ECONOMIC GROWTH CENTER

YALE UNIVERSITY

P.O. Box 208269
New Haven, CT 06520-8269
http://www.econ.yale.edu/~egcenter/

CENTER DISCUSSION PAPER NO. 847

TRADE POLICY, TRADE VOLUMES AND PLANT-LEVEL PRODUCTIVITY IN COLOMBIAN MANUFACTURING INDUSTRIES

Ana Fernandes
Yale University

July 2002

Notes: Center Discussion Papers are preliminary materials circulated to stimulate discussions and critical comments.

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

Ana Fernandes
Yale University
July 2002

Abstract

This paper offers new insights on a central question in trade and development economics: does increased exposure to foreign competition generate gains in plant productivity? We find that it does. We examine Colombian trade policy from 1977 to 1991, a period during which trade liberalization alternates with increased trade protection in varied ways across industries, to investigate the link between trade policy and plant productivity. Using a rich panel of manufacturing plants, we obtain production function estimates separately across industries that are consistent in face of the simultaneity between input demands and productivity. These estimates are used to derive plant-level time-varying productivity measures for which a systematic component related to trade policy is identified. We find a strong negative impact of nominal tariffs on plant productivity controlling for observed and unobserved plant characteristics and industry heterogeneity. The use of lagged tariffs and the evidence on the political economy of tariff determination in Colombia allow us to argue that the negative impact of tariffs is unlikely to reflect the endogeneity of protection. Plant exit plays a minor role in generating productivity gains in face of lower trade protection. Also, accounting for variation in the Colombian peso's real exchange rate does not weaken the main findings. The negative impact of trade protection on productivity is stronger for large plants relative to small plants, as measured by employment and market shares. The negative impact of trade protection on productivity is stronger for plants in less competitive industries according to Herfindahl indexes and turnover rates. The main findings are robust to the use of effective rates of protection and import penetration ratios as measures of trade protection and openness. Finally, we also find evidence of a negative impact of trade protection on the rate of growth of plant productivity.

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

1. Introduction

This paper addresses a central question in trade and development economics: does increased exposure to foreign competition generate gains in industrial productivity? We find that it does, focusing on the interesting case of Colombia, which has experienced significant variation in trade policy during the last three decades, with periods of trade liberalization alternating with periods of increased trade protection. Moreover, there were substantial differences in the levels and changes in protection across industries. In this paper, we use a panel of manufacturing plants between 1977 and 1991 to investigate the relation between plant-level productivity and trade policy. Our evidence contributes to the ongoing theoretical and empirical debate on trade openness, productivity and growth.[1]

The empirical literature on the impact of trade liberalization on productivity follows three approaches. The macro-level approach uses cross-country GDP growth regressions, associating growth with an aggregate measure of openness to trade.[2] The comparison of outward policy orientation across countries and over time is plagued by difficulties (Pritchett (1996)). Furthermore, the use of an aggregate measure of openness to trade discards interesting information on the incentives provided by trade protection to different industries.

The industry-level approach considers regressions of industries' Solow (1957) residual TFP growth on demand growth from export expansion and import substitution or on trade-related policy variables.[3] Too often, the studies within this approach do not control for other industry characteristics shifting productivity. Furthermore, having a unique productivity measure per industry and period ignores cross-plant heterogeneity, a stylized finding in manufacturing datasets from developed and developing countries, that may help identify

[1] See, for example, Edwards (1993) and Srinivasan and Bhagwati (1999) on the debate from a cross-country perspective. The static long-run benefits from trade liberalization in terms of improved resource allocation according to comparative advantage, are well-established in Ricardian and neoclassical trade theories. New trade theory recognizes that trade policy and exposure may interact with producers' performance and market structure (e.g., Helpman and Krugman (1985)). Endogenous growth models consider dynamic effects of trade on productivity (e.g., Grossman and Helpman (1991a), Romer (1994) and Young (1991)), where trade policy can affect growth through technological change. But in these models, the assumptions imposed on the nature of technology spillovers determine whether trade protection enhances or hampers productivity growth. Further micro-level theoretical predictions are discussed in section 6.

[2] See, for example, Dollar (1992), Edwards (1993, 1994, 1998), Harrison (1996), Levine and Renelt (1992), Sachs and Warner (1995) and for a critical analysis of the literature, Rodriguez and Rodrik (1999). This approach is characterized by various methodological and data problems.

[3] See, for example, Nishimizu and Robinson (1984) (trade volumes), Lee (1995), Kim (2000) (trade-related policy variables) and Rodrik (1995) for a survey.

the impact of trade policy.

The micro-level approach uses either firm or plant residual TFP measures or consistent productivity measures. Harrison (1994) and Krishna and Mitra (1998) estimate output growth regressions derived in a Solow framework and measure the productivity gains due to trade liberalization by the coefficient on a dummy variable for the period of trade reform. Such a variable, however, captures also contemporaneous macroeconomic shocks and ignores the rich variation in protection levels and changes across industries.[4] Pavcnik (2002) uses consistent productivity measures and identifies trade reform effects from a comparison of plant productivity in import-competing and export-oriented industries relative to nontraded industries over time, as trade reform proceeds. But, during trade liberalization, unobserved factors may change both plant productivity and trade orientation subjecting her approach to an endogeneity problem.[5] Overall, the literature presents some evidence of a positive effect of trade liberalization on cross-country output growth, industrial and plant productivity levels and growth, but it is not definitive and often not robust.

This paper contributes to the micro-level approach using consistent time-varying measures of plant productivity, obtained by an estimation method that differs from previous work. Our identification strategy for the impact of trade protection on productivity relies on trade policy measures exhibiting significant variation across industries and over time, rather than on a single change in trade regime as is the case in previous studies. We focus on nominal tariffs across industries as those constitute direct price measures of trade barriers and reflect the degree of government intervention and the changes in trade regime. The use of tariffs is appealing but has often been neglected in the literature, in favor of time indicators for the period of trade liberalization.[6] We check the robustness of the tariff results across an array of different measures of trade openness. Conducting the analysis at the plant-level is interesting since it allows us to consider heterogeneity across plants and industries in the

[4] Harrison addresses this criticism by interacting a proxy for markups with annual industry-level import penetration and tariffs in a year before and a year after the trade reform. But the tariff measure used (tariff revenues as a fraction of imports) does not accurately reflect the degree of government intervention.

[5] Pavcnik obtains qualitatively similar results considering import penetration at a 4-digit industry-level and an average tariff in a subperiod. However, since tariffs are uniform across Chilean industries, they are equivalent to year effects. Hence, her analysis cannot exploit what is the most interesting feature of the Colombian case: i.e., variation in trade policy across industries.

[6] Using nominal tariffs addresses a fundamental criticism made to the literature on trade and productivity by Harrison (1996) and Rodriguez and Rodrik (1999).

effect of trade policy on technological performance, as well as to identify that effect as an average pattern.

The major findings of this paper are as follows. First, we provide strong evidence supporting the hypothesis that Colombian plants' productivity is negatively affected by trade protection. Lagged nominal tariffs at 3 and 4-digit industry levels have a significant and economically important impact on productivity, even after controlling for observed and unobserved plant characteristics and for industry heterogeneity. We find that plant exit plays a minor role in generating productivity gains in face of lower trade protection. Also, accounting explicitly for variation in the Colombian peso's real exchange rate does not affect our results. Second, we find that the impact of trade protection on productivity is stronger for large plants than for small plants, when size is measured by employment and market shares. Third, we present evidence of a differential impact of trade protection on productivity depending on the degree of domestic competition in the industry: the impact is stronger for plants in industries that are less competitive according to Herfindahl indexes and turnover rates. Fourth, we verify the robustness of our main findings using lagged effective rates of protection and import penetration ratios as measures of trade protection and exposure, respectively. Finally, we also find evidence of a negative impact of trade protection on the rate of growth of plant productivity.

In this paper we follow a two-stage estimation procedure. Allowing for cross-industry technological differences, we estimate a separate production function for each industry and derive plant-level time-varying productivity measures. We then evaluate the impact of changes in trade policy on plant productivity.

The use of ordinary least squares (OLS) for production function estimation is inappropriate because regressors such as labor and intermediate inputs, are treated as *exogenous* variables. As Griliches and Mairesse (1995) argue, inputs are *endogenous*, chosen optimally by producers. For example, a producer's input choices are likely to depend on improvements in managerial ability, which are part of the productivity shock known to the producer but unknown to the econometrician. Consequently, since input choices and productivity are correlated, OLS estimates suffer from a simultaneity bias. Also, industry evolution models, such as Jovanovic (1982), hypothesize that more efficient producers are likely to expand. Variable inputs, which are easier to adjust, tend to have upwardly biased OLS coefficient estimates.[7]

Fixed effects estimation is not appealing, since it eliminates the simultaneity bias only in the restrictive and uninteresting case of constant productivity. Instrumental variables estimation can correct the bias but is not pursued given the lack of good instruments for plants' input choices. Lagged inputs are inappropriate instruments in face of serially correlated productivity shocks, which we assume.

Our methodology for production function estimation follows Levinsohn and Petrin (2000). Under general conditions, a plant's demand for variable inputs increases monotonically with productivity, conditional on its capital stock. Therefore, we use a nonparametric estimate of the inverse input demand as the control for unobservable productivity. Raw materials is the variable input chosen to correct the simultaneity bias given its ease of adjustment in face of productivity shocks, namely through adjustments in inventories, that are richly documented in our dataset. So, production function parameters are consistently estimated. The variable inputs' coefficients thereby obtained are lower than those resulting from OLS estimation, revealing the endogeneity of input choices with respect to productivity across industries. As a robustness check, we compare our main production function estimates with alternative estimates, among which those obtained following Olley and Pakes (1996) estimation technique, with raw materials as the instrument to correct the simultaneity bias.

The channels through which trade liberalization may affect plant productivity levels and growth are diverse, ranging from reduced "X-inefficiency" or slack (as well as costs) in face of increased competitive pressure from imports to increased access to foreign (higher quality) intermediate inputs and capital goods or to higher incentives to invest in technological innovation. But the theoretical literature on the impact of trade policy on plant productivity through a specific channel, discussed in section 6, is not extensive and tends to ignore plant heterogeneity, relying mostly on the case of a representative plant. Our empirical approach relates plant-level time-varying productivity to trade policy in a regression framework. We exploit cross-industry and temporal variation in protection to identify a systematic component of productivity related to trade policy. Both OLS and plant fixed effects specifications are considered and unobserved industry heterogeneity is controlled for. We give careful consideration to the potential endogeneity of trade policy. We also consider whether movements

[7] With more than two inputs, biases cannot be all exactly signed, as they depend upon the degree of correlation between each input and the productivity shock.

in the real exchange rate alter the trade policy-productivity link. In periods of real devaluation, the resulting higher import prices may provide protection to domestic plants even in face of tariff declines. We find that in such periods plant productivity gains still hold. It is possible to claim that the negative impact of trade protection on productivity is driven by the exit of less productive plants in face of liberalization. We find only weak evidence for such claim, i.e., the productivity gains associated with lower tariffs reflect largely within-plant changes in productivity. Our finding of substantial within-industry heterogeneity in output, inputs and especially in productivity leads us to consider cross-plant variation in the impact of trade policy on productivity. To the best of our knowledge, our paper is the first to analyze such variation and plant size is an interesting characteristic across which to differentiate the impact of trade policy. Also, taking into account the cross-industry heterogeneity that portrays our dataset, we allow the impact of changes in tariffs on plant productivity to vary with entry barriers and the degree of concentration in the plant's industry.

The paper is organized as follows. In Section 2 we present the model and method for production function estimation. In Section 3 we describe the data. In Section 4 we discuss the results from production function estimation, the corresponding productivity levels and growth. In Section 5 we discuss trade policy regimes and measures and the endogeneity of trade policy. In section 6 we analyze the relation between trade policy and productivity using nominal tariffs, effective rates of protection and import penetration ratios. Section 7 concludes. All tables and figures are provided at the end of the paper.

2. Productivity Estimation

We obtain consistent production function estimates following a strategy that builds upon that proposed by Olley and Pakes (1996). The authors use plant investment to correct the simultaneity bias between plants' input choices and privately known productivity. Relying on investment for identification is problematic given the lumpiness in investment across Colombian plants, which may lead to unrealistic year-to-year variability in estimated plant productivity.[8] Furthermore, combining investment to correct the bias with the build-up of

[8] The distribution of investment across plants is characterized by a large fraction of plants with positive investment (varying significantly in levels) in half the years of plant presence in the sample and null in the remaining years. Olley and Pakes (1996) argue that the technical condition required for estimation (investment being a monotonic function of productivity, conditional on capital) is not verified for plants with zero investment. For the Colombian dataset, that would generate a bias as small plants, that invest less

the capital stock in our dataset would seriously bias the capital coefficient.[9] So, we follow a methodology better suited for developing countries' datasets, proposed by Levinsohn and Petrin (2000). Intermediate inputs control for the part of productivity observed by the plant's decision maker and correlated with input choices. The appeal of the approach is to combine elements of a structural approach and parametric estimation with the flexible nonparametric estimation of unknown functions. But for comparison purposes, we also obtain production function estimates using Olley and Pakes' estimation methods with raw materials, rather than investment, correcting the bias.

We use an unbalanced panel that accounts for entry into and exit from different industries, and therefore partly controls for the selection bias that arises if exit decisions by plants are made with knowledge of their current productivity. By not incorporating endogenous selection into the estimation, we implicitly assume that producers do not observe current productivity when they decide whether to stay in the industry. For Chilean manufacturing data, Levinsohn and Petrin (2000) argue the estimation results are similar whether or not endogenous selection is considered.

The input chosen to correct the simultaneity bias is raw materials. In contrast to Levinsohn and Petrin (2000), materials is a good choice for the Colombian dataset because information on materials use, not just purchase, is available, and that captures storage or running down of materials' inventories, highly correlated with year-to-year productivity shocks. Also, across industries, almost all plants report use of raw materials, whereas that is less prevalent for electricity and fuels, the other two intermediate inputs.

Implicit in the estimation procedure is a structural dynamic model of plant production decisions with cross-plant heterogeneity, plant specific uncertainty and the maximization of the expected discounted values of future net profits. The timing of plant i's decisions within period t is as follows. First, the plant observes productivity ω_{it}^j, then it chooses variable inputs labor l_{it}^j, raw materials m_{it}^j and energy (electricity and fuels) e_{it}^j to be combined with the quasi-fixed input capital k_{it}^j for production of output $y_{it}^j = f(l_{it}^j, m_{it}^j, e_{it}^j, k_{it}^j, \omega_{it}^j, \varepsilon_{it}^j)$. Output

often than large plants, would be systematically eliminated from the sample.

[9] The timing of plant i's choices and the build-up of the capital stock in Olley and Pakes (1996) are as follows: plant i starts period t with capital stock k_{it}^j and observes productivity ω_{it}^j. If it stays in industry j, it chooses labor, intermediate inputs and investment i_{it}^j (correlated with ω_{it}^j) which enters the capital stock at $t+1$. In our data, i_{it}^j enters the capital stock at t. Hence, k_{it}^j, which enters production at t, would be correlated with productivity and investment choices would not correct the corresponding bias.

depends also on observed productivity ω^j_{it} and on an unobserved shock ε^j_{it}. The capital stock build-up assumed is consistent with the definition and construction of capital in the dataset, $k^j_{it} = (1-\delta)k^j_{it-1} + i^j_{it}$, where i^j_{it} is plant investment and δ is the depreciation rate. Plants' investment choices (not modeled) need to be consistent with a crucial identification assumption in the estimation, discussed below: k^j_{it} does not adjust to an unexpected productivity shock, that is part of the stochastic process for observed productivity ω^j_{it}.[10]

The functional form chosen for production is Cobb-Douglas in a logarithmic form, with Hicks-neutral technical change, to make our results comparable to previous studies. We choose an output over a value-added specification (where intermediate inputs are subtracted from output). Steindel and Stiroh (2001) argue that the technical assumption required for value-added to be a valid production index (separability of the production technology in all intermediate inputs) is not verified empirically.[11] The estimating equation for plant i in industry j and period t is given by:

$$y^j_{it} = \beta_0 + \beta_l l^j_{it} + \beta_e e^j_{it} + \beta_m m^j_{it} + \beta_k k^j_{it} + \omega^j_{it} + \varepsilon^j_{it}. \qquad (1)$$

The error in (1) is constituted by productivity ω^j_{it}, known to the plant manager, possibly correlated with l^j_{it}, e^j_{it} and m^j_{it}, generating the simultaneity bias and by a shock ε^j_{it} assumed to be mean zero, uncorrelated with the regressors representing any unpredictable shocks to production and/or productivity realized after input choices are made.

The productivity residual, $\omega^j_{it} + \varepsilon^j_{it}$, concerns the efficiency with which inputs are transformed into output, coming through learning-by-doing, adopting newer and better methods of production, improvements in managerial practices, worker training, among others. An important part of productivity may relate to short-run adjustments to external shocks, i.e., changes in labor or capital utilization, as costs rise when plants operate below capacity. The use of raw materials to correct the simultaneity between inputs and unobserved productivity parallels its use to correct for unobserved variation in labor and capital utilization (Basu (1996)). So, our productivity estimates may reflect in part changes in capital or labor utilization. Considering a broad productivity concept is interesting in light of the main objective of the paper: i.e., to find whether plant productivity is affected by trade policy.

[10] So, investment choices depend only on the plant's lagged productivity.

[11] In the Colombian dataset, the assumption that intermediate inputs are used in fixed proportion to output is not supported: the ratio of intermediate inputs to output is not constant across plants in any industry, e.g. the coefficient of variation of that ratio is 69% in the transport equipment equipment.

Producers maximize profits and the corresponding variable input demands can be derived. Input demands depend on capital (a quasi-fixed input to which we return below) and on observed productivity. The assumption required to invert the raw materials demand function, $m_{it} = m_t(\omega_{it}, k_{it})$, and express productivity as a function of raw materials and capital is an intuitive monotonicity condition: for profit maximizing plants, raw materials use increases with productivity, conditional on capital. A sufficient condition for monotonicity to hold, with a well behaved production function (twice continuously differentiable) such as our Cobb-Douglas function, is perfect competition in input and output markets, but that is not necessary: output markets can be imperfectly competitive.[12] So, we obtain a productivity function $\omega_{it} = \omega_t(m_{it}, k_{it})$ depending only on plant observable variables. Equation (1) can be written in the partially linear form (omitting industry superscript j):

$$y_{it} = \beta_l l_{it} + \beta_e e_{it} + \phi_t(m_{it}, k_{it}) + \varepsilon_{it} \text{ with } \phi_t(m_{it}, k_{it}) = \beta_0 + \beta_k k_{it} + \beta_m m_{it} + \omega_t(k_{it}, m_{it}). \tag{2}$$

Since ε_{it} has zero unconditional mean, $E[\varepsilon_{it} \mid m_{it}, k_{it}]$ is also zero. The difference between (2) and its expectation, conditional on raw materials and capital is given by:

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

Equation (3) is estimated by OLS (with no constant term) -once the conditional expectations are obtained by locally weighted least squares (LWLS) regressions of output, employment and energy on m and k- to obtain consistent parameter estimates for labor and energy, the variable inputs that do not correct the simultaneity bias.[13]Though the raw materials demand $m_{it} = m_t(\omega_{it}, k_{it})$ does not explicitly depend on plant-level input and output prices (unavailable in the dataset), we partly address this restrictiveness by allowing that demand function (along with the productivity function resulting from its inversion and $\phi_t(m_{it}, k_{it})$ in (2)) to differ across two periods. Growth cycles in Colombian manufacturing output may

[12]Levinsohn and Petrin (2000) argue the estimation is valid under some imperfect competition structures, e.g., Cournot oligopoly with linear demand functions.

[13]We use a flexible approach to estimate the conditional expectations of the form $m(x_1, x_2) = E[Y \mid X_1 = x_1, X_2 = x_2]$. For any given pair (x_1, x_2), we estimate a weighted linear regression of Y on a constant term plus a second order polynomial on (X_1, X_2) for the data neighboring (x_1, x_2). The bandwidth matrix is diagonal, with different diagonal elements (corresponding to smoothing in X_1 and X_2 directions) following Fan and Gijbels (1996, p. 47). The weights are given by a bivariate Normal density function, whose fast decay decreases the weight given to points far from (x_1, x_2). For each point (x_1, x_2), the estimated conditional expected value, $\widehat{E}[Y \mid X_1 = x_1, X_2 = x_2]$, is the intercept of the LWLS regression. This regression is estimated as many times as there are points on a grid chosen to be the entire sample.

generate different conditions in input markets affecting input demands through e.g., variation in the unobservable ratios of input to output prices. So, $\phi_t(.)$ is estimated separately across two periods (1977-1983, a period of slow output growth and 1984-1991, a period of faster output growth) as a LWLS regression of output net of the contribution of variable inputs (except the input correcting the bias) $(y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it})$ on (m_{it}, k_{it}).[14]

To obtain consistent estimates for (β_m, β_k), we pursue a strategy whose crucial identification assumption is that capital may adjust to expected productivity, but does not adjust to an unexpected productivity shock, ξ_{it}, when productivity is assumed to follow a first order Markov process $\omega_{it} = E[\omega_{it} \mid \omega_{it-1}] + \xi_{it}$, with ξ_{it} being independent identically distributed (i.i.d.). Such a stochastic process has been assumed for productivity in models of industrial evolution and productivity estimation such as Olley and Pakes (1996) and Ericson and Pakes (1995). Two moment conditions are estimated by GMM. The first, equation (4), says that capital at t is uncorrelated with the unexpected productivity shock at t. The second, equation (5), says that raw materials at $t-1$ is uncorrelated with the unexpected productivity shock at t. Both conditions hold controlling for the expected part of productivity conditional on lagged productivity, $E[\omega_{it} \mid \omega_{it-1}]$. Given the Markov process for productivity, lagged raw materials, that depend on lagged productivity and lagged capital, also satisfies the other condition defining an instrument, i.e., being correlated with current raw materials. Taking the conditional expectation of (1) separately with respect to capital and to lagged raw materials and replacing productivity ω_{it} by its Markov process, we obtain:

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

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

The residuals in the moment conditions, $\varepsilon_{it} + \xi_{it}$, are obtained by combining the estimated coefficients $(\widehat{\beta}_l, \widehat{\beta}_e)$, initial values for (β_m, β_k) and an estimate for $E[\omega_{it} \mid \omega_{it-1}]$. The error ε_{it} has zero unconditional mean, so it is uncorrelated with lagged productivity and $E[\omega_{it} + \varepsilon_{it} \mid \omega_{it-1}] = E[\omega_{it} \mid \omega_{it-1}]$. The conditional expectation $E[\omega_{it} \mid \omega_{it-1}]$ is estimated by a LWLS

[14]The time subscript in $m_t(.)$, $\omega_t(.)$, $\phi_t(.)$ is such that $t = t+1$ if $t < 1983$ (same function in 1977-1983); $t \neq t+1$ if $t = 1983$ and $t = t+1$ if $t \geq 1984$ (same function in 1984-1991). For the LWLS regressions from which estimates for $\phi_t(.)$ are obtained, weighting and smoothing are applied separately to data points observed before or in 1983 and to data points observed in or after 1984.

regression of $\widehat{\omega_{it}+\varepsilon_{it}} = y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it} - \beta_m^* m_{it} - \beta_k^* k_{it}$ on lagged productivity $\widehat{\omega}_{it-1} = \widehat{\phi}_t(m_{it-1}, k_{it-1}) - \beta_m^* m_{it-1} - \beta_k^* k_{it-1}$. We do not include year effects, temporal variation is accounted for by estimating different $\phi_t(.)$ functions across periods. We consider year effects in section 6 when analyzing the link between productivity and trade policy. Our GMM criterion function weights plant-year moment conditions by their variance-covariance matrix. The estimation algorithm starts from candidate OLS estimates (β_m^*, β_k^*) and iterates on the sample moment conditions to match them to their theoretical zero value, reaching final parameter estimates. A derivative optimization routine is used, complemented by a grid search, given the existence in several industries of multiple minima for the GMM criterion function. The final estimates minimize the criterion function under the grid or the derivative optimization routine. For all industries where the minimizers result from the grid search, these are used as starting values in the derivative optimization routine to reach more precise final values for $(\widehat{\beta}_m, \widehat{\beta}_k)$. Plants in different industries operate with different technologies, so the production functions are estimated separately across a slightly modified 3-digit level industry classification (ISIC). The standard errors for the production function parameter estimates are bootstrapped as several estimated regressors are repeatedly used at different stages of the estimation.[15]

To obtain alternative production function parameters closer to Olley and Pakes (1996), the following equation, with i.i.d. residuals ε_{it}, is estimated by OLS:

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_e e_{it} + P_t(m_{it}, k_{it}) + \varepsilon_{it}, \tag{6}$$

$P_t(m_{it}, k_{it})$ is a fourth degree polynomial in materials and capital including all interaction terms (separately estimated across 1977-1983 and 1984-1991) that estimates $\phi_t(.)$. Raw materials and capital coefficients are obtained by the nonlinear minimization of the sum of

[15]Our specific 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 the plant is randomly selected (i.e., all of the plant's observations are included in the bootstrap sample), given that the estimation procedure uses a lag structure. The total number of observations differs across bootstrap samples. The estimation procedure is run for 100 bootstrap samples obtaining estimates of $(\beta_l, \beta_e, \beta_m, \beta_k)$ at each step. The standard deviation of a parameter estimate across the bootstrap samples constitutes the standard error for that parameter. The procedure is computationally burdensome for the larger industries since for each plant-year observation, a regression is estimated whenever LWLS is used, with the sole purpose of obtaining the constant term.

squared errors from the following equation, with i.i.d. residuals η_{it}:[16]

$$(y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it}) = \beta_c + \beta_m m_{it} + \beta_k k_{it} + P(\widehat{\omega}_{it-1}) + \eta_{it}. \tag{7}$$

3. Data

Our productivity analysis is based on plant-level panel data from the Colombian Manufacturing census provided by DANE (Colombian National Statistical Institute) for the years 1977 through 1991.[17] Small plants (less than 10 employees) are included in the survey during 1977-1982, excluded during 1983-1984 and included as a small proportion of the sample after 1985. The unbalanced nature of the panel allows the identification of entering and exiting plants each year. Naturally, the concept of entry and exit are relative to the DANE survey e.g., an entering plant may or may not represent a movement out of the informal sector. The survey covers extensively formal production in the Colombian industrial sector.

