output measures, as well as sector size measures, that have been averaged over the period of the sample, 1977-1999.

Table 4

Results from Alternative Production Function Estimation Methods (standard errors in parentheses)

Variable	L-P	OLS	FE	Share	L-P	OLS	FE	Share	L-P	OLS	FE	Share
	311				**312**				**314**			
Labor	0.231	0.236	0.238	0.095	0.243	0.295	0.202	0.084	0.405	0.247	0.241	0.165
	(0.003)	(0.004)	(0.006)		(0.010)	(0.015)	(0.013)		(0.091)	(0.079)	(0.084)	
Energy	0.053	0.068	0.078	0.013	0.064	0.147	0.080	0.012	0.370	0.292	0.194	0.008
	(0.002)	(0.003)	(0.004)		(0.006)	(0.008)	(0.007)		(0.053)	(0.045)	(0.070)	
Materials	0.621	0.695	0.549	0.745	0.648	0.543	0.616	0.781	0.387	0.361	0.261	0.634
	(0.039)	(0.003)	(0.004)		(0.203)	(0.006)	(0.008)		(0.080)	(0.046)	(0.047)	
Capital	0.049	0.060	0.059	0.147	0.119	0.098	0.024	0.123	0.022	0.155	-0.018	0.194
	(0.014)	(0.003)	(0.003)		(0.091)	(0.009)	(0.006)		(0.063)	(0.038)	(0.043)	
Dummy	-	-0.230	-0.137		-	-0.152	-0.001		-	-0.586	-0.066	
		(0.006)	(0.007)			(0.019)	(0.012)			(0.115)	(0.113)	
Obs.				13472				2851				222
	321				**322**				**323**			
Labor	0.260	0.322	0.303	0.176	0.346	0.451	0.372	0.248	0.280	0.328	0.244	0.161
	(0.006)	(0.007)	(0.010)		(0.006)	(0.006)	(0.008)		(0.013)	(0.014)	(0.023)	
Energy	0.065	0.091	0.090	0.030	0.069	0.103	0.085	0.011	0.030	0.036	0.093	0.014
	(0.003)	(0.004)	(0.005)		(0.004)	(0.004)	(0.004)		(0.008)	(0.007)	(0.012)	
Materials	0.548	0.555	0.496	0.489	0.456	0.482	0.410	0.595	0.630	0.629	0.593	0.709
	(0.067)	(0.005)	(0.006)		(0.024)	(0.003)	(0.004)		(0.149)	(0.010)	(0.012)	
Capital	0.054	0.065	0.062	0.305	0.059	0.046	0.062	0.146	0.059	0.054	0.086	0.115
	(0.033)	(0.004)	(0.004)		(0.030)	(0.003)	(0.004)		(0.054)	(0.008)	(0.010)	
Dummy	-	0.036	0.060		-	0.102	0.054		-	0.040	-0.036	
		(0.009)	(0.009)			(0.007)	(0.008)			(0.018)	(0.023)	
Obs.				6919				12248				1466
	324				**332**				**341**			
Labor	0.305	0.365	0.292	0.226	0.323	0.351	0.335	0.289	0.226	0.234	0.233	0.126
	(0.009)	(0.010)	(0.013)		(0.013)	(0.014)	(0.018)		(0.011)	(0.012)	(0.013)	
Energy	0.041	0.056	0.050	0.013	0.040	0.047	0.080	0.020	0.076	0.077	0.081	0.033
	(0.005)	(0.006)	(0.007)		(0.007)	(0.008)	(0.010)		(0.004)	(0.005)	(0.006)	
Materials	0.529	0.602	0.576	0.593	0.560	0.594	0.568	0.472	0.486	0.687	0.615	0.594
	(0.053)	(0.007)	(0.008)		(0.116)	(0.008)	(0.011)		(0.183)	(0.006)	(0.008)	
Capital	0.040	0.041	0.057	0.168	0.072	0.049	0.064	0.219	0.055	0.073	0.044	0.247
	(0.030)	(0.004)	(0.006)		(0.040)	(0.005)	(0.007)		(0.061)	(0.006)	(0.005)	
Dummy	-	-0.016	-0.020		-	0.048	0.057		-	-0.051	0.034	
		(0.01)	(0.011)			(0.013)	(0.015)			(0.014)	(0.013)	
Obs.				3079				2682				2504
	342				**351**				**352**			
Labor	0.431	0.445	0.383	0.216	0.182	0.164	0.259	0.139	0.311	0.300	0.283	0.172
	(0.009)	(0.010)	(0.014)		(0.014)	(0.016)	(0.025)		(0.008)	(0.009)	(0.011)	
Energy	0.046	0.053	0.060	0.012	0.088	0.109	0.223	0.036	0.043	0.033	0.031	0.008
	(0.006)	(0.006)	(0.006)		(0.006)	(0.008)	(0.011)		(0.005)	(0.005)	(0.006)	
Materials	0.510	0.522	0.451	0.459	0.407	0.546	0.341	0.607	0.660	0.657	0.610	0.667
	(0.095)	(0.006)	(0.007)		(0.128)	(0.008)	(0.014)		(0.047)	(0.006)	(0.008)	
Capital	0.080	0.088	0.047	0.314	0.276	0.197	0.046	0.218	0.067	0.102	0.068	0.154
	(0.038)	(0.005)	(0.005)		(0.048)	(0.009)	(0.010)		(0.043)	(0.005)	(0.005)	
Dummy	-	-0.083	0.010		-	-0.113	0.227		-	-0.187	-0.102	
		(0.010)	(0.010)			(0.023)	(0.023)			(0.011)	(0.011)	
Obs.				4817				2218				4739

