WPS 3064

POLICY RESEARCH WORKING PAPER 3064

Trade Policy, Trade Volumes, and Plant-Level Productivity in Colombian Manufacturing Industries

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The World Bank
Development Research Group
Investment Climate
May 2003

Abstract

Fernandes explores Colombian trade policy from 1977–91, a period of substantial variation in protection across industries, to examine whether increased exposure to foreign competition generates plant-level productivity gains. Using a large panel of manufacturing plants, she finds a strong positive impact of tariff liberalization on consistent productivity estimates, controlling for plant and industry heterogeneity. This result is not driven by the endogeneity of protection nor by plant exit. The impact of tariff liberalization on productivity is stronger for large plants and for plants in less competitive industries. Qualitatively similar results are obtained when using effective rates of protection and import penetration ratios as measures of protection.

This paper—a product of Investment Climate, Development Research Group—is part of a larger effort in the group to understand the links between trade and productivity. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Ana Fernandes, room MC3-363, telephone 202-473-3983, fax 202-522-3518, email address afernandes@worldbank.org. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. May 2003. (42 pages)

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JEL Classification Numbers: F13, D24, C14, O54.
Keywords: Simultaneity and Production Functions, Trade Policy, Productivity, Colombian Manufacturing, Endogeneity of Protection.

*I would like to thank Christopher Udry, Steve Berry, and Phil Levy for their invaluable guidance. This paper has also benefited from the suggestions of Patrik Bayer, Garth Frazer, Pinelopi Goldberg, David MacKenzie, Marc Melitz, Peter Schott, Christopher Timmins, and seminar participants at Yale University, NEUDC 2001, UCLA, UC-San Diego, Georgetown U., Indiana U., U. Montreal, Rutgers U., Syracuse U., U. Texas-Austin, the World Bank, and the 2003 Winter Meetings of the Econometric Society in Washington, DC. I also thank the Colombian Statistical Institute (DANE) for authorizing the use of the data and Mark Roberts for providing it. Financial support from Sub-Programa Ciência e Tecnologia do Segundo Quadro Comunitário de Apoio (Portugal) is gratefully acknowledged. The findings expressed in this paper are those of the author and do not necessarily represent the views of the World Bank. Please address correspondence to Ana M. Fernandes, The World Bank, 1818 H Street, NW, Washington DC 20433. Phone: 202-473-3983. Fax: 202-522-3518. E-mail: afernandes@worldbank.org.

1. Introduction

This paper addresses a central question in trade and development economics: does increased exposure to foreign competition generate gains in industrial productivity? Focusing on the case of Colombia, we find that it does. A panel of manufacturing plants between 1977 and 1991 is used to investigate the link between trade policy and plant-level productivity. During these fifteen years, trade policy exhibited significant variation, with periods of trade liberalization alternating with periods of increased trade protection. Moreover, these changes in protection differed substantially across industries.

The empirical literature on the impact of trade liberalization on productivity provides some, but not definitive, evidence of a positive effect of trade liberalization on productivity levels and growth following three approaches. First, the macro-level approach utilizes cross-country growth regressions, associating output growth with an aggregate measure of trade openness.[1] Using measures of outward policy orientation across countries and over time is plagued by difficulties (see, e.g., Pritchett, 1996; Rodrik and Rodriguez, 2001). Furthermore, an aggregate measure of openness to trade cannot capture the differential incentives provided by trade protection to different industries.

Second, the industry-level approach considers cross-industry regressions of Solow (1957) residual total factor productivity (TFP) growth on trade policy variables or on demand growth due to export expansion and import substitution.[2] Having a single productivity measure per industry, however, ignores cross-plant heterogeneity, a stylized finding for developed and developing countries, which is useful to fully investigate the impact of trade policy on productivity.

Finally, the micro-level approach uses regressions of either (i) firm output growth derived in a Solow framework on an indicator variable for the period of trade reform, or (ii) plant TFP measures on trade orientation in the plant's industry. Harrison (1994) and Krishna and Mitra (1998) estimate the former for firms in Cote d'Ivoire and India, respectively. However, the coefficient on the indicator variable for the trade reform period cannot isolate the corresponding productivity gains since it also captures contemporaneous macroeconomic shocks. Moreover, it ignores the variation in protection across industries. Pavcnik (2002)

[1] See, for example, Dollar (1992), Edwards (1993, 1998), Harrison (1996), Levine and Renelt (1992), Sachs and Warner (1995), and the references therein.

[2] For example, Nishimizu and Robinson (1984) use export expansion and import substitution, while Kim (2000) and Lee (1995) use trade policy variables. See Rodrik (1995) for a survey.

estimates the latter, identifying the effect of trade reform in Chile from the comparison of consistent TFP measures of plants in import-competing and export-oriented industries to those of plants in nontraded industries over time as trade reform proceeds.[3]

Our study contributes to the micro-level approach by examining the impact of trade policy on Colombian plant productivity following a two-stage estimation procedure. In the first stage, we obtain new time-varying measures of plant productivity applying an estimation method that addresses a fundamental simultaneity problem. The use of ordinary least squares (OLS) for production function estimation assumes that regressors such as labor are treated as *exogenous* variables. However, input choices are *endogenous*, depending for example on managerial ability known to the plant's decision-maker, but unknown to the researcher. Since input choices and productivity are correlated, OLS estimates suffer from a simultaneity bias.[4] Our methodology for production function estimation follows Levinsohn and Petrin (2001). Under general conditions, a plant's demand for raw materials increases monotonically with productivity, conditional on its capital stock. Hence, we use a nonparametric estimate for the inverse raw materials demand function as the control for unobservable productivity to correct for the simultaneity bias.

In the second stage, we estimate the link between trade policy and plant productivity in a regression framework, relying on measures that exhibit significant variation across industries and over time, rather than on a single change in trade regime as in previous studies. We focus on nominal tariffs since they are direct price measures of trade barriers reflecting the degree of government intervention and the changes in trade regime. Harrison (1996) and Rodrik and Rodriguez (2001) argue that the use of tariffs, instead of indicator variables for the liberalization period, is more useful to precisely identify the impact of trade policy on productivity. However, trade policy (e.g., tariffs) is subject to a potential endogeneity problem: the government may raise current trade policy barriers in response to lobbying by firms in industries with relatively low productivity. We address this problem in our estimation by (i) considering lagged trade policy measures, (ii) controlling for unobserved

[3] Pavcnik also considers import penetration and an average tariff in a sub-period of her main sample. However, since tariffs are uniform across Chilean industries, they are equivalent to year effects. Hence, her analysis cannot exploit the variation in trade policy across industries, which is the most appealing feature of the Colombian case.

[4] This bias was initially discussed by Marschak and Andrews (1944). See Griliches and Mairesse (1995) for a comprehensive survey. Variable inputs, which are easier to adjust, tend to have upwardly biased OLS coefficient estimates. But with more than two inputs, not all biases can be exactly signed, as they depend upon the degree of correlation between each input and the productivity shock.

industry fixed characteristics, and (iii) examining the economic rationales underlying trade policy determination in Colombia.

The main findings of this paper are as follows. First, our production function estimates reveal the importance of correcting for the endogeneity of input choices with respect to productivity across industries. Second, we provide strong evidence supporting the hypothesis that Colombian plants' productivity is negatively affected by trade protection. Lagged nominal tariffs have an economically and statistically significant negative impact on productivity, even after controlling for plant characteristics, for industry heterogeneity, and for variation in the real exchange rate (RER). Changes in Colombian tariffs during the sample period are a response to fiscal and external imbalances, which suggests that the negative impact of tariffs does not reflect causality running from productivity to trade policy. Third, the negative impact of tariffs is not driven by the exit of less productive plants under trade liberalization, rather it reflects within-plant productivity gains. We provide evidence suggesting that these gains are associated with an increase in (i) skilled labor intensity of production, (ii) imports of intermediate inputs, and (iii) investments in machinery at the plant level. Fourth, we allow for heterogeneity in the impact of trade policy on productivity according to plant size and find that the negative impact of tariffs on productivity is stronger for larger plants. To the best of our knowledge, this finding has not been previously provided in the literature. Finally, we introduce cross-industry heterogeneity in the impact of trade policy on productivity and estimate a stronger negative impact of tariffs for plants in industries with a lower degree of domestic competition. Our main findings are robust to the use of effective rates of protection (ERP) and import penetration ratios as measures of trade protection.

Trade liberalization may affect plant productivity through several mechanisms. First, as imports expand, the ensuing competitive pressure results in higher productivity if domestic firms eliminate X-inefficiency or slack and use inputs more efficiently.[5] In contrast, infant-industry arguments sustain that selected protection allows for productivity gains in industries where learning-by-doing is important. Second, trade liberalization may boost plant productivity by allowing for an increased access to imported intermediate inputs of

[5] Vousden and Campbell (1994) examine the efficiency of a firm with internal informational asymmetries and show that trade protection induces slack, by reducing competition. Extending the technology ladder model in Grossman and Helpman (1991b), Holmes and Schmitz (2001) show that for an entrepreneur, lowering the tariffs protecting his/her industry makes it less attractive to engage in nonproductive activities (wasting efforts blocking competitors' potential innovations) and more attractive to pursue productive activities (engaging in research).

higher quality and/or broader variety (e.g., Grossman and Helpman, 1991a), through export activities, the exposure to technologies embodied in imported final goods and the access to imported capital goods corresponding to technologies that were previously unavailable. Third, trade liberalization may influence the incentives to invest in technological innovation. In fact, Colombian government agencies attribute weak industrial productivity in the early 1980s to existing trade protection mechanisms that reduced those incentives (Zerda, 1992). Goh (2000) focuses on the opportunity cost of technological effort (the foregone profits due to the delay in the commercialization of output) and shows that trade liberalization increases a firm's incentives to engage in productivity-enhancing technological effort since it reduces its profits for any productivity level. In contrast, Rodrik (1991) and Traça (1997) find that lower trade protection or higher import competition reduce a firm's investments in productivity-enhancing technological upgrading, when the incentives to invest depend on the firm's output or market share reduced by trade liberalization. In sum, the theoretical literature delivers some disparate predictions: trade liberalization may result in either productivity gains or losses.[6] Hence, empirical evidence is essential to inform the debate.

This paper is organized as follows. In Section 2, we present the empirical methodology. In Section 3, we describe the data. In Section 4, the production function and productivity estimates are presented. In Section 5, we estimate the impact of trade policy on plant productivity. In Sections 6 and 7, we examine the differential impact of trade policy on productivity according to plant size and to the degree of domestic competition in the industry, respectively. Section 8 concludes.

2. Empirical Methodology

We estimate consistent production function estimates combining parametric and non-parametric techniques as in Levinsohn and Petrin (2001). This methodology builds upon that proposed by Olley and Pakes (1996), where investment corrects for the simultaneity bias resulting from the correlation between plants' input choices and privately known productivity, but is more suitable for developing countries' datasets. A technical condition for Olley and Pakes' methodology - investment is a monotonic function of productivity conditional on capital - is verified only for plants with positive investment (Pakes, 1994). In

[6] The exploitation of scale economies is another mechanism by which trade liberalization could lead to productivity gains. In our framework, we capture intra-plant gains unrelated to scale economies since these are embodied in the production function coefficients and productivity estimates.

Colombia, small plants invest infrequently, so they would be systematically eliminated from the estimating sample. Using investment to correct for simultaneity would in fact result in biased production function estimates and possibly unrealistic annual variability in estimated plant productivity. In our estimation procedure, we use raw materials to control for the simultaneity bias.[7] Our dataset allows us to precisely measure raw materials *usage* (hereafter simply 'raw materials') that is easily adjustable to productivity shocks.[8]

We assume that a plant decision-maker maximizes expected profits from a Cobb-Douglas production function under uncertainty. Plant-level heterogeneity is allowed in the form of plant specific productivity shocks. The timing of decisions of plant i in industry j in year t is as follows. The decision-maker initially observes current productivity ω_{it}^{j} and then chooses variable inputs labor l_{it}^{j}, raw materials m_{it}^{j} and energy e_{it}^{j} to be combined with the quasi-fixed input capital k_{it}^{j} for production of output y_{it}^{j}. We assume that plants' decision-makers decide whether or not to exit the industry before observing ω_{it}^{j}. The unbalanced nature of our panel dataset (described in Section 3) controls in part for the selection bias that arises if this assumption does not exactly hold in our sample. The estimating equation for plant i in industry j in year t is as follows (with output and inputs in logarithms):[9]

$$y_{it}^{j} = \alpha + \beta_l l_{it}^{j} + \beta_e e_{it}^{j} + \beta_m m_{it}^{j} + \beta_k k_{it}^{j} + \omega_{it}^{j} + \varepsilon_{it}^{j}, \quad (1)$$

where ω_{it}^{j}, privately known to the decision-maker and correlated with l_{it}^{j}, e_{it}^{j}, and m_{it}^{j}, generates the simultaneity bias and ε_{it}^{j}, unknown to the decision-maker, represents unpredictable mean-zero shocks to productivity realized after input choices are made. A set of production function parameters is obtained for each industry j to allow for technological differences across industries.