For each plant and year, the survey collects data on production and sales revenues, value added, input use (labor categories, raw materials, electricity, fuels), inventories, investments (buildings, machinery, transportation, office, land), exports (1981-1991), plant ownership type, location, 3 and 4-digit ISIC industry code, a plant identification number and year of start-up operations (plant age). Capital stock measures are constructed according to the perpetual inventory method for each plant and each of five types of capital. Several corrections are implemented to obtain the final capital stock variable. Nominal variables in current pesos are converted to 1980 pesos by the corresponding price deflator.[18] The

[16] OLS estimates are the initial values for the iterative search in the non-linear least squares estimation. $P(\widehat{\omega}_{it-1})$ is a fourth degree polynomial in $\widehat{\omega}_{it-1} = \widehat{\phi}_{t-1}(m_{it-1}, k_{it-1}) - \beta_m^* m_{it-1} - \beta_k^* k_{it-1}$. The estimate of $\phi_t(.)$ is $P_t(.)$ evaluated at the polynomial coefficients estimated in (6).

[17] Plants are the unit of observation. There are important industrial groups in Colombia (most being vertically integrated and holding plants across very different industries), but the census provides no information on which plants are firms and which plants belong to a firm or group. It is unlikely that the consideration of plants instead of firms biases the estimated impact of trade policy on productivity. Suppose that for cost efficiency reasons in face of trade liberalization, all industrial groups and firms replace less productive plants by more productive new plants keeping a common 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 problem for our analysis since DANE registers any new plant (belonging to a firm or not) with a new identification number in the census. Suppose now that plants belonging to vertically integrated industrial groups have better access to inputs (domestic and especially imported) and therefore have potentially less to gain (in productivity terms) from trade liberalization. This would merely imply that plants belonging to industrial groups experience weaker changes in productivity as a result of changes in trade policy. Unfortunately this hypothesis is not testable.

[18] We thank Mark Roberts (Penn State U.) for providing us with output price indexes at a 3-digit ISIC level (28 industries) that are used to deflate plants' nominal sales generating a measure of plant-level output. The

selection of observations, from the original total of 102,911, is based on different types of data problems such as incomplete series or zero values of output, employment, intermediate inputs, capital or clear reporting errors. Further observations are eliminated given their ambiguous industrial classification, as productivity estimation is done at the level of the industry, to reach a final sample of 97,107 observations when raw materials controls for the correlation between input choices and unobservable productivity.

A large degree of plant heterogeneity is found for size, ownership type, location, age, output and inputs.[19] For output and inputs, standard deviations 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 percent of manufacturing in any given year. The geographical distribution of plants is concentrated in the regions around Bogota, Cali and Medellin. The median plant age increases from 10 years in 1977 to 14 years in 1991.[20] More than 50 percent of plants in any year belong to the industries food, apparel, textiles, printing, nonmetallic minerals and metal products. The distribution of plants across industries is relatively stable over time, but there is significant entry and exit into and out of various industries. Average annual entry and exit rates into manufacturing during 1977-1991 are 11.4 percent and 9.8 percent, respectively. The cohorts of entrant and exiting plants contribute a small percentage to total output produced, are much smaller than incumbents and have lower labor productivity. Average entry and exit rates are computed across industries and periods: trade liberalization (1977-1982), increased trade protection (1982-1985), trade liberalization (1985-1991). For a majority of industries, entry and exit rates increase from 1977-1982 to 1982-1985 but decrease from 1982-1985 to 1985-1991. These findings on unconditional exit rates are contrary to trade liberalization leading to significant

procedure of deflating sales by industry price indices is not innocuous, as Klette and Griliches (1995) point out, but is the only possibility in the absence of plant-level price data. Measuring plant output by deflated sales is a serious problem when studying productivity dispersion, but a minor problem for the study of trade policy and productivity levels and growth. Specific price indexes from the Colombian Central Bank are used to deflate the different types of capital and intermediate inputs. Since output is defined as (deflated) production plus changes in inventories of finished goods, our productivity measures are free from a downward bias that would result if goods produced in year t but not sold in that year were unaccounted for.

[19]The sample statistics discussed here are presented in Appendix B; further comments and results can be found in the Data Appendix, available at http://pantheon.yale.edu/~amf28/research.

[20]Curiously, the age of entering plants is not always zero years. Many entrants are in operation previous to entry, but are not included in the census. This can be interpreted as evidence of the importance of the informal manufacturing sector in Colombia. In most industries, average and median plant age are similar (beverages, tobacco and industrial chemicals are exceptions). But within industries there is significant heterogeneity in plant age.

industry rationalization. Analyzing the correlation between industries' entry and exit rates, we conclude that years of high entry are also years of high exit, i.e., there is divergence of outcomes for plants within an industry during a given time period.

4. Results from Estimation

4.1 Production Function Estimates

In this section, we discuss the results from the estimation procedure described in section 2, as well as those from OLS and plant fixed effects, presented in Table 1 and Figure 1.[21] In Table 1, most parameter estimates take on values within reasonable ranges, when compared to other productivity studies. The variable inputs' coefficients are precisely estimated at the 1 percent confidence level in almost all industries. The bootstrapped standard errors are higher than those of OLS estimates for all inputs, given the nature of the estimation procedure: the repeated use of estimated regressors increases the variance of estimates. If more employees are hired and more energy is consumed in periods of high productivity, OLS estimates of variable inputs' coefficients are upwardly biased. The graphs in Figure 1 depict the relationship between OLS and nonparametric/GMM parameter estimates for all industries and the four inputs, together with the 45 degree line. Figures 1a-b allow us to conclude that in most Colombian industries, OLS estimates of the contribution of labor and energy inputs to output are higher than those obtained with materials correcting the simultaneity bias. One can expect a similar type of bias for the OLS raw materials' coefficient relative to that by nonparametric/GMM estimation, as it is also a variable input. In fact, figure 1c shows that the OLS raw materials coefficient is upward biased in a majority of industries. The estimated capital coefficient covers the widest range of values across industries and is not precisely estimated in some industries, though it is significant in the largest industries

[21] As mentioned in section 2, production functions are estimated at a slightly modified 3-digit level industry classification. All observations belonging to a plant need to enter the production function estimation for a single industry since lagged inputs are used. In the original sample, less than 1% of plants are classified in different industries in different years. So, we reclassify plants into the industry to which they belong in the majority of years and eliminate the plants for which no majority industry is identified. The pairs food plus food-miscellaneous, textiles plus apparel, wood products plus furniture are considered as three industries (instead of six) for estimation, as many plants belong an equal number of years to the two industries in the pair. Moreover, the production processes can be plausibly considered to be similar for the two industries in each of these pairs. In Table 1, the number of observations listed for each industry is that used for OLS and fixed effects estimation. That number is smaller for nonparametric/GMM estimation given the use of lagged variables. The OLS and fixed effects estimates obtained using the smaller number of observations are very similar to those in Table 1.

(food plus food-miscellaneous and nonelectrical machinery are exceptions). On the one hand, capital is a quasi-fixed input that may be correlated with current expected or lagged productivity, so an upward bias in the OLS estimate is possible. This is entirely consistent with the identification assumption in the estimation, that capital does not adjust to the unexpected part of productivity. But on the other hand, if capital is uncorrelated with expected productivity, the positive bias in OLS variable inputs' coefficients may be transmitted into a negative bias in the capital coefficient, if capital and variable inputs are positively correlated. In fact, labor, materials and energy are positively correlated with capital, significantly in all industries, except in electrical machinery. Figure 1d shows that in half the industries, the OLS capital coefficient is higher than that obtained by nonparametric/GMM estimation, whereas in the other half the OLS coefficient is lower. A test for constant returns to scale from nonparametric/GMM estimates is rejected only in printing and rubber products. Naturally, these estimates are lower than OLS returns to scale for most industries.

We perform a robustness check to the results from our main estimation method by comparing them to alternative estimates. The coefficients obtained by polynomials/NLLS estimation do not differ much from those obtained by nonparametric/GMM estimation. In fact, in several intermediate and capital goods industries, the capital coefficient is almost identical under both estimation methods. The fixed effects estimates for labor, energy and raw materials coefficients are smaller than nonparametric/GMM estimates in most industries. The fixed effects capital coefficient is larger than the nonparametric/GMM in half the industries. These results are expected, as downward biases due to measurement error in inputs are exacerbated with fixed effects estimates, obtained from within-plant variation in output and inputs. An interesting comparison can be made between the parameters obtained by nonparametric/GMM estimation and average input revenue shares, as the literature on trade and productivity relies often on Solow TFP residuals, assuming that the contribution of an input to production is equal to that input's share in total revenue. Average labor and energy revenue shares are lower than estimated coefficients in most industries, whereas capital revenue shares are higher than capital coefficients.[22] Raw materials revenue shares are lower than estimated coefficients in half the industries. These results hold when the comparison

[22]For any industry, average and median input revenue shares are taken across all plants and years. The capital revenue share is obtained as one minus the shares of labor, electricity plus fuels and raw materials.

is made to median input revenue shares. By using Solow residual TFP measures, we would introduce unnecessary biases in the link between trade policy and plant productivity.

We pursue the main question in the paper using the estimates obtained with raw materials correcting the bias. But, as a final robustness check on the methodology, we estimate the production functions across industries with a different intermediate input, electricity, correcting the simultaneity bias.[23]

4.2 Industry and Plant-Level Productivity Estimates

In this section, we focus on the dynamics of productivity across Colombian industries. We construct different measures of logarithmic productivity for the two estimation methods depending on whether a TFP measure or a no-shock productivity measure is considered. From equation (1) evaluated at parameter estimates, the TFP measure is given by $\widehat{\omega_{it}+\varepsilon_{it}} = y_{it} - \widehat{\beta}_l l_{it} - \widehat{\beta}_e e_{it} - \widehat{\beta}_m m_{it} - \widehat{\beta}_k k_{it} = pr_{it}$. The no-shock productivity measure (excluding the shock to output that is uncorrelated with inputs) results from combining the estimated $\phi_t(.)$ with capital and materials coefficients: $\widehat{\omega_{it}} = \widehat{\phi}_t(m_{it}, k_{it}) - \widehat{\beta}_k k_{it} - \widehat{\beta}_m m_{it}$. The TFP and no-shock productivity are significantly positively correlated when obtained by nonparametric/GMM or by polynomials/NLLS estimation: e.g. for the estimates obtained by nonparametric/GMM, correlation coefficients range between 0.61 for ceramics and 0.93 for petroleum derivatives. The main source of cross-plant variation in TFP is variation in no-shock productivity, though variation in the shock also plays a role.[24] Productivity in industry j and year t can be defined as the output-share weighted sum of plant-level productivity, $\Omega_t^j = \sum_{i=1}^{N_{jt}} s_{it}^j pr_{it}^j$, where pr_{it}^j and s_{it}^j are plant i's productivity and market share in industry output, respectively, and N_{jt} is the number of plants in industry j. From these measures, we compute year-to-year industry TFP growth rates from nonparametric/GMM

[23] With electricity, the variable inputs in (1) are labor, raw materials plus fuels and electricity. The sample differs from that used in the raw materials estimation, as plants reporting no electricity use are dropped from the sample. The main findings are relatively similar to those with materials and are described in the Data Appendix. The OLS estimates of labor, raw materials plus fuels and electricity coefficients are higher than the nonparametric/GMM estimates in most industries. We find an upwardly biased OLS capital coefficient relative to the nonparametric/GMM estimate in half the industries. Most coefficients are close whether obtained by polynomial/NLLS or by nonparametric/GMM estimation, except for those on the instrument correcting the bias. In several industries, the coefficients on labor and capital obtained by nonparametric/GMM differ depending on which instrument is used to correct the bias. This can be expected to the extent that electricity and raw materials control for the endogeneity of inputs at different degrees.

[24] In Appendix B, Table B.6, the share of the variance of $\widehat{\omega_{it}+\varepsilon_{it}}$ accounted for by the variance of $\widehat{\omega_{it}}$ is presented for each industry and both estimation methods.

estimation, and find a large degree of heterogeneity: short periods of productivity growth alternate repeatedly with short periods of productivity decline. For most industries, these industry TFP growth rates are very similar to those from polynomials/NLLS estimation. The frequent changes are not always associated with the swings in trade policy directed at those industries. By computing the changes in productivity over two sample subperiods we find the 'procyclical' or 'countercyclical' nature of industry productivity relative to aggregate manufacturing output. An industry has 'procyclical' productivity if during 1977-1983 productivity grows by less or declines by more than it grows or declines, respectively, during 1984-1991, or if it declines during 1977-1983 and grows during 1984-1991. Most industries are characterized by procyclical productivity, except beverages, leather products, printing, plastics, nonelectrical and electrical machinery and professional equipment.

We compare our industry productivity growth rates from nonparametric/GMM estimates to those obtained by M. Roberts in World Bank (1991) using the Colombian data from 1977 to 1987. Roberts obtains TFP Tornqvist index numbers, using industry-level inputs, output and input cost shares, assuming constant returns to scale and computes productivity growth rates for 3-digit industries. These growth rates differ much from those derived from the nonparametric/GMM estimates. One of the reasons for the divergence is the difference in methods to compute industry productivity, consistent measures versus Solow residual calculation. Another reason for the divergence is the type of aggregation (even when productivity is obtained by the same method): growth rates at the industry-level versus growth rates at the plant-level aggregated to the industry-level as an output-weighted sum.[25]

Given the skewness of the size distribution in all Colombian industries, movements of output across plants with different productivity may affect industry productivity levels, Ω_t^j and corresponding growth rates. So, we follow Olley and Pakes (1996) to decompose industry TFP levels into unweighted average productivity and the covariance between plant productivity and output share: $\Omega_t^j = \overline{pr}_t^j + \sum_{i=1}^{N_{jt}}(s_{it}^j - \bar{s}_t^j)(pr_{it}^j - \overline{pr}_t^j)$, where $\bar{s}_t^j$ and $\overline{pr}_t^j$ are industry average output share and average productivity, respectively. The covariance is positive in all years in all but four industries, i.e., the allocation of output is such that more productive than average plants have higher than average output shares.[26] We decompose

[25] In fact, we also obtain plant-level TFP Tornqvist index numbers and the corresponding productivity growth rates and aggregate those to the industry-level using output-share weights (as with the nonparametric/GMM measures). These industry productivity growth rates also differ from those obtained by Roberts.

[26]

industry productivity changes to find whether industry productivity growth is driven by growth in unweighted average productivity or by a reallocation of output to more productive plants. In particular, we examine whether this decomposition varies in a systematic way with trade policy, as trade protection may permit an inefficient reallocation of resources (such as e.g., output) from more to less productive plants. In general, unweighted average productivity growth tends to drive industry productivity growth. But output reallocations from less to more productive plants are the main cause of productivity growth for some industries and years. In most years, only half the industries undergo productivity-enhancing output reallocations. But, during 1980-1982, a period when trade barriers are liberalized in most industries at different degrees, output is reallocated to more productive plants in almost all industries and during 1982-1983, a period when trade barriers are substantially tightened, the opposite occurs.

Overall, the results point to some heterogeneity in productivity growth across industries over time, partly reflecting the different possibilities for technological progress across Colombian industries. In section 6, we focus on another reason for such heterogeneity, variation in trade policy. Also, there is evidence of intra-industry heterogeneity: at a given point in time, some plants experience an evolution of productivity that differs from that of industry productivity. This finding reinforces the need to use plant-level data for an accurate analysis of trade and productivity, as industry data masks differences in plant behavior.

Technology was allowed to differ across industries in the estimation and plant productivity, pr_{it}, is associated with a specific technology, so it is not comparable across industries. We follow Aw, Chen and Roberts (2001) and Pavcnik (2002) to obtain a relative productivity measure, comparable across years and industries. For each plant in an industry, relative productivity is the difference between the plant's TFP and TFP of an average plant in the industry in 1977. TFP of an average plant is obtained combining average (logarithmic) output and inputs in 1977 with parameter estimates in Table 1. In what follows, pr_{it} refers to plant productivity comparable across industries and years.

The exceptions are food, food-miscellaneous, glass and iron and steel that have an allocation of output accruing disproportionately to less productive plants in some years. This phenomenon could be partly due to industry regulation. In most years when the output allocation accrues disproportionately to less productive plants, capital is also disproportionately allocated to plants that are less productive than average.

5. Trade Policy: Regimes, Measures and Endogeneity

5.1 Colombian Trade Policy

Our empirical framework takes advantage of the significant swings in Colombian trade policy from 1977 to 1991.[27] Three trade regimes are clearly identified: trade liberalization until 1981, increased trade protection from 1982 to 1984 and liberalization after 1985. Across regimes, protection was characterized by a large dispersion in tariff levels and a cascading tariff structure: lower tariffs on raw materials and intermediate inputs not produced domestically such as industrial chemicals, iron and steel, nonferrous metals and higher tariffs on consumer and finished products produced domestically such as textiles, apparel, footwear and furniture. Also, quantitative restrictions were in place, in the form of an import licensing system, whereby each item in the tariff code was classified into a free import list, a prior-licensing list, or a prohibited import list.

Until 1981, import barriers were decreased. The average tariff declined to around 26 percent in 1980. In 1981, the proportion of items under the free import regime (69 percent) was 16 percent higher than in 1978. An interesting feature of this liberalization episode was that it essentially responded to exchange rate pressures due to an increase in world coffee prices, high foreign borrowing by the government and illegal drug trade, so it favored a larger decrease in protection of those sectors with larger response elasticities. The liberalization was strong for tobacco, some intermediate goods and raw materials, (e.g., nonmetallic products) but weaker for beverages, textiles, wood and furniture. Strong real exchange appreciation, hurting producers in tradable goods sectors, combined with a world recession, led to a reversal of liberalization starting in 1982, with a significant increase in trade restrictions. Tariffs increased on all items three times between 1982 and 1984, reaching an average of almost 41 percent in 1984. A large number of items was transferred to the prior-licensing list and the importance of the free list decreased from 36 percent of items in 1981 to 0.5 percent in 1984. Also, the proportion of approved import licenses decreased from 30 percent of licenses requested in 1980 to only 2.5 percent in 1984. The prohibited import list was reactivated in 1984 and all manufacturing was covered by import restrictions. The more

[27] See Lopez and Castro (1987), Garcia (1991), World Bank (1984, 1989, 1991) GATT (1990) and Garay (1991) on Colombian trade policy. These sources report average tariffs (mentioned below) differing slightly from the average tariffs used in Table 2 and sections 5.2 and 6 due to weighting.

protected sectors were non-durable and durable consumer goods with average tariffs of 70 and 62 percent in 1984, 13 and 11 percent higher than in 1983, respectively. After 1985, a gradual shift to trade liberalization occurred. In 1985 and 1986, the major goal was an 'administrative rationalization' of the structure controlling imports. By 1986, 36 percent of items were freely importable. Reductions in tariff rates and dispersion proceeded in 1987. In 1988, the average tariff (27 percent) was 15 percent below that in 1985 and unrestricted tariff items represented 38 percent of total imports. At this time, only 82 percent of manufacturing was covered by import restrictions. Important tariff reductions in all industries continued in 1990-1991.

In Table 2, we present nominal tariffs for 3-digit industries, averaged across the trade regimes just described. For most industries, there is a sharp increase in tariffs from 1976-1980 to 1983-1984, followed by a decline in 1985-1988. Broad trends in trade orientation across industries are presented in Table 3.[28] Most industries experience a decrease in import penetration between 1980 and 1985 and an increase between 1985 and 1991. Despite the liberalization process, the strong devaluation of the peso in 1985, continuing on through 1988, contributes to smaller increases in import penetration than otherwise expected. In 1991, less than half the industries have import penetration ratios higher than in 1980. Export orientation declines for most industries between 1980 and 1984, partly due to increased trade restrictions and mostly due to a real exchange rate (RER) appreciation, then increases between 1984 and 1991. For most industries, export orientation in 1991 is higher than in 1980. The pattern of trade policy in Colombia makes it an interesting case to identify the dynamics of plant productivity adjustment to *changes in trade policy.*

5.2 Trade Policy Measures: Correlations

A challenge to the empirical analysis of trade and productivity is that trade openness and commercial policies are not fully described by a single variable. The use of trade policy measures or trade volumes has advantages as well as drawbacks. Edwards (1998) criticizes the use of trade volumes, which are not necessarily related to the actual trade orientation of a country. Tariff levels or quota coverage reflect the degree of government intervention and

[28]For any industry, the export orientation ratio is the ratio of exports to total output (domestic output plus exports) and the import penetration ratio is the ratio of imports to domestic demand (domestic output plus imports).

protection at the level of the industry and are better suited to capture a significant opening of trade policy that raises productivity, without being reflected in trade volumes. But export orientation and import penetration ratios are also valuable, by reflecting how important foreign consumers and producers are to domestic producers. In Table 4, we relate levels and changes of different measures of trade exposure to check their consistency in indicating the relative openness of industries and the evolution of protection over time.[29] High tariffs and effective rates of protection (ERP) are associated with low import penetration into 3 and 4-digit industries but not clearly related to export orientation (Table 4a).[30] Reductions in tariffs or ERP are weakly associated with increases in import penetration and decreases in export orientation (Table 4b). Across different trade policy regimes (between 1980, a year in the first liberalization period, 1983, a year in the protection period and 1988, a year in the second liberalization period), tariff reductions are weakly associated with reductions in import penetration (Table 4c). Between 1984, a year of increased protection, and 1990, a year of trade liberalization, reductions in ERP are weakly associated with increases in import penetration (Table 4d). For the years of available 3-digit tariffs and ERP data, the corresponding levels and changes are highly correlated (Table 4e). This finding is also verified across different trade regimes (Table 4f). But, curiously, we find that a different group of Colombian industries experiences the largest relative increase or decline in protection during 1980-1984 and 1984-1990, depending on how trade exposure is measured. This finding is similar to that in Tybout and Westbrook (1995) for Mexican industries.

Licenses limiting imports of some items across tariff lines are an important instrument of Colombian trade policy during the sample period. These licenses would ideally be measured by tariff or price equivalents but unfortunately, only data for coverage ratios of domestic production by import licenses for 1989 is available. Such ratios measure imprecisely the restrictiveness of import barriers, providing no information of which licenses are truly binding

[29]Tariff levels at 2, 3 and 4-digit ISIC levels were obtained from J. G. Garcia at the World Bank (for years 1976, 1978, 1980, 1983-1988) and from Colombia's National Planning Department (DNP) 3-digit ISIC level (for the same years as well as 1979, 1989 and 1990). For a small set of industries, the two data sources provide slightly different values for tariffs in the common years. Effective rates of protection at the 3-digit ISIC level were obtained from DNP (for years 1979, 1983, 1984, 1989, 1990). A report with coverage of domestic production by import licenses in 1989 was obtained from the World Bank. Imports and exports at 3 and 4-digit ISIC levels were obtained from J. G. Garcia (for years 1980-1991).

[30]The ERP is calculated by the Colombian National Planning Department following to the Corden (1966) formula: the tariff on the final good from which is subtracted a weighted average of tariffs on inputs (according to an input-output matrix for Andean countries in 1982).

and which are issued automatically.[31] In 1989, coverage ratios, tariff and ERP levels are highly correlated (Table 4g). In World Bank (1989, 1991) it is argued that Colombian tariffs are higher for the commodities subject to import licenses. Tariffs place a minimum bound on the protection of items for which licenses are the binding constraint on imports. So our finding of an effect of tariffs on productivity would most likely be strengthened by the finding of a similar effect of quantitative restrictions, if these were satisfactorily measured.

