Plant Turnover and Structural Reforms in Colombia

MARCELA ESLAVA, JOHN HALTIWANGER,
ADRIANA KUGLER, and MAURICE KUGLER*

In a healthy economy, plant turnover increases aggregate productivity because efficient producers are more likely to survive. Given high entry and exit rates and the potential importance of turnover in accounting for aggregate productivity, in this paper we examine the determinants of plant exits and then examine how exits and other forms of output reallocation contribute to aggregate productivity. Using a unique plant-level longitudinal data set for Colombia for the period 1982–98, we examine the role of productivity and demand as well as input costs in determining plant exits. Moreover, given the important structural reforms introduced in Colombia during the early 1990s, we explore whether and how plant survival changed after these reforms. Our data permit measurement of plant-level quantities and prices, which allows us to decompose productivity and demand shocks and, in turn, to estimate the effects of these fundamentals on plant exit. We find that higher productivity, higher demand, and lower input prices decrease the probability of plant exit. We also find that the importance of physical efficiency and costs in determining exits increases after the introduction of structural reforms. Finally, a decomposition of aggregate productivity suggests that reallocation through entry and exit is important in accounting for the increase in aggregate productivity after the introduction of structural reforms. [JEL F43, L25, O47]

*Marcela Eslava is an Assistant Professor of Economics at the Universidad de Los Andes. John Haltiwanger is a Professor of Economics at the University of Maryland and a Research Associate with the National Bureau of Economic Research (NBER) and the Institute for the Study of Labor (IZA). Adriana Kugler is an Associate Professor of Economics at the University of Houston, a Faculty Research Fellow with the NBER and IZA, and a Research Affiliate of the Center for Economic Policy and Research. Maurice Kugler is a Reader in Economics at the University of Southampton and a Research Fellow at the Leverhulme Centre for Research on Globalisation and Economic Policy and at CESifo. The authors thank Juanita Gonzalez, Luis Eduardo Quintero, and Diana Hincapie for superb research assistance. Support for this research was provided by the Tinker Foundation, and a GEAR grant from the University of Houston.

Reallocation and restructuring are ubiquitous features of market economies. Evidence from longitudinal microbusiness databases for developed countries shows that a large fraction of measured productivity growth is explained by more-productive entering and expanding businesses displacing less-productive exiting and contracting businesses. Although the role of efficient reallocation has been broadly studied for developed countries, it has received much less attention in the context of developing economies. Understanding the determinants of business exit and its contribution to productivity dynamics is of particular interest in the context of emerging economies, where the development of institutions and market structure play a key role in improving allocative efficiency.

In this paper, we focus on one of the key aspects of the connection between productivity growth and firm dynamics—namely, the relationship between plant exit and the underlying efficiency, cost, and demand factors. We take advantage of a unique database of Colombian manufacturing plants, which allows the measurement of these fundamental factors at the plant level.[1] Studying these factors is of interest for any country, because measures of such a rich set of market fundamentals are rarely available, and empirical studies of plant survival have traditionally focused on composite measures of productivity and related proxies of these determinants of exit, such as size and age. The case of Colombia, moreover, is of particular interest because of the important trade, labor, and financial sector reforms in this country in the early 1990s, which allow us also to explore the interactions between underlying market fundamentals and structural reforms in determining plant exits. This is a crucial question because a key objective of these reforms was to make product and input markets more competitive, with the expected effect of triggering the exit of less-profitable establishments.

Our novel analysis explicitly measures and separates out the role of physical productivity, cost, and demand factors for plant exit. Our ability to separate out these factors stems in part from the availability of plant-level output and input prices in the Colombian Annual Manufacturing Survey. The availability of plant-level prices is rare in longitudinal business data, and is important in terms of improving productivity measures and separating physical efficiency from demand shocks. Establishment output is frequently measured in the empirical literature as revenue deflated by a common industry-level output price index, and establishment materials inputs are measured as materials expenditures divided by a common materials industry-level input price deflator. Therefore, within-industry price differences in both outputs

[1]Because many of the variables we use in our analysis here were also used in Eslava and others (2004), the data description in this section closely follows that paper. In particular, Eslava and others (2004) describes in detail the construction of the capital stock, hours of work, output and materials prices, and total factor productivity (TFP) and demand shock measures. We include an abbreviated version of the discussion on the database and variable construction in this paper. However, the focus of Eslava and others (2004) was on the evolution of TFP and demand shocks over the 1980s and 1990s in Colombia and the contribution of overall reallocation to aggregate productivity. By contrast, the focus of this paper is on the determinants of plant exits—including TFP and demand shocks—and the changing importance of these determinants after the market reforms of the 1990s. In addition, we examine here the impact of reallocation through exits on aggregate productivity.

and inputs are embodied in traditional output, materials, and productivity measures. In traditional measures of productivity, high output prices and high productivity may not be distinguished. Similarly, traditional measures of plant-level productivity may not distinguish low productivity from high input price measures. Given that our data provide plant-level prices for both inputs and output, we are able to separate out the effects of productivity, demand shocks, and cost shocks on plant survival.

In exploring these issues, our approach to studying plant survival takes advantage of a number of methodological innovations relative to much of the literature. In particular, the database we have and the approach we take permits us to decompose efficiency, cost, and demand effects at the plant level and thus to estimate exit equations in terms of these fundamentals.[2] Therefore, we do not have to rely on endogenous proxies such as plant age or size, which are commonly used in this context when fundamentals are less directly observable.