The plant's variable input demands derived from profit maximization depend on cap-

7 The simultaneity bias could also be addressed by fixed plant effects estimation. However, doing so would impose the particularly restrictive assumption of no dynamics in plant productivity. Alternatively, instrumental variables (IV) estimation would correct for simultaneity but would require the use of plant-level instruments correlated with input choices and uncorrelated with productivity, such as input prices, which are not reported for Colombian plants. Lagged inputs cannot serve as instruments, since our framework allows for serial correlation in plant productivity.

8 Raw materials usage is measured as purchases of raw materials plus the net change in inventories. By accounting for changes in inventories, this measure captures the current demand for raw materials that is undoubtedly correlated with current productivity. Furthermore, most plants report positive raw materials usage in all years (a requirement to belong to the estimating sample), whereas that is less prevalent for other intermediate inputs.

9 We choose an output over a value-added specification since the separability of the production technology in intermediate inputs, required for value-added to be a valid production index, is not verified for our data. Within industries, the ratio of intermediate inputs to output exhibits high variability.

ital and on privately known productivity. We invert the raw materials demand function $m_{it}^j = m_t^j(\omega_{it}^j, k_{it}^j)$ to obtain a productivity function imposing the following monotonicity assumption: conditional on capital, the demand for raw materials increases with productivity.[10] The productivity function $\omega_{it}^j = \omega_t^j(m_{it}^j, k_{it}^j)$ depends only on observable variables. Eq. (1) can be rewritten in the partially linear form (hereafter omitting industry superscript j):

$$y_{it} = \beta_l l_{it} + \beta_e e_{it} + \phi_t(m_{it}, k_{it}) + \varepsilon_{it}, \qquad (2)$$

where

$$\phi_t(m_{it}, k_{it}) = \alpha + \beta_m m_{it} + \beta_k k_{it} + \omega_t(m_{it}, k_{it}).$$

Since $E[\varepsilon_{it} \mid m_{it}, k_{it}] = 0$, the difference between Eq. (2) and its expectation, conditional on raw materials and capital is given by:

$$y_{it} - E[\, y_{it} \mid m_{it}, k_{it}] = \beta_l(l_{it} - E[\, l_{it} \mid m_{it}, k_{it}]) + \beta_e(e_{it} - E[\, e_{it} \mid m_{it}, k_{it}\,]) + \varepsilon_{it}. \qquad (3)$$

Eq. (3) is estimated by OLS (with no constant term) to obtain consistent parameter estimates for the variable inputs that do not correct for simultaneity, labor and energy. The conditional expectations are obtained by locally weighted least squares (LWLS) regressions of output, labor and energy on (m_{it}, k_{it}).[11]

Cycles in Colombian manufacturing output growth affect input demands through, e.g., variation in the ratios of input to output prices. While the raw materials demand function does not explicitly depend on plant-level input and output prices, it is allowed to differ across two periods: (i) 1977-1983, a period of slow output growth, and (ii) 1984-1991, a period of faster output growth.[12] Consequently, the productivity function $\omega_t(.)$ and the function $\phi_t(.)$ also differ across two periods. In particular, $\phi_t(.)$ is obtained from a LWLS regression of $(y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it})$ on (m_{it}, k_{it}) estimated separately across the two periods.

To estimate (β_m, β_k) consistently, we assume that productivity follows a first order Markov process as in, e.g., Hopenhayn and Rogerson (1993) and Olley and Pakes (1996):

[10] A sufficient (but not necessary) condition for this monotonicity assumption to hold is perfect competition in input and output markets. The estimation is also valid under some types of imperfect competition in output markets (e.g., Cournot oligopoly with linear demand functions (Levinsohn and Petrin, 2001)). Note that the raw materials demand *function* is industry-specific, not plant-specific.

[11] For example in the case of output, we estimate a weighted linear regression of y_{it} on a second order polynomial in (m_{it}, k_{it}) using data in the neighborhood of a data point $(\widetilde{m}_{it}, \widetilde{k}_{it})$. The intercept from this regression is an estimate for the expected value of y_{it} conditional on $(\widetilde{m}_{it}, \widetilde{k}_{it})$. See Fernandes (2002) for further details.

[12] For brevity, a t subscript indexes $m_t(.)$, $\omega_t(.)$, $\phi_t(.)$. However, these functions are allowed to differ only across the two periods, not across years. Also, note that the break years for the productivity function $\omega_t(.)$ differ from the break years for the trade regimes later described in Section 3.2.

$\omega_{it} = E[\omega_{it} \mid \omega_{it-1}] + \xi_{it}$, where ξ_{it}, the unexpected productivity shock, is independent and identically distributed. Our estimation strategy is based on the identification assumption that capital may adjust to expected productivity but does not adjust to the unexpected productivity shock. The following moment conditions are obtained by taking the expectation of Eq. (1) conditional on, respectively, capital and lagged raw materials, and replacing ω_{it} by its Markov process:

$$E[y_{it} - \beta_l l_{it} - \beta_e e_{it} - \beta_m m_{it} - \beta_k k_{it} - E[\omega_{it} \mid \omega_{it-1}] \mid k_{it}] = E[\varepsilon_{it} + \xi_{it} \mid k_{it}] = 0, \quad (4)$$

$$E[y_{it} - \beta_l l_{it} - \beta_e e_{it} - \beta_m m_{it} - \beta_k k_{it} - E[\omega_{it} \mid \omega_{it-1}] \mid m_{it-1}] = E[\varepsilon_{it} + \xi_{it} \mid m_{it-1}] = 0. \quad (5)$$

Since $E[\varepsilon_{it} \mid k_{it}] = 0$, Eq. (4) indicates that capital in year t is uncorrelated with the unexpected productivity shock in year t. Given that $E[\varepsilon_{it} \mid m_{it-1}] = 0$, Eq. (5) indicates that raw materials in year $t-1$ is uncorrelated with the unexpected productivity shock in year t.[13] The residuals $\varepsilon_{it} + \xi_{it}$ are obtained using the estimated coefficients $(\widehat{\beta}_l, \widehat{\beta}_e)$, some initial values (β^*_m, β^*_k), and a non-parametric estimate for expected productivity $E[\omega_{it} \mid \omega_{it-1}]$.[14] A generalized method of moments (GMM) criterion function weights the plant-year moment conditions by their variance-covariance matrix. The estimation algorithm starts from initial OLS estimates, iterates on the sample moment conditions to match them to their theoretical value of zero, and then reaches final parameter estimates.[15] The standard errors for the parameter estimates are bootstrapped.[16]

The plant-level Hicks-neutral TFP residual is defined as $pr_{it} = \omega_{it} + \varepsilon_{it}$ and represents the efficiency in transforming inputs into output, through learning-by-doing, adopting newer and better methods of production, improvements in managerial practices, worker training, among others. It may incorporate unobservable changes in factor utilization, since costs rise when plants operate below capacity. In fact, the use of raw materials to correct for simultaneity parallels its use to correct for unobserved variation in factor utilization (e.g.,

[13] Eq. (5) identifies the parameter β_m since m_{it-1} and m_{it} are correlated under the Markov structure.

[14] This estimate is obtained as a LWLS regression of $(\omega_{it} + \varepsilon_{it})^* = y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it} - \beta^*_m m_{it} - \beta^*_k k_{it}$ on $\omega^*_{it-1} = \widehat{\phi}_{t-1}(m_{it-1}, k_{it-1}) - \beta^*_m m_{it-1} - \beta^*_k k_{it-1}$. Note that the parameter α cannot be separately identified from the estimated $E[\omega_{it} \mid \omega_{it-1}]$.

[15] A derivative optimization routine is complemented by a grid search, given the existence of multiple local minima for the GMM criterion function in some industries. The minimizers resulting from grid search are used as starting values in the derivative optimization routine to reach more precise $(\widehat{\beta}_m, \widehat{\beta}_k)$ values.

[16] For any industry, our bootstrap procedure consists of sampling randomly with replacement plants from the dataset, matching in any year the number of plants in the original sample. Each plant is taken as a block if it is randomly selected (i.e., all its observations are included in the bootstrap sample), since the estimation requires the use of lagged inputs. We obtain estimates $(\beta_l, \beta_e, \beta_m, \beta_k)$ for 100 different bootstrap samples. The standard deviation of a parameter estimate across bootstrap samples constitutes its standard error.

Basu, 1996). Considering this broader concept of productivity is useful to examine whether plant productivity is affected by trade policy. Using the consistent production function coefficients, plant TFP is estimated by $\widehat{pr}_{it} = y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it} - \widehat{\beta}_m m_{it} - \widehat{\beta}_k k_{it}$. This TFP measure is associated with a particular industry's technology, so it is not comparable across industries. We follow Aw, Chen and Roberts (2001) and Pavcnik (2002) to obtain a relative TFP measure, comparable across years and industries. For each plant in an industry, relative TFP is the difference between the plant's estimated TFP and the TFP of an average plant in the industry in 1977 (obtained combining average logarithmic output and inputs in 1977 with the estimated production coefficients). Hereafter, pr_{it} denotes the relative TFP measure.

Our analysis of the impact of trade policy on plant productivity is based on the following specification that pools plants across all industries and years:

$$pr_{it}^{j} = \beta_0 + \lambda_t + \beta_1 TP_{t-1}^{j} + (\beta_2)' X_{it}^{j} + I^{j} + u_{it}^{j}, \tag{6}$$

where λ_t is an indicator variable for sample years, TP_{t-1}^{j} is a measure of lagged trade protection, X_{it}^{j} is a matrix of plant characteristics affecting productivity, I^{j} is an indicator variable for the plant's 3 or 4-digit industry and u_{it}^{j} represents other omitted factors influencing productivity. Part of the heterogeneity in plant productivity is deliberately left unexplained in Eq. (6), as our interest lies in a specific factor affecting productivity: trade protection. Note that β_1 is negative if trade liberalization is associated with an increase in plant productivity.

3. Data: Production and Trade Policy

3.1. Production Variables

This paper uses plant-level panel data from the Colombian Manufacturing census provided by DANE (National Statistical Institute) for the years 1977 through 1991. Plants with less than 10 employees are: (i) included in the census in 1977-1982, (ii) excluded in 1983-1984, and (iii) included as a small proportion after 1985.[17] The census covers extensively formal industrial production in all 3-digit ISIC (revision 2) industries in Colombia.

[17]The census does not indicate whether a plant is a single-plant firm or belongs to a multi-plant firm. It is unlikely, however, that this biases the estimated effect of trade liberalization on productivity. If, for cost efficiency purposes under liberalization, firms replace less productive plants by more productive new plants keeping the same identification number in the census, then a positive effect of liberalization on productivity would be largely due to the exit of less productive plants. This is not a concern for our study since DANE registers any new plant with a new identification number. Also, if plants belonging to industrial groups have better access to domestic and especially to imported inputs, they may derive less productivity gains from liberalization, but that does not bias the estimated effect of liberalization.

The unbalanced nature of the panel allows the identification of entering and exiting plants each year. For each plant and year, the survey collects data on production and sales revenues, value added, input use (labor categories, raw materials, electricity and fuels which are aggregated into an energy input), inventories of output and raw materials, investments (buildings, machinery, transportation, office, land), exports (1981-1991), 3 and 4-digit ISIC industry code and year of start-up operations.[18] Some plants in the original sample (102,911 observations) are eliminated due to, e.g., incomplete series, zero values for output or inputs, clear reporting errors, or an ambiguous industrial classification. The final sample has 97,107 observations corresponding to an average of 6,474 plants per year.

A large degree of plant heterogeneity is found in size, location, age, output and inputs. Standard deviations of output and inputs across plants are more than twice the size of means in all industries. The distribution of plant size is relatively stable over time, with plants with less than 50 employees representing more than 70% of manufacturing in any year. The median plant age increases from 10 years in 1977 to 14 years in 1991. The major industries are food, apparel, textiles, printing, nonmetallic minerals and metal products. While the distribution of plants across industries is relatively stable over time, a large number of plants enter into and exit from the various industries. Average annual entry and exit rates in our sample are 11.4% and 9.8%, respectively. Nevertheless, entrant and exiting plants represent a small percentage of total output and are much smaller than incumbents.