5.3 Endogeneity of Trade Policy

Consider the following specification:

$$pr_{it}^{j} = \beta_0 + \lambda_t + \beta_1 TP_t^j + I^j + u_{it}, \tag{8}$$

where pr_{it}^{j} is plant productivity, TP_t^j is a measure of trade policy varying over time and across industries, λ_t are year effects and I^j are industry effects. Using equation (8) to analyze the link between trade policy and productivity under the assumption that TP_t^j is given to plants can be subject to an endogeneity problem. That is the case if government authorities increase trade protection in response to lobbying pressures by firms in industries with productivity disadvantages or alternatively if they adjust trade policy measures to reflect industries' relative productivities.[32] In those cases, the residuals u_{it} would be correlated with trade policy measures resulting in inconsistent OLS estimates for β_1.[33]

Changes in nominal tariffs would be a genuinely exogenous policy change if they resulted from GATT negotiations. But even though Colombia became a GATT member in 1981, it did not participate in trade negotiations before the Uruguay Round (1986-1994), so tariff changes during 1981-1991 were independent of GATT regulations.

[31] The coverage ratio indicates the percentage of domestic production for which competing imports are subject to licensing restrictions. During the sample period, some items were kept in the prior import list for government control of over and underinvoicing of imports, but were in fact freely importable. Also, a foreign exchange budget was rationed among importers through import licenses. So, the degree to which import restrictions were binding was variable, depending on the availability of foreign exchange. This uncertainty for producers of import substitutes increased the protective effect of existing trade barriers.

[32] A productivity disadvantage may be defined relative to foreign or domestic industries. Pack (1994) explains a cross-section of ERP on Indonesian industries testing whether trade policy adjusts to cost disadvantages of domestic industries relative to potential foreign competitors. But in fact, an opposite argument could also be made: the most productive industries (relative to domestic and/or foreign competitors) are those able to pressure the government for higher tariffs, as is the case e.g., for U.S. pharmaceutical industries.

[33] To determine how serious is the econometric endogeneity of trade protection, we test for Granger causality between productivity and tariffs and find that average productivity is not significant in explaining contemporaneous 3 or 4-digit tariffs, once lagged tariffs are controlled for. This is verified also when further lags of tariffs and average productivity are included.

We could instrument trade policy measures with political economy determinants of protection to address the endogeneity bias. But most political economy models, such as Grossman and Helpman (1994) empirically tested by Goldberg and Maggi (1999), predict cross-sectional patterns of protection. We would need a dynamic model with simultaneous determination of protection and productivity to obtain instruments for time-varying cross-sectional patterns of protection, which is beyond the scope of this paper. Moreover, several covariates of protection in cross-sectional models cannot be used in the Colombian case due to lack of data. Nevertheless, we follow Trefler (1993) adapting to our panel setting his cross-sectional regression that explains U.S. nontariff barriers with variables corresponding to political economy pressures and to the propensity of industries to get organized, derived from political economy models. Tariffs on Colombian 3-digit industries are found to depend negatively on Herfindahl indexes and on capital, positively on total employment, on a proxy for minimum efficient scale, on the share of unskilled workers in total employment and on output growth and not significantly on import penetration growth. Tariffs on 4-digit industries are found to depend negatively on capital and on output growth, positively on total employment and on the share of unskilled workers in total employment and not significantly on Herfindahl indexes, on scale and on import penetration growth. A detailed rationale for each of the covariates can be found in Trefler (1993, pp.141-42), we comment now on a selected set of covariates. The coefficient on total employment is expected if a larger labor force bringing more votes leads to higher protection. The coefficient on total capital is expected if entry barriers restrict domestic and foreign entry, decreasing the required level of protection. The coefficient on output growth in 4-digit tariff regressions is expected if protection is progressive in aiding disadvantaged industries as they face lower opportunity costs of lobbying. A problem with these specifications is that many of the explanatory variables exhibit weak time variation, and therefore have little power as instrumental variables to correct the endogeneity of trade policy. More crucially, it is difficult to argue that some of these covariates are correlated with trade policy but uncorrelated with productivity. Being fully aware of the caveats, we use the covariates above in an instrumental variables estimation of equation (9) and discuss the results in section 6.1.1.

An examination of the political economy of tariff policy in Colombia enables us to argue that endogeneity is not a major problem for our nominal tariff measures. Namely, we find evidence that the increase in protection in 1982-1984 was a change in policy responding to escalating fiscal and current account deficits and was not driven by less productive industries' lobbying, so its impact on productivity can be identified. Political economy pressures in Colombia are important during the sample period, but widespread across industries. Regarding the liberalization in 1977-1981, Urrutia (1994, p.290) states that "opposition from industrialists was strong and unanimous since most saw a protected national market as a source of growth." Given the import substitution industrialization followed in Colombia since the 1950s, producers expected government protection from outside competition. Various authors emphasize that movements in tariffs are cyclical, driven by macroeconomic conditions for short-run stabilization purposes. Urrutia (1994, p.297) points out that until the 1980s, "trade liberalization [was] stimulated by a desire to control money supply and inflation without an export-destroying revaluation." Hallberg and Takacs (1994) argue that "import controls [were] alternatively tightened or eased to smooth out aggregate expenditure in response to external payment deficits [1982-1984] or coffee booms [1977-1981]." Our claim that tariff changes are a policy response to macroeconomic disequilibria is further supported in the fact that tariff revenue constitutes an important part of government tax revenue: more than 16 percent in 1981-1986 (Worldbank (1989)). Across any pair of years, we find that tariffs move almost uniformly in an upward or downward direction, though the magnitude of changes differs across industries. Exploiting these differential changes in protection across industries is our main interest throughout the rest of the paper. But the Colombian government does not seem to be changing asymmetrically tariffs protecting less productive industries in response to pressures. Rather, the differentials are mostly due to policymakers' interest in changing more strongly the tariffs protecting goods with higher demand elasticity, so that imports increase or decline more rapidly: in Garay (1998, p.331) it is argued that trade liberalization until 1981 "favored those goods which had a higher elasticity to tariff movements". The ideal, though unavailable, instruments to control for such type of endogeneity in tariff changes would therefore be interactions of changes in the peso's exchange rate with industry demand elasticities.

For most of our sample period, there is no evidence that trade policy adjusts to relative productivities. Garcia (1988, p.168) argues that "import liberalization was not (...) a way to accelerate the country's rate of growth or to improve the allocation of resources."

Urrutia (1994, pp.304-05) points out though, that in 1990 the official justification for trade liberalization by DNP was that the "economy [needed] a major shake-up to start achieving greater productivity growth and efficiency." Also, by the end of the 1980s, exporters became a strong pressure group and most industrialists realized that the internal market was not a dynamic source of growth and protection had high costs, such as the necessity to produce an inefficiently large range of products.

The approval process for a license within an import licensing regime is subject to discretion. So, it is possible that political economy pressures in Colombia operated more through nontariff barriers than on tariffs. In any case, to circumvent the possible endogeneity of contemporaneous trade policy measures with respect to industry productivity, we consider the impact of lagged measures on plant productivity. Thereby, we also address Tybout's (1992) concern that uncertainty about the sustainability of changes in trade policy delays any resulting changes in productive efficiency.[34] Such uncertainty may be relevant for Colombia, given the frequent changes in trade regime. For GATT member countries, a further source of uncertainty regarding trade policy is the freedom of authorities to vary tariff levels above or below bound levels. But this is a minor concern for Colombia since only 36 items were bound upon GATT membership representing a small percentage of imports (GATT (1990)). Even without policy uncertainty, plants require time to adjust their production process to changing trade policies. We are aware though, that the dynamic structure may be more complex than one-period lagged trade policy measures affecting productivity.

6. Trade Policy and Productivity: Results

6.1 Impact of Nominal Tariffs

In this section, we analyze the impact of trade protection on manufacturing plants' productivity. There are several channels by which trade liberalization may impact firm or plant productivity levels and growth. First, the increased foreign competitive pressure felt by domestic producers as imports expand can be transmitted into higher productivity if they

[34]In fact, uncertainty about the sustainability of changes in trade policy might strengthen the impact of trade policy on productivity if e.g., producers choose more flexible labor-intensive production techniques, not the most cost-efficient in the absence of uncertainty (Lambson (1991)). Lopez and Castro (1987) believe the instability in Colombian tariffs before 1985, translating into variability of imported raw materials' prices, had adverse consequences on the manufacturing sector, making production planning difficult and leading plants to choose less efficient combinations of inputs, harming productivity.

eliminate slack, cut costs and use inputs more efficiently to remain competitive. Development economists believe that trade protection damages productive efficiency, by tolerating high levels of 'X-inefficiency' among producers in import-competing industries. 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 by Grossman and Helpman (1991b), Holmes and Schmitz (2001) show that (under certain conditions) for an entrepreneur, lowering the tariffs protecting his/her industry makes it less attractive to engage in nonproductive activities and more attractive to pursue productive activities. In their model, productive activities are to engage in research and unproductive activities are to waste efforts blocking competitors' potential innovations. A different view holds that selected protection and moderate import penetration may allow for productivity gains in infant industries, where learning-by-doing plays a role.

Second, trade liberalization may affect plant performance by allowing an increase in imports of capital goods and intermediate inputs, embodying technologies unavailable in developing countries, which contribute to reduced costs and productivity gains. Also, trade liberalization may allow for technology diffusion, as producers learn from technologies embodied in imported final goods, as well as from exporting. In fact, previous studies and government agencies in Colombia attribute weak industrial productivity in the early 1980s to existing trade protection mechanisms that reduced the incentives to invest in technological innovation (Zerda (1992)). Models that examine investment in productivity improvement through technology acquisition lead to opposite predictions. These models consider only protection to imports of final goods and do not specify whether the technology is domestic or imported. Goh (2000) focuses on the opportunity cost of acquisition and implementation of new technology. As protection raises the foregone profits from delayed commercialization of the plant's output (the opportunity cost), it reduces the incentive for a producer to engage in technological effort to improve productivity. Rodrik (1991) finds that the degree of trade protection received by a firm can raise its level of investment in technological upgrading, when the incentive to invest in cost-reducing technologies depends on the firm's market share (possibly) reduced by trade liberalization. Traca (1997) analyzes the impact of competition from imports on investments in productivity improvement in the context of a monopolistic domestic market. When the direct effect from import competition (as plant output and imports are substitutes, demand and output decline) dominates the pro-competitive effect (the plant's market power and markup decline, so output increases), plant productivity worsens given that investments in productivity improvement increase with plant output. In face of theoretical models that predict productivity gains as well as losses in face of trade liberalization, empirical evidence is crucial.[35]

6.1.1 Average Impact

Our plant-level dataset is a valuable source to examine how trade policy affects plants' technological performance. We do not identify trade liberalization from a before-after change in productivity, a shortfall of most studies of trade and productivity. Rather, we consider empirical specifications exploiting time-series and cross-industry differences in trade policy and trade volumes, to analyze how differences in trade policy across sectors shape the variation in plant productivity. In this section, we focus on nominal tariffs and estimate the following regression pooling plants in all industries:

$$pr_{it}^j = \beta_0 + \lambda_t + \beta_1 TP_{t-1}^j + \beta_2 age_{it}^j + \beta_3 (age^2)_{it}^j + I^j + u_{it}^j, \tag{9}$$

where TP_{t-1}^j is a lagged trade policy measure for 3 or 4-digit industries, year dummies λ_t capture common shocks to productivity affecting plants in all industries and I^j is an indicator variable for the 3 or 4-digit industry the plant belongs to. We allow plant age to exert an independent nonlinear effect on productivity.[36] The residual u_{it}^j is i.i.d. across plants and years in OLS specifications, and includes unobserved permanent plant effects in fixed effects specifications.[37] The results from estimating equation (9) are presented in Table 5 columns

[35] The exploitation of scale economies is another mechanism by which trade liberalization may lead to plant and industry-level productivity gains. In our framework, we capture intra-plant improvements unrelated to scale economies since those are embodied in the production function and productivity estimates.

[36] There is theoretical and empirical evidence of a link between plant productivity and age: see, e.g., Campbell (1997), Power (1995) and Jensen, McGuckin and Stiroh (2001). Plant productivity increases with age if learning-by-doing effects or improvements in the workforce quality are important, if plant size increases as plants age and productivity-improving economies of scale are achieved or if older plants manage to modernize their capital. But the relation between productivity and age may also be concave, productivity increasing rapidly for younger plants, then slowly for older plants.

[37] The time subscripts in (9) and all equations that follow need a careful interpretation. Suppose $t-1$, t, $\tau-1$, τ are sample years in chronological order. Plant productivity 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-distance 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, as tariff data in 1981-1982 is not available.

(1)-(10), for OLS estimation with robust standard errors (White correction for heteroskedasticity) and for plant fixed effects. All columns control for the effects of the macroeconomic cycle affecting equally plants in all industries by including year effects. In all specifications, productivity increases with age at a decreasing rate. In columns (1) and (6), the coefficient of interest, β_1, is positive. But this unconditional effect of tariffs on productivity could be fully driven by unobserved industry characteristics. In columns (2)-(3), (7)-(8), we include 3 or 4 -digit industry effects to control for productivity differences across industries and obtain the impact of trade policy on productivity within industries over time. The effect of 3 or 4-digit tariffs on plant productivity is always negative and precisely estimated at the 1 percent level. Controlling for unobserved persistent plant characteristics that may cause serial correlation in a plant's error terms, we also find a negative and significant impact of tariffs on productivity. In columns (5) and (10), industry effects are identified of changes in plant classification across 4-digit industries over time. Tariffs are measured in fractional terms, so a percentage point reduction in nominal tariffs changes productivity by β_1 percent. The coefficient in column (7) implies that a reduction in tariffs of 10 percentage points would lead to an increase in plant productivity of almost 3 percent. This is a large economic impact. Overall the results provide robust support for the hypothesis that plants in industries less protected from foreign competition exhibit higher productivity once unobservable industry or plant-level heterogeneity is accounted for. In the more interesting specifications allowing for industry heterogeneity, the coefficients on tariffs are systematically more negative for more disaggregated tariffs. For disclosure reasons, tariff data is not available for some 4-digit industries, so the number of observations differs using 3 or 4-digit tariffs. We reestimate all regressions with 3-digit tariffs and the 4-digit tariffs' sample and find tariff coefficients similar to those in Table 5, columns (1)-(5).

Even though we maintain that plant-level data is preferable to industry-level data for analyzing the impact of trade policy on productivity, we also estimate (9) using data across industries (where productivity is Ω_t^j as in section 4.2). The resulting tariff effects are qualitatively similar to those in Table 5 but larger in magnitude.

Besides plant age, other factors, many of which unobservable, may affect productivity but we deliberately leave much heterogeneity in plant productivity unexplained, as our interest lies in one factor affecting productivity: changes in trade policy. The residual u_{it}^j includes all other omitted factors driving productivity. The coefficient on trade policy will be unbiased, unless such factors are systematically correlated with year-to-year variation in trade policy. But it is not implausible that unobserved time-varying factors affect simultaneously productivity and trade protection. Although the use of lagged tariffs partly mitigates this potential bias, we address the problem directly by estimating a specification where tariffs are instrumented according to the discussion in section 5.3. When instrumented, the coefficients on lagged 3 and 4-digit tariffs remain negative and precisely estimated and increase fourfold in magnitude, relative to the OLS coefficients for the period 1981-1989.[38] The OLS coefficients for the sample covering 1981-1989 are higher than those in Table 5: e.g., the coefficient corresponding to column (2) is -0.196. Our earlier finding of a switch, from positive to negative, in the sign of the tariff coefficient, when controlling for fixed industry effects may reveal that any endogeneity still biasing our lagged nominal tariffs' coefficients is being corrected. As Goldberg and Pavcnik (2001) argue, industry effects account for time-invariant political economy factors underlying higher or lower protection across industries.[39]

The concern that OLS production function estimates suffer from a simultaneity bias in face of the correlation between input choices and productivity was validated in section 4.2 for Colombian industries. Such bias would be transmitted to the corresponding residual productivity measures and affect the estimated impact of tariffs on productivity. In fact, we find the impact of lagged nominal tariffs on OLS residual productivity to be negative but overestimated relative to the unbiased results in Table 5.

Given the trade regimes identified in section 5.1, an interesting check to the results in Table 5 consists of estimating (9) for a subperiod of our sample, 1984-1989, covering a protectionist and a liberalizing period. Even though an advantage of our approach is to depart from the before-after comparison made in previous studies, the results for this subperiod are directly comparable to such studies. A negative impact of lagged tariffs on plant productivity is found that is stronger in magnitude than those in Table 5.[40]

[38]The instrumental variables specification can be estimated for this smaller sample period only, given some restrictions on data availability for tariff correlates.

[39]We also estimated (9) using contemporaneous tariffs instead of lagged tariffs. The effects of contemporaneous tariffs on productivity are found to be negative but smaller in magnitude than those of lagged tariffs: e.g., the coefficient corresponding to column (2) in Table (5) is -0.069, significant at the 1% level. We consider this to be indicative, though not definitive, evidence that the productivity effect of trade policy operates with a lag and that endogenous trade policy is not a major concern for our main results.

[40]For 3-digit tariffs, the coefficients corresponding to columns (2) and (4) in Table 5 are -0.19 and -0.132, respectively. For 4-digit tariffs, the coefficients corresponding to columns (7) and (9) in Table 5 are -0.327

6.1.2 Robustness Analysis: Plant Exit and the Real Exchange Rate

One can argue that the productivity gains associated with tariff declines shown in Table 5, reflect large numbers of less efficient plants going out of business. Reduced trade protection and the corresponding decline in output prices may push previously profitable high cost, low productivity producers to exit the industry (if exit barriers are not too high). Intuitively, this effect is expected to operate in import competing industries.[41] But in Colombia, all industries are significantly protected (tariffs higher than 15 percent) even in the most liberal years, so exit in face of decreased protection could occur in any industry. Using four different approaches, we now establish how important plant exit is for the dynamics of productivity in face of tariffs changes.

First, we decompose changes in industry productivity across available years of tariff data into changes in continuing plants' productivity, output share reallocations among continuing plants and a term representing differences in productivity between cohorts of entrant and exiting plants. According to both types of decomposition described in Appendix A, for all industries (except professional equipment) and years, the differences in entrants and exiting plants' productivity (e.g., the lower productivity of exiting plants) contribute to changes in industry productivity, but the major sources of variation are changes in continuing plants' productivity and reallocations of output among continuing plants with different productivity levels. Second, we estimate (9) on a subsample of plants that do not exit until 1989. The estimated impact of lagged 3 and 4-digit tariffs is significant at the 1 percent level and actually more negative than that in Table 5. Third, we investigate how exit probabilities vary with trade policy, conditional on productivity. From a probit regression of plant exit on lagged 3 or 4-digit tariffs, plant productivity and year effects, we find that on average exit probabilities increase with tariffs. But once time-invariant differences in exit barriers across industries

and -0.142, respectively. All estimates are significant at the 1 percent level.

[41] We classify industries according to their degree of trade orientation as in Nishimizu and Robinson (1984): traded import-competing and export-oriented industries and nontraded industries. Traded import-competing industries have an average import penetration ratio in 1980-1991 above 10%, traded export-oriented industries have an average export orientation ratio in 1980-1991 above 10% and the remaining industries are nontraded. If an industry has export orientation and import penetration ratios above 10% (which occurs for some 4-digit industries and for the 3-digit industry professional equipment), it is classified as traded. Export data for petroleum derivatives and iron and steel has irregularities, so these industries' trade orientation is not defined. All results are robust to a change in the cutoff defining traded industries to 8%.

are controlled for by industry effects, exit probabilities increase as tariffs decline.[42] As an alternative to the use of tariffs, we define trade regimes relative to the 1977-1981 liberalization period, as period 2 of protection (1984-1985) and period 3 of liberalization (1986-1989). The results from the corresponding probit specifications are qualitatively similar with or without industry effects and indicate that exit probabilities decrease in periods 2 and 3 relative to 1977-1981, conditional on productivity, as was mentioned at the end of section 3.[43] So, no systematic differences in exit rates emerge during periods of trade liberalization relative to periods of increased protection. Fourth, we find that the average exit rates out of industries experiencing relatively stronger reductions in tariffs are as often higher as they are lower than the average exit rates out of industries experiencing weaker reductions in tariffs. Overall, there is evidence that less productive plants exit, but higher exit is not tightly linked to trade liberalization. So, the gains associated with lower tariffs in Table 5 must largely reflect within-plant changes in productivity.

Variation in real exchange rates (RER) could confound the impact of protection on productivity.[44] Year effects account for changes in macroeconomic conditions, but RER may affect plants differently depending on their industry's trade orientation (Levinsohn (1999)). In Colombia, during trade liberalization in 1977-1981, the peso's RER appreciates, whereas during trade liberalization in 1985-1990, the peso's nominal and real exchange rates devalue. A RER devaluation increases the demand for (and profitability of) tradable industries' output. This results in an increase in producers' measured productivity, if, in the short run, plants respond by exploiting unobserved unused capacity, before adjusting input choices. If such a devaluation accompanies trade liberalization, the productivity gains observed across plants could result from this capacity adjustment. Given a wide concept of productivity, an increase in capacity utilization is considered an increase in productivity, so this RER effect

[42]In the probit specification with year effects only, the marginal effect (at sample means) of productivity is -0.014 and the marginal effect of 3-digit tariffs is 0.097, both significant at the 1% level. In the specification with year and 3-digit industry effects, the marginal effect of productivity is -0.017 significant at the 1% level and the marginal effect of 3-digit tariffs is -0.044 significant at the 10% level.

[43]In section 5.1, trade regimes are defined as trade liberalization (1977-1981), trade protection (1982-1984), trade liberalization (1985-1989). Since we consider the effect of lagged tariffs on productivity and tariff data is available only for a restricted number of years, trade regimes are redefined as 1977-1981, a liberalization period (1976, 1978, 1980 tariffs), 1984-1985, period 2 of protection (1983-1984 tariffs) and 1986-1989, period 3 of liberalization (1985-1988 tariffs). With industry effects, the marginal effect of productivity is -0.02 and the marginal effects of period 2 and period 3 are -0.089 and -0.171, all significant at the 1% level.

[44]Variation in RER is taken as exogenous to changes in industrial productivity. RER data is taken from IMF International Financial Statistics (REER based on relative consumer prices).

does not affect the validity of our results. Nevertheless, we shortly present some evidence on plants' changes in capacity utilization using, as Pavcnik (2002), correlations of plant-level productivity growth and output growth in Colombian industries. If in response to RER revaluation output expands in nontraded industries and contracts in traded industries without a change in inputs, and correspondingly measured productivity expands in nontraded industries and contracts in traded industries, the correlation between changes in plant output and changes in plant productivity should be strong and positive. These correlations are small across industries ranging from 0.044 in glass to 0.335 in furniture. Also following Pavcnik (2002), we compute average levels of finished goods inventories for traded and nontraded industries in 1980-1991, to see whether they significantly decrease in traded industries in years of RER devaluation. Only in few years is RER devaluation accompanied by a decline in average inventories in 3 and 4-digit traded industries.[45]

To investigate directly whether RER exert a different impact on plant productivity in traded versus nontraded industries, 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. A trend replaces year effects due to the collinearity between year effects and the RER. The results are presented in Table 6, columns (1)-(5). In all specifications, a RER devaluation (RER decrease by the IMF definition) is associated with a decrease in plant productivity in traded industries, relative to a productivity gain in nontraded industries, with precise estimates. This result holds controlling for unobserved plant characteristics affecting productivity. The positive coefficient on the interaction between the trend and the traded industries' indicator shows that productivity increases over time in those industries. The impact of RER on productivity is contrary to the prediction related to demand changes.

The discussion on RER originated in the concern that the productivity gains in face of lower tariffs might not be robust to the consideration of RER changes. Furthermore, RER could exert a direct effect on productivity. We present in Table 6, columns (6)-(9) the results from estimating (9) augmented by the RER. The negative impact of lagged tariffs on

[45]Similar results are found using output inventories as a fraction of total output. Also, when comparing the percentage of plants running down output and materials' inventories (i.e., having lower inventories in December than in January of a given year) across traded and nontraded industries to fluctuations in RER, the findings are similar: only in few years of RER devaluation does the percentage of plants running down inventories in traded industries increase and that percentage is not close to a majority.

productivity is maintained, being precisely estimated in all specifications.[46]

Finally, from a long-run perspective, a RER devaluation along with trade liberalization may have a protective effect on producers, by increasing the relative price of imports, partly counteracting the pressure for productivity improvement, cost reduction and survival brought by tariff reductions. We estimate (9) using data for 1985-1989, a period of trade liberalization and RER devaluation and find a negative impact of tariffs on productivity, larger in magnitude than that in Table 5. The results are qualitatively similar including the RER directly. So, the effect of a devaluation on producers' incentives does not overcome the impact of tariff liberalization. Overall, our findings of a negative impact of tariffs on productivity are robust to the consideration of movements in Colombian RER.[47]

From a dual perspective, one would expect the effect of tariffs on plant productivity to be accompanied by an opposite effect on plant costs. We estimate (9) changing the dependent variable to plant average variable costs (defined as in Clerides, Lach and Tybout (1998)) and find those to be negatively affected by lower 3 and 4-digit lagged tariffs, controlling for plant or industry unobserved heterogeneity.

6.1.3 Changes in Input intensities, Investment and Imports of Intermediate Inputs

An interesting investigation to pursue is that of what "changes" at the level of the plant underlie productivity gains in face of trade liberalization and losses in face of increased trade protection. Controlling for plant and industry unobservables, a negative impact of trade policy on plant productivity is robustly shown in Tables 5-6 as an average pattern,

[46]Interestingly, in column (8) the effect of a RER devaluation on productivity is negative, whereas it is positive in columns (6), (7) and (9), but only the positive effects are precisely estimated. A specification with tariffs and a differential impact of RER across traded and nontraded industries cannot be estimated, given the high collinearity between trade orientation and tariffs: most nontraded industries in Colombia have very high tariffs.