We find that market fundamentals are important determinants of plant exit. In particular, we find that higher physical productivity, higher demand, and lower input costs reduce the probability that plants exit. In addition, we find a general pattern showing that structural reforms increased the role of market fundamentals in determining plant exits. The increased impact of market fundamentals is the result of both a general increase in the dispersion across plants in market fundamentals as well as, for some factors (in particular input costs), an increase in the marginal effect of the factor. In particular, we find that the importance of physical efficiency and materials costs in determining exits increased, whereas high demand became a less important determinant of survival after the introduction of structural reforms.

Finally, we conduct decompositions of average industry productivity into the contribution of the average plant and the contribution of allocative efficiency following the approach introduced by Olley and Pakes (1996). To gauge the contribution of entry and exit, we examine this decomposition for both balanced and unbalanced panels of plants. We find that average and total productivity is lower and grows more slowly after the reforms when we use a balanced panel compared with when we rely on an unbalanced panel. By construction, the difference between the balanced and unbalanced panels reflects the contribution of entering and exiting businesses. The greater productivity levels and growth of productivity in the unbalanced panel are consistent with the view that plant exit and entry contribute to aggregate productivity, especially after the structural reforms were introduced.

I. Structural Reforms in Colombia

Reforms in Colombia during the 1990s occurred in the areas of trade, financial and labor markets, privatization, and the tax system.[3] Many of these reforms were part

[2]Foster, Haltiwanger, and Syverson (2005) use plant-level physical quantity data for selected U.S. detailed product classes to analyze the determinants of market selection in the United States using a similar approach. Their findings in broad terms are consistent with the findings we report here. However, in contrast to the approach taken here, there is no comparable set of market reforms in the United States to investigate the interaction between market reforms and market selection.

[3]See Eslava and others (2004) for a more extensive discussion of the Colombian reforms.

of a package introduced during the administration of President Cesar Gaviria. The most important changes occurred in the early 1990s in the areas of trade and financial and labor markets, although important changes in privatization and tax reform also occurred during the second half of the 1990s.

Trade was largely liberalized in Colombia during the 1990s. The gradual decrease in tariffs initiated by the preceding Barco government was accelerated by Gaviria after June 1991. By the end of 1991, nominal protection reached 14.4 percent and effective protection 26.6 percent, the latter down from 62.5 percent a year earlier, while 99.9 percent of items were moved to the free import regime.

Other reforms sought to reduce frictions in labor markets. In December 1990, Law 50 introduced severance payments savings accounts and reduced dismissal costs by between 60 percent and 80 percent (see, for example, Kugler, 1999 and 2005). In 1993, Law 100 was passed, which allowed voluntary individual conversions from a pay-as-you-go pension system to a fully funded system with accounts, but also increased employer and employee contributions to 13.5 percent of salaries, of which 75 percent was paid by employers (see, for example, Kugler and Kugler, 2003).

Frictions in financial markets were also reduced during the 1990s. In 1990, Law 45 eliminated interest rate ceilings, eliminated investment requirements in government securities, and reduced reserve requirements. Supervision for capitalization requirements was reinforced by establishing minimum capital requirements weighted by risk in a manner consistent with the Basel accords. In addition, Law 9 of 1991 eliminated exchange controls, ending the central bank monopoly on foreign exchange transactions and reducing restrictions on capital flows. Resolution 49 of 1991 reduced constraints on foreign direct investment, which facilitated foreign entry into all sectors and, in particular, induced entry of foreign banks, which increased competition in the financial sector (see, for example, Kugler, forthcoming).

In 1994, Ernesto Samper won the presidential election by proposing policies opposed to trade liberalization and other reforms.[4] Although the new government did not reverse the reforms put in place by the previous administration, it managed to avoid further liberalization of labor and financial markets as well as trade. Instead, the Samper government made progress in the areas of privatization and tax reforms. Overall, however, the process of privatization has been relatively limited in Colombia compared with the rest of Latin America. Cumulative privatizations represented more than 10 percent of GDP in 1999 in several countries, in Colombia cumulative privatizations were only 5 percent of GDP. Moreover, privatizations have been highly concentrated in Colombia, with about 80 percent of all privatizations taking place in the energy sector and another 15 percent in the financial sector (Lora, 2001).

A number of changes in the tax system also occurred in the 1990s. For instance, in an effort to increase tax collection and the neutrality of the tax system, value-added tax rates were increased, whereas income and corporate taxes were reduced. The value-added tax increased in Colombia from 10 percent in 1985 to more than 16 percent in 1999. At the same time, maximum tax rates on personal income were lowered to 30 percent, whereas the maximum tax rate on corporate income was

[4]Note that the Colombian electoral system at the time ruled out election for more than one term.

reduced from 40 percent in 1985 to 35 percent in 1999. In spite of these changes, Colombia's tax system remains one of the most distorted when compared with those of other Latin American countries (Lora, 2001).

It is clear from this description that substantial structural reforms occurred over our sample period and are especially concentrated in the 1990s. In this paper we ask whether there is evidence that the impact of market fundamentals on plant exit changed in the post-reform relative to the pre-reform period (defined as before 1991). In addition, we ask whether there is evidence that allocative efficiency improved over the post-reform period and, if so, whether allocative efficiency improved only among continuing plants or improved through the exit of less-efficient plants and entry of more-efficient plants.[5]

II. Plant-Level Data

In this section, we first provide a description of the data and then explain the measurement of physical productivity and demand shocks. A more detailed description of the construction of the variables used in our analysis can be found in Eslava and others (2004).