3.2. Trade Regimes in Colombia

From 1977 to 1991, Colombian trade policy underwent significant swings, making it an interesting case to identify the adjustment of plant productivity to changes in protection.[19] Three trade regimes can be clearly identified:

(i) *First liberalization period* (1977-1981): the government liberalized import barriers by lowering tariffs and increasing the proportion of items under the free import regime, as a response to exchange rate pressures from an increase in world coffee prices, high foreign

[18]Capital stock measures are constructed by the perpetual inventory method for each plant and the five types of capital. Nominal variables in current pesos are converted to 1980 pesos by the corresponding price deflator. Specific price indexes from the Colombian Central Bank are used to deflate the different types of capital and intermediate inputs. We thank Mark Roberts at Pennsylvania State Univ. for providing output price indexes at the 3-digit ISIC level used to deflate plants' nominal sales (adjusted for changes in inventories) and generate a measure of output. This procedure has some limitations (Klette and Griliches, 1996) but has been widely used in previous studies in the absence of plant-specific price data.

[19]See Garay (1991), Garcia (1991), GATT (1990) and World Bank (1984, 1989, 1991).

borrowing and illegal drug trade.

(ii) *Protection period* (1982-1984): trade restrictions were significantly increased. All tariffs increased three times, most items were transferred to the prior-licensing list and some imports were prohibited. A strong real exchange appreciation that hurt producers in traded sectors and a world recession motivated this increase in protection.

(iii) *Second liberalization period* (1985-1991): a gradual shift to trade liberalization occurred. Initially, the major goal was the administrative rationalization of the structure controlling imports. Subsequently, significant reductions in tariff rates and dispersion were pursued and unrestricted tariff items represented an increasing fraction of total imports.

During the entire sample period, protection was characterized by a large dispersion in tariff levels and a cascading structure: lower tariffs on raw materials and intermediate inputs not produced domestically (e.g., industrial chemicals and nonferrous metals) and higher tariffs on consumer and finished products produced domestically (e.g., apparel and furniture). Also, an import licensing system was in place, whereby each item in the tariff code was classified into a free-import, a prior-licensing, or a prohibited import list.

3.3. Measures of Trade Protection

A challenge to an examination of the link between trade protection and productivity is that trade protection cannot be described by a single measure. We consider three different measures of trade protection.[20] Tariffs and ERP reflect the degree of government intervention and protection at the industry-level. Volume measures such as import penetration and export orientation reflect how important foreign consumers and producers are to domestic producers. In the case of Colombia, the different measures are consistent in indicating the relative openness of industries and the evolution of protection over time. For example, high tariffs and ERP are associated with low import penetration into 3 and 4-digit industries. Also, the levels and changes of 3-digit tariffs and ERP are highly correlated.

Table 1 shows the average nominal tariffs for 3-digit industries across the three trade

[20]Tariff levels at 3 and 4-digit ISIC levels were obtained from Jorge Garcia at the World Bank and from DNP (National Planning Department). In two of the common years across these sources, the value of tariffs differs, but the differences are negligible, except for printing and transport equipment. ERP at the 3-digit ISIC level were obtained from DNP calculated according to the Corden (1966) formula (i.e., from the tariff on the final good a weighted average of tariffs on inputs is subtracted where the weights are taken from an input-output matrix for Andean countries in 1982). Imports and exports at 3 and 4-digit levels were obtained from Jorge Garcia. Coverage of domestic production by import licenses was obtained from the World Bank. The correlations across measures are presented in Fernandes (2002).

regimes. For most industries, a sharp increase in tariffs from the first liberalization period to the protection period is followed by a decline in the second liberalization period. Broad trends in trade orientation across industries are presented in Table 2. For most industries, import penetration decreases between 1980 and 1985 and increases between 1985 and 1991 (though less than expected given a strong depreciation in 1985-1988). Export orientation declines between 1980 and 1984, under increased protection and RER appreciation, then increases between 1984 and 1991.[21]

4. Production Function and Productivity Results

The results from the nonparametric/GMM production function estimation are presented in Table 3 and Figure 1.[22] Observe that our parameter estimates are reasonable relative to previous studies. The variable inputs' coefficients are precisely estimated at the 1% confidence level in most industries, even though bootstrapped standard errors are very high when compared to those obtained using OLS. The use of estimated regressors at different stages of the procedure increases the final coefficients' variability. The coefficient on capital is significant in the major industries. Also, we cannot reject the hypothesis that nonparametric/GMM estimates exhibit constant returns to scale in most industries.

If more labor is hired and more energy is consumed in periods of high productivity, OLS estimates for variable inputs' coefficients are upwardly biased. Figure 1 depicts the relationship between OLS and nonparametric/GMM coefficients for all inputs and industries and the 45 degree line. Figures 1a, b and c indicate that in most industries, the OLS coefficients on labor, energy and raw materials are upwardly biased relative to those from nonparametric/GMM estimation. If capital is correlated with lagged or expected productivity, then an

[21]Licenses limiting the imports of items across tariff lines are another important measure of trade protection in Colombia. They would ideally be measured by tariff or price equivalents. Unfortunately, only data for coverage ratios of domestic production is available for a single year, indicating the percentage of domestic production for which competing imports are subject to licensing restrictions. But these ratios do not show which licenses are truly binding and which are issued automatically. In 1989, coverage ratios, tariff and ERP levels are highly correlated. Tariffs place a minimum bound on the protection of items for which licenses are the binding constraint. Also, Colombian tariffs are higher for the items also subject to import licenses (World Bank, 1989, 1991). Given this positive correlation, it is possible that the impact of tariffs on productivity in Section 5 is overestimated, as it picks up also the impact of the omitted licenses.

[22]The production functions are estimated at a slightly modified 3-digit industry level. In the original sample, less than 1% of plants belong to different 3-digit industries across years. All of a plant's observations enter estimation for one industry. So, we reclassify plants into the industry to which they belong in a majority of years and eliminate the few plants for which no majority industry is found. Food plus food-miscellaneous, textiles plus apparel, wood products plus furniture are considered as three industries for estimation, since many plants belong an equal number of years to the two industries in the pair. Moreover, the technologies of the two industries in those pairs are sufficiently similar.

upward bias in its OLS coefficient is possible. However, if capital is uncorrelated with expected productivity but is positively correlated with variable inputs, then a negative bias in the OLS capital coefficient could result. In fact, the correlations between capital and labor, materials and energy are positive and significant for all industries. Figure 1d shows that the OLS coefficient on capital is higher than that from nonparametric/GMM estimation in half of the industries.

As a robustness check, we use Olley and Pakes' techniques with raw materials, rather than investment, correcting for simultaneity to obtain production function coefficients that do not differ much from those in Table 3 (see Fernandes, 2002). Also, the trade and productivity literature has often relied upon Solow TFP residuals, assuming that the contribution of an input to output is equal to its share in total revenue. So, it is interesting to compare our coefficients to average and median input revenue shares in Table 3. Labor and energy revenue shares are lower than the corresponding coefficients in most industries, whereas the opposite is true for capital revenue shares. Raw materials' revenue shares are lower than the coefficients in half of the industries. Overall, using Solow residual TFP measures could bias the estimated link between trade policy and plant productivity.[23]

For each plant, we obtain the relative TFP measure pr_{it} and privately known productivity $\widehat{\omega}_{it} = \widehat{\phi}_t(m_{it}, k_{it}) - \widehat{\beta}_k k_{it} - \widehat{\beta}_m m_{it}$. The correlation between these measures is positive and significant, with coefficients ranging from 0.61 for ceramics to 0.93 for petroleum derivatives. A decomposition of the variance of TFP within industries indicates that the main source of cross-plant variation in TFP is variation in privately known productivity.

Across industries, TFP levels (obtained as output-share weighted sums of plant-level productivities) and growth rates are generally procyclical relative to manufacturing output growth and exhibit significant heterogeneity. Also, there is evidence of intra-industry heterogeneity: at any point in time, some plants' TFP evolves differently from industry TFP, which stresses the importance of using disaggregated data for an accurate analysis of trade and productivity.

[23]We also compare our coefficients to those obtained from plant fixed effects estimation. Fixed effects coefficients on labor, energy and raw materials are smaller than nonparametric/GMM coefficients in most industries, whereas the coefficients on capital are larger than nonparametric/GMM coefficients in half the industries. These results are expected, since downward biases due to measurement error in inputs are exacerbated with estimates obtained from within-plant variation in output and inputs. As a final robustness check, we use electricity to correct for simultaneity in the nonparametric/GMM estimation and obtain coefficients relatively close in magnitude to those in Table 3.

5. Productivity and Trade Policy

5.1. Average Impact of Tariffs

In this section we examine the effect of tariffs on plant productivity. The results from estimating Eq. (6) are presented in Table 4 for OLS estimation with robust standard errors (White correction for heteroskedasticity) clustered by plant and for plant fixed effects estimation.[24] We include plant age in X_{it}^{j}, allowing it to have a non-linear effect on productivity (see Campbell, 1998; Jensen, McGuckin and Stiroh, 2001; Power, 1998). Through year effects, we control for shocks (e.g., macroeconomic cycles) affecting equally plant productivity in all industries. The coefficient of interest β_1 is negative and precisely estimated at the 1% confidence level in columns (2)-(3) and (7)-(8), where unobserved fixed industry heterogeneity is controlled for.[25] Note that these columns provide estimates of the impact of tariffs on plant productivity within industries over time. We also find a negative and significant impact of tariffs on productivity in columns (4)-(5) and (9)-(10), where we account for unobserved persistent characteristics causing serial correlation in plants' error terms. Nominal tariffs are measured in fractional terms, so their reduction by one percentage point increases productivity by β_1%. For example, the coefficient in column (7) implies that a 10% reduction in 4-digit tariffs would lead to an increase in plant productivity of almost 3%. Overall, the results support the hypothesis that lowering protection from foreign competition generates productivity gains, even after controlling for unobservable industry or plant-level heterogeneity.

The coefficient on tariffs in Eq. (6) is unbiased, unless some omitted factor influencing productivity is correlated with tariffs. A difficulty that may arise in our framework is the possibility of endogenous trade policy with respect to plant productivity, especially when considering current (rather than lagged) trade policy. A biased estimate of β_1 would be obtained if (i) the government increased trade protection in response to lobbying by firms in industries with lower productivity, or (ii) it adjusted protection to reflect industries' productivity relative to other domestic or foreign industries. Changes in tariff could be taken

[24]In Eqs. (6)-(9), when trade protection TP is measured by tariffs, time subscripts require a careful interpretation. Suppose $t-1$, t, $\tau-1$, τ are sample years in chronological order. pr_{it}^{j} is affected by tariffs TP_{t-1}^{j}, where t and $t-1$ are consecutive sample years. But for the next pair considered $pr_{i\tau}^{j}$ and $TP_{\tau-1}^{j}$, $\tau-1$ may be strictly larger than t if tariff data at t is unavailable (though the same one year lag separates $t-1$ from t and $\tau-1$ from τ): e.g., TFP in 1981 is affected by tariffs in 1980, but the following pair considered is TFP in 1984 affected by tariffs in 1983, since tariff data is unavailable in 1981-1982.

[25]Sample sizes differ in columns (1)-(5) and (6)-(10) since tariff data for some 4-digit industries is not disclosed.

as exogenous if they resulted from GATT negotiations. But although Colombia became a GATT member in 1981, it did not participate in trade negotiations before the Uruguay Round (1986-1994), so tariff changes during our sample period are unrelated to GATT regulations.

We argue that during our sample period, trade policy determination in Colombia was such that its endogeneity with respect to productivity is not a serious concern. The changes in tariffs were cyclical and a policy response by the government to macroeconomic shocks for short-run stabilization purposes. Import barriers were alternatively loosened or tightened to smooth out aggregate expenditure in response to coffee booms in the first liberalization period or to external payment deficits in the protection period (Hallberg and Takacs, 1992). While the first liberalization period was "stimulated by a desire to control money supply and inflation without an export-destroying revaluation" (Urrutia, 1994, p. 297), the protection period responded to escalating fiscal and current account deficits. Indeed, tariff revenue represented an important fraction of government tax revenue in Colombia - more than 16% in 1981-1986 (World Bank, 1989).

Furthermore, across any pair of years, tariffs moved uniformly in an upward or downward direction. Although the magnitude of changes in tariffs differed significantly across industries, they did not result from the government asymmetrically changing the tariffs protecting less productive industries in response to pressures. Rather, the differential changes resulted from the government's interest in changing more strongly the tariffs protecting goods "whose demand was relatively more elastic to price movements" (Garay, 1991, p. 19), so that imports increased or declined more rapidly.[26]

For most of the sample period, there is no evidence that trade policy was adjusted by the government to reflect industries' relative productivities. Trade liberalization was not considered as a channel to accelerate growth or to improve the allocation of resources (Garcia, 1991). In fact, trade liberalization was presented by DNP as a change needed for the economy to "start achieving greater productivity growth and efficiency" (Urrutia, 1994, pp. 304-305) only in 1990. Moreover, industrialists only began to realize that (i) the domestic market was not a dynamic source of growth, (ii) trade protection had high costs and, (iii) exporters became a strong pressure group only by the end of the 1980s.