[47]To investigate differences in the evolution of productivity for plants in industries with different trade orientation, amidst the variation in Colombian trade policy in 1980-1991, we estimate a specification close to Pavcnik (2002), that identifies the impact of trade on plant productivity exploiting variation in productivity over time and across plants in industries with different trade orientation. Our results do not show significant differences in the evolution of productivity of plants in import-competing, export-oriented and nontraded 3 and 4-digit industries until 1985. We believe the contrast between our results and Pavcnik's clear-cut results rests on the fact that her Chilean plants are analyzed in years following trade liberalization only. Colombian plants are analyzed in years following liberalization, in years following increased protection and again in years following liberalization. Pavcnik's specification is less suited to identify the effects of trade on productivity in the case of a changing trade regime. Also, an assumption required to interpret her results (plant productivity in import-competing industries increases with liberalization whereas that of plants in nontraded industries is unchanged) does not seem to be verified for Colombian plants.

but there is heterogeneity in productivity dynamics across plants. So, arguing e.g., that in face of lower protection all plants' productivity improves as they acquire imported capital goods, would be incorrect because productivity does not improve across all plants and for those for which it does, a myriad of mechanisms could be operating. We now provide some suggestive, albeit tentative, evidence derived from correlations and cross-tabulations, of observable changes in plant input intensities, investment and imports of intermediate inputs and changes in productivity in face of the evolution in trade policy, using subsamples for which plant variables and tariff data are available. Our findings are limited to the extent that we consider mostly contemporaneous changes and that we are unable to discuss other relevant changes, e.g., reductions in X-inefficiency and improvements in managerial effort.

Focusing on the skill intensity across plants (ratio of skilled to unskilled labor), we find that a large majority of plants with productivity growth during liberalization periods (1977-1981 or 1985-1989) experiences increased skilled labor intensity.[48] This finding could be interpreted as an improvement in the underlying product-mix for some plants in face of increased foreign competition. Also, Hunt and Tybout (1998) argue that a plant's technological sophistication can be assessed from the plant's skilled labor intensity of production.

Increased imports of intermediate inputs can be an important mechanism for plant productivity gains in face of trade liberalization. Our dataset includes information on imported intermediate inputs. These are utilized in production by 23 to 30 percent of plants across sample years.[49] Across pairs of years and across trade regimes, a third to a half of plants do not change their imports of intermediate inputs (most remain null). But for those plants

[48] Skilled labor intensity is defined initially as the ratio of plant skilled to unskilled employment. Skilled employment includes management, skilled workers, local technicians and foreign technicians and unskilled employment includes unskilled workers and apprentices. A measure of total employment is used in the production function estimation, so there could be a correlation between productivity and skilled labor intensity not necessarily associated with changes in trade policy. Furthermore many (unaccounted for) variables determine a plant's skilled labor intensity at any point in time. In any case, the findings for skilled labor intensity are very similar when focusing on each year separately (instead of trade regimes), on plants in 3-digit industries experiencing the larger (positive or negative) relative changes in tariffs and for all cases when skilled intensity is measured by the ratio of plant skilled employment to total employment.

[49] We adjust nominal imports of intermediate inputs by a deflator (mentioned in section 3) for comparability over time. This could introduce measurement error since that deflator is obtained weighting the costs of domestic and imported inputs. No imported inputs deflator is available. The argument relating productivity gains to imported inputs concerns increased access to inputs with no domestic substitute as well as access to inputs at lower cost (if lower tariffs translate into lower prices). If imported input prices evolve differently than domestic input prices, e.g., they increase by less, our deflated values would be lower than the true real value of imported inputs. In the analysis, we consider the real value of imported inputs as well as the share of imported inputs out of total intermediate inputs used by the plant. The findings are much stronger in magnitude for the share of imported inputs.

changing their imports, a large majority of those that experience productivity gains in face of trade liberalization increases its use of imported inputs. Industries differ in the degree to which production relies on imported inputs, therefore in the degree to which the imported input mechanism may underlie productivity gains. So, it is interesting to note that considering only the industries with higher than average ratios of imported intermediate inputs to industry output, we find a much larger majority of plants with productivity gains under trade liberalization relying increasingly on imported inputs than the majority found considering all industries.[50]

The theoretical evidence in section 6, referring to investments in productivity improvement through technology acquisition points more often than not to trade protection favoring that acquisition. But, it is appealing to argue the contrary, i.e., in order for plants to improve productivity under increased foreign competition, they need to acquire better technology, possibly foreign. We cast some light on the issue of productivity and technology acquisition, using both plant-level information on machinery and equipment purchases and industry-level information on machinery imports.[51] As noted in section 2, Colombian plants' investment is lumpy and in any given year or trade regime period, about 25 percent of plants does not invest in machinery. But under trade liberalization, we find a large majority of plants with productivity growth experiencing an increase in machinery investment and equipment as measured by its real value or as a fraction of output.[52] These findings hold also for the subsample of industries with the largest tariff changes. Interestingly, in face of increased trade protection, a strong majority of plants with productivity losses are found to experience a

[50] The ratios of industry imported intermediate inputs to output are calculated as an industry average across sample years. The industries characterized by heavier reliance on imported inputs (ratios above 15%) are industrial and other chemicals, rubber products, glass, iron and steel, nonferrous metals, electrical and nonelectrical machinery and transport equipment. Considering a slightly different set of industries, those with high ratios of imported inputs to output calculated as an average across plants and years (above 10%), the results also show that a strong majority of plants with productivity gains increases its use of imported inputs. This effect appears to be asymmetric: only a minority of plants with productivity losses under trade protection is found to reduce its imports of intermediate inputs.

[51] Analyzing machinery acquisition is a difficult empirical task with our dataset. Plant-level machinery investments are not disaggregated into domestic and foreign (incidentally, that is also the case in the theoretical models). Industry-level data on machinery imports provides no indication of which plants use the machinery. The industry-level data used here is from World Trade Analyzer 1980-1991 (Statistics Canada CD-Rom) commodity class 7 (Machinery and transport equipment) in the SITC (rev.2) classification. Aggregating some of the subclasses in class 7, one obtains imports of machinery for use in manufacturing industries. For some of the import subclasses, one unambiguously identifies which 3-digit ISIC industry uses the imports e.g., subclass 726: printing and bookbinding machinery and parts is used by industry 342 printing.

[52] This does not hold, however, for investment in machinery and equipment as a fraction of the capital stock.

decline in machinery investment, regardless of how investment is measured. We cannot argue that a strong link between changes in plant productivity and changes in machinery investment exists, given the imperfections of the data, i.e., the fact that machinery purchases do not necessarily represent better (productivity-enhancing) technology acquisition. Detailed plant-level data on machinery imports would be required to assert whether the diffusion of technology embodied in imported machinery is crucial for productivity gains under trade liberalization. In the absence of such data, we turn to industry-level data for more insight. As a percentage of GDP, imports of machinery for use in the manufacturing sector increase in 1980-1981, sharply decline in 1982 and the years of increased protection and recover after 1986 (declining in 1991). Similar paths are verified for the subcategories corresponding to machinery for use in the 3-digit industries textile and leather, paper (except in 1983 when it strongly increases despite heightened trade protection), printing, food and metals.

There is a growing literature on exporting and productivity at a micro-level testing the hypothesis of self-selection of productive plants into exports markets versus learning-by-exporting (Bernard and Jensen (1999a, 1999b)). Such issues have been addressed for the Colombian dataset in Clerides, Lach and Tybout (1998). We investigate whether a plant's export status is associated with productivity gains in face of trade liberalization. Correlations and regressions with and without industry effects show that the fact that a plant exports in year t is not significantly positively associated with productivity increases from t to $t+1$. These findings agree with those for U.S. exporters in Bernard and Jensen (1999b). In the next section, we take a different perspective and allow the impact of trade policy on productivity to differ according to plants' export status.

6.1.4 Differential Impact by Plant Size

Our finding of substantial within-industry heterogeneity in output, inputs and productivity in sections 3 and 4.2 leads us to consider cross-plant variation in the impact of trade policy on productivity. To the best of our knowledge, our study is the first to analyze such variation and plant size is an important characteristic across which to differentiate the impact of trade policy. No theoretical results are established regarding the effect of trade policy on productivity across plants of different sizes but some intuition can be drawn from the effect of trade policy on related plant outcomes. Dutz (1996) develops an oligopoly model showing how incumbents adjust output to loosened import quotas, concluding that small plants (with lower market shares and higher marginal costs) experience relatively larger output contractions than large plants in response to increased imports. Preliminary evidence in Roberts and Tybout (1996) for the Colombian dataset (1977-1985) suggests that size and ownership type influence the way in which plants are affected by foreign competition. The authors find that within industries facing increased import penetration, large producers experience stronger declines in price-cost margins than small ones. A different argument would hold that developing countries' manufacturing sectors are characterized by a dualistic structure, i.e., industries accommodate a few oligopolistic producers and a large number of small firms under stronger competition, more sensitive to the economic environment and more flexible to change. This could lead to a larger impact of changes in trade protection on small plants' productivity. We consider the following specification:

$$pr_{it}^{j} = \beta_{0S} + \beta_{0L} + \lambda_t * I^S + \lambda_t * I^L + \beta_{1S}(TP_{t-1}^{j} * I^S) + \beta_{1L}(TP_{t-1}^{j} * I^L) + I^j + u_{it}^{j}, \quad (10)$$

where I^S, I^L are indicator variables for small and large plants, respectively. Plant size is defined as employment at a plant in its initial year in the sample. This mitigates 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.[53] In Table 7 Part A, we present results from estimating (10) with small plants having less than 50 employees. The effect of tariffs on productivity is much more negative for large plants and F-tests confirm that this effect differs significantly across plant sizes. These tariff effects are economically important and the magnitude of the differential is interesting to consider: e.g., the coefficients in column (5) imply that reducing tariffs by 10 percentage points would result in a productivity gain of 4 percent for large plants, twice the gain of 2 percent for small plants. Large plants are significantly more productive than small plants, as the F-test for a differential intercept indicates. All results are robust to restricting year effects to be equal across large and small plants and to changing the cutoff defining small plants to 20 or 100 employees. Even though the endogeneity above mentioned may be a problem, we also estimate (10) measuring plant size by average employment over the sample period and find qualitatively similar results.[54]

[53]Increased exposure to foreign competition may increase plant size by increasing the elasticity of demand (reinforced by entry and exit). But, alternatively, import competition may reduce demand, causing industry contraction and decreasing plant size. Empirically, most studies find that trade liberalization is associated with reductions in plant size (Dutz (1996), Roberts and Tybout (1991) and Tybout and Westbrook (1995)).

[54]

An alternative definition of plant size is the plant's market share in total industry output in its initial year in the sample, $(msh)^j_{i1}$. The following specification is estimated, allowing for a non-linear relation between plant size and productivity:

$$pr^j_{it} = \beta_0 + \lambda_t + \beta_1(msh)^j_{i1} + \beta_2(msh^2)^j_{i1} + \beta_3 TP^j_{t-1} + \beta_4(TP^j_{t-1} * (msh)^j_{i1}) + I^j + u^j_{it}. \quad (11)$$

The results are presented in Table 7 Part B for plant market shares relative to 3-digit industry output. Plant productivity increases with plant market share at a diminishing rate. Controlling for industry effects, tariffs affect negatively productivity with a precisely estimated coefficient, as in Table 5. The interaction of tariff levels and plant market shares is negative and significant, i.e., tariff protection has a more negative impact on the productivity of plants with higher market shares. For example, in column (2), the marginal effect of tariffs on productivity for a plant with the average market share is -0.11.[55] All results are qualitatively similar using market shares relative to 4-digit industry output.[56]

Overall, Colombian industries are characterized by stronger productivity gains for large plants as a result of trade liberalization. Decreases in trade protection bring a larger decline in 'inefficiency rents' benefiting large producers. A plausible explanation is that large producers' output likely competes more directly with imports. Our evidence complements that in Roberts and Tybout (1996) for price-cost margins of large plants, more strongly reduced than those of small plants in face of increased import penetration into the industry.

An interesting question to address in our framework is whether the effect of trade policy on productivity differs for plants engaging in exports. Plant size and export status are distinct plant characteristics that may differentially affect the impact of trade policy on productivity as well as productivity levels per se. But these plant characteristics are so highly correlated for Colombian plants that it is almost impossible to disentangle their effects.

We also estimate (10) with residual productivity obtained using OLS production function estimates as a dependent variable. As in section 6.1.1, a bias is found for the tariff coefficients, in this case more severe: instead of a stronger negative impact of tariffs on large plants' productivity relative to small plants' productivity, the opposite is found.

[55]The marginal effect of tariffs is obtained as $\widehat{\beta}_3 + \widehat{\beta}_4\overline{msh}$ ($\overline{msh}$ is the mean market share in the sample). All marginal effects (evaluated at mean values) for the regressors in the specifications in sections 6.1.4, 6.1.5, 6.2.2, 6.2.3, 6.3.2 and 6.3.3 can be found in Appendix B, Table B.9.

[56]We also estimate (11) defining plant size as a plant's time-varying market share in total industry output, though an endogeneity bias arises if changes in plant market shares are related to changes in tariffs. The results are qualitatively similar to those in Table 7 Part B for OLS specifications. In fixed effects specifications (possible to estimate with time-varying market shares) there is no evidence that tariffs affect plants differently according to their market share.

Exporter plants are more subject to foreign competition (in foreign markets), so their productivity may benefit more strongly from the pressures for reduction in X-inefficiencies and costs and from the exposure to possibly more advanced technologies. But, in Colombia, trade protection generated an anti-export bias or artificial incentive to produce for the domestic market. Policies to reduce that bias were implemented, such as a duty-drawback scheme (Plan Vallejo) for the import of intermediate inputs, though not all exporters benefited from it. So, ultimately, if increased access to imported inputs is the main mechanism by which liberalization impacts plant productivity, that impact could be weaker for exporters than for nonexporters. Also, if a plant is able to export (especially when subject to an anti-export bias) it is likely to be highly productive and have therefore less to gain from trade liberalization. Considering the differential impact of trade policy on productivity according to a plant's export status as in (11) with size, could be complex. The consideration of a separate constant for exporters addresses the repeated finding in the literature of a cross-sectional correlation between a plant's involvement in exports and its productivity. The main difficulty is the choice of the timing for a plant's export status. If the export status is time-varying, a simultaneity problem might result, as trade policy affects a plant's decision to export. This problem may be more acute for lagged trade policy measures, as those we use. To mitigate this simultaneity problem, we estimate a specification where exporters are defined as plants exporting in their first year in the sample. But this introduces the unpleasant feature that the impact of trade policy on a plant's productivity is determined by the fact that the plant exports or does not export in a specific year (its entry year or 1981 for incumbents). A plant exporting in any subsequent year is considered a nonexporter. Also, this precludes the interesting analysis of turnover of plants in the export market. From OLS specifications presented in Appendix B, Table B.8, with lagged 3 or 4-digit tariffs and exporters in their first year in the sample, year and industry effects, we conclude that exporters are significantly more productive than nonexporters and their productivity is more positively affected by trade liberalization than that of nonexporters. We find very similar results when defining exporters as plants that export in every sample year.[57] These findings agree with those of a stronger positive effect of trade liberalization on large plants, as Colombian exporter plants

[57]But curiously, the differential effect of tariffs on productivity for exporters and nonexporters is not significant when exporters are defined as plants that export more than 25 percent of their production on average over the sample period.

are significantly larger than nonexporter plants. In face of the differential impact of trade policy on large versus small plants and on exporter versus nonexporter plants, it is difficult to identify whether plant size proxies for the effect of export status, the export status proxies for the effect of plant size or both are genuinely different effects.

6.1.5 Differential Impact by the Degree of Domestic Competition in the Industry

Plant productivity may be differently affected by changes in protection depending on its industry's characteristics. In this section, we introduce cross-industry variation in the effect of tariffs according to the degree of domestic competition in the industry. Investigating this claim faces the difficult task of measuring the degree of competition in an industry. We choose two measures commonly used in the industrial organization literature that capture different dimensions of competition: Herfindahl indexes and industry turnover rates.[58] The Herfindahl index summarizes the degree of inequality of market shares across plants in an industry. The turnover rate reflects, 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. In section 6.1.2, plant exit was found to play a minor role in productivity gains in face of trade liberalization. Turnover rates allow us to consider the role of exit (as well as entry) from a different perspective i.e., to investigate the possibility that in industries with low costs of entry, productivity is less affected by trade liberalization if the adjustment occurs through plant entry and/or exit. Given the potential impact of trade policy on concentration, entry and exit, domestic competition is taken as a time-invariant industry characteristic (values in the first sample year). This analysis can be interpreted as the search for the complementarity or substitutability between domestic and foreign competition in their effect on plant productivity. Previous studies find two types of results for a subsample of our dataset (1977-1985). At the industry-level, Roberts and Tybout (1996) find that the reduction in price-cost margins due to increased import penetration is larger in more concentrated 3-digit industries. At the plant-level, the authors find no contemporaneous correlation between import penetration and entry and exit into Colombian industries. If

[58]The Herfindahl index for an industry and year is the sum of plants' squared market shares relative to 3 or 4-digit industries' output. The turnover rate for an industry and period is the sum of entry and exit rates into 3-digit industries. The Herfindahl indexes and turnover rates used in the specifications in this section, sections 6.2.3 and 6.3.3 are presented in Appendix B, Table B.7.

trade policy affects entry and exit, it likely does it with a lag, as producers require time to gain certitude about the irreversibility of any policy change. The specification considered is the following:

$$pr_{it}^{j,k} = \beta_0 + \lambda_t + \beta_1 TP_{t-1}^j + \beta_2 \overline{DC}^j + \beta_3 (TP_{t-1}^j * \overline{DC}^j) + I^k + u_{it}^{j,k}, \tag{12}$$

where $\overline{DC}^j$ represents the degree of domestic competition in industry j. 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 (12). The results from estimating (12) with tariffs and 1977 Herfindahl indexes are presented in Table 8. With Herfindahl indexes for 3-digit industries' output, in columns (1)-(2), 3 and 4-digit lagged tariffs affect more negatively plant productivity in more concentrated industries, i.e., foreign competition induces greater productivity change in less competitive domestic industries. Both types of competition operate in the same direction, namely, plants have lower productivity when faced with less competition. With all else constant, plants in more concentrated domestic industries have lower productivity and the marginal impact of Herfindahl indexes on productivity at mean tariff levels is negative. With Herfindahl indexes for 4-digit industries' output, in columns (3)-(4), 3-digit tariffs affect less negatively plants in more concentrated industries. Controlling for unobservable 3-digit industry heterogeneity, the marginal effect of tariffs at mean 4-digit Herfindahl indexes is negative and significant. Productivity is significantly lower in more concentrated industries. But with industry effects, the marginal impact of 4-digit Herfindahl indexes on productivity at mean tariff levels is not significant. Finally, with 4-digit Herfindahl indexes, in column (6), 4-digit tariffs affect less negatively plants in more concentrated industries. Also, productivity is significantly lower in more concentrated industries.

The results from estimating (12) with 3-digit industries' 1977-1978 turnover rates are presented in Table 8, columns (7)-(8). Tariffs affect less negatively plant productivity in industries with high turnover rates. So, stronger domestic competition in the form of higher entry and exit into different industries may partly dampen within-plant productivity adjustment to changes in trade protection. Though relative to a different dimension of competition, the less negative impact of tariffs on plant productivity in 3-digit industries with higher turnover matches the finding with 3-digit Herfindahl indexes. But the finding that plant productivity is lower the higher is its industry's turnover rate differs from that of higher plant productivity in more competitive industries according to Herfindahl indexes. Ultimately, the two findings are reconciled since the marginal impact of turnover rates on productivity at mean 3 or 4-digit tariff levels is positive and significant.

6.2 Impact of Effective Rates of Protection

6.2.1 Average Impact

To check the robustness of the results obtained in the previous sections, we use an alternative measure of trade protection: effective rates of protection. ERP constitute an index of protection to productive processes summarizing information on the protective structure resulting from tariffs on output and on imported inputs.[59]

The results from estimating (9) with lagged 3-digit ERP are presented in Table 9. The impact of ERP on plant productivity is positive but imprecisely estimated when industry effects are included. The coefficients on ERP in plant fixed effects specifications are positive and significant. The contrast between the positive impact of ERP and the negative impact of nominal tariffs on productivity in Table 5 could stem from a difference in the samples used. So, we present in Table 9, columns (1')-(4'), the results from estimating (9) with tariffs but the ERP sample, that show a negative impact of tariffs on plant productivity.[60] There seems to be a genuine difference between the impact of nominal protection to final output and the impact of effective protection to final output on plant productivity. That is curious given the positive correlation between nominal tariffs and ERP in any year and across the entire period (Table 4e). Intuitively, one might expect the ERP coefficient to be insignificant since data requirements and restrictions (e.g., coefficients from input-output tables) introduce serious noise in ERP calculations. This is confirmed in OLS specifications but not in plant fixed effects specifications. But the results for ERP coefficients in OLS specifications are not robust. We experiment with eliminating either i) the most influential observations or ii) the outliers in two industries (electrical machinery and transport equipment). In both cases the ERP coefficient becomes negative (significant in case i)) and importantly, the tariff

[59]Comparing the ERP results to the tariff results is interesting for robustness purposes. But the use of ERP could be problematic since our production function estimation allows for elasticities between inputs and for changes in the mix of primary factors (labor and capital) and intermediate inputs. ERP are calculated as protection to value-added, which assumes that intermediate inputs are used in fixed proportion to output.

[60]In Table 9, the 3-digit tariff data for years 1979, 1983, 1984, 1989, 1990 is from DNP, a different source than that of tariffs in Tables 5-8. In two of the common years across the two sources of data (1983-1984) the value of tariffs differs, but the differences are negligeable, except for printing and transport equipment.

coefficient remains negative and significant under the same experiments.[61]

The ERP on a final good declines if either tariffs on the final good decline or if tariffs on intermediate inputs increase (both in relative terms). So, an interpretation of the different results with plant fixed effects could be that lowering tariffs on final goods generates gains in plant productivity but lowering ERP via increased tariffs on intermediate inputs generates losses in plant productivity. In the absence of information on the specific inputs imported and used in each industry, we cannot be sure that this interpretation is correct. But we can at least argue that a requirement for the validity of this interpretation is verified: in a specification relating plant productivity to both tariffs and ERP, a negative tariff coefficient and a positive ERP coefficient should be obtained. In fact, with plant fixed effects, the tariff coefficient is -1.013 and the ERP coefficient is 0.465, both precisely estimated at the 1 percent level.

6.2.2 Differential Impact by Plant Size

In Table 10 Part A, we present results from estimating (10) with lagged ERP and small plants having less than 50 employees in their initial year in the sample. The impact of ERP on plant productivity is positive for small plants but negative for large plants, both being precisely estimated. F-tests indicate that the impact differs significantly across large and small plants. We find qualitatively unchanged results when the cutoff defining small plants is changed to 20 or 100 employees. Defining plant size according to a plant's average employment over the sample period leads to similar conclusions. The finding of large plants being more negatively affected by ERP is similar to that with tariffs in Table 7 Part A and that with tariffs (ERP sample) in Table 10 Part A, columns (1')-(2').

Measuring size by a plant's market share relative to 3-digit industry output in its initial year in the sample, equation (12) is estimated with lagged ERP and the results are presented in Table 10 Part B. We find evidence that ERP impact negatively the productivity of plants with higher market shares with a precise coefficient in OLS specifications. This finding matches that with tariffs in Table 7 Part B and that with tariffs (ERP sample) in Table 10 Part B, columns (1')-(2'). The marginal impact of ERP on productivity at average market shares is positive but not significant when industry effects are included. All results are

[61]The analysis of outliers and influential observations follows Fox and Long (1990). Details are available upon request.

qualitatively similar using plant market shares relative to 4-digit industry output.[62]

6.2.3 Differential Impact by the Degree of Domestic Competition in the Industry

The results from estimating (12) with ERP and 1980 Herfindahl indexes are presented in Table 11. These results should be viewed with caution and a few occasional inconsistencies can be attributed to the caveats surrounding ERP measures. With Herfindahl indexes for 3-digit industries, in column (1), plant productivity is negatively affected by industry concentration. The marginal effect of Herfindahl indexes at mean ERP is negative and significant. ERP impact positively plant productivity in more concentrated industries. This points to a lesser role of foreign competition in generating productivity gains in less competitive domestic industries and stands in contrast to the findings with tariffs in Table 8, column (1). With Herfindahl indexes for 4-digit industries, in columns (2)-(3), the impact of ERP on plant productivity in less competitive 4-digit industries is negative and significant at the 1 percent level. This finding also stands in contrast to the findings with tariffs in Table 8, column (3)-(4), though it agrees with the findings for tariffs and 3-digit Herfindahl indexes.