Data Description

Our data come from the Colombian Annual Manufacturers Survey (AMS) for the years 1982 to 1998. The AMS is an unbalanced panel of Colombian plants with more than 10 employees, or sales above a certain limit (about US$35,000 in 1998). The AMS includes information for each plant on: value of output and number of units for each product manufactured, overall cost and units purchased for each material used in the production process, energy consumption in physical units and energy expenditures, number of workers and payroll, and book values of equipment and structures. The construction of the variables we use in the analysis is described in detail in Eslava and others (2004); here we provide a brief overview.

Because we are interested in the effects of efficiency and demand on plant exits, we need to construct measures of productivity and demand shocks at the plant level. We estimate total factor productivity (TFP) values for each plant using a capital-labor-materials-energy (KLEM) production function and demand shock values for each plant using a standard demand function. To estimate the production function, we need to construct physical quantities and prices of output and inputs, capital stock series, and total labor hours.

With the rich information collected in the AMS on value and number of units of each product and input, we construct plant-level price indices for output and

[5]It may be interesting to develop measures of reforms that permit understanding of how the reforms may have affected different types of firms differently. One way to proceed would be to note that the trade reform affected different sectors differently, because changes in effective tariff rates vary across sectors. In addition, it is likely that some reforms (for example, financial reforms) affected small and young firms differently than large and mature firms. In this paper, we take a more parsimonious approach, which focuses on the time-series variation of the reforms, and leave the construction of specific reform indices that vary by sector and other observable factors for future work.

materials using Tornqvist indices. Given prices for output and materials, our measures of physical output and materials use are constructed by dividing the value of output and cost of materials by the corresponding prices. Quantities of energy consumption are directly reported by the plant. In addition, we need capital stocks to estimate a KLEM production function. The plant capital stock is constructed using a perpetual inventory method using book values and capital expenditures together with the appropriate capital price deflators and depreciation rates. Because the AMS does not have data on hours per worker (only employment), we construct a sector-level measure of hours per worker at the three-digit level, constructed as the ratio of earnings per worker over the sectoral wage. The latter is obtained from the Monthly Manufacturing Survey.

Descriptive Statistics

Table 1 presents descriptive statistics of the quantity and price variables just described, for the pre- and post-reform periods. Entry and exit rates are 9.8 percent

Table 1. Descriptive Statistics, Before and After Reforms

	Before Reforms	After Reforms
Output	10.49	10.90
	(1.67)	(1.88)
Capital	8.21	8.75
	(2.05)	(2.18)
Labor	10.97	10.95
	(1.1)	(1.25)
Energy	11.30	11.55
	(1.88)	(1.99)
Materials	9.61	10.25
	(1.85)	(1.88)
Output prices	–0.08	–0.15
	(0.44)	(0.74)
Energy prices	0.25	0.55
	(0.50)	(0.43)
Material prices	0.02	–0.10
	(0.35)	(0.57)
Entry rate	0.10	0.08
Exit rate	0.09	0.11
Number of observations	55,298	44,816

Source: Authors' calculations.

Notes: This table reports means and standard deviations of the log of quantities and of log price indices deviated from yearly log producer price indices (PPIs), for all plants reporting positive production levels from 1982 through 1998. The entry and exit rates are the number of entrants divided by total plants and number of exiting plants divided by total number of plants. A plant that enters in t is defined as a plant that produced in t but not in $t - 1$, and a plant that exits in t is one that produced in t but not in $t + 1$. The prereform period includes the years 1982–90, and the post-reform period includes the years 1991–98.

and 8.7 percent during the pre-reform period, with a lower entry rate of 8.4 percent and a higher exit rate of 10.7 percent during the post-reform period. All physical quantity and price variables are in logs with prices measured as relative to a yearly producer price index to discount inflation. Outputs and inputs, except for labor, increased between the pre- and post-reform periods. Relative prices of output and materials declined between the pre- and post-reform periods for all plants.[6] In the next section, we use these variables to estimate the production function and inverse-demand equation.

Estimation of Productivity and Demand Shocks

We follow here a strategy we introduced in Eslava and others (2004) to estimate productivity and demand shocks. We first estimate the production function with plant-level physical output and input data, using downstream demand to instrument inputs. The residual from this production function is our estimate of TFP. We then estimate the demand function with plant-level price and output data, using TFP to instrument for output in the demand equation.[7]

Productivity shocks

We estimate total factor productivity for each establishment as the residual from a KLEM production function:

$$Y_{jt} = K_{jt}^{\alpha} \left(L_{jt} H_{jt} \right)^{\beta} E_{jt}^{\gamma} M_{jt}^{\phi} V_{jt},$$

where Y_{jt} is output, K_{jt} is capital, L_{jt} is total employment, H_{jt} is hours per worker, E_{jt} is energy consumption, M_{jt} is materials, and V_{jt} is a productivity shock.