Table 4 (continued)

Results from Alternative Production Function Estimation Methods (standard errors in parentheses)

	354				356				361			
Labor	0.369	0.243	0.215	0.054	0.196	0.245	0.218	0.131	0.428	0.462	0.447	0.292
	(0.028)	(0.031)	(0.041)		(0.007)	(0.007)	(0.010)		(0.026)	(0.029)	(0.043)	
Energy	0.011	0.001	-0.001	0.006	0.035	0.062	0.103	0.033	0.136	0.109	0.170	0.045
	(0.010)	(0.014)	(0.014)		(0.004)	(0.004)	(0.006)		(0.017)	(0.021)	(0.020)	
Materials	0.847	0.784	0.534	0.805	0.622	0.641	0.611	0.575	0.458	0.471	0.295	0.299
	(0.111)	(0.015)	(0.027)		(0.059)	(0.005)	(0.006)		(0.112)	(0.022)	(0.023)	
Capital	0.011	0.103	0.055	0.135	0.078	0.087	0.057	0.260	0.126	0.101	0.091	0.364
	(0.082)	(0.017)	(0.017)		(0.033)	(0.004)	(0.005)		(0.129)	(0.016)	(0.016)	
Dummy	-	-0.139	0.021		-	0.183	0.206		-	0.009	0.039	
		(0.038)	(0.037)			(0.008)	(0.010)			(0.039)	(0.035)	
Obs.				430				4922				391
	369				371				372			
Labor	0.414	0.412	0.448	0.151	0.210	0.225	0.193	0.135	0.222	0.280	0.312	0.151
	(0.013)	(0.015)	(0.020)		(0.019)	(0.022)	(0.031)		(0.026)	(0.037)	(0.044)	
Energy	0.194	0.219	0.176	0.057	0.044	0.105	0.084	0.047	0.011	0.184	0.108	0.032
	(0.006)	(0.007)	(0.010)		(0.010)	(0.011)	(0.019)		(0.014)	(0.021)	(0.024)	
Materials	0.351	0.392	0.300	0.249	0.618	0.614	0.584	0.323	0.384	0.359	0.419	0.641
	(0.155)	(0.005)	(0.009)		(0.335)	(0.009)	(0.020)		(0.160)	(0.016)	(0.018)	
Capital	0.074	0.091	0.031	0.544	0.145	0.115	0.030	0.495	0.205	0.160	0.078	0.175
	(0.066)	(0.007)	(0.007)		(0.113)	(0.010)	(0.014)		(0.082)	(0.020)	(0.019)	
Dummy	-	-0.132	-0.040		-	0.177	0.303		-	0.260	0.307	
		(0.018)	(0.017)			(0.027)	(0.032)			(0.045)	(0.040)	
Obs.				3755				888				497
	381				382				384			
Labor	0.270	0.302	0.280	0.201	0.295	0.332	0.287	0.205	0.257	0.287	0.311	0.120
	(0.007)	(0.007)	(0.010)		(0.011)	(0.012)	(0.014)		(0.011)	(0.012)	(0.016)	
Energy	0.056	0.078	0.063	0.021	0.043	0.056	0.073	0.019	0.071	0.079	0.079	0.007
	(0.004)	(0.004)	(0.005)		(0.005)	(0.006)	(0.008)		(0.007)	(0.008)	(0.008)	
Materials	0.573	0.606	0.543	0.564	0.386	0.600	0.539	0.601	0.664	0.595	0.534	0.727
	(0.050)	(0.004)	(0.006)		(0.267)	(0.006)	(0.008)		(0.068)	(0.006)	(0.008)	
Capital	0.020	0.079	0.059	0.214	0.051	0.058	0.045	0.175	0.043	0.099	0.054	0.146
	(0.054)	(0.004)	(0.004)		(0.052)	(0.005)	(0.006)		(0.052)	(0.006)	(0.006)	
Dummy	-	0.100	0.134		-	0.158	0.186		-	0.061	0.136	
		(0.008)	(0.009)			(0.011)	(0.012)			(0.013)	(0.014)	
Obs.				7871				4642				3348