The results from estimating (12) with ERP and 3-digit industries 1980-1981 turnover rates are presented in Table 11, column (4). Interestingly, in this specification the impact of ERP on plant productivity is negative and significant, similar to that of tariffs. Productivity seems to be lower for plants in industries with higher turnover rates, but the marginal impact of turnover rates at mean ERP is positive and significant, as in Table 8. ERP affect less negatively plant productivity in industries with potentially stronger domestic competition through higher turnover rates.

6.3 Impact of Import Penetration Ratios

6.3.1 Average Impact

Another interesting robustness check to perform is to use a measure of exposure to foreign competition based on trade volumes (an outcome of trade policy): import penetration ratios that exhibit variation over time and across industries. Our specifications consider the impact

[62]Defining plant size as its time-varying market share in total industry output, the results are qualitatively similar to those in Table 10 Part B for OLS specifications. With plant fixed effects, the differential effect of ERP according to plants' market shares loses its significance as it did with tariffs.

of lagged penetration ratios on productivity to be consistent with the previous sections.

We expect to find a positive impact of import penetration on plant productivity if plants lower costs and become more efficient in face of increased import competition.[63] But one can argue that imports are endogenous to domestic industries' productivity: e.g., in a simple Ricardian framework, imports are attracted to relatively less productive industries. In this case, a negative correlation between import penetration and productivity might be found.[64] Equation (9) is estimated using import penetration ratios for 3 and 4-digit industries. The results, correcting for possible heteroskedasticity, are presented in Table 12. Import penetration has a positive and precisely estimated impact on plant productivity (except in columns (6)-(7)). This impact is large in magnitude: e.g., in column (4), an increase in import penetration by 10 percentage points increases plant productivity by 6 percent. Year-to-year changes in import penetration ratios of such magnitude are common for most Colombian industries. In contrast to the findings with tariffs, the coefficients on import penetration ratios are systematically larger in magnitude for the more aggregate industry-level. These findings with trade volumes strengthen the findings with trade policy measures. Furthermore, this evidence complements, on the productivity side, that in Roberts (1996) that price-cost margins in Colombian industries (1977-1985) decline with increases in import penetration. As the samples in Tables 5 and 12 differ, we reestimate equation (9) on a sample for which data on tariffs and import penetration ratios is available (1981, 1984-1989). All coefficients are precisely estimated, slightly smaller than those in Table 12, but the same strong conclusion is drawn: lagged import penetration affects positively plant productivity and lagged tariffs affect it negatively.

6.3.2 Differential Impact by Plant Size

In Table 13 Part A, we present the results from estimating (10) with import penetration and small plants having less than 50 employees in their initial year in the sample. Import penetration impacts positively large plants' productivity in all specifications and small plants'

[63]A positive impact may also result from productivity being procyclical: imports lead to output contraction in the corresponding domestic industry and that is transmitted into lower productivity via reduced capacity utilization. In section 4.2, we found most industries to have procyclical productivity growth. As we consider an increase in capacity utilization to be an increase in productivity, this interpretation does not differ ultimately from that of trade liberalization generating within-plant productivity gains.

[64]This interpretation is subject to strong caveats, namely, the simplifying assumptions of the Ricardian model do not hold in our context: our production process depends on four inputs not just on a labor input.

productivity in almost all specifications. F-tests show that the impact of import penetration differs significantly across large and small plants. All results are robust to restricting year effects to be equal across large and small plants and to a change in the cutoff defining small plants to 20 or 100 employees. These findings are consistent with those of large plants being more negatively affected by tariffs and add to the plausibility of the hypothesis that across industries, the output produced by large plants competes more directly with imports.

In Table 13 Part B, we present the results from estimating (11) with market shares relative to 3-digit industry output in the plant's initial year in the sample and lagged import penetration ratios. Import penetration affects more positively the productivity of plants with higher market shares. This finding is consistent with those in Table 7 Part B with tariffs and in Table 10 Part B with ERP. Also, the marginal impact of market shares, at average import penetration ratios and market shares, is significantly positive in all specifications.[65]

6.3.3 Differential Impact by the Degree of Domestic Competition in the Industry

In Table 14, we present the results from estimating (12) with import penetration ratios and 1981 Herfindahl indexes. With Herfindahl indexes for 3-digit industries, in columns (1)-(2), industry concentration impacts negatively productivity. Stronger foreign competition through import penetration into 3 or 4-digit industries affects positively plant productivity in more concentrated domestic industries. These findings complement those by Roberts (1996) that price-cost margins decline by more in concentrated 3-digit industries faced with increased import penetration. With Herfindahl indexes for 4-digit industries, in columns (3)-(6), the impact of industry concentration on productivity is negative and significant. In our preferred specifications that control for 3-digit industry effects and obtain the coefficient of import penetration on plant productivity within industries, import penetration at 3 or 4-digit levels affects more positively plant productivity in more concentrated 4-digit industries.

Finally, we estimate (12) with import penetration ratios and 1981-1982 turnover rates and present the results in Table 14, columns (7)-(8). Import penetration affects positively

[65] The results obtained measuring plant size by its time-varying market share in total industry output are qualitatively similar to those in Table 13 Part B for OLS specifications. Controlling for omitted fixed plant characteristics affecting plant productivity and market shares, the results are similar for market shares relative to 4-digit industries' output but are reversed for market shares relative to 3-digit industries' output. Since this last specification could suffer from an endogeneity problem, we believe the overall robustness of our findings is unaffected.

plant productivity but less strongly so for plants in industries with higher turnover rates. This finding is in agreement with those with tariffs or ERP and turnover rates and those with import penetration and Herfindahl indexes.

Across trade policy and exposure and domestic competition measures, the general finding is that of a stronger role of increases in foreign competition in improving productivity in less competitive domestic industries: in Table 8 with tariffs, 3-digit Herfindahl indexes and turnover rates, in Table 11 with ERP, 3-digit Herfindahl indexes and turnover rates as well as with tariffs (ERP sample), Herfindahl indexes and turnover rates (not shown) and in Table 14 with import penetration, 3 and 4-digit Herfindahl indexes and turnover rates. Even though the different specifications consider different (initial) years for domestic competition measures, the ranking of industries relative to the average degree of domestic competition is generally stable over time, providing a rationale for the general finding.

6.4 Impact on Plant Productivity Growth

Some of the arguments for an impact of trade liberalization on productivity are dynamic in nature. Several endogenous growth models consider dynamic effects of trade on productivity: increases in the variety and quality of inputs, increases in product sophistication, knowledge diffusion and learning-by-doing. Tybout (2000) argues that trade protection may improve productivity growth if it promotes industries whose production processes benefit from learning-by-doing and generate knowledge spillovers. But in contrast, trade protection may reduce productivity growth, if as noted in section 6, producers gain access to better technologies from the exposure to imported final goods or from exporting.

The argument concerning the possible endogeneity of trade policy with respect to productivity, made in section 5.3, can be extended to a dynamic setting . If government authorities changed trade policy in response to pressures by industries experiencing lower productivity growth, there would be simultaneity between trade policy at t and productivity growth from $t-1$ to t. So, we consider the impact of trade protection at $t-1$ on plant productivity growth from $t-1$ to t. Changes in plant productivity are obtained from estimated plant productivity measures and the corresponding standard errors indicate that the changes are statistically significantly for more than 99 percent of observations.

In Table 15, we present the estimation results for a specification that relates plant productivity growth rates to tariffs, ERP and import penetration ratios. Overall technological progress or other shocks affecting productivity growth rates of plants in all industries are controlled for by year effects. In order to prevent differences in technological progress across industries to be attributed to changes in trade policy, our preferred specifications include growth tendencies in industry productivity (through industry effects), therefore tariffs e.g., affect the deviation of plant productivity growth from industry growth. In fact, these growth tendencies are important, as is indicated by the switch in the sign of the tariff coefficient between columns (1) and (6) (no industry effects) and the remaining columns.

Overall, the estimates suggest that protection affects negatively plant productivity growth. In particular, allowing for permanent differences in plant productivity growth rates, we find higher lagged 3 and 4-digit tariffs and ERP to be associated with lower productivity growth rates. Higher import penetration ratios have a positive and precisely estimated impact on plant productivity growth.

7. Conclusion

This study provides new plant-level evidence of an important link between trade policy and industrial productivity using Colombian manufacturing data from 1977 to 1991. We find that nominal tariffs have a strong negative impact on plant productivity even after controlling for factors such as the real exchange rate, observed and unobserved plant characteristics and unobserved industry heterogeneity. Our use of lagged tariffs and the evidence on the economic reasons underlying changes tariffs in Colombia allow us to argue that the negative impact of tariffs is unlikely to reflect the endogeneity of protection. The impact of trade protection on productivity is more negative for large plants and for plants in less competitive industries. These findings are robust to the use of alternative measures of trade protection such as effective rates of protection and import penetration ratios. We also find evidence of a negative impact of trade protection on plant productivity growth.

We emphasize two distinct methodological points. First, our production function parameter estimates obtained by nonparametric and GMM techniques reveal, by comparison to OLS, the existence of a simultaneity bias between plants' input choices and productivity. Therefore, using productivity measures that address such simultaneity is important to infer an effect of trade policy on productivity that is closer to its true magnitude. Second, our analysis circumvents the shortfalls of studies that focus on a single episode of liberalization, the predominant approach in the trade and productivity literature, by exploiting cross-industry and time variation in trade policy. Our estimates isolate the impact of tariffs on productivity from the confounding impact of macroeconomic changes.

Applying our analysis to other countries datasets and building cross-country comparisons from the micro data would be a fruitful research direction to pursue. Also, estimating the effect on manufacturing plants' productivity of the large tariff reductions verified in Colombia after 1991 would be of interest. The findings in this paper motivate a theoretical and empirical investigation of alternative channels linking plant productivity gains to trade liberalization, with emphasis on plant heterogeneity. Finally, it would be interesting to allow for plant entry and exit into and out of the export market and determine if and how that influences the impact of trade policy on plant productivity.

The policy implications of our study are straightforward: in face of important productivity gains from trade liberalization, the elimination of policy instruments still protecting manufacturing industries is important. But these productivity gains are not necessarily translated into equal welfare gains due to the unmeasured costs of trade liberalization. Our novel finding of heterogeneous effects of trade policy across plants with different characteristics deserves further research, as it could be relevant to the design of trade reforms.

8. References

Aw, B., Chen, X. and M. Roberts, 2001. "Firm-Level Evidence on Productivity Differentials and Turnover in Taiwanese Manufacturing," *Journal of Development Economics* 66(1), pp.51-86.

Basu, S. 1996. "Procyclical Productivity: Increasing Returns or Cyclical Utilization?," *Quarterly Journal of Economics* 111(3), pp.719-51.

Bernard, A. and B. Jensen, 1999a. "Exceptional Exporter Performance: Cause, Effects or Both?," *Journal of International Economics* 47(1), pp.1-25.

Bernard, A. and B. Jensen, 1999b. "Exporting and Productivity: The Importance of Reallocation," Tuck School of Business, Dartmouth College, Manuscript.

Campbell, J., 1997. "Entry, Exit, Embodied Technology and Business Cycles," NBER Working Paper 5955.

Clerides, S., Lach S. and J. Tybout, 1998. "Is "Learning-By-Exporting" Important?," *Quarterly Journal of Economics,* 113(3), pp.903-47.

Corden, W., 1966. "The Structure of a Tariff System and the Effective Protective Rate," *Journal of Political Economy,* 74(3), pp.221-37.

Dollar, D., 1992. "Outward-Oriented Developing Economies Really Do Grow More Rapidly: Evidence from 95 LDCs, 1976-85," *Economic Development and Cultural Change* 40(3), pp.523-44.

Dutz, M., 1996. "Oligopolistic firms' Adjustment to Quota Liberalization: Theory and Evidence," in Roberts, M. and J. Tybout, eds.1996. *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure.* NY: Oxford U. Press.

Edwards, S., 1993. "Openness, Trade Liberalization, and Growth in Developing Countries," *Journal of Economic Literature* 31(3), pp.1358-93.

Edwards, S., 1994. "Trade and Industrial Policy Reform in Latin America," NBER Working Paper 4772.

Edwards, S., 1998. "Openness, Productivity and Growth: What Do We Really Know?," *Economic Journal* 108(447), pp.383-98.

Ericson, R. and A. Pakes, 1995. "Markov-Perfect Industry Dynamics: A Framework for Empirical Analysis," *Review of Economic Studies* 62(1), pp.53-82.

Fan, J. and I. Gijbels, 1996. *Local Polynomial Modelling and Its Applications.* Monographs on Statistics and Applied Probability 66, Chapman & Hall.

Fox, J. and J. S. Long, eds. 1990. *Modern Methods of Data Analysis.* Newbury Park, CA: Sage Publications.

Garay, L., 1991. *Apertura y Proteccion: Evaluacion de la Politica de Importaciones.* Tercer Mundo Editores. U. Nacional de Colombia.

Garay, L. ed. 1998. *Colombia: Estructura Industrial e Internacionalizacion: 1967-1996.* Colombia: Departamento Nacional de Planeacion e Colciencias.

Garcia, J., 1991. "Colombia," in Papageorgiou, D., Michaely, M. and A. Choski eds. *Liberalizing Foreign Trade,* Vol.4.

GATT, 1990. *Trade Policy Review Colombia.*

Goh, A.-T., 2000. "Opportunity Cost, Trade Policies and the Efficiency of firms," *Journal of Development Economics* 62(2), pp.363-83.
Goldberg, P. and G. Maggi, 1999. "Protection for Sale: An Empirical Investigation," *American Economic Review* 89(5), pp.1135-55.

Goldberg, P. and N. Pavcnik, 2001. "Trade Protection and Wages: Evidence from the Colombian Trade Reforms," NBER Working Paper 8575.

Griliches, Z. and J. Mairesse, 1995. "Production Functions: the Search for Identification," NBER Working Paper 5067.

Grossman, G. and E. Helpman, 1991a. *Innovation and Growth in the World Economy.* MIT Press Cambridge, MA.

Grossman, G. and E. Helpman, 1991b. "Quality ladders in the Theory of Economic Growth," *Review of Economic Studies* 58(1), pp.*43-61.*

Grossman, G. and E. Helpman, 1994. "Protection for Sale," *American Economic Review* 84(4), pp.*833-50.*

Hallberg, K. and W. Takacs, 1992. "Trade Reform in Colombia: 1990-94," in Cohen, A. and F. Gunter, eds. *The Colombian Economy: Issues of Trade and Development.* Oxford: Westview Press.

Harrison, A. 1994. "Productivity, Imperfect Competition and Trade Reform: Theory and Evidence," *Journal of International Economics* 36(1-2), pp.53-73.

Harrison, A. 1996. "Openness and Growth: a Time-Series Cross-Country Analysis for Developing Countries," *Journal of Development Economics* 48(2), pp.419-47.

Helpman, E. and P. Krugman, 1985. *Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition and the International Economy.* MIT Press Cambridge, MA.

Holmes, T. and J. Schmitz, 2001. "A Gain From Trade: From Unproductive to Productive Entrepreneurship ," *Journal of Monetary Economics* 47(2), pp.417-46.

Hunt, J. and J. Tybout, 1998. "Does Promoting High-Tech Products Spurs Development?," FEEM Fondazione Eni Enrico Matteo Working Paper No. REG 42.98.

Jensen, J., McGuckin R. and K. Stiroh, 2001. "The Impact of Vintage and Age on Productivity: Evidence from U.S. Manufacturing Plants," *Review of Economics and Statistics,* forthcoming.

Jovanovic, B., 1982. "Selection and the Evolution of Industry," *Econometrica* 50(3), pp.649-70.

Kim, E. , 2000. "Trade Liberalization and Productivity Growth in Korean Manufacturing Industries: Price Protection, Market Power and Scale Efficiency," *Journal of Development Economics* 62(1), pp.55-83.

Klette, J. and Z. Griliches, 1996. "The Inconsistency of Common Scale Estimators When Output Prices are Unobserved and Endogenous," *Journal of Applied Econometrics* 11(4), pp.343-61.

Krishna, P. and D., Mitra, 1998. "Trade Liberalization, Market Discipline and Productivity Growth: New Evidence from India," *Journal of Development Economics* 56(2), pp.447-62.

Lambson, V., 1991. "Industrial Evolution with Sunk Costs and Uncertain Market Conditions," *International Journal of Industrial Organization* 9(2), pp.171-96.

Lee, J.-W., 1995. "Government Interventions and Productivity Growth in Korean Manufacturing Industries," NBER Working Paper 5060.

Levine, R., and D. Renelt, 1992. "A Sensitivity Analysis of Cross-Country Growth Regressions," *American Economic Review* 82(4), pp.942-63.

Levinsohn, J. and A. Petrin, 2000. "Estimating Production Functions Using Inputs to Control for Unobservables," NBER Working Paper 7819.

Lopez, R. and L. Castro, 1987. "La Proteccion a la Industria en un Regimen de Exenciones, " *Revista de Planeacion y Desarrollo* 19, pp.45-100.

Nishimizu, M. and S. Robinson, 1984. "Trade Policies and Productivity Change in Semi-industrialized Countries," *Journal of Development Economics 1*6(1-2), pp.177-206.

Olley, S. and A. Pakes, 1996. "The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica* 64(6), pp.1263-97.

Pack, H., 1994. "Productivity or Politics: The Determinants of the Indonesian Tariff Structure," *Journal of Development Economics* 44(2), pp.441-51.

Pavcnik, N., 2002. "Trade Liberalization, Exit and Productivity Improvements: Evidence from Chilean Plants," *Review of Economic Studies*, 69(1), pp.245-76.

Power, L., 1995. "The Missing Link: Technology, Productivity and Investment," Center for Economic Studies Discussion Paper CES 95-12, Bureau of the Census.

Pritchett, L., 1996. "Measuring Outward Orientation in LDCs: Can It Be Done?," *Journal of Development Economics* 49(2), pp.307-35.

Roberts, M. and J. Tybout, 1991. "Size Rationalization and Trade Exposure in Developing Countries," in Baldwin, R. ed. *Empirical Studies of Commercial Policy.* U. of Chicago Press for NBER.

Roberts, M. and J. Tybout, eds.1996. *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity and Market Structure.* NY: Oxford U. Press.

Rodrik, D., 1991. "Closing the Productivity Gap: Does Trade Liberalization Really Help?," in Helleiner, G. ed. *Trade policy, Industrialization and Development.* Clarendon Press. Oxford.

Rodrik, D., 1995. "Trade and Industrial Policy Reform," in Behrman, J. and T. N. Srinivasan eds. *Handbook of Development Economics,* Vol. 3. North Holland, Amsterdam.

Rodrik, D., and F. Rodriguez, 1999. "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence," NBER Working Paper 7081.

Romer, P., 1994. "New Goods, Old Theory and the Welfare Costs of Trade Restrictions," *Journal of Development Economics* 43(1), pp.5-38.

Sachs, J. and A. Warner, 1995. "Economic Reform and the Process of Global Integration," *Brookings Papers on Economic Activity* 1, pp.1-118.

Solow, R., 1957. "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics* 39(3), pp.312-320.

Steindel, C. and K. Stiroh, 2001. "Productivity: What Is It, and Why Do We Care About It?," Staff Reports No. 122, Federal Reserve Bank of New York.

Srinivasan, T.N. and J. Bhagwati, 1999. "Outward-Orientation and Development: Are Revisionists Right?," Center Discussion Paper No. 806, Economic Growth Center, Yale University.

Traca, D., 1997 . "Import-Competition, Market Power and Productivity Change," Wissenschaftszentrum Berlin für Sozialforschung Working Paper FS-IV 97-29.

Tybout, J., 1992. "Linking Trade and Productivity: New Research Directions," *The World Bank Economic Review* 6(2), pp.189-211.

Tybout, J., 2000. "Manufacturing Firms in Developing Countries: How Well Do They Do and Why?," *Journal of Economic Literature* 38(1), pp.11-44.

Tybout, J. and M. Westbrook 1995. "Trade Liberalization and the Dimensions of Efficiency Change in Mexican Manufacturing Industries ," *Journal of International Economics* 39(1-2), pp.53-78.

Urrutia, M., 1994. "Colombia," in Williamson, J., ed. *The Political Economy of Policy Reform.* Washington, DC: Institute for International Economics.

Vousden, N. and N. Campbell, 1994. "The Organizational Cost of Protection," *Journal of International Economics* 37(3-4), pp.219-38.

World Bank, 1989. "Colombia: Commercial Policy Survey," Report no. 7510-CO. World Bank. Washington, DC.

World Bank, 1991. *Colombia: Industrial Competition and Performance.*World Bank. Washington, DC.

Young, A., 1991. "Learning-by-Doing and the Dynamic Effects of International Trade," *Quarterly Journal of Economics* 106(2), pp.369-405.

Zerda, A., 1992. "El Comportamiento de la Productividade y sus Determinantes: Un Debate Abierto," in Garay, L. ed. *Estrategia Industrial e Insercion Internacional.* FESCOL.

Appendix A

One of the decompositions of changes in industry productivity which we discuss in section 6.1.2 is given by:

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

where Ω_t^j is industry productivity as in section 4.2, 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, the third and fourth terms represents average productivity of entrant and exiting plants, respectively. The other decomposition as in Aw, Chen and Roberts (2001) is given by:

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

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

Both decompositions can be computed only if continuing plants switching from industry A to industry B in year t are considered as exiting plants in industry A and entrants in industry B. So exit incorporates plant deaths but also plant switches across 3-digit industries, which represent 2 percent of the sample for the years of available tariff data. The results from these decompositions are available upon request.