Our total factor productivity measure is thus:

$$TFP_{jt} = \log Y_{jt} - \hat{\alpha} \log K_{jt} - \hat{\beta}\left(\log L_{jt} + \log H_{jt} \right) - \hat{\gamma} \log E_{jt} - \hat{\phi} \log M_{jt}, \quad (1)$$

where $\hat{\alpha}$, $\hat{\beta}$, $\hat{\gamma}$, and $\hat{\phi}$ are the estimated factor elasticities for capital, labor hours, energy, and materials, respectively. Because ordinary least squares (OLS) estimates of factor elasticities are likely to be biased, we use factor elasticities estimated using an Instrumental Variables (IV) procedure to estimate TFP. For our IV approach, we use demand-shift instruments that are correlated with input use but uncorrelated with productivity shocks. As described in Eslava and others (2004), we construct Shea (1993) and Syverson (2004) type instruments by selecting industries whose output fluctuations are likely to function as approximately exogenous demand shocks for other industries. In addition, we use as instruments one- and

[6]Caution needs to be used in interpreting the aggregate (mean) relative prices in this context because the relative price at the micro level is the log difference between the plant-level price and the log of the aggregate producer price index. See Eslava and others (2004) for additional discussion on this issue.

[7]However, in contrast to the demand function estimation in Eslava and others (2004), which is done at the aggregate level, here we allow the demand function to vary by three-digit sector.

Table 2. Production Function Equations

	Production Function Ordinary Least Squares (1)	Production Function Two-Stages Least Squares (2)	First-Stage Partial *R*-Squared (3)
Capital	0.0764	0.3027	0.128
	(0.0025)	(0.0225)	
Labor hours	0.2393	0.2125	0.139
	(0.0037)	(0.0313)	
Energy	0.124	0.1757	0.231
	(0.0028)	(0.0143)	
Materials	0.5891	0.2752	0.324
	(0.0026)	(0.0095)	
Root mean squared error	0.6545	0.7670	
Number of observations	48,114	48,114	

Source: Authors' calculations.

Notes: Standard errors are reported in parentheses. The regressions in columns 1 and 2 use physical output as the dependent variable, and capital, employment hours, energy, and materials as regressors, where all variables are in logs. For column 2, the following variables are used to instrument the inputs: downstream demand instruments constructed as the demand for the intermediate output (calculated using the input-output matrix); one- and two-period lags of downstream demand; regional government expenditures, excluding government investment; and energy and material plant-level prices, deviated from the yearly producer price indices (PPI). The first partial R^2 reports the sample correlation coefficient between s_{jt} and $\hat{s}_{jt}$, where the s_{jt} are the residuals from a regression of I_{jt} on all other inputs, and the $\hat{s}_{jt}$ are the correlations between $\hat{I}_{jt}$ and the predicted values of all other inputs $\hat{I}_{1jt}$.

two-period lags of the demand shifters just described, energy and materials prices, and regional government expenditures in the region where the plant is located.[8]

Table 2 reports results for the KLEM specification of the production function. For reference purposes, column 1 presents the OLS results from the estimation of the KLEM specification. Column 2 presents the factor elasticities used in our estimates of the TFP measure used in the survival analysis. Although we do not impose constant returns to scale, our IV results are consistent with this assumption. Even if we think the instruments are weakly correlated with productivity shocks, large biases could be introduced when using IV estimation if the instruments are weakly correlated with the inputs. To check whether inputs are highly and significantly correlated with the instruments, and given that we are considering instrument relevance with multiple endogenous regressors, we report in column 3 the partial R^2 measures suggested by Shea (1997) for the first stages. The partial R^2's for capital, employment hours, energy, and materials in the KLEM specification are 0.128, 0.139, 0.231, and 0.324, respectively, showing that the relevant instruments for each input can explain a substantial fraction of the variation in the use of that input.

[8]Sargan tests suggest these are valid instruments, including energy and materials prices, which are unlikely to be affected by buyers' market power in the Colombian context. See Eslava and others (2004) for further details on the instruments.

One potential limitation of our approach is that we have imposed the same factor elasticities for all plants in the manufacturing sector. We make this assumption because our IV approach distinguishes mainly between industry differences in downstream demand factors. As a robustness check, we have also estimated factor elasticities at the three-digit industry level using the standard cost-share approach (in which the shares are estimated out of total revenue in the sector) and assuming constant returns to scale so that the capital share can be measured as a residual. Using these alternative factor elasticities, which vary at the sectoral level, with the plant-level data, we obtain an alternative measure of TFP. The correlation of this alternative measure, which allows elasticities to vary by sector, with our preferred IV measure is very high—namely, 0.88. Moreover, the standard deviations of the two TFP measures are about the same and the correlations of the cost-share-based TFP with other key variables (for example, plant-level prices) are very similar to those with our instrumented TFP measure. In other words, our TFP measure has properties that are robust with respect to reasonable alternative methods for estimating TFP, including allowing for sectoral differences in factor elasticities. As a consequence, we have found that the results in this paper are largely robust to using these alternative TFP measure and factor elasticities.[9]

Demand shocks

In addition to productivity, demand factors are also likely determinants of plant exits. For example, even if plants are highly productive, they may be forced to exit the market if faced with large negative demand shocks. We estimate establishment-level demand shocks as the residual of the following demand equation:[10]

$$Y_{jt} = P_{jt}^{-\varepsilon} D_{jt},$$

where D_{jt} is a demand shock faced by firm j at time t, and $-\varepsilon$ is the elasticity of demand. Our demand shock measure is estimated as the residual from estimating this demand equation:

$$d_{jt} = \log \hat{D}_{jt} = \log Y_{jt} + \hat{\varepsilon} \log P_{jt}. \quad (2)$$

OLS estimates of equation (2) will tend to be upward biased. To eliminate this bias, we follow the strategy we introduced in Eslava and others (2004): we use TFP as an instrument for Y_{jt} because TFP is positively correlated with output (by construction) but unlikely to be correlated with demand shocks.