[26]Our discussion does not imply the absence of political economy pressures during the sample period. Colombian producers expected government protection from foreign competition since the 1950s' import substitution industrialization, but the pressures were not specific to less productive industries, but rather were widespread across industries. It is possible that these pressures operated through nontariff barriers and not through tariffs, since the approval processes in import licensing regimes are more highly subject to discretion.

While we believe that the endogeneity of trade policy with respect to productivity is not pronounced for Colombian industries, we address it as follows. We estimate the effect of lagged rather than contemporaneous tariffs on plant productivity.[27] In addition, we control for unobserved fixed industry characteristics that influence simultaneously productivity and lagged tariffs with industry fixed effects. In fact, the positive sign of the tariff coefficients in columns (1) and (6) is reversed once those fixed effects are controlled for. Goldberg and Pavcnik (2001) argue that industry fixed effects account for time-invariant political economy factors underlying higher or lower trade protection across industries. Finally, since it is plausible that unobserved time-varying industry characteristics influence simultaneously productivity and tariffs, we instrument for tariffs with the same industry characteristics used by Trefler (1993) in explaining U.S. nontariff barriers.[28] These characteristics, such as the share of unskilled labor in total employment, reflect industries' propensity to get organized and political economy determinants of protection. The instrumented coefficients on lagged 3 and 4-digit tariffs remain negative and significant and increase four times in magnitude, relative to OLS coefficients.[29] Nevertheless, these IV estimates should be viewed with caution since they suffer from serious caveats.[30]

As discussed earlier, OLS production function estimates are biased due to the correlation between inputs and productivity. Such bias is transmitted to the corresponding residual productivity measures. Our main concern is that this would be reflected in the estimated impact of tariffs on productivity. In fact, although the results are qualitatively unchanged,

[27]This also addresses Tybout's (1992) concern that uncertainty about the sustainability of changes in trade policy delays the ensuing changes in productivity, a relevant concern for Colombia, given the frequent changes in trade regime. For GATT member countries, another source of trade policy uncertainty is the freedom of authorities to vary tariff levels above or below bound levels. This is a minor concern for Colombia since only 36 items were bound upon GATT membership representing a small percentage of imports (GATT, 1990). However, the dynamics may be more complex than one-period lagged tariffs affecting plant productivity.

[28]Ideally, a dynamic model with simultaneous determination of protection and productivity should be used to derive instruments for time-varying cross-sectional patterns of protection, since most political economy models such as Grossman and Helpman (1994) predict only cross-sectional patterns of protection. Developing such a model, however, is beyond the scope of this paper.

[29]IV estimation covers the period 1981-1989 only, given some restrictions in the availability of data for the instruments. The corresponding OLS estimates of Eq. (6) are higher than those in Table 4. The first-stage regressions for 3-digit tariffs indicate that these depend negatively on Herfindahl indexes and on capital and positively on total employment, on a proxy for minimum efficient scale, on the share of unskilled labor in total employment and on output growth. The first-stage regressions for 4-digit tariffs indicate that these depend negatively on capital and on output growth and positively on total employment and on the share of unskilled labor in total employment. The results for the first-stage are available upon request and include further instruments not mentioned here due to their lack of significance in explaining tariffs.

[30]Some instruments exhibit little variation over time and hence cannot account for the variability in trade policy. More crucially, some instruments are correlated with productivity, as it will be shown in Section 7.

the actual impact of tariffs on OLS productivity is overestimated relative to the unbiased impacts in Table 4.

5.3. Robustness of the Impact of Tariffs

We now investigate the robustness of our main findings along several dimensions. First, the productivity gains associated with tariff declines could reflect the exit of less productive plants with no change in the remaining plants' productivity levels. Reduced trade protection and the consequent decline in output prices may push previously profitable low productivity producers out of business, if exit barriers are not too high. We use four approaches to examine whether plant exit affects our results. The first approach consists of decomposing changes in industry productivity into: (i) changes in continuing plants' productivity, (ii) reallocations of output among continuing plants with different productivity levels, and (iii) a term representing differences in productivity between cohorts of entrant and exiting plants (see the Appendix). The major sources of change in industry productivity are (i) and (ii) while (iii) contributes little to the change, particularly the lower productivity of exiting plants. The second approach involves estimating Eq. (6) only for plants that remain in operation until 1989 or after. The negative impact of tariffs is maintained. The third approach uses probit regressions to assess how exit probabilities vary with trade policy. Exit probabilities increase with tariffs, controlling for plant productivity and year effects. However, when a control for time-invariant differences in exit barriers across industries is added, exit probabilities decrease with tariffs. As an alternative to tariffs, we use trade regimes. The results show that exit probabilities decrease in the protection and the second liberalization periods relative to the first liberalization period, with or without industry effects. The fourth approach considers average exit rates out of industries with relatively stronger tariff reductions and shows that they are not systematically higher than exit rates out of industries with weaker tariff reductions. In sum, there is evidence that less productive plants exit, but higher exit is not linked to liberalization. So, the gains associated with lower tariffs in Table 4 reflect largely within-plant changes in productivity.

Second, RER variation could confound the impact of trade protection on productivity. Year effects account for macroeconomic changes, but the RER may affect plants differently depending on their industry's trade orientation (Levinsohn, 1999). In Colombia, during the first liberalization period the RER appreciates, whereas it depreciates during the second liberalization period.[31] A RER depreciation increases the demand for and profitability of traded industries' output.[32] In the short-run, an increase in measured productivity occurs when plants respond by exploiting unobserved unused capacity, before adjusting input choices. If such a depreciation accompanies trade liberalization, then the estimated productivity gains (in traded industries) could reflect this capacity adjustment. Using a broad concept of productivity, an increase in capacity utilization is indistinguishable from an increase in productivity, so this RER effect, if verified, does not affect our results. However, we estimate a specification where productivity depends on the RER individually and interacted with an indicator for traded industries, that indicator individually, a time trend and the trend interacted with the traded industries' indicator.[33] The evidence in Table 5, columns (1)-(5), suggests that the RER effect is not verified: RER depreciations are significantly associated with a productivity decline in traded industries. To examine directly whether the productivity gains due to lower tariffs are robust to variation in the RER, we include the RER in Eq. (6). The results in columns (6)-(9) show a negative and significant impact of tariffs on productivity. In the long run, a RER depreciation accompanying trade liberalization may protect producers by increasing the relative price of imports, partly counteracting the pressure for productivity improvement and survival brought by tariff reductions. However, estimating Eq. (6) for a period where both liberalization and RER depreciation occur (1985-1989), the negative effect of tariffs is maintained. The same is verified if the RER is included directly. So, the effect of a depreciation on producers' incentives does not overcome the effect of tariff liberalization. Overall, the negative impact of tariffs on productivity is robust to variation in the RER.

Third, several other robustness checks are performed. Eq. (6) is reestimated (i) using

[31] RER data is taken from the IMF International Financial Statistics (based on relative consumer prices).

[32] We classify industries according to their degree of trade orientation as in Nishimizu and Robinson (1984). During 1980-1991, import-competing industries have an average import penetration ratio above 10%, while export-oriented industries have an average export orientation ratio above 10%, all remaining industries are nontraded. If an industry has both ratios above 10%, it is classified as traded. All results are robust to a change in the cutoff point defining traded industries from 10 to 8%.

[33] Also, we attempt to find evidence of plants' changes in capacity utilization by considering correlations of plant productivity growth and output growth as in Pavcnik (2002). If in response to a RER depreciation output expands (contracts) in traded (nontraded) industries without a change in inputs, and correspondingly measured productivity expands (contracts), the correlation between changes in plant output and changes in plant productivity should be strong and positive. This correlation is positive but weak, ranging from 0.044 in glass to 0.335 in furniture. Also, in traded industries in years of RER depreciation, average inventories of finished goods (in levels or as a fraction of output) do not systematically decline and the percentage of plants running down output and raw materials inventories (i.e., reporting lower inventories in December than in January of that year) does not systematically increase.

data for the protection and second liberalization periods only (which amounts to a framework directly comparable to that in before-after studies), (ii) measuring trade protection by two-period lagged tariffs, and (iii) adding industry-level output as a regressor to account for procyclicality and address the possibility that the negative effect of tariffs is not a real productivity effect but rather it results from the procyclical nature of aggregate productivity combined with lower output levels under high trade protection. In all three cases, the negative and significant effect of tariffs on productivity is maintained.[34] Finally, to address the concern that our findings could result from the very disaggregated level of analysis, we examine whether reduced trade protection generates productivity gains at the industry-level. Tariffs have a negative effect on industry-level productivity.

5.4. Skill Intensity, Imports of Intermediate Inputs and Investment

The impact of tariff protection on plant productivity reflects to a large extent within-plant changes in productivity. In this section, we provide evidence on the possible sources of productivity gains at the plant level related to trade liberalization.

Focusing on the ratio of skilled employment to total employment, we find that a large majority of plants with productivity gains under liberalization experience an increase in their skilled labor intensity of production.[35] This finding can be interpreted as an improvement in the underlying product-mix and/or an increase in plants' technological sophistication (Hunt and Tybout, 1998) due to increased foreign competition.

Increased imports of intermediate inputs can be a crucial mechanism for productivity gains under trade liberalization. Imported inputs are utilized by about 25% of the plants in our sample. Almost half of the plants do not change their imports of inputs across years or trade regimes, most remain null. However, for plants that change their imports, most of those having productivity gains under trade liberalization increase their imports of inputs. Industries differ in the degree to which production relies on imported inputs, therefore in the degree to which this mechanism may underlie productivity gains. We find that a much larger fraction of plants with productivity gains under trade liberalization increase their imports of inputs in the industries whose production depends more heavily on imported

[34]We also reestimate Eq. (6) using contemporaneous tariffs (despite the endogeneity problems). Their impact on productivity is negative and smaller than that of one-period lagged tariffs.
[35]This finding is robust to focusing on each year separately, on 3-digit industries with the largest relative changes in tariffs and to measuring skill intensity by the ratio of plant skilled to unskilled employment.

inputs, compared to the fraction of plants increasing their imports in other industries.[36]

Some models of investment in productivity improvement through technology acquisition show that protection favors that acquisition. Nevertheless, it is appealing to argue the contrary, i.e., for productivity to increase under liberalization, plants need to invest in technology, in particular imported. We use plant-level machinery investments and industry-level machinery imports to examine this issue.[37] Colombian plants' investment is lumpy and in any year or trade regime, about 25% of plants do not invest in machinery. Under trade liberalization, however, most plants with productivity gains increase their machinery investments in real terms or as a fraction of output. Interestingly, under trade protection, a large fraction of plants with productivity losses reduce their investments in machinery. These conclusions are tentative given the imperfections of the data, e.g., machinery investments do not necessarily represent the acquisition of productivity-enhancing technology. Industry machinery imports provide some insight on whether liberalization-related technology diffusion is crucial for productivity gains. Imports of machinery for use in manufacturing (as a percentage of GDP) increase in 1980-1981, sharply decline with increased protection and recover after 1986 (declining in 1991). Similar paths are verified for machinery used by the 3-digit industries textiles, leather, paper, printing, food and metals.

A growing micro-level literature on exporting and productivity tests the hypotheses of self-selection of more productive plants into exports markets versus learning-by-exporting (Bernard and Jensen, 1999a, 1999b for the U.S.; Clerides, Lach and Tybout, 1998 for Colombia, Mexico and Morocco). We examine whether a plant's export status influences its productivity gains due to trade liberalization. As in previous studies, our findings suggest that exporting in year t is not associated with productivity gains from year t to year $t+1$.

[36]Nominal imports of inputs are normalized by a deflator that weights the costs of domestic and imported inputs. If imported input prices increase, e.g., by less than domestic input prices, the deflated values are measured with error, being lower than true imported inputs. We believe that this measurement problem is not serious since the results are qualitatively similar for deflated values of imported inputs and for imported inputs as a fraction of total intermediate inputs. We consider two measures for the dependence of an industry's production on imported inputs: the average ratio of industry-level imported inputs to industry-level output calculated across years and the average ratio of plant-level imported inputs to plant-level output calculated within industries across years.

[37]Note that plant-level machinery investments are not disaggregated into domestic and foreign (as is the case in the theoretical models). Industry-level machinery imports are taken from World Trade Analyzer 1980-1991 (Statistics Canada CD-Rom), commodity class 7 (Machinery and transport equipment) in the SITC revision 2 classification. Aggregating the subclasses in class 7, one obtains machinery imports for use in manufacturing industries. For some subclasses, it is possible to identify unambiguously which 3-digit ISIC industry uses the imports: e.g., subclass 726 printing and bookbinding machinery and parts is used by industry 342 printing. But these data do not indicate which plants use the imported machinery.