Table 1 Production Function Estimates with Materials Controlling for Simultaneity Bias

Industry	Input	OLS	R. scale	Plant fixed effects	Input revenue shares	Materials correcting endog. bias	R. scale	Polynomials	R. scale
321+322 Textiles	Labor	0.316 ***		0.136 ***	0.275	0.242 ***		0.263 ***	
and Apparel		(0.004)		(0.005)		(0.014)		(0.003)	
	Energy	0.146 ***	0.982	0.111 ***	0.018	0.115 ***	1.028	0.1 ***	0.904
		(0.003)		(0.003)		(0.007)		(0.002)	
N.obs	Materials	0.471 ***		0.497 ***	0.500	0.66 ***		0.429 ***	
20379		(0.003)		(0.003)		(0.053)		(0.005)	
	Capital	0.049 ***		0.098 ***	0.207	0.011		0.112 ***	
		(0.003)		(0.004)		(0.03)		(0.007)	
311+312 Food	Labor	0.22 ***		0.134 ***	0.149	0.154 ***		0.176 ***	
products		(0.005)		(0.005)		(0.008)		(0.004)	
	Energy	0.16 ***	1.055	0.108 ***	0.034	0.095 ***	1.058	0.104 ***	0.875
		(0.004)		(0.004)		(0.007)		(0.003)	
N. obs.	Materials	0.588 ***		0.562 ***	0.647	0.731 ***		0.529 ***	
17651		(0.002)		(0.003)		(0.043)		(0.004)	
	Capital	0.088 ***		0.08 ***	0.170	0.077 *		0.066 ***	
		(0.003)		(0.004)		(0.042)		(0.007)	
381 Metal	Labor	0.329		0.291 ***	0.266	0.288 ***		0.243 ***	
products		(0.006)		(0.008)		(0.012)		(0.005)	
	Energy	0.095 ***	1.060	0.012 ***	0.024	0.053 ***	0.962	0.074 ***	0.985
		(0.004)		(0.005)		(0.007)		(0.003)	
N.obs	Materials	0.587 ***		0.595 ***	0.509	0.523 ***		0.573 ***	
8581		(0.004)		(0.005)		(0.046)		(0.006)	
	Capital	0.048 ***		0.015 ***	0.201	0.098 ***		0.095 ***	
		(0.003)		(0.005)		(0.031)		(0.009)	
331+332 Wood	Labor	0.234 ***		0.255 ***	0.302	0.21 ***		0.22 ***	
products and		(0.007)		(0.011)		(0.015)		(0.007)	
furniture	Energy	0.115 ***	1.016	0.081 ***	0.021	0.096 ***	0.886	0.096 ***	0.943
		(0.005)		(0.006)		(0.008)		(0.005)	
N.obs	Materials	0.635 ***		0.616 ***	0.496	0.48 ***		0.587 ***	
5652		(0.005)		(0.007)		(0.069)		(0.008)	
	Capital	0.033 ***		0.046 ***	0.181	0.1 ***		0.04 ***	
		(0.003)		(0.007)		(0.026)		(0.01)	
342 Printing	Labor	0.586 ***		0.384 ***	0.295	0.516 ***		0.399 ***	
		(0.011)		(0.015)		(0.025)		(0.01)	
	Energy	-0.026 ***	1.120	-0.081 ***	0.017	-0.055 ***	1.096	0.042 ***	1.026
		(0.007)		(0.008)		(0.013)		(0.006)	
N.obs	Materials	0.484 ***		0.488 ***	0.443	0.523 ***		0.453 ***	
5224		(0.007)		(0.009)		(0.04)		(0.01)	
	Capital	0.077 ***		0.002	0.244	0.112 ***		0.132 ***	
		(0.005)		(0.009)		(0.03)		(0.012)	
382 Nonelectrical	Labor	0.302 ***		0.256 ***	0.280	0.284 ***		0.247 ***	
machinery		(0.01)		(0.014)		(0.016)		(0.01)	
	Energy	0.056 ***	1.055	0.075 ***	0.023	0.046 ***	0.842	0.065 ***	0.946
		(0.006)		(0.008)		(0.009)		(0.006)	
	Materials	0.612 ***		0.548 ***	0.468	0.381 ***		0.563 ***	
N.obs		(0.005)		(0.009)		(0.162)		(0.007)	
4585	Capital	0.084 ***		0.094 ***	0.229	0.131		0.071 ***	
		(0.005)		(0.009)		(0.084)		(0.01)	
369 Nonmetallic	Labor	0.405 ***		0.314 ***	0.330	0.381 ***		0.367 ***	
minerals		(0.01)		(0.016)		(0.02)		(0.009)	
	Energy	0.212 ***	1.070	0.189 ***	0.090	0.186 ***	0.992	0.19 ***	0.987
		(0.005)		(0.008)		(0.012)		(0.005)	
N.obs	Materials	0.406 ***		0.3 ***	0.344	0.31 ***		0.315 ***	
4502		(0.004)		(0.007)		(0.084)		(0.008)	
	Capital	0.047 ***		0.058 ***	0.237	0.116 ***		0.115 ***	
		(0.005)		(0.009)		(0.038)		(0.014)	
352 Other	Labor	0.287 ***		0.198 ***	0.194	0.269 ***		0.25 ***	
Chemicals		(0.007)		(0.009)		(0.014)		(0.007)	
	Energy	0.018 ***	1.083	0.009 ***	0.012	0.008	0.996	0.015 ***	0.992
		(0.004)		(0.005)		(0.009)		(0.004)	
N.obs	Materials	0.707 ***		0.657 ***	0.521	0.658 ***		0.651 ***	
4296		(0.005)		(0.007)		(0.045)		(0.01)	
	Capital	0.071 ***		0.021 ***	0.273	0.061 **		0.076 ***	
		(0.004)		(0.006)		(0.027)		(0.012)	

Table 1 (continued)

Industry	Input	OLS	R. scale	Plant *** fixed *** effects	Input revenue shares	Materials correcting endog. bias	R. scale	Polynomials	R. scale
356 Plastics	Labor	0.325 ***		0.237 ***	0.196	0.303 ***		0.225 ***	
		(0.008)		(0.011)		(0.015)		(0.007)	
	Energy	0.014 ***	1.047	-0.017 ***	0.032	-0.015	1.032	0.043 ***	0.954
		(0.005)		(0.006)		(0.008)		(0.004)	
N.obs	Materials	0.596 ***		0.554 ***	0.548	0.642 ***		0.59 ***	
4059		(0.005)		(0.007)		(0.034)		(0.008)	
	Capital	0.112 ***		0.021 ***	0.224	0.103 ***		0.096 ***	
		(0.005)		(0.008)		(0.03)		(0.01)	
324 Footwear	Labor	0.259 ***		0.161 ***	0.255	0.228 ***		0.199 ***	
		(0.008)		(0.009)		(0.021)		(0.007)	
	Energy	0.109 ***	1.003	0.02 ***	0.010	0.067 **	1.018	0.104 ***	0.993
		(0.006)		(0.007)		(0.029)		(0.006)	
N.obs	Materials	0.608 ***		0.647 ***	0.531	0.674 ***		0.615 ***	
3594		(0.006)		(0.008)		(0.049)		(0.01)	
	Capital	0.027 ***		0.062 ***	0.204	0.049		0.075 ***	
		(0.005)		(0.008)		(0.032)		(0.012)	
384 Transport equipment	Labor	0.372 ***		0.361 ***	0.274	0.353 ***		0.233 ***	
		(0.012)		(0.016)		(0.025)		(0.01)	
	Energy	0.025 ***	1.069	-0.035 ***	0.024	0.009	0.922	0.047 ***	0.923
		(0.007)		(0.009)		(0.012)		(0.006)	
N.obs	Materials	0.574 ***		0.522 ***	0.491	0.47 ***		0.559 ***	
3310		(0.006)		(0.01)		(0.083)		(0.009)	
	Capital	0.097 ***		-0.006 ***	0.211	0.09		0.084 ***	
		(0.007)		(0.012)		(0.058)		(0.016)	
383 Electrical machinery	Labor	0.291 ***		0.283 ***	0.264	0.286 ***		0.233 ***	
		(0.01)		(0.013)		(0.022)		(0.01)	
	Energy	0.04 ***	1.067	-0.005	0.018	0.031 ***	0.907	0.047 ***	0.981
		(0.006)		(0.008)		(0.012)		(0.006)	
N.obs	Materials	0.669 ***		0.635 ***	0.518	0.526 ***		0.636 ***	
2824		(0.007)		(0.009)		(0.121)		(0.012)	
	Capital	0.068 ***		0.004	0.200	0.064		0.065 ***	
		(0.006)		(0.008)		(0.055)		(0.015)	
341 Paper	Labor	0.2 ***		0.191 ***	0.181	0.204 ***		0.178 ***	
		(0.01)		(0.015)		(0.03)		(0.009)	
	Energy	0.065 ***	1.056	0.053 ***	0.032	0.043 ***	0.917	0.053 ***	0.991
		(0.005)		(0.009)		(0.007)		(0.005)	
N.obs	Materials	0.723 ***		0.68 ***	0.581	0.57 ***		0.668 ***	
2017		(0.005)		(0.01)		(0.09)		(0.011)	
	Capital	0.067 ***		0.035 ***	0.205	0.1 **		0.092 ***	
		(0.005)		(0.01)		(0.044)		(0.011)	
313 Beverages	Labor	0.265 ***		0.208 ***	0.197	0.233 ***		0.182 ***	
		(0.016)		(0.024)		(0.03)		(0.015)	
	Energy	0.193 ***	1.063	0.07 ***	0.027	0.119 ***	0.909	0.122 ***	1.030
		(0.009)		(0.012)		(0.021)		(0.008)	
N. obs.	Materials	0.555 ***		0.442 ***	0.438	0.543 ***		0.63 ***	
1975		(0.01)		(0.011)		(0.079)		(0.014)	
	Capital	0.05 ***		0.033 ***	0.338	0.014		0.096 ***	
		(0.009)		(0.012)		(0.056)		(0.016)	
351 Industrial chemicals	Labor	0.095 ***		0.138 ***	0.148	0.116 ***		0.102 ***	
		(0.017)		(0.02)		(0.03)		(0.013)	
	Energy	0.084 ***	0.973	0.085 ***	0.062	0.08 ***	0.913	0.081 ***	0.924
		(0.009)		(0.009)		(0.022)		(0.007)	
N.obs	Materials	0.555 ***		0.596 ***	0.497	0.278 ***		0.563 ***	
1713		(0.008)		(0.013)		(0.121)		(0.019)	
	Capital	0.238 ***		0.049 ***	0.294	0.439 ***		0.178 ***	
		(0.011)		(0.013)		(0.132)		(0.024)	
323 Leather products	Labor	0.198 ***		0.198 ***	0.233	0.243 ***		0.213 ***	
		(0.01)		(0.017)		(0.019)		(0.009)	
	Energy	0.035 ***	0.951	0.007	0.014	0.009	0.845	0.038 ***	0.941
		(0.007)		(0.012)		(0.013)		(0.007)	
N.obs	Materials	0.684 ***		0.66 ***	0.571	0.53 ***		0.615 ***	
1462		(0.009)		(0.012)		(0.1)		(0.01)	
	Capital	0.035 ***		0.033 ***	0.182	0.063		0.075 ***	
		(0.006)		(0.013)		(0.048)		0.012)	

Table 1 (continued)

Industry	Input	OLS	R. scale	Plant fixed effects	Input revenue shares	Materials correcting endog. bias	R. scale	Polynomials	R. scale
355 Rubber	Labor	0.294 ***		0.213 ***	0.234	0.261 ***		0.216 ***	
products		(0.013)		(0.017)		(0.025)		(0.013)	
	Energy	0.046 ***	1.064	-0.01 ***	0.035	0.051 ***	0.862	0.072 ***	0.973
		(0.009)		(0.012)		(0.014)		(0.009)	
N.obs	Materials	0.673 ***		0.608 ***	0.511	0.53 ***		0.628 ***	
1196		(0.01)		(0.015)		(0.054)		(0.017)	
	Capital	0.051 ***		-0.014 ***	0.220	0.02		0.057 ***	
		(0.009)		(0.014)		(0.057)		(0.017)	
385 Professional	Labor	0.39 ***		0.282 ***	0.321	0.396 ***		0.369 ***	
equipment		(0.02)		(0.03)		(0.04)		(0.018)	
	Energy	0.042 ***	1.063	0.046 ***	0.019	0.017	0.898	0.015	0.988
		(0.013)		(0.015)		(0.016)		(0.011)	
N. obs.	Materials	0.539 ***		0.529 ***	0.423	0.418 ***		0.541 ***	
935		(0.012)		(0.017)		(0.135)		(0.013)	
	Capital	0.091 ***		0.021	0.238	0.075		0.063 ***	
		(0.01)		(0.018)		(0.09)		(0.015)	
371 Iron and steel	Labor	0.238 ***		0.258 ***	0.227	0.201 ***		0.187 ***	
		(0.019)		(0.031)		(0.029)		(0.017)	
	Energy	0.07 ***	1.060	0.085 ***	0.049	0.051 ***	1.041	0.064 ***	0.956
		(0.012)		(0.016)		(0.013)		(0.01)	
N.obs	Materials	0.674 ***		0.573 ***	0.528	0.78 ***		0.603 ***	
823		(0.009)		(0.017)		(0.183)		(0.018)	
	Capital	0.078 ***		0.047 ***	0.196	0.009		0.102 ***	
		(0.01)		(0.018)		(0.131)		(0.018)	
362 Glass	Labor	0.35 ***		0.353 ***	0.272	0.342 ***		0.329 ***	
		(0.015)		(0.022)		(0.031)		(0.015)	
	Energy	0.119 ***	1.075	0.107 ***	0.075	0.102 ***	1.124	0.106 ***	1.015
		(0.008)		(0.012)		(0.016)		(0.008)	
N.obs	Materials	0.581 ***		0.534 ***	0.435	0.67 ***		0.529 ***	
815		(0.011)		(0.016)		(0.071)		(0.021)	
	Capital	0.025 ***		0.009	0.218	0.01		0.051 ***	
		(0.01)		(0.016)		(0.056)		(0.023)	
361 Ceramics	Labor	0.5 ***		0.487 ***	0.455	0.506 ***		0.468 ***	
		(0.026)		(0.035)		(0.067)		(0.027)	
	Energy	0.12 ***	1.096	0.135 ***	0.092	0.081 ***	1.050	0.09 ***	1.038
		(0.014)		(0.021)		(0.022)		(0.014)	
N.obs	Materials	0.45 ***		0.359 ***	0.259	0.386 ***		0.369 ***	
503		(0.018)		(0.026)		(0.133)		(0.024)	
	Capital	0.026 **		0.038	0.194	0.077		0.111 ***	
		(0.012)		(0.03)		(0.094)		(0.02)	
372 Nonferrous	Labor	0.355 ***		0.409 ***	0.230	0.315 ***		0.267 ***	
metals		(0.035)		(0.043)		(0.047)		(0.032)	
	Energy	0.17 ***	1.079	0.028	0.039	0.08 **	0.978	0.088 ***	0.860
		(0.023)		(0.024)		(0.035)		(0.018)	
N.obs	Materials	0.416 ***		0.409 ***	0.489	0.549 ***		0.466 ***	
435		(0.019)		(0.021)		(0.17)		(0.021)	
	Capital	0.138 ***		-0.115 ***	0.242	0.034		0.039	
		(0.018)		(0.028)		(0.176)		(0.033)	
354 Petroleum	Labor	0.213 ***		0.19 ***	0.104	0.283 ***		0.216 ***	
derivatives		(0.041)		(0.021)		(0.079)		(0.034)	
	Energy	0.052 ***	1.094	-0.066 ***	0.042	0.027	1.001	0.049 ***	1.123
		(0.017)		(0.021)		(0.029)		(0.012)	
N.obs	Materials	0.821 ***		0.63 ***	0.634	0.52 ***		0.713 ***	
306		(0.019)		(0.034)		(0.159)		(0.028)	
	Capital	0.007		-0.102 ***	0.220	0.171 ***		0.145 ***	
		(0.022)		(0.026)		(0.087)		(0.025)	
314 Tobacco	Labor	0.266 ***		0.22 ***	0.202	0.322 ***		0.224 ***	
		(0.053)		(0.066)		(0.08)		(0.041)	
	Energy	0.187 ***	1.066	-0.0003	0.009	0.018	0.917	0.079 ***	0.647
		(0.035)		(0.05)		(0.039)		(0.025)	
N.obs	Materials	0.535 ***		0.392 ***	0.52	0.389 ***		0.332 ***	
269		(0.034)		(0.039)		(0.224)		(0.03)	
	Capital	0.077 ***		-0.135 **	0.3	0.188		0.011	
		(0.029)		(0.064)		(0.193)		(0.055)	

Notes: Bootstrapped standard errors in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. The energy input is constituted by fuels plus electricity.

Table 2 Nominal Tariffs across 3-digit Industries

Industry	Average Tariff (%) 1976-80	Average Tariff (%) 1983-84	Average Tariff (%) 1985-88
311 Food	30.5	45.1*	43.4
312 Food-miscellaneous	28.4	39.8*	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

Notes: * for industries 311 and 312, tariff values in the second column are for 1984.
A comparison between average tariffs in 1983-84 and 1985-88 would indicate that protection increased in the period of trade liberalization post-1985, whereas in fact what happened was that relative to 1985-88. tariffs were very strongly increased in 1984 not in 1983.

Table 3 Import Penetration Ratios and Export Orientation Ratios across Industries

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

Notes: n.a. exports data for Petroleum derivatives and Iron and Steel has irregularities.
Export orientation ratios are defined as the ratio of exports to total output (domestic output plus exports).
Import penetration ratios are defined as the ratio of imports to domestic demand (domestic output plus imports).

Table 4 Relation between Measures of Trade Exposure

Table 4a Levels Correlations across Industries and Over Time

(3-digit industries)	Import penetration	Export orientation
Nominal tariffs	-0.537**	0.007
	*-0.702***	*-0.029*
Effective rate of protection	-0.545**	-0.045
	*-0.674***	*-0.081*
Import penetration		-0.074
		-0.024

(4-digit industries)	Import penetration	Export orientation
Nominal tariffs	-0.398**	-0.08
	*-0.413***	*-0.026*
Import penetration		0.086**
		0.291

Notes: Spearman rank correlation coefficient in italics. ** and * represent significance at 5 and 10% levels, respectively. Tariff levels considered for years 1980 and 1983-1988 and ERP for years 1983, 1984, 1989, 1990. Correlations with export orientation exclude petroleum derivatives and iron and steel.

Table 4b Changes Correlations across Industries and Over Time

(3-digit industries)	Change imp. penet.	Change export orient.
Change tariffs	-0.038	-0.301**
	0.058	*-0.193***
Change in effective rate protection	-0.317**	-0.56**
	*-0.494***	*-0.628***
Change import penetration		0.137
		*0.201***

(4-digit industries)	Change imp. penet.	Change export orient.
Change tariffs	-0.028	-0.005
	-0.049	*-0.081*
Change import penetration		-0.05

Notes: Spearman rank correlation coefficient in italics. ** and * represent significance at 5 and 10% levels, respectively. Tariff changes considered for years between 1983 and 1984 and between 1987 and 1988. ERP changes considered for years between 1983 and 1984 and between 1989 and 1990. Correlations with export orientation exclude petroleum derivatives and iron and steel.

Table 4c Tariff Changes Correlations across Industries and Trade Policy Regimes

(3-digit industries)	Change imp. penet.	Change export orient.
Change tariffs	0.242	-0.56**
	*0.358***	*-0.59***
Change imp. penet.		-0.092
		-0.138

(4-digit industries)	Change imp. penet.	Change export orient.
Change tariffs	0.088	-0.0416
	0.155	*-0.249***
Change imp. penet.		-0.139
		0.068

Notes: Spearman rank correlation coefficient in italics. ** and * represent significance at 5 and 10% levels, respectively. Tariff changes considered for years between 1980 and 1983 and 1983 and 1988. Correlations with export orientation exclude petroleum derivatives and iron and steel.

Table 4d ERP Changes Correlations across Industries and Trade Policy Regimes

(3-digit industries)	Change imp. penet.	Change export orient.
Change in eff. rate protection	-0.117	-0.366
	-0.262	*-0.155*
Change imp. penet.		0.067
		0.048

Notes: Spearman rank correlation coefficient *in italics.* ** and * represent significance at 5 and 10% levels, respectively. ERP changes considered for years between 1984 and 1990. Correlations with export orientation exclude petroleum derivatives and iron and steel.

Table 4e Tariffs and ERP Levels and Changes Correlations across Industries

(3-digit industries)	ERP	Change in ERP
Tariffs	0.909**	
	*0.914***	
Changes in tariffs		0.973**
		*0.984***

Notes: Spearman rank correlation coefficient *in italics.* ** and * represent significance at 5 and 10% levels, respectively. Tariffs, ERP levels considered for years 1983, 1984, 1989, 1990 and changes for years between 1983 and 1984 and between 1989 and 1990

Table 4f Tariffs and ERP Changes Correlations across Industries and Trade Regimes

(3-digit industries)	Change in ERP
Changes in tariffs	0.974**
	*0.976***

Notes: Spearman rank correlation coefficient *in italics.* ** and * represent significance at 5 and 10% levels, respectively. Tariff changes considered for years between 1980 and 1984 and between 1984 and 1988. ERP changes considered for years between 1979 and 1984 and between 1984 and 1990.

Table 4g Licenses, Tariffs and ERP Levels Correlations across Industries

	Tariffs 3-dig.1989	ERP 3-dig.1989	Tariffs 4-dig.1988
License coverage 3-dig. 1989	0.636**	0.644**	
	*0.747***	*0.883***	
License coverage 4-dig. 1989			0.598**
			*0.579***

Notes: Spearman rank correlation coefficient *in italics.* ** and * represent significance at 5 and 10% levels, respectively.

Table 5 Impact of Lagged Trade Policy on Productivity

Regressors	OLS (1)	OLS (2)	OLS (3)	Plant F.Effects (4)	Plant F.Effects (5)
Nominal tariff 3-digit	0.176 ***	-0.095 ***	-0.092 ***	-0.051 ***	-0.07 ***
	(0.01)	(0.026)	(0.026)	(0.015)	(0.016)
Age	0.003 ***	0.003 ***	0.002 ***	0.006 ***	0.006 ***
	(0.0004)	(0.0004)	-0.0003	(0.001)	(0.001)
Age squared	-0.00002 ***	-0.00001 *	-0.00001 *	-0.0007 ***	-0.0007 ***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
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 F.Effects (9)	Plant F.Effects (10)
Nominal tariff 4-digit	0.08 ***	-0.268 ***	-0.096 ***	-0.077 ***	-0.076 ***
	(0.01)	(0.018)	(0.025)	(0.015)	(0.016)
Age	0.002 ***	0.003 ***	0.002 ***	0.006 ***	0.006 ***
	(0.0004)	(0.0004)	-0.0003	(0.001)	(0.001)
Age squared	-0.00001	-0.00001 *	-0.00001 *	-0.0008 ***	-0.0008 ***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
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

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. Years included are 1977, 1979, 1981, 1984-1989. One period lagged tariff measures are used.

Table 6 Impact of the Real Exchange Rate and Lagged Trade Policy on Productivity

Regressor	OLS (1)	Plant F.Effects (2)	OLS (3)	OLS (4)	Plant F.Effects (5)	OLS (6)	Plant F.Effects (7)	OLS (8)	Plant F.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*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*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)
Age						0.002 ***	0.005 ***	0.002 ***	0.005 ***
						(0.0004)	(0.001)	(0.0004)	(0.001)
Age squared						0.000004	-0.00007 ***	0.000004	-0.00007 ***
						(0.00001)	(0.00001)	(0.00001)	(0.00001)
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

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. An increase in RER represents a real appreciation of the Colombian peso (IMF definition). In columns (1)-(5), Petroleum Derivatives and Iron and Steel are excluded due to irregularities in their export data (the classification according to trade orientation is not defined). In columns (1)-(5), the omitted category are nontraded industries. In columns (1)-(2), interactions refer to 3-digit traded industries, in columns (3)-(5) they refer to 4-digit traded industries. Years included in columns (1)-(5): 1980-1991. In columns (6)-(9): 1981, 1983, 1984-1989. One period lagged tariff measures ar used.

Table 7 Impact of Lagged Trade Policy on Productivity Differentiated by Size

Part A

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-digit*Small	0.253 ***	-0.017	-0.013			
	(0.011)	(0.026)	(0.026)			
Nominal tariff 3-digit*Large	-0.104 ***	-0.336 ***	-0.33 ***			
	(0.022)	(0.033)	(0.033)			
Nominal tariff 4-digit*Small				0.154 ***	-0.171 ***	-0.025
				(0.01)	(0.018)	(0.025)
Nominal tariff 4-digit*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

Part B

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.tariff3*M.share	-3.625 ***	-5.51 ***	-5.622 ***			
	(0.97)	(0.901)	(0.831)			
Nominal tariff4-digit				0.106 ***	-0.218 ***	-0.091 ***
				(0.01)	(0.017)	(0.024)
Nom.tariff4*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

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. In Part A, small plants have less than 50 employees in the initial year of presence in the sample. In Part B, market shares are relative to 3-digit industry output in the initial year of presence in the sample. Years included are 1977, 1979, 1981, 1984-1989. One period lagged tariff measures are used.

Table 8 Impact of Lagged Trade Policy on Productivity Differentiated by Degree of Domestic Competition

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.tariff3*Herf.3	-0.781 ***							
	(0.259)							
Nominal tariff 4-digit		0.06 ***			0.012	-0.31 ***		-0.939 ***
		(0.013)			(0.013)	(0.02)		(0.038)
Nom.tariff4*Herf.3		-1.441 ***						
		(0.242)						
Herfindahl Index 4-digit			-0.282 ***	-0.218 ***	-0.339 ***	-0.227 ***		
			(0.054)	(0.063)	(0.065)	(0.075)		
Nom.tariff3*Herf.4			0.161	0.532 ***				
			(0.119)	(0.144)				
Nom.tariff4*Herf.4					-0.131	0.406 ***		
					(0.129)	(0.142)		
Turnover rate 3-digit							-1.115 ***	-1.127 ***
							(0.067)	(0.068)
Nominal tariff3*Turnover3							3.122 ***	
							(0.143)	
Nominal tariff4*Turnover3								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	0.013	0.02	0.01	0.340	0.01	0.12	0.02	0.02

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. Herfindahl indexes and turnover rates used are for the first sample year. Years included are 1977, 1979, 1981, 1984-1989. One period lagged tariff measures are used.

Table 9 Impact of Lagged Trade Policy on Productivity, Effective Rates of Protection

Regressors	OLS (1)	OLS (1')	OLS (2)	OLS (2')	Plant F.Effects (3)	Plant F.Effects (3')	Plant F.Effects (4)	Plant F.Effects (4')
Nominal tariff 3-digit		-0.181 ***		-0.179 ***		-0.114 ***		-0.132 ***
		(0.029)		(0.029)		(0.018)		(0.019)
ERP 3-digit	0.004		0.004		0.023 ***		0.03 ***	
	(0.014)		(0.013)		(0.009)		(0.009)	
Age	0.002 ***	0.002 ***	0.001 ***	0.001 ***	0.005 ***	0.005 ***	0.006 ***	0.005 ***
	(0.0004)	(0.0005)	(0.0005)	(0.0005)	(0.001)	(0.001)	(0.001)	(0.001)
Age squared	0.000007	0.000009	0.000007	0.000009	-0.00007 ***	-0.00006 ***	-0.00008 ***	-0.00006 ***
	(0.000009)	(0.000009)	(0.000008)	(0.000009)	(0.00001)	(0.00001)	(0.00001)	(0.00001)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes	Yes						
Industry effects 4-digit			Yes	Yes			Yes	Yes
N. observations	32456	32456	32456	32456	32456	32456	32456	32456
R-squared	0.15	0.15	0.19	0.19	0.02	0.02	0.06	0.06

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. Nominal tariffs at a 3-digit level are from DNP, a source that differs from that of tariffs in Tables 5-8 (J. Garcia at the World Bank). Years include are 1980, 1984, 1985, 1990, 1991. One period lagged ERP and tariff measures are used.