[9] It is still of interest to explore further the possibility of estimating sector factor elasticities using our IV approach. This would require finding additional instruments (for example, demand shifters) that vary across plants within the same sector. We leave the construction of such additional demand shifters for future work.

[10] The demand estimation and demand shocks here differ in notable ways from Eslava and others (2004). First, we estimate the direct demand function rather than the inverse demand function here. Second, we estimate the demand function at the three-digit level here whereas in the earlier paper we estimated a common demand function for the manufacturing sector.

Table 3. Demand Estimation

Regressor	Ordinary Least Squares (1)	Two-Stages Least Squares (2SLS) (2)
Relative price	–0.8243	–2.2295
	(0.0996)	(0.1907)
First stage *R*-squared	—	0.4299
Root mean squared error	1.6949	1.8621
Number of observations	86,251	86,251

Source: Authors' calculations.

Notes: Standard errors are in parentheses. The dependent variable is physical output in logs, and the regressor is the log difference between plant-level price and the yearly producer price indices (PPI). Both the estimation constant and demand elasticities are allowed to vary by three-digit sector; the figures reported are simple means of three-digit sector statistics, except for the number of observations, which is the total number of observations including all sectors. The 2SLS regression instruments price with the 2SLS total factor productivity (TFP) measure estimated using column 2 in Table 2. The first-stage *R*-squared reports the square of the correlation between Y_{jt} and $\hat{Y}_{jt}$, where $\hat{Y}_{jt}$ is the predicted value of output from a regression of Y_{jt} on the instruments.

Table 3 reports the OLS and IV results of the demand equation.[11] We estimate the demand equations at the three-digit level—this is feasible because our instruments vary across plants. The reported results are the averages of the elasticities across the three-digit sectors. OLS results presented in column 1 suggest an elasticity of –0.8. Meanwhile, IV results in column 2, which use TFP as an instrument for output, show a much higher elasticity (in absolute value) of –2.23. Finally, note that the second row of column 2 reports an R^2 for the first stage of close to 0.4, indicating that our instrument explains a large fraction of price variability.

III. Effects of Market Fundamentals and Reforms on Plant Exit

According to selection models of industry dynamics (for example, Jovanovic, 1982; Hopenhayn, 1992; Ericson and Pakes, 1995; and Melitz, 2003), producers should continue operations if the discounted value of future profits exceeds the opportunity cost of remaining in operation. The model we regard as most relevant is the one presented by Melitz (2003), in which a producer with market power makes decisions on outputs, inputs, and output prices, given productivity shocks, demand shocks, and input price shocks drawn by the producer from a joint distribution. Moreover, given fixed costs of operating each period, the producer makes a decision on whether to stay or exit at each time. In this model (as in other closely

[11]The sample size is larger in this table than in Table 2 because the estimations in that table require information on the instruments used for estimating the production function, whereas demand estimations require only information on output prices, physical output, and TFP estimates.

related models), the producer's exit decisions should be affected by the productivity, demand, and input price shocks:

$$e_{jt} = \begin{cases} 1 \ \ if \ \ PDV\left\{\pi\left(D_{jt}, P_{Ijt}, TFP_{jt}\right)\right\} - C_{jt} < 0 \\ 0 \ \ if \ \ PDV\left\{\pi\left(D_{jt}, P_{Ijt}, TFP_{jt}\right)\right\} - C_{jt} > 0 \end{cases}.$$

That is, plant j exits if the discounted value of net profits is below the fixed cost of operating, and the plant continues in operation if the opposite holds. Profits, π (and, in turn, the present discounted value, *PDV*), are a positive function of demand shocks and productivity and a decreasing function of input price shocks.

In practice, we estimate this relationship using a probit model in which we specify the probability of exit between t and $t + 1$ as a function of measures of market fundamentals in period $t - 1$:

$$e^*_{jst} = \lambda_S + \theta GDP_t + \delta_1 TFP_{jt-1} + P'_{Ijt-1}\delta_2 + \delta_3 D_{jt-1} + u_{jt},\ e_{jst} = 1 \text{ if } e^*_{jst} > 0,\ 0 \text{ otherwise} \qquad (3)$$

where e_{jst} takes the value of 1 if the plant j in sector s exits between periods t and $t + 1$, λ_S is three-digit industry effects, GDP_t is the growth of aggregate gross domestic product in year t, TFP_{jt} and D_{jt} are productivity and demand shocks, P_{Ijt} is a vector including energy and materials prices, and u_{jt} is an independent and identically distributed error term. Table 4 reports summary statistics for the determinants of exit in equation (3) (except for input prices, which are reported in Table 1). This table shows more volatility during the 1990s than the 1980s. Both the means and standard deviations of total factor productivity and demand shocks increased during the 1990s.