5.5. *Average Impact of ERP and Import Penetration*

To check the robustness of the findings with tariffs, we use alternative measures of trade protection. ERP provide information on the protective structure resulting from tariffs on output and on imported inputs.[38] The results from estimating Eq. (6) with lagged 3-digit ERP are presented in Table 6, columns (1)-(4). The impact of ERP on plant productivity is positive, not significant with industry effects and significant with plant fixed effects.[39] The contrast relative to the negative impact of tariffs could stem from a difference in the samples used. However, using the ERP sample, a negative impact of tariffs on productivity is still obtained. There appears to be a real difference between the impact of nominal protection and that of effective protection to final output on productivity that is curious given the positive correlation between tariffs and ERP during the period. Ultimately, ERP coefficients are not robust and become negative eliminating the most influential observations or the outliers, whereas the coefficients on tariffs are always negative. Also, ERP coefficients are expected to be insignificant since data requirements (e.g., coefficients from input-output tables) introduce serious noise in ERP calculations, which is confirmed in OLS specifications.

Import penetration ratios are an outcome of trade policy and measure the exposure to foreign competition. We expect these ratios to affect productivity positively if plants lower costs and become more efficient when import competition increases. However, if imports are endogenous with respect to domestic industries' productivity (e.g., in a Ricardian framework, imports are attracted to relatively less productive industries), a negative correlation between import penetration and productivity could be found. Eq. (6) is estimated using lagged 3 and 4-digit import penetration ratios and the results are presented in Table 6, columns (5)-(12). In general, import penetration has a large, positive and significant impact on plant productivity. For example, column (7) indicates that a 10% increase in import penetration into 3-digit industries increases plant productivity by 6%. These findings are not driven by the period used in the import penetration specifications. In fact, using an alternative period,

[38] However, the use of ERP could be conceptually problematic. Our production function estimation allows for changes in the mix of primary factors and intermediate inputs, but ERP represent protection to value-added which assumes that intermediate inputs are used in fixed proportion to output.

[39] The ERP on a final good declines if either tariffs on the final good decline or if tariffs on intermediate inputs increase, in relative terms. So, an interpretation of the significant positive impact in fixed effects specifications could be that lowering ERP leads to productivity losses if that occurs via increased tariffs on intermediate inputs. With no information on the tariffs on inputs imported and used in each industry, we cannot tell whether this interpretation is correct. But a requirement for its validity is verified: in a fixed effects specification relating productivity to tariffs and ERP, a negative tariff coefficient (-1.013) and a positive ERP coefficient (0.465) are obtained and both are significant.

for which data on tariffs and import penetration is available (1981, 1984-1989), the same robust conclusion is drawn: lagged import penetration affects positively plant productivity and lagged tariffs affect it negatively.

6. Productivity, Trade Policy and Plant Size

6.1. Tariffs, Plant Size and Exports

Of particular interest is the question of whether tariffs affect productivity differentially according to plant size.[40] We estimate the following specification:

$$pr_{it}^{j} = \beta_{0S} + \beta_{0L} + \lambda_t \times I^S + \lambda_t \times I^L + \beta_{1S}(TP_{t-1}^{j} \times I^S) + \beta_{1L}(TP_{t-1}^{j} \times I^L) + I^{j} + u_{it}^{j}, \quad (7)$$

where β_{0S}, β_{0L}, I^S, I^L are intercepts and indicator variables for small and large plants, respectively, and TP_{t-1}^{j}, λ_t, I^{j} are defined as in Eq. (6). Size is defined as employment at a plant in its first year in the sample to mitigate the endogeneity problem that would result if I^S and I^L were indexed by time, given the potential impact of trade liberalization on plant size.[41] Panel A of Table 7 presents the results from estimating Eq. (7) with small plants having less than 50 employees. F-tests indicate that large plants are significantly more productive than small plants. F-tests also show that the effect of tariffs on productivity differs significantly across plant size. This effect is much more negative for large plants. For example, the coefficients in column (5) imply that reducing tariffs by 10% would result in a productivity gain of 4% for large plants, twice as much as the gain for small plants. The results are robust to restricting year effects to be equal across all plants and to changing the cutoff defining small plants to 20 or 100 employees.

An alternative definition of plant size is the plant's market share in total industry output in its first year in the sample, msh_{i1}^{j}. The following specification is estimated, allowing for

[40] Some theoretical and empirical evidence is available regarding the differential effect of trade policy on output and price-cost margins across plant size. Roberts and Tybout (1996) find that, within Colombian industries facing increased import penetration, larger plants experience stronger declines in price-cost margins. In contrast, Dutz (1996) shows how incumbents adjust output to liberalized import quotas in an oligopoly model, concluding that smaller plants, with lower market shares and higher marginal costs, experience relatively stronger output contractions in response to increased imports. Also, developing countries' manufacturing industries are often dualistic, accommodating a few oligopolistic producers and a large number of small firms that operate under stronger competition, are more sensitive to the economic environment and more flexible to change.

[41] Increased exposure to foreign competition may increase plant size by increasing the elasticity of demand (reinforced by entry and exit). But, it may reduce demand, causing industry contraction and decreasing plant size. Most empirical studies find that trade liberalization is associated with reduced plant size (Dutz, 1996; Roberts and Tybout, 1991; Tybout and Westbrook, 1995).

a non-linear relationship between plant size and productivity:

$$pr_{it}^{j}=\beta_0 + \lambda_t + \beta_1 msh_{i1}^{j} + \beta_2 (msh_{i1}^{j})^2 + \beta_3 TP_{t-1}^{j} + \beta_4 (TP_{t-1}^{j} \times msh_{i1}^{j}) + I^{j} + u_{it}^{j}. \quad (8)$$

Panel B of Table 7 presents the results for plant market shares relative to 3-digit industry output. Plant productivity increases with market share at a diminishing rate. Controlling for industry effects, tariffs affect negatively and significantly productivity, as in Table 4. Tariff liberalization has a more positive impact on the productivity of plants with higher market shares. In column (2), for example, the marginal effect of tariffs on productivity for a plant with the average market share is -0.11.[42] The results are qualitatively similar for market shares relative to 4-digit industry output.

The finding that productivity gains are higher for large plants suggests that trade liberalization brings a decline in 'inefficiency rents' benefiting large producers and/or that large producers' output competes more directly with imports. Also, large plants use imported inputs in production more often than small plants. Therefore, the stronger effect of liberalization on large plants' productivity could be operating through the imported inputs mechanism. In fact, we find a much higher proportion of large plants with productivity gains under liberalization that increase their imports of inputs than the proportion of small plants doing so.

We also examine whether the impact of trade policy on productivity is stronger for plants engaging in export activities. Our specification parallels that of Eq. (7) and includes lagged tariffs, year and industry effects, an indicator variable for exporters defined as plants exporting in their first year in the sample and the interaction of this variable with tariffs.[43] The estimates indicate that the productivity of exporters is more positively affected by trade liberalization than that of non-exporters. A similar result is obtained when exporters are defined as plants exporting in every sample year. These results are consistent with the finding of a stronger positive effect of trade liberalization on large plants, since Colombian exporters are significantly larger than non-exporters. Size and export status are highly correlated across plants, so it is difficult to sort out their individual influence on the impact of trade policy on plant productivity.

[42]The marginal effect of tariffs in Eq. (8) is obtained as $\widehat{\beta}_3 + \widehat{\beta}_4 \overline{msh}$ ($\overline{msh}$ is the average market share in the sample). The averages of the regressors used to calculate the corresponding marginal effects are reported in Tables 7-10. The marginal effects of the regressors in Eqs. (7)-(9) are shown in Fernandes (2002).

[43]Allowing a plant's export status to be time-varying would result in an endogeneity problem since trade policy affects a plant's decision to export.

6.2. ERP, Import Penetration and Plant Size

Table 8 assesses the robustness of the finding that the effect of tariffs on productivity depends on plant size. Panel A shows the results from estimating Eq. (7) with lagged ERP (columns (1)-(2)) and lagged import penetration ratios (columns (3)-(6)). Panel B presents the results from estimating Eq. (8) with lagged ERP (columns (1)-(2)) and lagged import penetration ratios (columns (3)-(6)). Both panels are consistent with our findings when using tariffs as a measure of trade protection.[44]

7. Productivity, Trade Policy and Domestic Competition

7.1. Tariffs and Domestic Competition

In this section, we examine whether trade liberalization affects more strongly the productivity of plants in industries with less domestic competition.[45] We use two measures from the industrial organization literature that capture different dimensions of domestic competition. Herfindahl indexes summarize the degree of market share inequality across plants in an industry. Turnover rates reflect, at least imperfectly, the market power of large plants and their ability to inhibit entry into an industry, as well as sunk costs preventing exit. Given the potential impact of trade liberalization on concentration, entry and exit, the degree of domestic competition is measured by the value of Herfindahl indexes and turnover rates in the first sample year and taken as a fixed industry characteristic. We estimate the following specification:

$$pr_{it}^{j,k}=\beta_0 + \lambda_t + \beta_1 TP_{t-1}^{j} + \beta_2 \overline{DC}^{\,j} + \beta_3 (TP_{t-1}^{j} \times \overline{DC}^{\,j}) + I^{\,k} + u_{it}^{j,k}, \qquad (9)$$

where $\overline{DC}^{\,j}$ represents the degree of domestic competition in industry j and TP_{t-1}^{j}, λ_t, $I^{\,j}$ are defined as in Eq. (6). Since $\overline{DC}^{\,j}$ is a fixed characteristic of industries indexed by j, only industry effects at a higher level of aggregation, k, are identified in Eq. (9). The results from estimation with lagged tariffs and Herfindahl indexes are presented in Table 9, columns (1)-(6). Overall, we find that plants in less competitive domestic industries according to 3 or 4-digit Herfindahl indexes have lower productivity. Columns (1)-(6) show that the effect of tariff liberalization on plant productivity depends on whether 3 or 4-digit Herfindahl indexes

[44]The findings in Panels A and B are qualitatively unchanged when restricting year effects to be equal across all plants, changing the cutoff defining small plants from 50 to 20 or 100 employees or using plant market shares relative to 4-digit industry output, respectively.

[45]Roberts and Tybout (1996) find that increased import penetration leads to larger reductions in the price-cost margins of the more concentrated Colombian industries.

are used. However, a more careful analysis with marginal effects of tariffs at average 3 and 4-digit Herfindahl indexes indicates that tariff liberalization affects more positively plant productivity in less competitive domestic industries.

The results from estimating Eq. (9) with 3-digit turnover rates are presented in Table 9, columns (7)-(8). The marginal effects of turnover rates at average tariffs indicate that plants in less competitive domestic industries have lower productivity. Both the coefficients on tariffs and the marginal effects of tariffs at average turnover rates indicate that tariff liberalization affects more positively plant productivity in less competitive domestic industries.

7.2. ERP, Import Penetration and Domestic Competition

Table 10 examines the robustness of the findings in section 7.1. Columns (1)-(4) show the results from estimating Eq. (9) with lagged ERP, Herfindahl indexes and turnover rates and columns (5)-(12) show the results from estimating Eq. (9) with lagged import penetration ratios, Herfindahl indexes and turnover rates. These results are consistent with those obtained when using tariffs as a measure of trade protection except when ERP and 3-digit Herfindahl indexes are used as measures of trade protection and domestic competition, respectively. In this case, the marginal effects suggest that ERP affect positively plant productivity in less competitive industries.

8. Conclusion

This paper provides new evidence on the link between trade policy and plant-level productivity using Colombian data. The consistent production function estimates reveal, by comparison to OLS, the endogeneity of plants' input choices with respect to productivity. Relying on productivity estimates that correct for such endogeneity is crucial to estimate accurately the effect of trade policy on productivity. Our analysis relies on cross-industry and time variation in measures of trade policy and thereby circumvents the shortfalls of previous studies that focus on a single episode of liberalization.

Our findings suggest that trade liberalization has a strong positive impact on plant productivity, even after controlling for unobserved plant and industry heterogeneity and for the real exchange rate. The use of lagged tariffs, the control for unobserved industry fixed characteristics, and the evidence that changes in Colombian tariffs were generally a policy response to fiscal and external imbalances suggest that the negative impact of tariffs does not reflect the endogeneity of protection. Plant exit is not a major source for increased productivity under trade liberalization. Within-plant productivity gains are the crucial source and appear to be associated with increased skilled labor intensity of production, imports of intermediate inputs and machinery investments. We find that the impact of trade liberalization on productivity is stronger for large plants and for plants in industries with less domestic competition. Further research on the plant-level characteristics associated with productivity gains due to trade liberalization would be fruitful.