Table 5

Descriptive Statistics, Manufacturing Sector Total Factor and Labor Productivity

	Total Factor Productivity				Labor Productivity
Year	**Output-Weighted Average**	**Average**	**Median**	**Standard Deviation**	**Output-Weighted Average**
1977	1.000	0.808	0.714	0.485	1.000
1978	1.039	0.838	0.728	0.563	1.068
1979	1.006	0.831	0.716	0.654	1.023
1980	0.915	0.791	0.687	0.622	0.950
1981	0.891	0.772	0.665	0.606	0.933
1982	0.890	0.754	0.651	0.534	0.929
1983	0.888	0.763	0.656	0.619	1.001
1984	0.902	0.757	0.668	0.482	1.088
1985	0.943	0.768	0.679	0.496	1.473
1986	0.973	0.765	0.680	0.479	1.924
1987	0.943	0.780	0.687	0.550	1.519
1988	1.091	0.779	0.666	0.712	1.644
1989	1.041	0.757	0.667	0.439	1.693
1990	1.057	0.748	0.655	0.542	1.765
1991	0.960	0.756	0.657	0.593	1.783
1992	*0.917*	*0.724*	*0.639*	*0.685*	*1.421*
1993	0.889	0.695	0.617	0.506	1.497
1994	0.938	0.726	0.633	0.481	1.659
1995	0.986	0.747	0.661	0.423	1.823
1996	0.996	0.741	0.667	0.442	1.978
1997	1.012	0.767	0.684	0.411	2.239
1998	0.971	0.755	0.687	0.371	2.107
1999	0.947	0.750	0.676	0.487	1.976

Note:
Output-weighted total factor- and real labor productivity are normalized to one in the base year, 1977, for comparison purposes. They represent output-weighted averages across sectors.