Table 5 reports results of alternative specifications for the probit models. Column 1 presents our baseline specification, in which we do not allow for differential effects before and after the reforms. We find that higher physical efficiency, lower input prices, and higher demand shocks are all economically and significantly

Table 4. Descriptive Statistics of Determinants of Survival, Before and After Reforms

	Before Reforms	After Reforms
Lagged TFP	1.0754	1.1425
	(0.6571)	(0.8569)
Lagged demand shocks	10.5255	10.8508
	(1.8441)	(2.0957)
Number of observations	39,945	30,460

Source: Authors' calculations.

Notes: This table reports means and standard deviations (in parentheses) of total factor productivity (TFP) and demand shocks for plants included in the exit equations reported in Table 5. The TFP measure is obtained using the factor elasticities estimated in column 2 of Table 2, and the measure of demand shocks is obtained using the sector-level demand elasticities summarized in column 2 of Table 3.

Table 5. Effect of Fundamentals and Reforms on Exit Probability

	(1)	(2)
Lagged productivity	–0.0165	–0.0161
	(0.0013)	(0.0020)
Lagged energy prices	0.009	–0.0031
	(0.00196)	(0.0030)
Lagged materials prices	0.0205	0.013
	(0.0023)	(0.0040)
Lagged demand shocks	–0.0184	–0.0207
	(0.0005)	(0.0008)
Lagged productivity*	–	–0.0005
post-reform dummy		(0.0025)
Lagged energy prices*	–	0.0034
post-reform dummy		(0.0041)
Lagged materials prices*	–	0.0136
post-reform dummy		(0.0046)
Lagged demand shocks*	–	0.0033
post-reform dummy		(0.0011)
post-reform dummy	–	–0.0021
		(0.0114)
Sector effects	Yes	Yes
GDP growth	Yes	Yes
Likelihood ratio	1,947.38 (37 degrees of freedom)	2,228.86 (42 degrees of freedom)
Number of observations	70,405	70,405

Source: Authors' calculations.

Notes: This table reports marginal effects from a probit estimation of the probability of exit (equation (3)), where exit is 1 for plant i in year t if the plant produced in year t but not in year $t + 1$. Standard errors are in parentheses. Specifications in both columns include sector effects at the three-digit level and growth of GDP, as well as plant-level productivity, energy prices, materials prices, and a measure of demand shocks estimated using column 2 in Table 3. Column 2 also reports the effects of interactions with a post-reform dummy, which takes the value of zero for years 1982–90 and the value of 1 for years 1991–98.

important factors in determining exit. A rise in productivity by one standard deviation in the previous year is associated with a fall of 1.2 percent in the probability of exit in the current year. Increases in energy and materials prices of one standard deviation in the previous year are associated with a rise of about 0.4 percent and 0.9 percent, respectively, in the probability of exit in the current year. We also find that an increase in plant-level demand by one standard deviation in the previous year is associated with a decline of 3.6 percent in the probability of closing down operations in the current year. To appreciate the considerable magnitude of these effects, note from Table 1 that the exit rate is less than 9 percent in the 1980s and less than 11 percent in the 1990s.

In column 2, we explore whether the reform package introduced during the 1990s increased the importance of market fundamentals in explaining plant exits. We extend the baseline specification by including interactions of productivity, input prices, and demand shocks with a post-reform dummy variable that takes the value of 1 from 1991 on, as well as a main effect for the post-reform period. Although the results suggest no direct effect of the reforms on plant exits, we find evidence that market fundamentals became more important determinants of plant exits after the reforms. Lower physical efficiency and higher materials costs increase the probability of exits, even more so after the introduction of structural reforms. A rise in productivity of one standard deviation reduced exit by 1.1 percent before the reforms and by 1.4 percent after the reforms. Similarly, a rise in materials costs of one standard deviation increased exit by 0.4 percent before the reforms and by 1.5 percent after the reforms. Although the increased importance of productive efficiency is driven mainly by the greater volatility of productivity shocks after reforms, the increased importance of materials costs is driven both by an increase in volatility in materials prices as well as by an increase in the marginal effect of materials on exit. By contrast, demand becomes less important in determining exit after the introduction of structural reforms. In particular, a rise of one standard deviation in demand decreased exit by 3.8 percent before the reforms and by 3.6 percent after the reforms. Although demand shocks became more volatile after structural reforms were introduced, the decreased marginal effect of demand on exits dominates so that demand for the product becomes a less important determinant of plant survival after the reforms. These results, thus, suggest that increased market competition after the introduction of structural reforms increased the importance of efficiency and costs for plant survival and decreased the importance of simply having higher demand.

IV. Plant Exits and Aggregate Productivity

In this section, we examine whether exit, entry, and other forms of reallocation are associated with important productivity gains over the 1980s and 1990s in Colombia. In particular, we quantify the contribution of allocative efficiency to aggregate productivity by using a cross-sectional decomposition methodology first introduced by Olley and Pakes (1996). We quantify what fraction of aggregate productivity is accounted for by higher average productivity in a sector and what part reflects the concentration of activity in more-productive plants within a sector in each year, by conducting the following decomposition of aggregate TFP:

$$TFP_t = \overline{TFP_t} + \sum_{j=1}^{J} \left(f_{jt} - \overline{f_t} \right) \left(TFP_{jt} - \overline{TFP_t} \right),$$

where TFP_t is the aggregate total factor productivity measure for a given three-digit manufacturing sector in year t.[12] These aggregate measures correspond to weighted averages of our plant-level TFP measures, where the weights are market shares (calculated as described below). The first term of the decomposition, $\overline{TFP_t}$,