From a policy perspective, our research suggests that the liberalization of policies protecting manufacturing industries from foreign competition brings benefits in terms of productivity. Of course, the generalization of our results to other countries' micro-level datasets is not immediate. The effect of trade liberalization on plant productivity depends on the details of the liberalization and on its interaction with institutions and other policies.

Appendix

Two decompositions of changes in industry productivity are considered in Section 5.3. The first is given by:

$$P_t^j - P_{t-1}^j = \sum_{i \in Cont} s_{it-1}^j (pr_{it}^j - pr_{it-1}^j) + \sum_{i \in Cont} pr_{it}^j (s_{it}^j - s_{it-1}^j) + \sum_{i \in Ent} s_{it}^j pr_{it}^j - \sum_{i \in Ex} s_{it-1}^j pr_{it-1}^j,$$

where P_t^j is industry productivity (weighted average of plants' productivities), pr_{it}^j and s_{it}^j are plant i's productivity and market share in industry j output for continuing plants $Cont$, entrant plants Ent and exiting plants Ex. The first term in the decomposition represents the change in continuing plants' productivity. The second term represents the output share reallocation among continuing plants with different productivity levels. Finally, the third and fourth terms represent average productivity of entrant and exiting plants, respectively.

The second follows Aw, Chen and Roberts (2001) and is given by:

$$\begin{aligned} P_t^j - P_{t-1}^j &= \sum_{i \in Cont} \frac{1}{2}(s_{it-1}^j + s_{it}^j)(pr_{it}^j - pr_{it-1}^j) + \sum_{i \in Cont} \frac{1}{2}(pr_{it-1}^j + pr_{it}^j)(s_{it}^j - s_{it-1}^j) \\ &+ \frac{1}{2}(s_{Ex\,t-1}^j + s_{Ent\,t}^j)(pr_{Ex\,t-1}^j - pr_{Ent\,t}^j) + \frac{1}{2}(pr_{Ex\,t-1}^j + pr_{Ent\,t}^j)(s_{Ex\,t-1}^j - s_{Ent\,t}^j), \end{aligned}$$

where pr_{it}^j and s_{it}^j are defined as above, $s_{Ex\,t-1}^j$ and $s_{Ent\,t}^j$ are the market share of entrant and exiting plants in industry j, and $\omega_{Ex\,t-1}^j$ and $\omega_{Ent\,t}^j$ are the output share-weighted average productivity of entrant and exiting plants in industry j. The first term represents the change in continuing plants' productivity. The second term represents the output share reallocation among continuing plants with different productivity levels. The third term represents the difference between the productivity of entrant plants in year t and of exiting plants in year $t-1$. Finally, the fourth term represents the output share reallocation between entrant and exiting plants.

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Table 1
Nominal Tariffs across 3-digit Industries[a]

Industry	Average Tariff (%) First Liberalization Period	Average Tariff (%) Protection Period	Average Tariff (%) Second Liberalization Period
311 Food	30.5	40.6	43.4
312 Food-miscellaneous	28.4	35.8	37.7
313 Beverages	54.5	73.9	58.1
314 Tobacco	26.4	34.5	42.0
321 Textiles	57.3	82.6	48.4
322 Apparel	75.6	109.6	66.4
323 Leather products	40.8	53.1	39.8
324 Footwear	56.4	84.0	71.8
331 Wood products	41.4	55.7	43.7
332 Furniture	54.2	75.9	47.5
341 Paper	28.7	38.9	35.3
342 Printing	38.6	45.9	42.6
351 Industrial chemicals	20.2	26.7	24.0
352 Other chemicals	19.8	24.4	22.3
354 Petroleum derivatives	18.8	24.5	23.3
355 Rubber products	47.8	55.6	43.9
356 Plastics	61.9	73.1	55.2
361 Ceramics	47.4	61.6	47.8
362 Glass	35.8	38.9	32.1
369 Nonmetallic minerals	29.4	36.2	30.8
371 Iron and steel	20.2	25.8	20.9
372 Nonferrous metals	20.1	26.6	18.9
381 Metal products	40.1	49.6	39.0
382 Nonelectrical machinery	23.6	30.1	20.9
383 Electrical machinery	34.4	43.5	31.7
384 Transport equipment	26.7	37.2	31.3
385 Professional equipment	25.1	30.4	24.4
390 Other manufacturing	37.1	49.2	37.3

[a] The periods used to compute the average tariffs are as follows: (i) 1976-1980 for the first liberalization period, (ii) 1983-1984 for the protection period, and (iii) 1985-1988 for the second liberalization period. Note that for industries 311 and 312 average tariffs in the protection period are higher than in the first liberalization period but lower than in the second liberalization period. The largest increase in tariffs for those industries only occurred in 1984 when the tariff levels were 45.1 for industry 311 and 39.8 for industry 312.

Table 2
Import Penetration Ratios and Export Orientation Ratios across 3-digit Industries[a]

Industry	Export Orientation Ratio (%)					Import Penetration Ratio (%)				
	Year					Year				
	1980	1984	1985	1988	1991	1980	1984	1985	1988	1991
311 Food	9.1	3.6	3.8	5.8	11.4	6.4	5.3	4.0	4.5	3.4
312 Food-miscellaneous	2.4	5.1	6.6	7.0	7.1	2.3	3.2	3.2	2.8	2.0
313 Beverages	0.0	0.2	0.2	0.2	0.6	1.5	1.4	1.4	1.9	1.0
314 Tobacco	0.6	0.9	0.7	3.1	13.4	9.5	4.4	3.1	1.8	4.1
321 Textiles	7.7	5.3	5.7	7.6	16.8	3.1	1.9	2.1	2.8	4.8
322 Apparel	17.6	7.3	9.8	27.7	47.3	1.9	3.1	2.7	3.3	4.5
323 Leather products	13.2	14.6	23.9	34.9	45.0	1.7	1.2	1.3	2.0	3.5
324 Footwear	10.4	5.0	8.4	11.4	31.6	0.8	1.0	1.1	0.7	0.6
331 Wood products	10.5	5.1	12.6	6.5	15.8	7.3	6.6	3.2	5.2	5.4
332 Furniture	4.6	2.4	6.2	4.1	8.1	1.5	0.9	0.3	0.9	1.0
341 Paper	5.1	4.5	3.3	1.8	2.9	16.6	15.7	17.2	17.0	16.9
342 Printing	10.1	7.0	11.9	16.9	26.5	11.5	7.9	11.2	6.2	5.3
351 Industrial chemicals	7.0	6.4	8.1	12.1	18.1	40.5	38.6	65.6	44.3	43.9
352 Other chemicals	2.9	2.9	3.1	2.3	3.2	14.4	14.5	16.9	12.6	11.8
354 Petroleum derivatives	n.a.	n.a.	n.a.	n.a.	n.a.	5.8	4.2	3.3	3.5	4.7
355 Rubber products	2.0	1.3	1.5	4.2	6.1	11.3	8.5	8.0	8.6	10.1
356 Plastics	2.8	2.1	2.1	1.3	2.5	2.0	2.2	1.9	2.1	3.6
361 Ceramics	9.9	2.8	5.1	7.0	28.3	7.2	3.8	2.0	2.9	6.1
362 Glass	9.7	5.2	4.3	4.2	10.6	9.5	6.1	5.7	4.7	8.2
369 Nonmetallic minerals	8.6	4.0	5.1	5.6	9.1	3.5	2.5	2.9	3.5	2.9
371 Iron and steel	n.a.	n.a.	n.a.	n.a.	n.a.	38.5	35.8	82.0	34.0	39.7
372 Nonferrous metals	2.6	10.3	13.9	7.4	4.8	51.2	51.8	92.2	45.4	50.2
381 Metal products	7.1	3.4	3.8	4.6	10.1	15.1	14.4	14.6	12.3	15.9
382 Nonelectrical machinery	12.1	4.1	6.6	5.7	17.6	71.8	70.5	178.8	68.3	70.2
383 Electrical machinery	3.1	1.4	3.3	4.6	9.6	38.6	37.8	42.4	36.4	43.5
384 Transport equipment	3.0	0.9	1.2	0.7	5.6	40.7	31.8	46.6	28.3	29.7
385 Professional equipment	14.6	7.6	8.6	6.8	14.4	57.4	53.6	116.8	46.3	54.1
390 Other manufacturing	37.0	18.4	17.5	42.9	58.1	11.7	9.6	5.7	7.2	12.4

[a] The export orientation ratio is defined as the ratio of exports to total output (domestic output plus exports). The import penetration ratio is defined as the ratio of imports to domestic demand (domestic output plus imports). n.a. indicates that export data for petroleum derivatives and iron and steel has irregularities.

Table 3
Production Function Estimates with Materials Controlling for Simultaneity Bias[a]

Industry	Input	OLS	Revenue shares	Nonparam./ GMM	R scale
321+322 Textiles	Labor	0.316***	0.275	0.242***	
and Apparel		(0.004)		(0.014)	
	Energy	0.146***	0.018	0.115***	1.028[c]
		(0.003)		(0.007)	
N.obs	Materials	0.471***	0.500	0.66***	
20379		(0.003)		(0.053)	
	Capital	0.049***	0.207	0.011	
		(0.003)		(0.03)	
311+312 Food	Labor	0.22***	0.149	0.154***	
products		(0.005)		(0.008)	
	Energy	0.16***	0.034	0.095***	1.058[c]
		(0.004)		(0.007)	
N. obs.	Materials	0.588***	0.647	0.731***	
17651		(0.002)		(0.043)	
	Capital	0.088***	0.170	0.077*	
		(0.003)		(0.042)	
381 Metal	Labor	0.329***	0.266	0.288***	
products		(0.006)		(0.012)	
	Energy	0.095***	0.024	0.053***	0.962[c]
		(0.004)		(0.007)	
N.obs	Materials	0.587***	0.509	0.523***	
8581		(0.004)		(0.046)	
	Capital	0.048***	0.201	0.098***	
		(0.003)		(0.031)	
331+332 Wood	Labor	0.234***	0.302	0.21***	
products and		(0.007)		(0.015)	
furniture	Energy	0.115***	0.021	0.096***	0.886[c]
		(0.005)		(0.008)	
N.obs	Materials	0.635***	0.496	0.48***	
5652		(0.005)		(0.069)	
	Capital	0.033***	0.181	0.1***	
		(0.003)		(0.026)	
342 Printing	Labor	0.586***	0.295	0.516***	
		(0.011)		(0.025)	
	Energy	-0.026***	0.017	-0.055***	1.096
		(0.007)		(0.013)	
N.obs	Materials	0.484***	0.443	0.523***	
5224		(0.007)		(0.04)	
	Capital	0.077***	0.244	0.112***	
		(0.005)		(0.03)	
382 Nonelectrical	Labor	0.302***	0.280	0.284***	
machinery		(0.01)		(0.016)	
	Energy	0.056***	0.023	0.046***	0.842[c]
		(0.006)		(0.009)	
N.obs	Materials	0.612***	0.468	0.381***	
4585		(0.005)		(0.162)	
	Capital	0.084***	0.229	0.131	
		(0.005)		(0.084)	
369 Nonmetallic	Labor	0.405***	0.330	0.381***	
minerals		(0.01)		(0.02)	
	Energy	0.212***	0.090	0.186***	0.992[c]
		(0.005)		(0.012)	
N.obs	Materials	0.406***	0.344	0.31***	
4502		(0.004)		(0.084)	
	Capital	0.047***	0.237	0.116***	
		(0.005)		(0.038)	
352 Other	Labor	0.287***	0.194	0.269***	
Chemicals		(0.007)		(0.014)	
	Energy	0.018***	0.012	0.008	0.996[c]
		(0.004)		(0.009)	
N.obs	Materials	0.707***	0.521	0.658***	
4296		(0.005)		(0.045)	
	Capital	0.071***	0.273	0.061**	
		(0.004)		(0.027)	
356 Plastics	Labor	0.325***	0.196	0.303***	
		(0.008)		(0.015)	
	Energy	0.014***	0.032	-0.015*	1.032[c]
		(0.005)		(0.008)	
N.obs	Materials	0.596***	0.548	0.642***	
4059		(0.005)		(0.034)	
	Capital	0.112***	0.224	0.103***	
		(0.005)		(0.03)	
324 Footwear	Labor	0.259***	0.255	0.228***	
		(0.008)		(0.021)	
	Energy	0.109***	0.010	0.067**	1.018[c]
		(0.006)		(0.029)	
N.obs	Materials	0.608***	0.531	0.674***	
3594		(0.006)		(0.049)	
	Capital	0.027***	0.204	0.049	
		(0.005)		(0.032)	
384 Transport	Labor	0.372***	0.274	0.353***	
equipment		(0.012)		(0.025)	
	Energy	0.025***	0.024	0.009	0.922[c]
		(0.007)		(0.012)	
N.obs	Materials	0.574***	0.491	0.47***	
3310		(0.006)		(0.083)	
	Capital	0.097***	0.211	0.09	
		(0.007)		(0.058)	
383 Electrical	Labor	0.291***	0.264	0.286***	
machinery		(0.01)		(0.022)	
	Energy	0.04***	0.018	0.031***	0.907[c]
		(0.006)		(0.012)	
N.obs	Materials	0.669***	0.518	0.526***	
2824		(0.007)		(0.121)	
	Capital	0.068***	0.200	0.064	
		(0.006)		(0.055)	