Figure 1
Change in Productivity: Alternative Estimation Methods

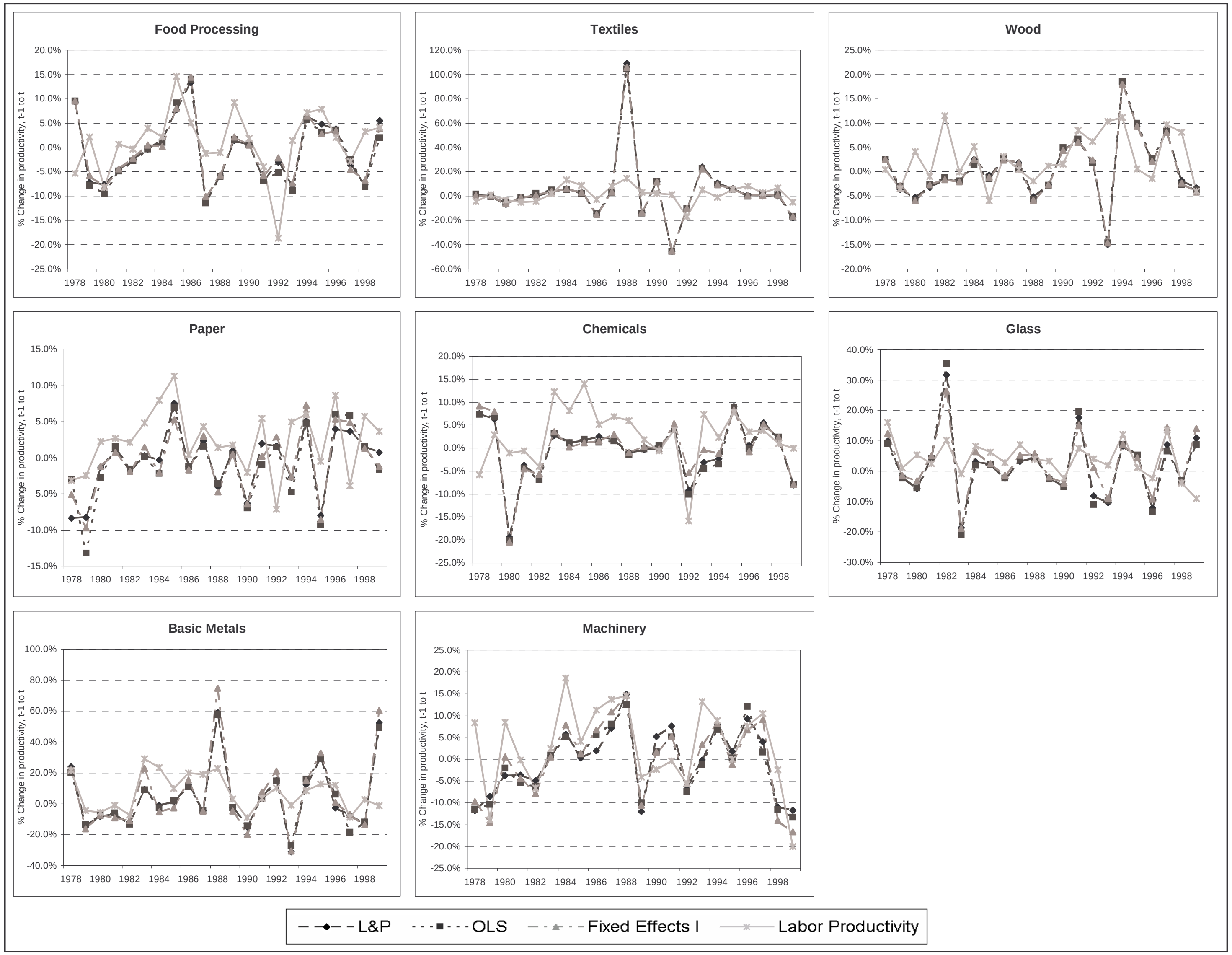

Table 6

Decomposition of Total Factor Productivity Growth, 1977-1999

Sector	Period	Annual Growth Rate (%)	Within	Between	Co-variance	Entry	Exit	Total Continuer	Net Entry
			Decomposition						
Manufacturing	1977 - 1984	-1.339	-2.500	-1.846	3.260	-0.308	-0.054	-1.085	-0.253
	1985 - 1995	1.593	-0.719	-1.218	3.449	0.163	0.083	1.512	0.080
	1996 - 1999	-0.333	-1.940	-1.553	3.620	0.123	0.583	0.127	-0.460
	Average	0.310	-1.508	-1.478	3.420	0.006	0.130	0.434	-0.124
31 Food Processing	1977 - 1984	-1.633	-2.700	-1.455	2.819	-0.186	0.110	-1.336	-0.296
	1985 - 1995	-0.157	-1.204	-0.958	2.340	0.152	0.487	0.178	-0.335
	1996 - 1999	-0.599	-0.136	-0.891	2.630	-0.076	2.127	1.603	-2.202
	Average	-0.707	-1.485	-1.104	2.545	0.003	0.665	-0.045	-0.662
32 Textiles	1977 - 1984	0.195	-0.117	-0.555	1.286	-0.728	-0.309	0.614	-0.419
	1985 - 1995	8.594	0.067	-2.411	10.929	-0.464	-0.474	8.585	0.010
	1996 - 1999	-3.716	-3.977	-4.607	3.879	-0.006	-0.996	-4.706	0.990
	Average	3.684	-0.727	-2.220	6.579	-0.465	-0.516	3.632	0.051
33 Wood	1977 - 1984	-1.511	-2.973	-2.193	3.979	-0.300	0.024	-1.187	-0.324
	1985 - 1995	1.902	1.073	-1.338	2.608	-0.490	-0.049	2.343	-0.441
	1996 - 1999	1.320	-1.568	-0.640	3.155	-0.019	-0.392	0.947	0.374
	Average	0.710	-0.695	-1.483	3.143	-0.344	-0.088	0.966	-0.256
34 Paper	1977 - 1984	-2.716	-2.150	-1.337	1.608	-0.427	0.409	-1.880	-0.836
	1985 - 1995	-0.232	-1.156	-1.154	2.038	-0.045	-0.085	-0.272	0.040
	1996 - 1999	2.786	0.723	-0.828	2.781	0.124	0.014	2.676	0.110
	Average	-0.474	-1.131	-1.153	2.036	-0.136	0.090	-0.248	-0.226
35 Chemicals	1977 - 1984	-1.429	-2.491	-1.954	3.274	-0.546	-0.288	-1.172	-0.257
	1985 - 1995	0.286	-1.002	-0.856	2.000	0.321	0.176	0.142	0.144
	1996 - 1999	-0.544	-2.663	-0.668	2.273	0.476	-0.038	-1.058	0.514
	Average	-0.411	-1.778	-1.171	2.455	0.073	-0.011	-0.494	0.084
36 Glass	1977 - 1984	3.365	3.271	-1.255	1.926	-0.187	0.391	3.942	-0.577
	1985 - 1995	1.213	-0.482	-0.536	1.770	0.531	0.070	0.751	0.462
	1996 - 1999	1.270	-1.975	-2.362	5.157	0.902	0.451	0.819	0.451
	Average	1.908	0.440	-1.097	2.435	0.370	0.241	1.779	0.129
37 Basic Metals	1977 - 1984	-1.327	-2.803	-1.825	3.195	-0.217	-0.323	-1.432	0.105