[12]This means that our focus here is on within-sector reallocation rather than on between-sector reallocation, for sectors defined at the three-digit level. For measurement and conceptual reasons, comparisons of TFP across sectors (in levels) are more problematic to interpret. Focusing on within-sector allocation permits us to emphasize the degree to which market reforms have led to an improved allocation of activity across businesses owing to higher competition.

is the average cross-sectional (unweighted) mean of TFP across all plants in that sector in year t. TFP_{jt} is the total factor productivity measure of plant j at time t, estimated as described in Section II; f_{jt} is the share or fraction of plant j's output out of sectoral output at the three-digit level in year t; and $\bar{f}_t$ is the cross-sectional unweighted mean of f_{jt}. The second term in this decomposition measures whether production is disproportionately located at high-productivity plants and, as such, is a measure of allocative efficiency. Examining this decomposition over time allows us to learn whether the average unweighted productivity as well as allocative efficiency has changed, in particular in response to the market reforms.[13]

To evaluate the contribution of net entry, we consider yearly Olley-Pakes decompositions for three samples. The first sample contains all plants in our data set, the second sample contains all plants that are continuously in existence for the entire sample period (that is, the balanced sample), and the third sample contains all year-t businesses that are also present in year $t - 1$ and year $t + 1$ (that is, three-year continuers). The first sample provides perspective on the role of allocative efficiency for all plants. Because allocative efficiency can improve either through entry and exit or through reallocation of activity among continuing plants, the next two samples provide perspective about the role of net entry. In particular, although the balanced panel decomposition provides information about long-lived continuously operating plants, the sample of three-year continuers contains some businesses that, although not in their first or last year, have entered recently or are about to exit. By examining these three panels, we can explore differences in the allocative efficiency across the different samples and differences in the paths of unweighted average productivity. Market selection will impact the latter as well in this context because exiting low-productivity plants can increase the average unweighted productivity.

Table 6 shows the results of this exercise. For each sample, the table reports the value of each term of the Olley-Pakes decomposition for the average three-digit sector. The results of this decomposition for the overall sample (columns 1–3) show that aggregate industry productivity increased substantially over the sample period. For the average industry, productivity increased by 30 log points from 1982 to 1998. The decomposition shows that most of this increase—21 out of the 30 log points—is accounted for by an increase in allocative efficiency. Interestingly, the unweighted average component increased during the 1980s but actually fell during the 1990s. In contrast, the increase in allocative efficiency is concentrated in the 1990s, after the market reforms. The decomposition results for the balanced panel (columns 4–6) show similar qualitative patterns with a large role for allocative efficiency, especially in the 1990s.

Thus, allocative efficiency improved following market reforms, even among the sample of long-lived plants. Interestingly, for this sample the productivity of the average plant was the same at the beginning and end of the period. The results for three-year continuers (columns 7–9) also show that the allocative efficiency term dominates the increase in productivity during the 1990s.

[13] An advantage of this cross-sectional method, over methods that decompose changes in productivity over time, is that cross-sectional differences in productivity are more persistent and less dominated by measurement error or transitory shocks.

Table 6. Aggregate Productivity Decompositions for Different Samples

	Overall Sample			Balanced Panel			Three-Year Continuers		
	Aggregate (weighted) (1)	Simple average (2)	Cross-term (3)	Aggregate (weighted) (4)	Simple average (5)	Cross-term (6)	Aggregate (weighted) (7)	Simple average (8)	Cross-term (9)
1982	1.34	1.01	0.33	1.38	1.09	0.30	—	—	—
1983	1.35	0.97	0.38	1.39	1.06	0.33	1.36	0.99	0.37
1984	1.31	0.98	0.33	1.36	1.09	0.26	1.32	1.02	0.30
1985	1.38	1.06	0.33	1.42	1.13	0.29	1.38	1.07	0.32
1986	1.39	1.11	0.28	1.41	1.19	0.22	1.39	1.12	0.27
1987	1.42	1.13	0.29	1.43	1.19	0.24	1.41	1.13	0.28
1988	1.48	1.19	0.29	1.47	1.26	0.22	1.47	1.19	0.28
1989	1.46	1.17	0.29	1.46	1.23	0.22	1.45	1.17	0.27
1990	1.51	1.16	0.35	1.49	1.21	0.28	1.51	1.18	0.33
1991	1.54	1.17	0.36	1.54	1.22	0.32	1.53	1.17	0.37
1992	1.52	1.11	0.41	1.48	1.17	0.30	1.50	1.14	0.36
1993	1.48	1.11	0.38	1.47	1.15	0.31	1.48	1.12	0.36
1994	1.53	1.09	0.44	1.49	1.12	0.37	1.52	1.09	0.43
1995	1.52	1.02	0.50	1.49	1.10	0.39	1.52	1.05	0.47
1996	1.59	1.01	0.58	1.52	1.09	0.43	1.58	1.06	0.52
1997	1.60	1.07	0.53	1.54	1.09	0.44	1.60	1.09	0.51
1998	1.64	1.10	0.54	1.55	1.09	0.46	—	—	—

Source: Authors' calculations.