Table 3 (continued)

Industry	Input	OLS	Revenue shares	Nonparam./ GMM	R. scale
341 Paper	Labor	0.2***	0.181	0.204***	
		(0.01)		(0.03)	
	Energy	0.065***	0.032	0.043***	0.917[c]
		(0.005)		(0.007)	
N.obs	Materials	0.723***	0.581	0.57***	
2017		(0.005)		(0.09)	
	Capital	0.067***	0.205	0.1**	
		(0.005)		(0.044)	
313 Beverages	Labor	0.265***	0.197	0.233***	
		(0.016)		(0.03)	
	Energy	0.193***	0.027	0.119***	0.909[c]
		(0.009)		(0.021)	
N. obs.	Materials	0.555***	0.438	0.543***	
1975		(0.01)		(0.079)	
	Capital	0.05***	0.338	0.014	
		(0.009)		(0.056)	
351 Industrial chemicals	Labor	0.095***	0.148	0.116***	
		(0.017)		(0.03)	
	Energy	0.084***	0.062	0.08***	0.913[c]
		(0.009)		(0.022)	
N.obs	Materials	0.555***	0.497	0.278***	
1713		(0.008)		(0.121)	
	Capital	0.238***	0.294	0.439***	
		(0.011)		(0.132)	
323 Leather products	Labor	0.198***	0.233	0.243***	
		(0.01)		(0.019)	
	Energy	0.035***	0.014	0.009	0.845[c]
		(0.007)		(0.013)	
N.obs	Materials	0.684***	0.571	0.53***	
1462		(0.009)		(0.1)	
	Capital	0.035***	0.182	0.063	
		(0.006)		(0.048)	
355 Rubber products	Labor	0.294***	0.234	0.261***	
		(0.013)		(0.025)	
	Energy	0.046***	0.035	0.051***	0.862
		(0.009)		(0.014)	
N.obs	Materials	0.673***	0.511	0.53***	
1196		(0.01)		(0.054)	
	Capital	0.051***	0.220	0.02	
		(0.009)		(0.057)	
385 Professional equipment	Labor	0.39***	0.321	0.396***	
		(0.02)		(0.04)	
	Energy	0.042***	0.019	0.017	0.898[c]
		(0.013)		(0.016)	
N. obs.	Materials	0.539***	0.423	0.418***	
935		(0.012)		(0.135)	
	Capital	0.091***	0.238	0.075	
		(0.01)		(0.09)	

Industry	Input	OLS	Revenue shares	Nonparam./ GMM	R. scale
371 Iron and steel	Labor	0.238***	0.227	0.201***	
		(0.019)		(0.029)	
	Energy	0.07***	0.049	0.051***	1.041[c]
		(0.012)		(0.013)	
N.obs	Materials	0.674***	0.528	0.78***	
823		(0.009)		(0.183)	
	Capital	0.078***	0.196	0.009	
		(0.01)		(0.131)	
362 Glass	Labor	0.35***	0.272	0.342***	
		(0.015)		(0.031)	
	Energy	0.119***	0.075	0.102***	1.124[c]
		(0.008)		(0.016)	
N.obs	Materials	0.581***	0.435	0.67***	
815		(0.011)		(0.071)	
	Capital	0.025***	0.218	0.01	
		(0.01)		(0.056)	
361 Ceramics	Labor	0.5***	0.455	0.506***	
		(0.026)		(0.067)	
	Energy	0.12***	0.092	0.081***	1.05[c]
		(0.014)		(0.022)	
N.obs	Materials	0.45***	0.259	0.386***	
503		(0.018)		(0.133)	
	Capital	0.026***	0.194	0.077	
		(0.012)		(0.094)	
372 Nonferrous metals	Labor	0.355***	0.230	0.315***	
		(0.035)		(0.047)	
	Energy	0.17***	0.039	0.08**	0.978[c]
		(0.023)		(0.035)	
N.obs	Materials	0.416***	0.489	0.549 ***	
435		(0.019)		(0.17)	
	Capital	0.138***	0.242	0.034	
		(0.018)		(0.176)	
354 Petroleum derivatives	Labor	0.213***	0.104	0.283***	
		(0.041)		(0.079)	
	Energy	0.052***	0.042	0.027	1.001[c]
		(0.017)		(0.029)	
N.obs	Materials	0.821***	0.634	0.52***	
306		(0.019)		(0.159)	
	Capital	0.007	0.220	0.171***	
		(0.022)		(0.087)	
314 Tobacco	Labor	0.266***	0.202	0.322***	
		(0.053)		(0.08)	
	Energy	0.187***	0.009	0.018	0.917[c]
		(0.035)		(0.039)	
N.obs	Materials	0.535***	0.516	0.389***	
269		(0.034)		(0.224)	
	Capital	0.077***	0.274	0.188	
		(0.029)		(0.193)	

[a] Bootstrapped standard errors in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. [c] indicates that the hypothesis of constant returns to scale cannot be rejected. Average revenue shares are considered and the average capital revenue share is obtained as one minus the average revenue shares of labor, energy and raw materials.

Table 4
Impact of Lagged Tariffs on Plant Productivity[a]

Regressors	OLS (1)	OLS (2)	OLS (3)	Plant Fixed Effects (4)	Plant Fixed Effects (5)
Nominal tariff 3-digit	0.177***	-0.095***	-0.092***	-0.051***	-0.07***
	(0.018)	(0.025)	(0.025)	(0.015)	(0.016)
Year effects	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			
Industry effects 4-digit			Yes		Yes
N. observations	57861	57861	57861	57861	57861
R-squared	0.01	0.11	0.15	0.03	0.06

Regressors	OLS (6)	OLS (7)	OLS (8)	Plant Fixed Effects (9)	Plant Fixed Effects (10)
Nominal tariff 4-digit	0.08***	-0.268***	-0.096 ***	-0.077***	-0.076***
	(0.017)	(0.027)	(0.023)	(0.015)	(0.016)
Year effects	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			
Industry effects 4-digit			Yes		Yes
N. observations	54501	54501	54501	54501	54501
R-squared	0.01	0.12	0.15	0.04	0.05

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant, plant age and age squared. The coefficients on age are significant at the 1% level and range from 0.002 to 0.006. The coefficients on age squared range from -0.00001 to -0.0008. Sample years included are 1977, 1979, 1981, 1984-1989. One-period lagged tariff measures are used.

Table 5
Impact of Real Exchange Rates and Lagged Tariffs on Plant Productivity[a]

Regressor	OLS (1)	Plant Fixed Effects (2)	OLS (3)	OLS (4)	Plant Fixed Effects (5)	OLS (6)	Plant Fixed Effects (7)	OLS (8)	Plant Fixed Effects (9)
Traded 3-digit Industries	-0.234***	-0.149***							
	(0.039)	(0.025)							
Traded 4-digit Industries			-0.225***	-0.179***	-0.184***				
			(0.04)	(0.042)	(0.025)				
RER	-0.002***	-0.002***	-0.002***	-0.002***	-0.002***	-0.0002	-0.0004***	0.00006	-0.0003***
	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)	(0.0002)	(0.0001)	(0.0002)	(0.0001)
RER x Traded Ind.	0.001***	0.001***	0.001***	0.001***	0.001***				
	(0.0002)	(0.0001)	(0.0002)	(0.0002)	(0.0001)				
Trend	-0.019***	-0.024***	-0.019***	-0.018***	-0.025***	0.001	-0.009***	0.003	-0.01***
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)	(0.003)	(0.002)	(0.003)	(0.002)
Trend x Traded Ind.	0.015***	0.014***	0.013***	0.01***	0.013***				
	(0.002)	(0.001)	(0.002)	(0.002)	(0.001)				
Nominal Tariff 3-digit						-0.134***	-0.12***		
						(0.02)	(0.011)		
Nominal Tariff 4-digit								-0.234***	-0.116***
								(0.015)	(0.011)
Industry effects 3-digit				Yes		Yes		Yes	
N. observations	77423	77423	72651	72651	72651	45304	45304	42630	42630
R-squared	0.002	0.012	0.003	0.361	0.012	0.157	0.005	0.166	0.005

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. Plant age and age squared are included in the regressions in columns (6)-(9). An increase in RER represents a real appreciation of the Colombian peso (IMF definition). In columns (1)-(2), interactions refer to 3-digit traded industries, in columns (3)-(5) they refer to 4-digit traded industries. In columns (1)-(5), petroleum derivatives and iron and steel are excluded due to irregularities in the export data and the omitted category are nontraded industries. Sample years included are 1980-1991 in columns (1)-(5) and 1981, 1984-1989 in columns (6)-(9). One-period lagged tariff measures are used.

Table 6
Impact of Lagged Effective Rates of Protection and Import Penetration Ratios on Plant Productivity[a]

Regressors	OLS (1)	OLS (2)	Plant Fixed Effects (3)	Plant Fixed Effects (4)
ERP 3-digit	0.004	0.004	0.023***	0.03***
	(0.014)	(0.013)	(0.009)	(0.009)
Year effects	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes			
Industry effects 4-digit		Yes		Yes
N. observations	32456	32456	32456	32456
R-squared	0.15	0.19	0.02	0.06

Regressors	OLS (5)	OLS (6)	Plant Fixed Effects (7)	Plant Fixed Effects (8)
Import penetration ratio 3-digit	1.797***	1.811***	0.601***	1.59***
	(0.077)	(0.075)	(0.024)	(0.049)
Year effects	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes			
Industry effects 4-digit		Yes		Yes
N. observations	71928	71928	71928	71928
R-squared	0.15	0.19	0.02	0.05

Regressors	OLS (9)	OLS (10)	Plant Fixed Effects (11)	Plant Fixed Effects (12)
Import penetration ratio 4-digit	-0.034*	0.668***	0.335***	0.634***
	(0.018)	(0.052)	(0.019)	(0.033)
Year effects	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes			
Industry effects 4-digit		Yes		Yes
N. observations	67686	67686	67686	67686
R-squared	0.15	0.19	0.01	0.04

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant, plant age and age squared. Sample years included are 1980, 1984, 1985, 1990, 1991 in columns (1)-(4) and 1981-1991 in columns (5)-(12). One-period lagged ERP measures and import penetration ratios are used.

Table 7
Impact of Lagged Tariffs on Plant Productivity Differentiated by Size[a]

Panel A Size Measured by Plant Employment

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Small	-0.163***	-0.02	-0.012	-0.122***	0.098***	-0.009
	(0.007)	(0.017)	(0.024)	(0.007)	(0.011)	(0.023)
Large	0.172***	0.331***	0.318***	0.189***	0.399***	0.292***
	(0.014)	(0.019)	(0.027)	(0.014)	(0.016)	(0.026)
Nominal tariff 3-d. x Small	0.253***	-0.017	-0.013			
	(0.011)	(0.026)	(0.026)			
Nominal tariff 3-d. x Large	-0.104***	-0.336***	-0.33***			
	(0.022)	(0.033)	(0.033)			
Nominal tariff 4-d. x Small				0.154***	-0.171***	-0.025
				(0.01)	(0.018)	(0.025)
Nominal tariff 4-d. x Large				-0.143***	-0.412***	-0.268***
				(0.02)	(0.024)	(0.031)
Year effects Small Large	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			Yes	
Industry effects 4-digit			Yes			Yes
N. observations	57861	57861	57861	54501	54501	54501
R-squared	0.04	0.15	0.18	0.04	0.15	0.18

Panel B Size Measured by Plant Market Share

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Market share 3-digit	7.969***	9.968***	9.417***	7.333***	8.7***	7.84***
	(0.54)	(0.503)	(0.47)	(0.439)	(0.392)	(0.404)
M. share squared	-11.06***	-12.32***	-11.13***	-10.41***	-11.14***	-9.92***
	(0.834)	(0.959)	(0.865)	(0.789)	(0.911)	(0.855)
Nominal tariff 3-digit	0.193***	-0.084***	-0.08***			
	(0.01)	(0.026)	(0.026)			
Nom.tariff 3-d. x M.share	-3.625***	-5.51***	-5.622***			
	(0.97)	(0.901)	(0.831)			
Nominal tariff 4-digit				0.106***	-0.218***	-0.091***
				(0.01)	(0.017)	(0.024)
Nom.tariff 4-d. x M.share				-2.636***	-3.172***	-2.378***
				(0.841)	(0.792)	(0.802)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			Yes	
Industry effects 4-digit			Yes			Yes
N. observations	57861	57861	57861	54501	54501	54501
R-squared	0.04	0.15	0.18	0.04	0.16	0.18
Average M. share 3-digit	0.004	0.004	0.004	0.004	0.004	0.004
Average M. share squared	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Average Nom. tariff 3-digit	0.464	0.464	0.464			
Average Nom. tariff 4-digit				0.477	0.477	0.477

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. In Panel A, small plants have less than 50 employees in their first year in the sample. In Panel B, market shares are relative to 3-digit industry output in the plant's first year in the sample. At the bottom of each column, the regressors' sample averages used to calculate the corresponding marginal effects are reported. Sample years included are 1977, 1979, 1981, 1984-1989. One-period lagged tariff measures are used.