	1985 - 1995	7.825	2.607	-0.877	4.386	0.739	-0.970	6.116	1.709
	1996 - 1999	7.864	1.563	1.820	5.189	-0.528	0.179	8.572	-0.708
	Average	4.920	0.696	-0.688	4.153	0.204	-0.555	4.161	0.759
38 Machinery	1977 - 1984	-3.442	-7.724	-5.218	8.735	0.393	-0.372	-4.207	0.765
	1985 - 1995	2.327	-0.011	-1.828	3.459	0.521	-0.186	1.620	0.707
	1996 - 1999	-1.050	-6.005	-3.249	8.181	-0.071	-0.095	-1.073	0.024
	Average	-0.122	-3.555	-3.165	5.996	0.373	-0.229	-0.724	0.601

Notes:
Productivity measures aggregated to the 2-digit sector level omit 3-digit sectors that were excluded from the estimation due to data problems (313 - Beverages, 353- Petroleum Refineries, 355 - Rubber Products, 362 - Glass, 383 - Electric Machinery, 385 - Professional and Scientific Equipment).

Table 7

Average Import Tariff as Percent of Total Value of Imported Goods by Three-Digit ISIC(2) Manufacturing Sector, 1977-89 and 1990-99 (%)

	1977-89		1990-99		
3-digit ISIC	**Mean Tariff Rates**	**Std. Dev. of Tariff Rates**	**Mean Tariff Rates**	**Std. Dev. of Tariff Rates**	**% Change, 1977-89 to 1990-99**
311	14.13	18.06	8.24	8.03	-41.70
312	16.69	3.69	10.60	4.64	-36.51
313	34.86	3.27	9.12	5.27	-73.82
314	6.85	1.75	6.14	0.91	-10.28
321	21.46	1.24	9.47	1.47	-55.84
322	9.36	3.55	12.95	2.69	38.35
323	9.04	4.66	8.38	4.50	-7.26
324	19.23	2.39	17.51	2.83	-8.92
331	16.20	4.42	8.52	4.77	-47.42
332	27.66	5.76	16.95	4.67	-38.70
341	6.86	8.83	4.30	4.21	-37.32
342	2.40	1.06	3.70	4.64	54.16
351	11.76	4.78	4.69	4.40	-60.13
352	16.32	4.80	9.61	6.74	-41.14
353	1.75	9.07	5.47	8.97	212.60
354	19.40	5.99	10.48	4.31	-46.00
355	22.25	4.78	16.24	2.51	-27.02
356	40.18	3.16	15.93	8.92	-60.36
361	24.77	5.33	15.61	4.45	-37.00
362	27.48	5.06	12.63	3.05	-54.03
369	20.77	3.80	12.31	2.46	-40.73
371	14.26	3.60	5.82	1.87	-59.18
372	9.64	0.51	3.01	1.77	-68.74
381	31.05	14.30	11.89	4.75	-61.71
382	16.20	5.22	7.80	3.78	-51.84
383	26.77	2.28	9.71	3.79	-63.74
384	25.37	11.87	11.41	5.27	-55.01
385	21.72	1.27	8.20	1.31	-62.24
390	29.04	5.40	18.10	3.97	-37.68

Notes:
Average sector-level import tariff rates are computed as the value of tariffs paid relative to the value of imports at the 3-digit ISIC level. Source: DANE Colombia.