Notes: All figures are simple means of three-digit sector level statistics. Columns 1, 4, and 7 show aggregate total factor productivity (TFP), calculated as the weighted mean of TFP, where the weight for each plant is its share in the corresponding three-digit-level sector output. Columns 2, 5, and 8 show the contribution to aggregate productivity of average TFP. Columns 3, 6, and 9 show the contribution of the cross-sectional correlation between plant-level market share and TFP. The first three columns use the full sample, including continuing, entering, and exiting plants. Columns (4)–(6) use a balanced panel, including all plants that were present in every year of the sample. Columns (7)–(9) use a sample of three-year continuers; a plant is considered a three-year continuer in year t if it was present in $t-1$, t, and $t+1$.

Comparing the dynamics of aggregate productivity across the three samples yields insights on the role of net entry. We find that productivity is lower and grows more slowly after the reforms when we use a balanced panel compared with when we rely on an unbalanced panel. By construction, the difference between the balanced and unbalanced panels reflects the contribution of entering and exiting businesses. The results for the overall sample show an increase in allocative efficiency of 18 log points from 1991 to 1997, whereas the results for the balanced panel show an increase of 13 log points over the same period. The greater productivity levels and growth of productivity in the unbalanced panel are consistent with the view that plant exit and entry contribute to aggregate productivity beyond reallocation among existing plants after the structural reforms were introduced. Moreover, comparing the increase in the cross-term for the unbalanced panel and the sample of three-year continuers, the contribution of plants' entries and exits to productivity goes beyond the contribution of young plants in their first few years after entering. The evidence suggests that the events of entering and exiting by themselves play an important role. In particular, the increase in allocative efficiency from 1991 to 1997 in the unbalanced panel is 18 log points, whereas it is only 14 log points in the sample of three-year continuers. These patterns provide support for the view that market selection is playing an important direct role in allocative efficiency. However, the substantial increase in allocative efficiency for long-lived plants also suggests that the reallocation from low- toward high-productivity existing plants does seem to play an important role as well. In Eslava and others (2005), we find that part of this is explained by increased reallocation of resources allowed by the added flexibility following the 1990 labor market reform. Another possible factor is an indirect role of market selection. An increased role of market fundamentals in market selection may impose greater market discipline on the survivors, which may increase allocative efficiency.

As noted, there are also differences in the unweighted productivity across the three samples. The balanced panel exhibits a decline in average unweighted productivity over the entire period whereas both the overall sample and the three-year continuers exhibit increases over the sample period. During the 1990s, the decrease in the unweighted average productivity is especially large in magnitude in the balanced panel relative to the changes in unweighted productivity for the overall sample and the three-year continuers. These patterns suggest that market selection played an important role in Colombia in the changes in unweighted productivity—namely, the differences in the patterns are consistent with low-productivity plants exiting, and thereby yield a pattern with higher growth in unweighted average productivity for samples including the contribution of market selection (the full sample and the three-year continuers). The balanced panel changes in unweighted average productivity by construction cannot reflect changes from market selection.

The results of productivity decompositions thus reveal three related phenomena. First, the increase in average productivity in our whole sample is very much associated with an improvement in allocative efficiency. Second, the rise in aggregate productivity among incumbents throughout the sample period is fully accounted for by the expanding market share for relatively efficient plants at the expense of shrinking market share for relatively inefficient ones. Third, the contribution of exit and entry works both through the increased market shares of more-productive businesses but also through the impact of market selection on average unweighted productivity. These findings suggest that the combination of within-sector reallocation and selection helps to account for the increase in aggregate productivity in Colombian manufacturing over the 1980s and 1990s.

V. Conclusions

Plant turnover in general, and exit in particular, are essential aspects of market selection. We have characterized the role of input costs, physical efficiency, and demand in determining the likelihood of plant survival. We find that each of these three components plays an important role in explaining the probability of survival the following year.

We also examined the response of plant exit after the introduction of structural reforms in the 1990s. In general, market fundamentals became more important following market reforms. Some of this greater impact is due to a greater dispersion of market fundamentals and some of this is due to a greater marginal effect. The increased importance of productivity variation in accounting for variation in market selection comes mainly from an increased dispersion in productivity shocks across businesses, whereas the increased importance of materials price shocks comes mainly from an increase in the marginal effect of materials prices following reforms. By contrast, demand shocks became less important determinants of survival after the reforms. Thus, these results suggest that efficiency and costs became more important determinants of survival than higher demand after market competition increased following the introduction of the reforms.

We find that average productivity increased in the average three-digit industry and that improvements in allocative efficiency are the primary driving force of this improvement. Our results suggest that plant turnover plays a substantial role, but that improved allocative efficiency among long-lived plants is also important. One issue for future research is to disentangle the respective contributions of improvement in allocative efficiency for continuing, entering, and exiting plants. Such an investigation requires capturing the impact of market reforms on adjustment dynamics of continuing, entering, and exiting businesses. A complicating factor in such an investigation is the recognition that all these dynamics are closely related—for example, an important component of the adjustment of continuing businesses might be the post-entry growth dynamics of young businesses as well as the exit of young businesses.

Our analysis of market reforms can be developed in additional interesting directions as well. We use broad measures of structural reforms via a pre/post-reform dummy to examine the interaction of microfundamentals and economy-wide reforms on market selection. We have not yet investigated how plants with observably different characteristics (for example, young and small businesses) might have responded differentially to the market reforms. Likewise, we have not yet investigated the extent to which market reforms themselves differ substantially across sectors or apply differently to businesses of observably different characteristics. We leave this investigation for future work.

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