Table 10 Impact of Lagged Trade Policy on Productivity Differentiated by Size, Effective Rates of Protection

Part A

Regressor	OLS (1)	OLS (1')	OLS (2)	OLS (2')
Small	-0.003	0.068 ***	-0.065 ***	-0.003
	(0.017)	(0.013)	(0.026)	(0.023)
Large	0.321 ***	0.361 ***	0.232 ***	0.277 ***
	(0.022)	(0.019)	(0.029)	(0.026)
ERP 3 digit*Small	0.058 ***		0.052 ***	
	(0.014)		(0.014)	
ERP 3-digit*Large	-0.14 *		-0.121 ***	
	(0.017)		(0.017)	
Nominal tariff 3-digit*Small		-0.097 ***		-0.099 ***
		(0.03)		(0.029)
Nominal tariff 3-digit*Large		-0.381 ***		-0.371 ***
		(0.037)		(0.037)
Year effects Small Large	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes	Yes		
Industry effects 4-digit			Yes	Yes
N. observations	32456	32456	32456	32456
R-squared	0.19	0.19	0.23	0.22

Part B

Regressor	OLS (1)	OLS (1')	OLS (2)	OLS (2')
Market share 3-digit	11.22 ***	11.62 ***	10.27 ***	10.8 ***
	(0.527)	(0.587)	(0.515)	(0.574)
M. share squared	-23.29 ***	-23.73 ***	-20.72 ***	-21.25 ***
	(1.376)	(1.424)	(1.297)	(1.346)
ERP 3-digit	0.009		0.009	
	(0.014)		(0.013)	
ERP3*M.share	-1.757 ***		-1.529 ***	
	(0.501)		(0.481)	
Nominal tariff 3-digit		-0.167 ***		-0.166 ***
		(0.029)		(0.029)
Nom.tariff3*M.share		-3.967 ***		-3.877 ***
		(1.038)		(0.995)
Year effects	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes	Yes		
Industry effects 4-digit			Yes	Yes
N. observations	32456	32456	32456	32456
R-squared	0.19	0.20	0.23	0.23

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. In Part A, small plants have less than 50 employees in the initial year of presence in the sample. In Part B, market shares are relative to 3-digit industry output in the initial year of presence in the sample. Years included are 1980, 1984, 1985, 1990, 1991. One period lagged ERP and tariff measures are used.

Table 11 Impact of Lagged Trade Policy on Productivity Differentiated by Degree of Domestic Competition, Effective Rates of Protection

Regressor	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)
Herfindahl Index 3-digit	-1.346 ***			
	(0.147)			
ERP 3-digit	0.066 ***	0.138 ***	0.011	-0.095 ***
	(0.009)	(0.008)	(0.014)	(0.018)
ERP3-digit*Herf.3	0.748 ***			
	(0.187)			
Herfindahl Index 4-digit		0.09	0.14 ***	
		(0.055)	(0.06)	
ERP3-digit*Herf.4-digit		-0.348 ***	-0.137 ***	
		(0.06)	(0.063)	
Turnover 3-digit				-0.239 ***
				(0.077)
ERP3-digit*Turnover3-digit				0.841 ***
				(0.079)
Year effects	Yes	Yes	Yes	Yes
Industry effects 3-digit			Yes	
N. observations	32456	32456	32456	32456
R-squared	0.02	0.02	0.15	0.02

Notes:The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. 1980 Herfindahl indexes and 1980-1981 turnover rates values are used. Years included are 1980, 1984, 1985, 1990, 1991 One period lagged ERP measures are used.

Table 12 Impact of Lagged Trade Exposure on Productivity

Regressors	OLS (1')	OLS (2')	OLS (3')	Plant F.Effects (4)	Plant F.Effects (5)
Import penetration ratio 3-digit	0.017 ***	1.797 ***	1.811 ***	0.601 ***	1.59 ***
	(0.01)	(0.077)	(0.075)	(0.024)	(0.049)
Age	0.0001	0.002 ***	0.002 ***	0.007 ***	0.007 ***
	(0.0003)	(0.0003)	(0.0003)	(0.0009)	(0.0009)
Age squared	0.00002	0.000006	0.000005	-0.00009 ***	-0.00008 ***
	(0.000006)	(0.000006)	(0.000006)	(0.00001)	(0.00001)
Year effects	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			
Industry effects 4-digit			Yes		Yes
N. observations	71928	71928	71928	71928	71928
R-squared	0.002	0.15	0.19	0.02	0.05

Regressors	OLS (6')	OLS (7')	OLS (8')	Plant F.Effects (9')	Plant F.Effects (10')
Import penetration ratio 4-digit	-0.078 ***	-0.034 *	0.668 ***	0.335 ***	0.634 ***
	(0.009)	(0.018)	(0.052)	(0.019)	(0.033)
Age	0.004 ***	0.002 ***	0.001 ***	0.006 ***	0.006 ***
	(0.0004)	(0.0003)	(0.0003)	(0.009)	(0.0009)
Age squared	0.00001 **	0.000007	0.000006	-0.00009 ***	-0.00009 ***
	(0.000006)	(0.000006)	(0.000006)	(0.00001)	(0.00001)
Year effects	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			
Industry effects 4-digit			Yes		Yes
N. observations	67686	67686	67686	67686	67686
R-squared	0.003	0.15	0.19	0.01	0.04

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. Years included are 1981-1991. One period lagged import penetration ratios are used.

Table 13 Impact of Lagged Trade Exposure on Productivity Differentiated by Size

Part A

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Small	-0.096 ***	-0.164 ***	-0.006	-0.126 ***
	(0.009)	(0.018)	(0.008)	(0.018)
Large	0.01	-0.056 ***	0.137 ***	0.006
	(0.013)	(0.02)	(0.013)	(0.02)
Import Penet.3-digit*Small	1.516 ***	1.646 ***		
	(0.073)	(0.072)		
Import Penet.3-digit*Large	2.241 ***	2.207 ***		
	(0.074)	(0.072)		
Import Penet.4-digit*Small			-0.149 ***	0.585 ***
			(0.019)	(0.05)
Import Penet.4-digit*Large			0.14 ***	0.876 ***
			(0.023)	(0.052)
Year effects Small Large	Yes	Yes	Yes	Yes
Industry effects 3 digit	Yes		Yes	
Industry effects 4 digit		Yes		Yes
N. observations	71928	71928	67686	67686
R-squared	0.19	0.23	0.18	0.22

Part B

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Market share 3-digit	8.738 ***	8.021 ***	9.039 ***	8.194 ***
	(0.219)	(0.216)	(0.222)	(0.223)
M. share squared	-20.8 ***	-18.46 ***	-20.5 ***	-18.13 ***
	(0.904)	(0.847)	(0.873)	(0.846)
Import penet. 3-digit	1.774 ***	1.789 ***		
	(0.072)	(0.071)		
Imp.penet.3*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*M.share			3.211 ***	3.144 ***
			(0.594)	(0.563)
Year effects	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes		Yes	
Industry effects 4-digit		Yes		Yes
N. observations	71928	71928	67686	67686
R-squared	0.19	0.23	0.19	0.22

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with material controlling for the simultaneity bias. Robust standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively. In Part A, small plants have less than 50 employees in the initial year of presence in the sample. In Part B, market shares are relative to 3-digit industry output in the initial year of presence in the sample. Years included are 1981-1991. One period lagged import penetration ratios are used.

Table 14 Impact of Lagged Trade Exposure on Productivity Differentiated by Degree of Domestic Competition

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)
Herfindahl Index 3-digit	-1.532 ***	-2.003 ***						
	(0.071)	(0.064)						
Import penet. 3-digit	-0.036 ***		-0.05 ***	1.633 ***			0.949 ***	
	(0.015)		(0.016)	(0.081)			(0.033)	
Imp.penet.3*Herf.3	2.339 ***							
	(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*Herf.3		3.538 ***						
		(0.178)						
Herfindahl Index 4-digit			-0.449 ***	-0.115 ***	-0.693 ***	-0.135 ***		
			(0.022)	(0.024)	(0.031)	(0.036)		
Imp.penet.3*Herf.4			1.014 ***	1.117 ***				
			(0.122)	(0.178)				
Imp.penet.4*Herf.4					1.32 ***	0.465 ***		
					(0.109)	(0.122)		
Turnover 3-digit							1.077 ***	0.916 ***
							(0.025)	(0.024)
Imp.penet.3*Turnover3							-5.156 ***	
							(0.211)	
Imp.penet.4*Turnover3								-4.226 ***
								(0.186)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit				Yes		Yes		
N. observations	71928	67686	71928	71928	67686	67686	71928	67686
R-squared	0.02	0.02	0.01	0.15	0.01	0.15	0.03	0.02

Notes: The dependent variable is productivity obtained by nonparametric/GMM estimation with materials controlling for the simultaneity bias. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. 1981 Herfindahl indexes and 1981-1982 turnover rates values are used. Years included are 1981-1991. One period lagged import penetration ratios are used.

Table 15 Impact of Lagged Trade Policy and Trade Exposure on Productivity Growth

Regressors	OLS (1)	OLS (2)	OLS (3)	Plant F.Effects (4)	Plant F.Effects (5)	OLS (6)	OLS (7)	OLS (8)	Plant F.Effects (9)	Plant F.Effects (10)
Nominal tariff 3-digit	0.03 ***	-0.058 ***	-0.058 ***	-0.035 *	-0.05 ***					
	(0.007)	(0.018)	(0.018)	(0.019)	(0.02)					
Nominal tariff 4-digit						0.02 ***	-0.033 ***	-0.062 ***	-0.06 ***	-0.053 ***
						(0.006)	(0.014)	(0.017)	(0.018)	(0.019)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes					Yes			
Industry effects 4-digit			Yes		Yes			Yes		Yes
N. observations	45514	45514	45514	45514	45514	42884	42884	42884	42884	42884
R-squared	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02

Regressors	OLS (1')	OLS (2')	OLS (3')	Plant F.Effects (4')	Plant F.Effects (5')
ERP 3-digit	0.008 **	-0.036 ***	-0.035 ***	-0.02 **	-0.02 *
	(0.004)	(0.009)	(0.009)	(0.01)	(0.01)
Year effects	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes			
Industry effects 4-digit			Yes		Yes
N. observations	29274	29274	29274	29274	29274
R-squared	0.01	0.02	0.02	0.01	0.02

Regressors	OLS (1'')	OLS (2'')	OLS (3'')	Plant F.Effects (4'')	Plant F.Effects (5'')	OLS (6'')	OLS (7'')	OLS (8'')	Plant F.Effects (9'')	Plant F.Effects (10'')
Import Penetration 3-digit	0.023 ***	0.239 ***	0.239 ***	0.238 ***	0.297 ***					
	(0.006)	(0.048)	(0.048)	(0.029)	(0.059)					
Import Penetration 4-digit						0.009	0.023 ***	0.065 *	0.115 ***	0.093 **
						(0.006)	(0.011)	(0.034)	(0.023)	(0.04)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit		Yes					Yes			
Industry effects 4-digit			Yes		Yes			Yes		Yes
N. observations	64238	64238	64238	64238	64238	60444	60444	60444	60444	60444
R-squared	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.01	0.02

Notes: The dependent variable is productivity growth are obtained for each plant as the difference between productivity (obtained by nonparametric/GMM estimation with materials controlling for simultaneity biases) at t and at productivity at t-1. Robust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels, respectively. All regressions include a constant. Years included are: for tariffs 1979, 1981, 1984-1989, for ERP 1980, 1984, 1985, 1990, 1991, for import penetration 1981-1991. One period lagged ERP, tariffs and import penetration ratios are used.

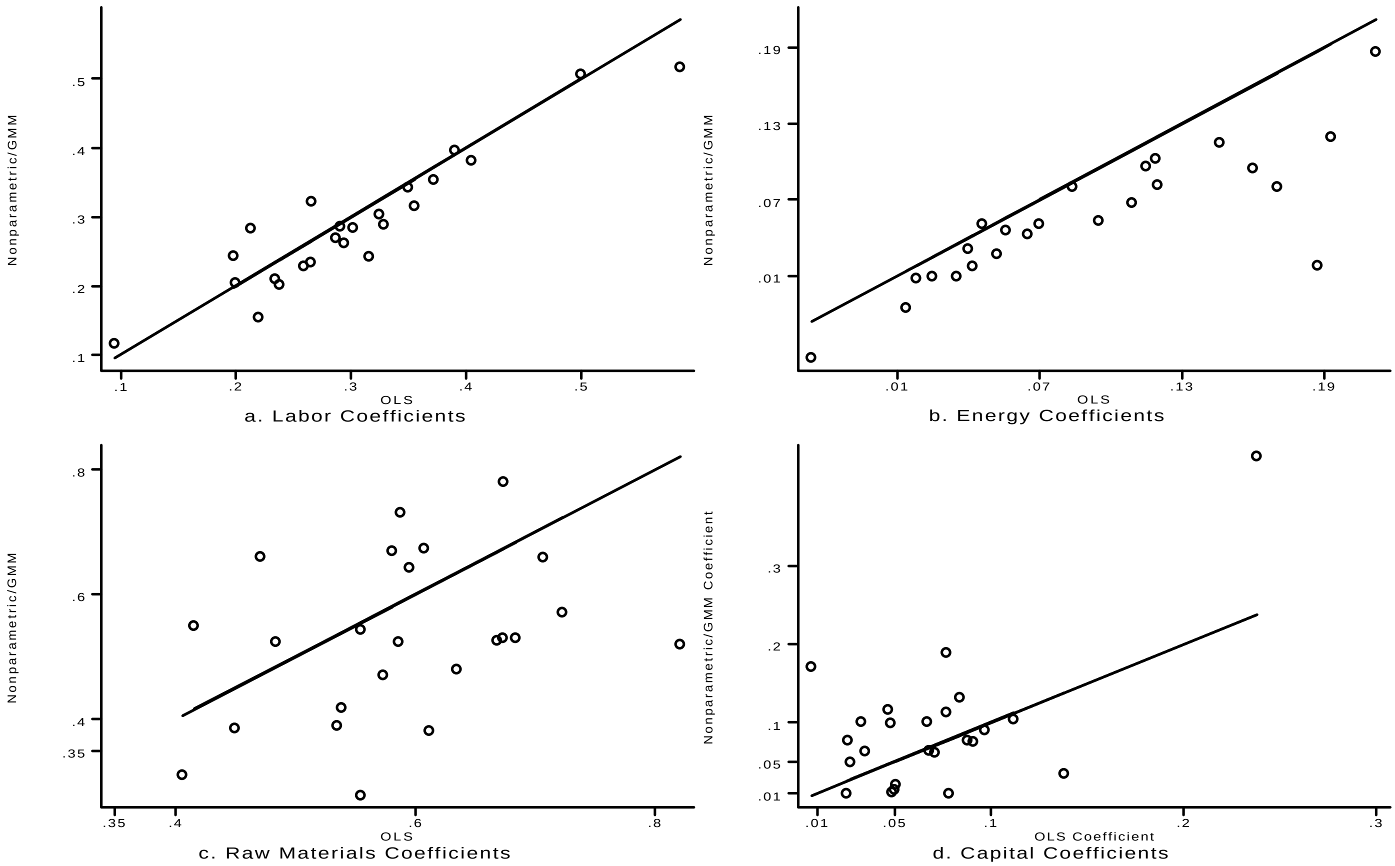

Figure 1 Production Function Estimates (circles are industries)

Appendix B

Table B.1 Manufacturing Plants' Characteristics

Table B.1a Distribution of Plants by Size Category (%)

Size Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0 to 9 employees	11.0	11.3	11.5	11.7	12.1	13.4	n.a.	n.a.	1.2	1.7	2.6	6.1	8.6	10.5	13.0
10 to 49 employees	59.3	57.9	57.8	58.6	58.0	58.1	68.6	68.9	69.8	69.5	68.5	65.9	64.1	61.3	57.6
50 to 99 employees	14.2	14.4	14.4	13.7	14.3	13.6	15.0	15.2	14.2	14.1	14.5	13.5	13.3	13.9	14.6
100 to 199 employees	7.9	8.5	8.3	8.3	8.1	8.0	8.9	8.4	7.7	7.6	7.4	7.8	7.6	7.6	7.8
Over 200 employees	7.6	7.9	7.9	7.7	7.6	7.0	7.5	7.5	7.1	7.0	7.0	6.7	6.4	6.7	7.1
Median size	26	27	26	26	26	24	28	28	26	26	26	25	24	25	25

Table B.1b Distribution of Plants by Location (%)

Metropolitan Area	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Bogota	33.8	34.1	33.5	32.8	32.3	31.6	32.4	32.7	32.9	33.0	33.2	32.3	31.1	31.2	30.9
Cali	10.5	10.3	10.3	10.5	10.7	11.1	11.2	10.8	11.0	11.2	11.7	11.4	11.4	11.2	10.8
Medellin	17.5	17.9	18.8	19.5	19.9	21.1	23.1	22.6	22.6	21.6	21.3	21.9	22.2	21.4	21.4
Manizales	1.8	1.8	1.7	1.7	1.6	1.7	1.5	1.6	1.6	1.7	1.6	1.7	1.7	1.6	1.8
Barranquilla	6.8	6.9	7.1	7.5	7.1	7.0	6.9	6.6	6.4	6.5	6.3	6.6	6.5	6.3	6.2
Bucamaranga	6.4	6.6	6.2	6.4	6.6	6.2	5.3	5.9	5.4	5.9	5.5	5.9	6.0	6.0	6.1
Pereira	3.6	3.5	3.2	3.0	2.9	2.8	2.6	2.5	2.7	2.8	2.7	2.7	3.0	2.9	2.8
Cartagena	1.6	1.5	1.4	1.3	1.3	1.3	1.3	1.6	1.6	1.6	1.9	1.9	1.8	1.8	1.9
Others	18.0	17.5	17.9	17.3	17.6	17.1	15.7	15.8	15.8	15.8	15.9	15.8	16.5	17.5	18.1

Table B.1c Distribution of Plants by Age Category (%)

Age Category	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
0 to 2 years	10.7	9.6	10.1	10.7	9.8	10.2	11.0	10.7	10.0	10.7	9.1	9.0	8.0	5.4	3.3
3 to 5 years	17.1	15.9	15.4	13.6	13.7	14.6	15.0	13.7	13.6	12.9	14.6	13.5	14.3	11.5	10.8
6 to 10 years	25.5	26.1	24.8	24.5	22.9	21.3	20.4	21.2	20.7	21.2	20.8	20.8	20.6	22.2	21.1
11 to 20 years	26.6	27.2	28.1	29.6	30.6	30.6	29.1	29.4	30.3	29.2	29.0	29.5	29.3	30.7	32.3
21 to 50 years	17.3	18.6	19.3	20.0	21.4	21.6	22.7	23.0	23.6	24.1	24.6	25.2	25.8	27.9	30.0
Over 50 years	2.8	2.6	2.3	1.7	1.7	1.7	1.8	1.9	1.9	1.9	1.9	2.0	2.1	2.3	2.5
Median age	10	10	10	11	11	11	12	12	12	12	12	13	12	13	14

Table B.1d Distribution of Plants by Business Type (%)

Business Type	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Proprietorship	24.3	23.4	22.0	21.2	20.2	19.6	14.6	13.8	13.1	12.4	11.9	11.9	12.5	12.1	12.2
Limited Partnership	55.4	56.0	58.3	59.5	60.8	61.7	65.2	65.4	65.6	66.6	67.0	67.1	66.5	66.6	65.8
Collective	1.4	1.4	1.1	1.0	0.8	0.7	0.7	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3
Corporation	12.2	12.5	12.4	12.4	12.2	12.0	13.9	14.6	15.2	15.2	15.5	15.4	15.5	15.8	16.6
De Facto Corporation	3.3	3.3	2.8	2.4	2.3	2.3	1.5	1.5	1.3	1.3	1.3	1.3	1.2	1.1	1.0
Joint Partnership	0.7	0.8	0.9	1.1	1.2	1.5	1.7	1.8	2.0	1.8	1.8	1.8	1.9	2.1	2.1
Joint Stock Company	1.0	1.0	0.9	0.9	1.1	1.0	1.0	0.9	0.8	0.7	0.6	0.6	0.6	0.6	0.6
Cooperative	0.6	0.6	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
Official Entity (Gov./ Relig.)	0.9	1.1	1.3	1.2	1.2	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0

Notes: Observations include plants in all 3-digit ISIC industries without data problems used for production function estimation with materials controlling for the simultaneity bias. Age is measured by the years of operation of a plant. Size is measured by a plant's total nember of employees.

n.a. In 1983 and 1984, survey coverage does not include plants with less than 10 employees.

Table B.2 Summary Statistics for Age, Ouput and Inputs

Industry	Age			Output			Employment			Intermediate inputs			Capital		
	Mean	edian	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.	Mean	Median	St. Dev.
311 Food	17	14	13	182017	26179	517947	64	22	145	134566	17897	367302	35274	4047	160530
312 Food-miscellaneous	17	14	13	212925	31118	485937	52	23	80	154735	22351	321501	35415	4870	125849
313 Beverages	28	23	20	484936	187585	937567	195	129	234	220160	82364	437324	139408	51004	335303
314 Tobacco	35	28	22	401093	13338	809097	170	34	245	224309	9579	453457	101703	1392	225998
321 Textiles	14	11	12	144785	19742	676969	121	34	359	81950	11532	342753	54159	5328	250785
322 Apparel	10	7	9	31660	11048	101716	52	26	115	15313	5204	49793	4697	1309	18368
323 Leather products	14	10	15	74198	11278	197716	72	24	117	60793	8024	181218	12319	2548	27182
324 Footwear	10	8	10	29141	7521	109410	47	20	100	19183	4578	75753	6703	1284	30781
331 Wood products	14	12	10	32819	9215	163026	34	18	74	15023	5025	57194	14857	1780	106209
332 Furniture	11	9	10	14761	6267	29244	38	22	50	9006	3592	18773	4651	1394	12389
341 Paper	17	16	12	230234	31661	659996	80	40	142	168268	22800	477470	77179	7509	281377
342 Printing	18	13	15	46582	6511	201707	58	20	148	30541	4073	137280	25694	3114	119058
351 Industrial chemicals	19	16	13	475487	75710	1134645	122	40	243	341473	42268	916931	161625	26046	473587
352 Other chemicals	22	19	15	169628	30161	457985	85	35	118	110929	18914	322513	33031	5362	104879
354 Petroleum derivatives	16	15	10	158557	37199	347051	36	28	33	138524	32969	325313	29265	10411	47230
355 Rubber products	17	14	13	160685	17743	598555	91	26	233	104019	11183	400819	33507	5322	117705
356 Plastics	11	9	9	68783	18677	190498	60	30	100	57354	14069	159330	32685	6458	116744
361 Ceramics	16	14	12	110261	3890	229575	157	24	286	59896	1630	133650	60749	1474	138765
362 Glass	14	11	10	146587	15840	452062	119	33	208	77613	9040	245101	69601	3552	242097
369 Nonmetallic minerals	17	14	13	86755	11060	255392	68	29	123	48662	4922	147145	75968	5115	528532
371 Iron and steel	16	12	13	515992	18488	1362199	210	28	751	275803	10459	636810	403153	5144	2103219
372 Nonferrous metals	18	16	14	147839	23361	360897	69	26	127	100027	11211	257025	34622	7776	77293
381 Metal products	14	12	11	46770	10351	126502	51	23	86	29952	6339	84021	14736	2885	47073
382 Nonelectrical machinery	16	13	13	45785	11667	147735	49	24	96	28812	6331	99740	10985	3578	30124
383 Electrical machinery	15	14	11	123248	22415	283946	89	35	142	79327	13832	188564	109365	5298	4231340
384 Transport equipment	15	12	13	155568	12226	846874	94	29	223	158882	8173	1059955	48480	4560	189804
385 Professional equipment	16	14	13	58532	12913	192018	50	28	65	27988	6009	85478	19027	2524	72959
390 Other manufacturing	14	13	10	97451	19281	250130	91	36	129	47265	10162	102592	23998	4505	66422

Notes: Observations include plants in all 3-digit ISIC industries without data problems used for production function estimation with materials controlling for the simultaneity bias. Output, intermediate inputs and capital are in 1980 pesos. For each industry, average, median and standard deviation are taken across all years.

Table B.3 Distribution of Plants across 3-digit Industries

Industry	Years														
	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
311 Food	1008	1001	992	983	981	1012	878	884	900	936	977	1000	1049	1079	1052
312 Food-miscellaneous	185	191	196	201	203	203	174	173	170	172	189	200	231	238	233
313 Beverages	126	129	132	134	130	131	127	125	124	128	127	130	131	132	128
314 Tobacco	36	27	25	23	21	20	15	14	13	13	13	12	13	12	12
321 Textiles	469	474	489	481	475	460	421	411	429	447	459	468	490	487	477
322 Apparel	692	703	727	799	846	926	873	891	943	990	1005	1034	1031	1006	939
323 Leather products	106	103	98	104	101	102	80	85	86	84	81	91	108	113	106
324 Footwear	200	191	201	210	212	253	208	224	228	256	269	291	295	279	272
331 Wood products	202	188	179	180	181	200	173	166	164	160	173	184	189	181	179
332 Furniture	196	200	203	201	191	218	177	164	163	182	204	207	233	235	216
341 Paper	138	134	140	140	138	141	128	133	130	132	130	140	148	145	139
342 Printing	341	335	347	348	354	375	327	327	329	330	341	350	367	361	360
351 Industrial chemicals	101	98	102	96	102	107	103	112	111	117	122	127	138	142	144
352 Other chemicals	280	288	290	285	277	280	261	257	270	284	287	297	320	320	315
354 Petroleum derivatives	10	18	20	21	18	17	17	20	18	19	20	21	27	27	23
355 Rubber products	80	83	83	81	84	86	81	77	72	83	78	76	80	76	75
356 Plastics	181	190	199	220	217	243	236	253	271	279	315	342	354	355	350
361 Ceramics	43	45	45	42	40	37	26	27	28	30	31	29	27	25	24
362 Glass	54	52	51	48	47	48	39	44	48	62	64	65	70	69	67
369 Nonmetallic minerals	326	303	321	324	318	328	284	276	278	269	284	288	298	302	305
371 Iron and steel	57	50	52	49	51	51	47	49	54	61	64	60	63	63	68
372 Nonferrous metals	36	36	37	38	34	33	25	27	23	27	29	29	33	33	33
381 Metal products	573	594	633	607	595	606	540	496	499	499	528	560	608	590	564
382 Nonelectrical machinery	283	286	304	315	309	296	256	263	286	293	304	327	338	326	323
383 Electrical machinery	190	190	192	192	187	188	171	165	171	184	203	202	202	203	192
384 Transport equipment	222	217	225	229	216	233	194	192	202	207	216	229	244	244	240
385 Professional equipment	56	57	56	61	61	57	56	59	57	61	67	72	75	71	69
390 Other manufacturing	19	16	8	11	10	9	7	5	7	10	8	6	10	10	11
Total number of plants	6210	6199	6347	6423	6399	6660	5924	5919	6074	6315	6588	6837	7172	7124	6916

Notes: Observations include plants in all 3-digit ISIC industries without data problems used for production function estimation with materials controlling for the simultaneity bias.