Figure 2
Average Tariff Rates by Two-Digit ISIC Sector, 1977-99

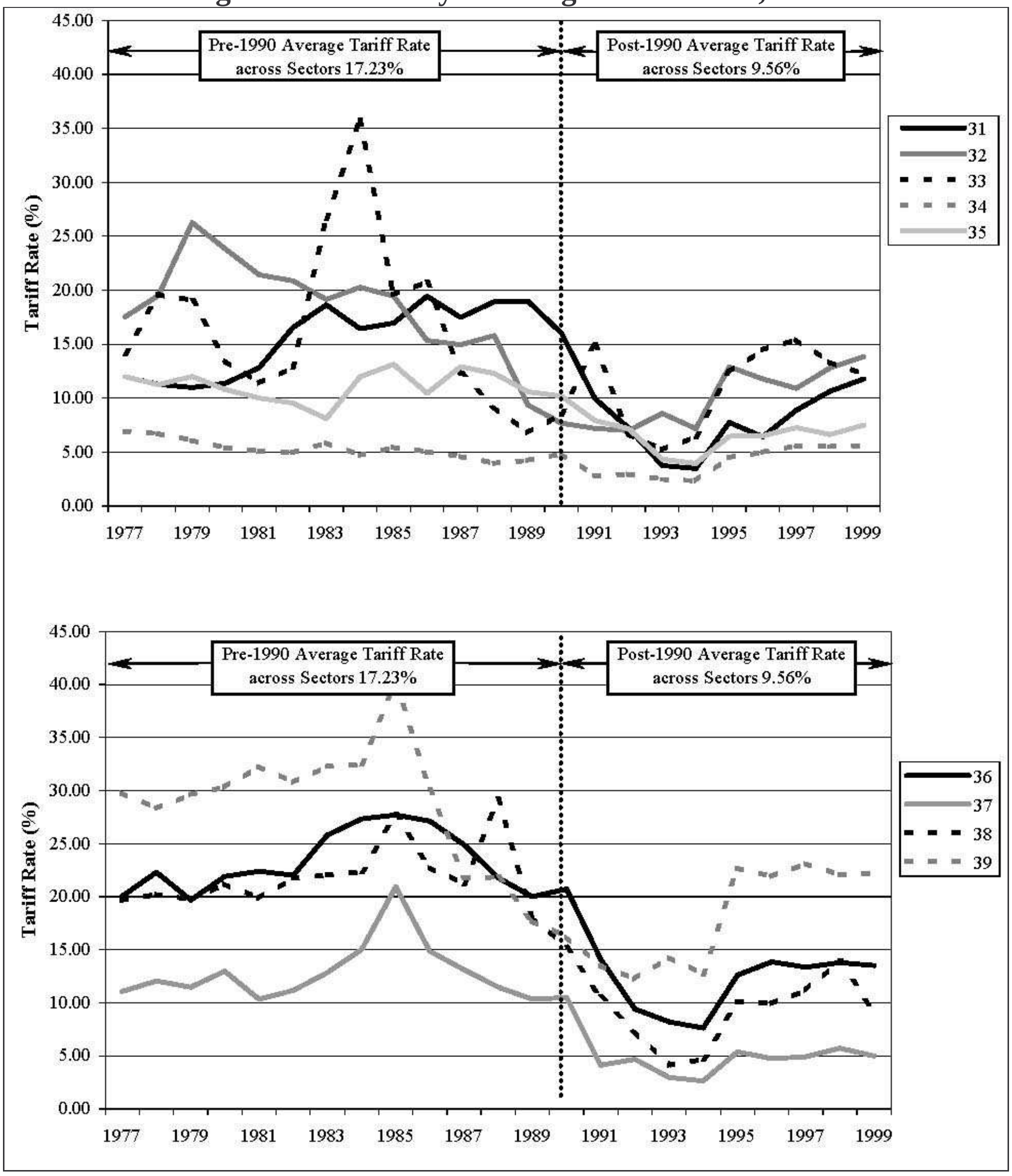

Table 8

Summary of Colombian Corporate Tax and Foreign Trade Legislation, 1979-1999

Year	Legislation		Corporate Taxation	Foreign Trade
1983	Laws 9 and 14	(1)	Tax rate decrease from 20 to 18% for firms of limited ownership.	
		(2)	Tax exemption granted to electric utilities and education service firms.	
		(3)	Introduction of income tax for trade and financial intermediary sectors.	
1986	Law 75	(1)	Unification of tax rate for all associations at 30%.	
		(2)	Introduction of income tax for investment and capital funds, mixed public and private firms, and other public firms.	
1990	Law 49	(1)	Tax exemption granted to equity markets, investment, and capital funds.	Reduction of non-tariff taxes on imports (VAT and import license) from a rate of 16.5 to 13%.
		(2)		Reduction of import tariff rate from 16.5 to 7%.
		(3)		Elimination of 861 tariff positions eliminated.
1992	Law 6		Tax exemption of value-added tax on capital goods.	
1995	Law 223		Tax rate increase from 30 to 35%.	
1995	Law 218		Tax exemptions granted to new firms in agriculture, cattle breeding, mining of raw materials excl. oil, manufacturing, tourism, or exporters from the Páez region.	
1996	Law 345	(1)	10-year tax exemption of value-added tax on capital goods.	
		(2)	Tax exemption of investment in the region of the river Paez.	
		(3)	10-year tax exemption of import tariff duties paid.	
1997	Law 383		Tax exemption of re-invested earnings.	Limit to value-added tax exemption on imported goods for which domestically produced substitutes are available.
1998	Law 488	(1)	Tax exemptions of contributions to pension funds, foreign debt, and investment in fixed assets.	
		(2)	Tax exemptions granted to firms that provide public services to homes.	

Sources:
Steiner and Soto (1999), Hernández, Ortega, Piraquive, Prada, Ramírez and Soto (2000), and tax legislation.

Table 9

Average Tax Rates and Tax Exemptions by Sector, by Three-Digit ISIC(2) Manufacturing Sector, 1993-99 (%)

3-digit ISIC	Nominal Tax Rate	Effective Tax Rate		Tax Exemption Rate		Tax Paid as % of Tax Due before Exemptions	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
311	32.86	25.19	5.91	9.09	19.06	70.58	22.57
312	32.86	28.93	3.07	2.08	1.79	86.34	7.62
313	32.86	26.10	8.53	9.81	22.41	70.78	29.00
314	32.86	26.26	6.36	0.00	0.00	79.44	16.57
321	32.86	26.33	5.11	1.96	3.89	78.03	11.54
322	32.86	28.64	3.07	4.69	4.06	82.84	2.52
323	32.86	28.08	3.80	0.39	1.04	84.95	7.74
324	32.86	28.27	4.46	2.41	2.91	83.56	7.67
331	32.86	30.42	3.00	4.08	6.56	88.83	8.25
332	32.86	30.79	3.05	0.49	0.40	93.13	1.80
341	32.86	25.04	4.90	2.25	3.18	74.55	14.34
342	32.86	27.73	3.41	44.29	7.30	46.68	4.64
351	32.86	26.17	4.07	2.17	3.21	78.26	12.85
352	32.86	29.50	3.20	2.26	3.30	87.92	8.74
353	32.86	29.09	3.54	1.73	3.21	87.11	9.31
354	32.86	28.51	2.67	1.73	3.21	85.46	7.61
355	32.86	28.24	3.91	1.58	1.74	84.34	7.27
356	32.86	25.44	1.94	3.30	4.97	74.98	5.54
361	32.86	23.21	2.78	2.77	3.07	69.43	12.58
362	32.86	18.48	9.45	0.05	0.07	57.92	31.41
369	32.86	26.42	3.31	8.13	9.63	73.79	10.30
371	32.86	26.98	3.01	1.72	1.95	80.93	8.81
372	32.86	27.84	3.31	7.26	9.73	78.41	9.98
381	32.86	28.68	3.04	1.57	2.90	85.96	7.30
382	32.86	28.46	4.87	2.07	3.43	84.93	13.85
383	32.86	28.75	2.50	1.30	2.06	86.69	8.16
384	32.86	30.42	3.16	3.01	8.23	90.09	12.00
385	32.86	28.95	5.36	5.59	14.18	82.69	17.21
390	32.86	30.51	3.21	2.37	5.85	90.63	8.52

Notes:
Average effective tax rates by sector represent nominal tax rates adjusted for deductions, while the tax exemption rate denotes the total amount of exemptions measured in Peso as a share of the taxable base. Source: Colombian Ministry of Finance.