Table 8

Impact of Lagged Effective Rates of Protection and Import Penetration Ratios on Plant Productivity Differentiated by Size[a]

Panel A Size Measured by Plant Employment

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Small	-0.003	-0.065***	-0.096***	-0.164***	-0.006	-0.126***
	(0.017)	(0.026)	(0.009)	(0.018)	(0.008)	(0.018)
Large	0.321***	0.232***	0.01	-0.056***	0.137***	0.006
	(0.022)	(0.029)	(0.013)	(0.02)	(0.013)	(0.02)
ERP 3 digit x Small	0.058***	0.052***				
	(0.014)	(0.014)				
ERP 3-digit x Large	-0.14*	-0.121***				
	(0.017)	(0.017)				
Import Penet.3-digit x Small			1.516***	1.646***		
			(0.073)	(0.072)		
Import Penet.3-digit x Large			2.241***	2.207***		
			(0.074)	(0.072)		
Import Penet.4-digit x Small					-0.149***	0.585***
					(0.019)	(0.05)
Import Penet.4-digit x Large					0.14***	0.876***
					(0.023)	(0.052)
Year effects Small Large	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes		Yes		Yes	
Industry effects 4-digit		Yes		Yes		Yes
N. observations	32456	32456	71928	71928	67686	67686
R-squared	0.19	0.23	0.19	0.23	0.18	0.22

Panel B Size Measured by Plant Market Share

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Market share 3-digit	11.22***	10.27***	8.738***	8.021***	9.039***	8.194***
	(0.527)	(0.515)	(0.219)	(0.216)	(0.222)	(0.223)
M. share squared	-23.29***	-20.72***	-20.8***	-18.46***	-20.5***	-18.13***
	(1.376)	(1.297)	(0.904)	(0.847)	(0.873)	(0.846)
ERP 3-digit	0.009	0.009				
	(0.014)	(0.013)				
ERP 3-d. x M.share	-1.757***	-1.529***				
	(0.501)	(0.481)				
Import penet. 3-digit			1.774***	1.789***		
			(0.072)	(0.071)		
Imp.penet.3-d. x M.share			4.49***	4.238***		
			(0.596)	(0.54)		
Import penet. 4-digit					0.011	0.672***
					(0.018)	(0.049)
Imp.penet.4-d. x M.share					3.211***	3.144***
					(0.594)	(0.563)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes		Yes		Yes	
Industry effects 4-digit		Yes		Yes		Yes
N. observations	32456	32456	71928	71928	67686	67686
R-squared	0.19	0.23	0.19	0.23	0.19	0.22
Average M. share 3-digit	0.004	0.004	0.004	0.004	0.004	0.004
Average M. share squared	0.00036	0.00036	0.00037	0.00037	0.00037	0.00037
Average ERP 3-digit	0.871	0.871				
Average Imp. penet. 3-digit			0.123	0.123		
Average Imp. penet. 4-digit					0.115	0.115

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. In Panel A, small plants have less than 50 employees in their first year in the sample. In Panel B, market shares are relative to 3-digit industry output in their first year in the sample. At the bottom of each column in Panel B, the regressors' sample averages used to calculate the corresponding marginal effects are reported. Sample years included are 1980, 1984, 1985, 1990, 1991 in Panels A and B, columns (1)-(2) and 1981-1991 in Panels A and B, columns (3)-(6). One-period lagged ERP measures and import penetration ratios are used.

Table 9
Impact of Lagged Tariffs on Plant Productivity Differentiated by Degree of Domestic Competition[a]

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)
Herfindahl Index 3-digit	-0.786***	-0.598***						
	(0.102)	(0.101)						
Nominal tariff 3-digit	0.114***		0.105***	-0.115***			-0.799***	
	(0.013)		(0.012)	(0.027)			(0.042)	
Nom.tariff 3-d. x Herfindahl 3-d.	-0.781***							
	(0.259)							
Nominal tariff 4-digit		0.06***			0.012	-0.313***		-0.939***
		(0.013)			(0.013)	(0.02)		(0.038)
Nom.tariff 4-d. x Herfindahl 3-d.		-1.441***						
		(0.242)						
Herfindahl Index 4-d.			-0.282***	-0.218***	-0.339***	-0.227***		
			(0.054)	(0.063)	(0.065)	(0.075)		
Nom.tariff 3-d. x Herfindahl 4-d.			0.161	0.532***				
			(0.119)	(0.144)				
Nom.tariff 4-d. x Herfindahl 4-d.					-0.131	0.406***		
					(0.129)	(0.142)		
Turnover rate 3-digit							-1.115***	-1.127***
							(0.067)	(0.068)
Nominal tariff 3-d. x Turnover 3-d.							3.122***	
							(0.143)	
Nominal tariff 4-d. x Turnover 3-d.								3.363***
								(0.135)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit				Yes		Yes		
N. observations	57861	54501	57861	57861	54501	54501	57861	54501
R-squared	0.01	0.02	0.01	0.34	0.01	0.12	0.02	0.02
Average Herf. Index 3-digit	0.045	0.045						
Average Herf. Index 4-digit			0.088	0.088	0.082	0.082		
Average Turn. rate 3-digit							25.66	25.78
Average Nom. tariff 3-digit	0.464		0.464	0.464			0.464	
Average Nom. tariff 4-digit		0.477			0.477	0.477		0.477

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. Herfindahl indexes for 1977 are used, defined as the sum of squared market shares of plants relative to industry output. Turnover rates for 1977-1978 are used, defined as the sum of entry and exit rates into 3-digit industries. At the bottom of each column, the regressors' sample averages used to calculate the corresponding marginal effects are reported. Sample years included are 1977, 1979, 1981, 1984-1989. One-period lagged tariff measures are used.

Table 10 Impact of Lagged Effective Rates of Protection and Import Penetration on Plant Productivity Differentiated by Degree of Domestic Competition

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)	OLS (9)	OLS (10)	OLS (11)	OLS (12)
Herfindahl Index 3-digit	-1.346***				-1.532***	-2.003***						
	(0.147)				(0.071)	(0.064)						
ERP 3-digit	0.066***	0.138***	0.011	-0.095***								
	(0.009)	(0.008)	(0.014)	(0.018)								
ERP3-d. x Herf.3-d.	0.748***											
	(0.187)											
Import penet. 3-digit					-0.036***		-0.05***	1.633***			0.949***	
					(0.015)		(0.016)	(0.081)			(0.033)	
Imp.penet.3-d. x Herf.3-d.					2.239***							
					(0.217)							
Import penet. 4-digit						-0.165***			-0.15***	-0.094***		0.672***
						(0.012)			(0.014)	(0.025)		(0.029)
Imp.penet 4-d. x Herf.3-d.						3.538***						
						(0.178)						
Herfindahl Index 4-digit		0.09	0.14***				-0.449***	-0.115***	-0.693***	-0.135***		
		(0.055)	(0.06)				(0.022)	(0.024)	(0.031)	(0.036)		
ERP3-d. x Herf.4-d.		-0.348***	-0.137***									
		(0.06)	(0.063)									
Imp.penet.3-d. x Herf.4-d.							1.014***	1.117***				
							(0.122)	(0.178)				
Imp.penet.4-d. x Herf.4-d.									1.32***	0.465***		
									(0.109)	(0.122)		
Turnover 3-digit				-0.239***							1.077***	0.916***
				(0.077)							(0.025)	(0.024)
ERP3-d. x Turn.3-digit				0.841***								
				(0.079)								
Imp.penet.3-d. x Turn.3-d.											-5.156***	
											(0.211)	
Imp.penet.4-d. x Turn.3-d.												-4.226***
												(0.186)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit			Yes					Yes		Yes		
N. observations	32456	32456	32456	32456	71928	67686	71928	71928	67686	67686	71928	67686
R-squared	0.02	0.02	0.15	0.02	0.02	0.02	0.01	0.15	0.01	0.15	0.03	0.02
Average Herf. Index 3-digit	0.044				0.043	0.043						
Average Herf. Index 4-digit		0.084	0.084				0.085	0.085	0.077	0.077		
Average Turn. rate 3-digit				0.198							0.224	0.227
Average ERP 3-digit	0.871	0.871	0.871	0.871								
Average Imp. penet. 3-digit					0.123		0.123	0.123			0.123	
Average Imp. penet. 4-digit						0.115			0.115	0.115		0.115

[a] The dependent variable is plant productivity. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. Herfindahl indexes for 1980 are used in columns (1)-(4) and for 1981 in columns (5)-(12). Turnover rates for 1980-1981 are used in columns (1)-(4) and for 1981-1982 in columns (5)-(12). At the bottom of each column, the regressors' sample averages used to calculate the corresponding marginal effects are reported. Sample years included are 1980, 1984, 1985, 1990, 1991 in columns (1)-(4) and 1981-1991 in columns (5)-(12). One-period lagged ERP measures and import penetration ratios are used.

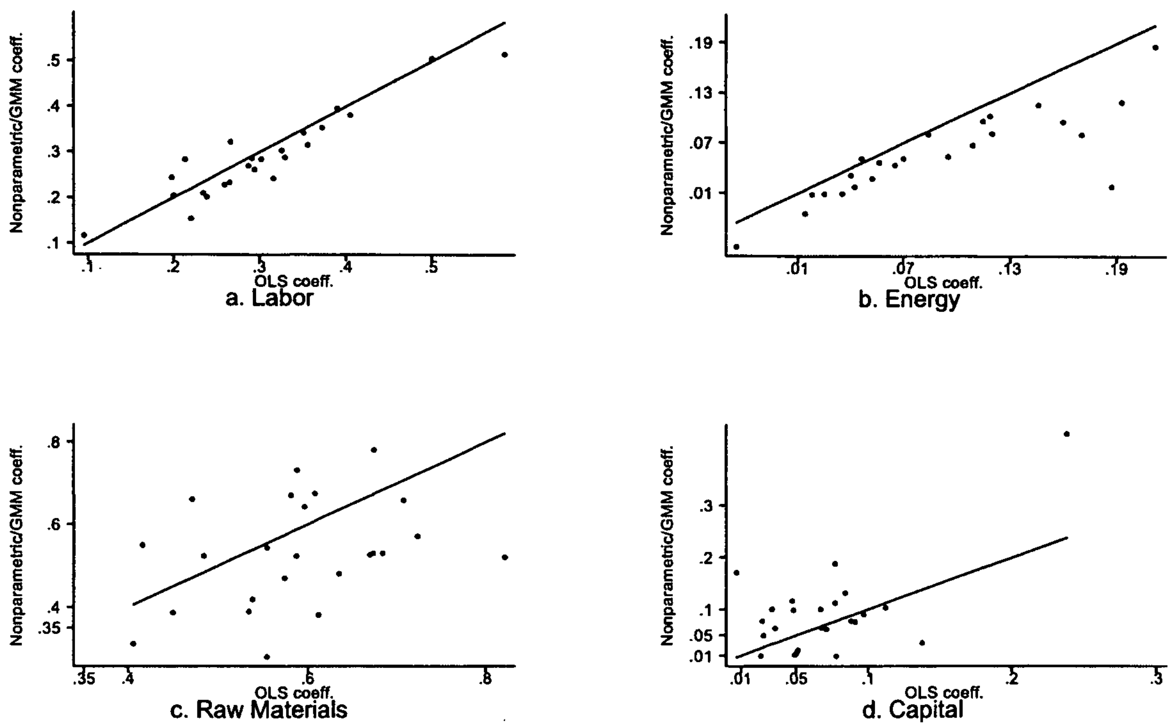

Fig. 1 Production Function Coefficients (each dot is an industry)

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