Table B.4 Entry and Exit in the Manufacturing Sector (%)

	Years													
	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	1982-1983	1983-1984	1984-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991
Entry rate	12.6	12.7	12.7	9.5	13.1	12.2 *	12.1	14.5	13.3	12.6	11.0	12.2	5.8	5.3
Output share of entrant plants	3.9	5.6	3.7	5.2	3.0	2.7	2.7	2.2	3.4	2.9	2.3	2.7	1.9	4.2
Entrant plants' output relative to incumbents	28.0	41.7	26.7	52.3	18.2	20.7	20.2	13.7	24.1	21.9	20.2	21.2	31.7	76.2
Entrant plants' total employment relative to incumbents	44.2	54.8	36.3	61.4	32.5	35.3	30.0	31.2	42.8	42.6	33.0	32.9	38.6	61.1
Entrant plants' labor productivity (output) relative to incumbents	90.9	60.3	70.0	85.3	68.6	77.0	77.0	50.2	44.0	59.9	140.0	70.1	164.8	180.2
Exit rate	12.8	10.3	11.5	9.9	9.0	*	12.2	11.8	9.4	8.3	7.2	7.3	6.5	8.3
Output share of exiting plants	2.9	4.7	3.8	5.7	2.5	*	2.4	1.9	3.5	1.1	1.9	2.0	1.2	5.1
Exiting plants' output relative to incumbents	20.4	43.0	30.0	55.0	25.6	*	17.6	14.7	34.8	12.3	25.4	26.1	17.5	59.9
Exiting plants' total employment relative to incumbents	37.2	56.5	36.9	50.0	40.3	*	29.5	33.4	51.2	33.6	54.8	39.9	37.3	50.0
Entrant plants' labor productivity (output) relative to incumbents	59.3	56.1	69.3	111.3	68.4	*	54.2	57.9	64.1	39.7	91.1	92.2	145.1	132.1

Notes: Observations include plants in all 3-digit ISIC industries without data problems used for production function estimation with materials controlling for the simultaneity bias.

* In 1983 and 1984, survey coverage does not include plants with less than 10 employees, so the 1982-1983 entry rate is calculated as the number of entrant plants in 1983 relative to the total number of plants in 1982 excluding the 1 to 9 employees category. Exit rates and exiting plants' characteristics are not calculated in 1982-1983 due to a change in survey coverage.

** Averages during 1977-1989.

Table B.5 Annual Entry Rates by Industry (%)

Part A Entry Rates

Industry	Years															
	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	Average 1977-1982	1982-1983	1983-1984	1984-1985	Average 1982-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	Average 1985-1991
311 Food	12.8	10.5	10.0	9.6	12.2	11.0	11.6	12.6	12.8	12.3	13.0	11.4	9.3	12.0	9.2	6.1	10.2
312 Food-miscellaneous	10.8	8.4	9.2	12.4	10.8	10.3	8.3	9.8	8.1	8.7	8.8	14.5	13.2	24.5	8.7	4.6	12.4
313 Beverages	6.3	6.2	3.8	1.5	6.9	5.0	3.2	4.7	4.0	4.0	5.6	1.6	4.7	6.2	3.8	12.9	5.8
314 Tobacco	8.3	7.4	16.0	8.7	4.8	9.0	0.0	6.7	7.1	4.6	7.7	0.0	0.0	16.7	0.0	8.3	5.4
321 Textiles	13.9	12.7	10.8	7.9	12.2	11.5	14.8	8.8	15.3	13.0	10.5	10.1	8.9	11.8	5.1	5.5	8.6
322 Apparel	17.8	19.8	24.8	18.9	21.0	20.4	15.9	17.1	19.9	17.6	16.5	12.8	13.9	11.5	6.7	4.5	11.0
323 Leather products	18.9	10.7	19.4	10.6	10.9	14.1	5.7	22.5	12.9	13.7	12.8	11.9	18.5	23.1	5.6	1.8	12.3
324 Footwear	12.0	17.3	19.4	16.7	29.7	19.0	12.6	20.2	19.6	17.5	25.4	18.0	18.2	13.1	7.1	5.0	14.5
331 Wood products	7.9	11.7	14.0	10.6	21.0	13.0	14.2	9.8	16.9	13.6	13.4	18.1	16.2	9.8	4.8	8.8	11.9
332 Furniture	19.9	18.0	17.2	9.0	21.5	17.1	16.1	16.4	19.5	17.3	23.3	24.2	9.3	19.3	8.2	5.1	14.9
341 Paper	5.1	13.4	12.1	2.9	5.8	7.9	8.3	6.3	12.0	8.9	6.9	9.1	6.9	7.1	0.7	4.1	5.8
342 Printing	12.9	13.7	14.1	9.2	13.8	12.8	15.5	15.9	15.6	15.7	12.2	10.9	8.8	11.7	5.7	5.3	9.1
351 Industrial chemicals	5.0	8.2	11.8	9.4	11.8	9.2	5.9	12.6	5.4	8.0	15.3	12.0	4.9	8.7	3.6	4.9	8.2
352 Other chemicals	9.3	7.3	3.8	3.9	5.1	5.9	8.0	5.4	10.1	7.8	10.0	6.3	9.8	11.8	4.7	3.8	7.7
354 Petroleum derivatives	80.0	0.0	10.0	0.0	11.1	20.2	6.7	11.8	5.0	7.8	5.6	5.3	15.0	23.8	0.0	0.0	8.3
355 Rubber products	10.0	7.2	12.0	8.6	11.9	10.0	12.5	6.2	5.2	8.0	22.2	8.4	3.8	7.9	0.0	2.6	7.5
356 Plastics	14.4	13.2	17.1	9.1	14.3	13.6	14.0	19.1	19.8	17.6	14.0	17.9	15.6	11.7	3.7	5.4	11.4
361 Ceramics	16.3	8.9	6.7	7.1	10.0	9.8	7.4	15.4	11.1	11.3	7.1	10.0	9.7	10.3	7.4	4.0	8.1
362 Glass	7.4	7.7	3.9	6.3	10.6	7.2	2.3	12.8	9.1	8.1	16.7	16.1	7.8	10.8	4.3	2.9	9.8
369 Nonmetallic minerals	8.6	15.2	13.4	9.3	11.9	11.7	10.5	8.8	13.4	10.9	10.8	14.9	9.9	8.7	6.0	6.3	9.4
371 Iron and steel	10.5	12.0	13.5	14.3	7.8	11.6	22.7	8.5	18.4	16.5	13.0	4.9	6.3	6.7	4.8	11.1	7.8
372 Nonferrous metals	2.8	13.9	10.8	2.6	0.0	6.0	8.0	12.0	7.4	9.1	8.7	11.1	3.4	13.8	3.0	12.1	8.7
381 Metal products	13.1	14.1	8.2	7.6	9.9	10.6	14.3	8.0	13.9	12.1	12.2	13.4	11.9	15.5	4.8	5.8	10.6
382 Nonelectrical machinery	11.7	14.0	8.9	4.8	4.9	8.8	9.4	10.9	14.4	11.6	11.2	12.3	10.5	11.3	4.1	4.6	9.0
383 Electrical machinery	8.4	5.8	10.9	3.6	5.9	6.9	8.0	8.2	12.1	9.5	11.7	15.8	6.4	7.9	2.5	2.0	7.7
384 Transport equipment	14.9	13.4	11.6	7.9	15.3	12.6	8.5	8.2	12.5	9.7	11.9	10.6	11.1	10.0	7.0	6.6	9.5
385 Professional equipment	16.1	7.0	17.9	6.6	3.3	10.2	21.7	14.3	8.5	14.8	8.8	13.1	11.9	11.1	1.3	2.8	8.2

Table B.5 Annual Exit Rates by Industry (%)

Part B Exit Rates

Industry	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	Average 1977-1982	1982-1983	1983-1984	1984-1985	Average 1982-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	Average 1985-1991
311 Food	13.3	11.4	10.7	9.7	9.6	10.9		11.7	11.3	11.5	9.0	7.2	7.1	6.6	6.2	8.6	7.4
312 Food-miscellaneous	6.5	6.3	8.2	12.4	7.9	8.3		10.3	8.7	9.5	7.1	2.9	8.5	8.5	7.4	7.6	7.0
313 Beverages	4.0	5.4	1.5	5.2	6.2	4.5		5.5	5.6	5.6	1.6	2.3	3.9	6.2	2.3	15.2	5.2
314 Tobacco	36.1	14.8	24.0	17.4	9.5	20.4		13.3	14.3	13.8	7.7	0.0	7.7	8.3	7.7	8.3	6.6
321 Textiles	12.2	11.4	10.0	12.3	13.3	11.8		10.5	11.4	10.9	6.8	6.0	7.8	6.6	5.9	7.4	6.8
322 Apparel	15.9	15.5	16.1	11.1	12.9	14.3		15.8	14.0	14.9	11.0	11.7	10.6	11.5	9.2	10.7	10.8
323 Leather products	23.6	12.6	16.3	13.5	9.9	15.2		13.8	8.2	11.0	9.3	13.1	7.4	3.3	4.6	5.3	7.2
324 Footwear	17.0	12.0	15.9	16.2	11.3	14.5		13.5	18.3	15.9	14.5	13.3	11.5	13.4	11.5	8.2	12.1
331 Wood products	15.8	13.3	12.3	12.2	8.8	12.5		14.5	18.7	16.6	13.4	11.9	9.2	6.5	9.5	10.5	10.2
332 Furniture	18.4	18.5	20.7	12.4	7.9	15.6		20.9	19.5	20.2	15.3	12.1	8.8	9.7	8.2	11.9	11.0
341 Paper	10.9	6.7	11.4	0.7	4.3	6.8		6.3	10.5	8.4	4.6	6.1	1.5	1.4	4.7	7.6	4.3
342 Printing	13.8	11.3	13.3	8.6	7.3	10.9		13.5	15.3	14.4	11.6	10.0	5.9	6.9	6.3	6.4	7.8
351 Industrial chemicals	5.9	2.0	13.7	12.5	5.9	8.0		6.8	5.4	6.1	9.0	8.5	2.5	2.4	2.9	1.4	4.4
352 Other chemicals	8.2	4.5	6.2	4.2	4.7	5.6		6.1	5.8	6.0	5.6	5.3	5.2	3.7	4.7	5.0	4.9
354 Petroleum derivatives	0.0	0.0	0.0	14.3	16.7	6.2		5.9	15.0	10.4	0.0	0.0	5.0	0.0	0.0	14.8	3.3
355 Rubber products	6.3	8.4	8.4	3.7	6.0	6.6		12.3	11.7	12.0	5.6	9.6	3.8	3.9	2.5	3.9	4.9
356 Plastics	9.9	10.5	9.0	10.5	5.1	9.0		12.3	13.4	12.9	12.5	7.2	6.0	7.3	4.2	7.0	7.4
361 Ceramics	14.0	6.7	13.3	14.3	15.0	12.6		11.5	7.4	9.5	3.6	6.7	16.1	17.2	14.8	4.0	10.4
362 Glass	9.3	13.5	9.8	10.4	8.5	10.3		2.6	4.5	3.6	2.1	9.7	9.4	3.1	1.4	10.1	6.0
369 Nonmetallic minerals	15.3	9.2	12.8	10.5	9.1	11.4		12.0	12.3	12.1	14.0	9.3	7.0	6.3	4.7	5.3	7.8
371 Iron and steel	14.0	4.0	19.2	16.3	13.7	13.5		8.5	10.2	9.4	1.9	3.3	7.8	5.0	3.2	9.5	5.1
372 Nonferrous metals	13.9	0.0	10.8	13.2	0.0	7.6		8.0	18.5	13.3	0.0	3.7	6.9	3.4	3.0	6.1	3.9
381 Metal products	10.3	8.8	10.9	8.6	7.7	9.2		16.3	11.9	14.1	11.2	7.6	5.3	5.7	7.9	9.3	7.8
382 Nonelectrical machinery	10.2	7.3	7.6	8.3	8.1	8.3		9.0	8.4	8.7	6.6	6.5	3.9	6.1	6.2	7.1	6.1
383 Electrical machinery	7.4	5.8	9.9	6.8	6.4	7.2		9.4	9.1	9.2	4.1	7.6	5.4	5.9	4.0	6.9	5.7
384 Transport equipment	17.1	11.5	10.7	10.5	8.8	11.7		8.8	7.8	8.3	8.4	6.8	6.5	7.0	4.1	10.2	7.2
385 Professional equipment	14.3	8.8	8.9	8.2	4.9	9.0		8.9	6.8	7.9	7.0	4.9	6.0	5.6	6.7	4.2	5.7

Part C Correlation between Annual Entry and Exit Rates

	1977-1978	1978-1979	1979-1980	1980-1981	1981-1982	Average 1977-1982	1982-1983	1983-1984	1984-1985	Average 1982-1985	1985-1986	1986-1987	1987-1988	1988-1989	1989-1990	1990-1991	Average 1985-1991
	-0.3	0.5	0.6	0.5	0.4	0.5		0.4	0.5	0.6	0.5	0.7	0.3	0.0	0.5	0.3	0.7

Note: Industry exit rates are not calculated in 1982-1983 due to a change in survey coverage.

Table B.6 Contribution of the Variance of the No-Shock Productivity Measure to the Variance of TFP

Industry	Materials - Nonpar./GMM			Materials - Polynomials/NLLS		
	Average %	Minimum %	Maximum %	Average %	Minimum %	Maximum %
311/2 Food/Food-miscellaneous	75	60	92	71	59	84
313 Beverages	62	49	73	18	4	74
314 Tobacco	93	56	151	99	71	123
321/2 Textiles/Apparel	56	39	65	41	28	53
323 Leather products	79	69	94	51	30	96
324 Footwear	45	28	59	26	8	40
331/2 Wood products/Furniture	45	32	53	17	11	26
341 Paper	82	56	105	63	44	82
342 Printing	29	14	47	31	20	45
351 Industrial chemicals	79	68	94	55	27	78
352 Other chemicals	48	38	65	42	32	56
354 Petroleum derivatives	91	61	120	81	54	114
355 Rubber products	38	21	77	43	21	66
356 Plastics	57	33	74	47	34	66
361 Ceramics	46	17	82	47	22	71
362 Glass	48	16	66	32	17	54
369 Nonmetallic minerals	47	31	57	42	32	50
371 Iron and steel	79	64	96	65	44	97
372 Nonferrous metals	73	52	95	89	71	104
381 Metal products	58	49	70	36	28	62
382 Nonelectrical machinery	78	67	90	37	27	50
383 Electrical machinery	65	57	76	28	19	37
384 Transport equipment	64	53	74	31	22	58
385 Professional equipment	72	53	89	48	26	70

Notes: The variance of the TFP measure and its components (variance of the no-shock productivity, varianc of the shock and covariance between these) are computed separately for each industry and year. Averages, minima and maxima are calculated for each industry across years.

Table B.7 Measures of Domestic Competition across 3-digit Industries

Industry	Herf. Index 1977	Herf. Index 1980	Herf. Index 1981	Turnover Rate (%) 1977-1978	Turnover Rate (%) 1980-1981	Turnover Rate (%) 1981-1982
311 Food	0.007	0.008	0.008	26.1	19.2	21.8
312 Food-miscellaneous	0.027	0.025	0.027	17.3	24.9	18.7
313 Beverages	0.037	0.042	0.044	10.3	6.7	13.1
314 Tobacco	0.269	0.213	0.223	44.4	26.1	14.3
321 Textiles	0.052	0.049	0.048	26.0	20.2	25.5
322 Apparel	0.012	0.014	0.012	33.7	30.0	33.9
323 Leather products	0.072	0.072	0.075	42.5	24.0	20.8
324 Footwear	0.060	0.051	0.057	29.0	32.9	41.0
331 Wood products	0.148	0.136	0.115	23.8	22.8	29.8
332 Furniture	0.039	0.028	0.025	38.3	21.4	29.3
341 Paper	0.107	0.066	0.062	15.9	3.6	10.1
342 Printing	0.060	0.078	0.071	26.7	17.8	21.2
351 Industrial chemicals	0.053	0.063	0.061	10.9	21.9	17.6
352 Other chemicals	0.024	0.027	0.030	17.5	8.1	9.7
354 Petroleum derivatives	0.501	0.265	0.300	80.0	14.3	27.8
355 Rubber products	0.170	0.175	0.175	16.3	12.3	17.9
356 Plastics	0.033	0.029	0.034	24.3	19.5	19.4
361 Ceramics	0.142	0.147	0.158	30.2	21.4	25.0
362 Glass	0.101	0.103	0.100	16.7	16.7	19.1
369 Nonmetallic minerals	0.038	0.031	0.031	23.9	19.8	21.1
371 Iron and steel	0.143	0.142	0.118	24.6	30.6	21.6
372 Nonferrous metals	0.195	0.197	0.205	16.7	15.8	0.0
381 Metal products	0.021	0.011	0.014	23.4	16.1	17.6
382 Nonelectrical machinery	0.027	0.031	0.030	21.9	13.0	12.9
383 Electrical machinery	0.031	0.033	0.036	15.8	10.4	12.3
384 Transport equipment	0.140	0.126	0.120	32.0	18.3	24.1
385 Professional equipment	0.067	0.173	0.217	30.4	14.8	8.2
390 Other manufacturing	0.256	0.846	0.774	0.0	10.0	0.0

Notes: The Herfindahl index for an industry and year is the sum of plants' squared market shares relative to 3-digit industries' output.
The turnover rate for an industry and period is the sum of entry and exit rates into the industry.

Table B.8 Impact of Lagged Trade Policy on Productivity Differentiated by Export Status of Plant

Regressor	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Exporter in Initial Year	0.332***	0.315***				
	(0.016)	(0.015)				
Exporter in All Years			0.375***	0.344***		
			(0.021)	(0.021)		
Exporter if Avg. Exp. Share >25%					0.207***	0.163***
					(0.036)	(0.037)
Nominal tariff 3-digit	-0.177***	-0.172***	-0.186***	-0.182***	-0.196***	-0.191***
	(0.028)	(0.027)	(0.028)	(0.027)	(0.028)	(0.027)
Nom.tariff3*Exporter	-0.277***	-0.26***	-0.257***	-0.21***	0.035	0.076
	(0.035)	(0.034)	(0.051)	(0.05)	(0.08)	(0.08)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes		Yes		Yes	
Industry effects 4-digit		Yes		Yes		Yes
N. observations	45304	45304	45304	45304	45304	45304
R-squared	0.18	0.21	0.17	0.21	0.16	0.20

Regressor	OLS (7)	OLS (8)	OLS (9)	OLS (10)	OLS (11)	OLS (12)
Exporter in Initial Year	0.284***	0.27***				
	(0.016)	(0.015)				
Exporter in All Years			0.309***	0.287***		
			(0.021)	(0.02)		
Exporter if Avg. Exp. Share >25%					0.225***	0.157***
					(0.038)	(0.038)
Nominal tariff 3-digit	-0.309***	-0.163***	-0.313***	-0.169***	-0.331***	-0.175***
	(0.02)	(0.026)	(0.019)	(0.026)	(0.019)	(0.026)
Nom.tariff3*Exporter	-0.166***	-0.151***	-0.114***	-0.082*	0.006	0.089
	(0.034)	(0.033)	(0.048)	(0.045)	(0.085)	(0.083)
Year effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry effects 3-digit	Yes		Yes		Yes	
Industry effects 4-digit		Yes		Yes		Yes
N. observations	42630	42630	42630	42630	42630	42630
R-squared	0.18	0.22	0.18	0.21	0.17	0.20

Notes: Productivity is obtained nonparametrically and by GMM with materials controlling for endogeneity. Ro bust standard errors are in parentheses. *** , ** and * indicate significance at 1%, 5% and 10% levels respectively. Years included are 1981, 1984-1989. One period lagged tariff measures are used.

Table B.9 Marginal Effects Evaluated at Mean Values (Tables 7-14 in the paper)

Table 7	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)
Nominal tariffs 3-digit at mean m. shares	0.178*** (0.009)	-0.11*** (0.026)	-0.1*** (0.025)			
Nominal tariffs 4-digit at mean m. shares				0.094*** (0.03)	-0.23*** (0.017)	-0.1*** (0.024)
Market share 3-digit at mean tariffs and m. shares	6.24*** (0.229)	7.358*** (0.246)	6.76*** (0.233)	6.033*** (0.24)	7.141*** (0.259)	6.665*** (0.25)

Table 8	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)
Nominal tariff 3-digit at mean Herf. ind./turn. rates	-0.258*** (0.012)		-0.127*** (0.012)	-0.086*** (0.027)			-0.421*** (0.017)	
Nominal tariff 4-digit at mean Herf. ind./turn. rates		-0.239*** (0.011)			-0.177*** (0.011)	-0.287*** (0.018)		-0.39*** (0.014)
Herfindahl Index 3-digit evaluated at mean tariffs	-0.975*** (0.047)	-0.758*** (0.046)						
Herfindahl Index 4-digit at mean tariffs			0.088*** (0.022)	0.026 (0.025)	0.025 (0.027)	-0.035 (0.033)		
Turnover rate 3-digit at mean tariffs							0.907*** (0.038)	0.937*** (0.035)

Table 10	OLS (1)	OLS (1')	OLS (2)	OLS (2')
ERP 3-digit at mean m. shares	0.002 (0.014)		0.003 (0.013)	
Nominal tariffs 3-digit at mean m. shares		-0.183*** (0.029)		-0.182*** (0.028)
Market share 3-digit at mean ERP and market shares	9.594*** (0.331)	9.722*** (0.329)	8.853*** (0.327)	8.953*** (0.325)

Table B.9 (cont.)

Table 11	OLS (1)	OLS (2)	OLS (3)	OLS (4)
ERP 3-digit	0.033***	0.109***	0.005	0.07***
at mean Herf. ind./turn. rates	(0.007)	(0.006)	(0.014)	(0.007)
Herfindahl Index 3-digit	-1.997***			
at mean Herf. ind./turn. rates	(0.069)			
Herfindahl Index 4-digit		-0.213***	0.021	
at mean ERP		(0.026)	(0.032)	
Turnover rate 3-digit				0.49***
at mean ERP				(0.042)

Table 13	OLS (1)	OLS (2)	OLS (3)	OLS (4)
Import Penetration 3-digit	1.793***	1.806***		
at mean m. shares	(0.072)	(0.071)		
Import Penetration 4-digit			0.024	0.685***
at mean m. shares			(0.017)	(0.049)
Market share 3-digit	9.205***	8.466***	9.324***	8.481***
at mean imp. pen. and m. shares	(0.209)	(0.207)	(0.211)	(0.214)

Table 14	OLS (1)	OLS (2)	OLS (3)	OLS (4)	OLS (5)	OLS (6)	OLS (7)	OLS (8)
Import Penetration 3-digit	0.067***		0.035***				-0.21***	
at mean Herf. ind./turn. rates	(0.01)		(0.01)				(0.02)	
Import Penetration 4-digit		-0.012		1.728***	-0.048***	-0.06***		-0.29***
at mean Herf. ind./turn. rates		(0.009)		(0.078)	(0.001)	(0.02)		(0.018)
Herfindahl Index 3-digit	-1.244***	-1.596***						
at mean imp. Pen.	(0.074)	(0.051)						
Herfindahl Index 4-digit			-0.032*	0.022	-0.054**	-0.08***		
at mean imp. pen.			(0.017)	(0.02)	(0.025)	(0.03)		
Turnover rate 3-digit							0.443***	0.043*
at mean imp. Pen.							(0.028)	(0.026)

Notes: Standard errors are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.
e.g. In Table 8, the marginal effect of tariffs is obtained as: b tariffs + b market share * avg. mkt. share.
The standard error of the marginal effect of tariffs is obtained as the square-root of: variance(b tariffs) + variance(b market share) * (avg. mkt. share ^ 2) + 2 * covariance (b tariffs, b market share) * avg. mkt. share.