Table 10

Two-digit ISIC(2) Manufacturing Sector Income Tax Exemptions (%, $), 1993-1999

2-digit Sector	1993	1994	1995	1996	1997	1998	1999
31	16,2%	21,2%	17,5%	31,2%	25,2%	19,1%	14,4%
32	18,5%	12,9%	7,3%	5,2%	8,2%	8,5%	10,8%
33	6,0%	1,5%	0,6%	0,4%	0,3%	0,2%	0,2%
34	27,2%	28,5%	19,9%	13,8%	21,8%	25,3%	28,5%
35	11,8%	10,6%	40,4%	35,8%	14,8%	13,9%	14,3%
36	6,0%	14,5%	7,1%	7,1%	16,0%	7,8%	4,3%
37	1,9%	2,2%	0,9%	0,6%	1,0%	0,4%	0,5%
38	10,1%	6,5%	5,1%	4,7%	9,9%	14,5%	11,7%
39	2,4%	2,1%	1,2%	1,2%	2,7%	10,4%	15,2%
Total Exemptions ($000000)	**285.432**	**310.878**	**556.075**	**723.297**	**470.997**	**384.416**	**259.484**
Average Exchange Rate PESO/$	788,69	827,33	919,50	1037,72	1154,10	1433,47	1770,30

Source: Colombian Ministry of Finance

Table 11

Panel Analysis
(standard errors in parentheses)

Dependent Variable : $\hat{\omega}$	Time Period: 1977 - 1999	Time Period: 1977 - 1992	Time Period: 1993 - 1999	Time Period: 1993 - 1999
Constant	3.95*** (0.013)	4.04*** (0.014)	3.94*** (0.038)	3.92*** (0.030)
Lagged Tariff Rate* Large Size Dummy	0.09* (0.053)	-0.02 (0.056)	-0.38* (0.230)	-0.39* (0.022)
Lagged Tariff Rate * Medium Size Dummy	-0.12*** (0.043)	-0.15*** (0.042)	-0.55*** (0.191)	-0.53*** (0.183)
Lagged Tariff Rate * Small Size Dummy	-0.09** (0.039)	-0.11*** (0.034)	-0.57*** (0.195)	-0.57*** (0.191)
Lagged Real Devaluation Rate*Large Size Dummy	0.45*** (0.071)	0.37*** (0.106)	-0.24*** (0.075)	-0.21*** (0.073)
Lagged Real Devaluation Rate * Medium Size Dummy	0.45*** (0.069)	0.37*** (0.107)	-0.21*** (0.065)	-0.18*** (0.063)
Lagged Real Devaluation Rate * Small Size Dummy	0.42*** (0.066)	0.34*** (0.105)	-0.22*** (0.068)	-0.19*** (0.066)
Foreign Exposure	0.23*** (0.033)	0.12*** (0.032)	0.34*** (0.089)	0.35*** (0.090)
Small Size Dummy	-0.04*** (0.009)	-0.03*** (0.012)	-0.02* (0.014)	-0.02 (0.016)
Large Size Dummy	0.00 (0.011)	0.00 (0.016)	-0.01 (0.022)	0.00 (0.023)
Regime Dummy	0.02** (0.012)	0.01 (0.016)		
Lagged Effective Tax Benefit*Large Size Dummy				-0.18* (0.092)
Lagged Effective Tax Benefit * Medium Size Dummy				-0.12* (0.068)
Lagged Effective Tax Benefit * Small Size Dummy				-0.19** (0.079)
No. Obs	77,816	48,746	24,741	24,741
No. Groups	10,122	8,098	5,662	5,662
F(29, 67665)	9.75			
F(22, 40626)		12.15		
F(14, 19065)			3.65	
F(17, 19062)				3.09

Notes:
Standard errors are robust standard errors that correct for the clustered nature of the data at the 4-digit ISIC level.
* denotes significance at the 10% level, ** at the 5% level and *** at the 1% level.

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