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Firm Entry, Productivity Differentials and Turnovers in Import Substituting Markets: A study of the petrochemical industry in Colombia

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Abstract

This paper analyses plant entry, total factor productivity growth, average productivity level differentials and turnovers across Colombia's petrochemical industry for the 1974-1998 period. Results show that successful entrants shaped industry productivity and induced plant restructuring among incumbent plants. There is consistent plant heterogeneity across plant cohorts as well as across sub-markets within petrochemicals. Entry flows were steady increasing within plastics regardless of trade policy regimes. Survival rates are remarkably high and consistent over time in medium-size plants meaning that entrants adopted competitive post-entry strategies. Total factor productivity growth decomposition shows that the incumbent effect dominates the turnover effect. Market share reallocation among continuing plants constitutes an important source of productivity growth. Econometric results suggest that barriers to entry associated with plant technology licensing and dependence of imported raw materials deter entry while complementary market variables such as industry productivity levels, growth in housing construction, and fringe competition induce firm entry.

Key Words: Entry, Turnover, Total Factor Productivity, Petrochemical Industry

JEL Classification: O12, D24, O47

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RESUMEN

El documento analiza la entrada, crecimiento de la productividad total de los factores, diferenciales en productividad promedio y rotación en la industria petroquímica colombiana para el período 1974-1998. Los resultados muestran que los entrantes exitosos dieron forma a la productividad de la industria e indujeron a la reestructuración de las plantas existentes. Existe gran heterogeneidad entre cohortes de empresas así como entre submercados al interior de la industria petroquímica. Los flujos de entrada crecieron constantemente en el sector de plásticos, a pesar de los cambios de política comercial. Las tasas de supervivencia son muy altas y consistentes en el tiempo para las plantas de tamaño mediano, lo que nos lleva a pensar que las empresas entrantes adoptaron para el período post-entrada estrategias competitivas. La descomposición del crecimiento de la productividad total de los factores, muestra que el efecto de las empresas establecidas domina sobre el efecto de rotación de empresas. La redistribución de participación de mercado entre las plantas establecidas hacia las de más alta productividad se constituye en una importante fuente del crecimiento de la eficiencia productiva. Los resultados econométricos sugieren que las barreras a la entrada, asociadas con el licenciamiento de la tecnología y la dependencia de materias primas importadas disuade la entrada, mientras que variables complementarias del mercado como los niveles de productividad, crecimiento en la construcción de vivienda y competencia periférica inducen la entrada de firmas.

Palabras clave: Entrada, Rotación, Productividad total de los Factores, Industria Petroquímica.

Clasificación JEL: O12, D24, O47

I. Introduction

The petrochemical industry worldwide is formed by vertically-integrated firms. They manufacture intermediate materials derived from the oil refinement and liquid gas industries that are essential in the manufacture of end products in several industries such as textiles, apparel, domestic appliances, transportation equipment, and housing construction among many others. This industry is intensive in physical capital and along with pharmaceuticals it is also intensive in research and development. Plastics are the most dynamic sub-groups representing around 60% of the industrial uses within petrochemicals because they are close cheap substitutes of other materials currently used in the manufacture of a variety of final goods. On the other hand, production of basic chemicals in Latin America is dominated by multinational enterprises that entered developing markets during the import substituting industrialization years from the 50s to the 70s in Latin America.

Two types of promoting strategies were implemented in the region. One was the Brazilian-type strategy, which relied on attracting massive direct foreign investment and multinationals through granting non-market entry barriers via tariff protection. Once those firms settled in the market they were expected to pass technological transfers to downstream local industries. The other was the Andean-type (Colombia-Venezuela) strategy, much less aggressive, perhaps because of their domestic market size, that relied both on developing a local basic-chemical industry dependent of crude oil and oil refinement, along with the promotion of foreign direct investment. Several economic policy instruments were used in Colombia three decades ago to promote import-substituting industries such as import licenses, tariffs, tax exceptions applied to specific industries, long-term credits with implicit subsidies, and the direct involvement of government credit institutions in the setup of industrial projects.

Empirical studies on firm entry and turnovers have been focused on the evidence of the OECD cases. The study of Dunne, Roberts, & Samuelson (1988) for the US manufacturing industry is still the most comprehensive country study ever made. Afterwards, there have been just a few efforts in studying firm-level entry, heterogeneity and productivity for the case of developing economies. The collective work of Roberts & Tybout (1996) is the first comprehensive attempt to gather several cases. They include the cases of Morocco, Chile, Colombia, and Mexico. The study of Colombia only covers the 1978-1988 period. Its results clearly are out of date because it leaves the decade of the nineties where the main commercial reforms took place in Colombia since 1959.

The studies of Levinsohn & Petrin (1999) and Pavnick (2002) use the same dataset of Chile from 1980 to 1986. They evaluate manufacturing productivity using the parametric approach of Olley & Pakes (1996). Both papers are more concerned about the econometric advantages of modeling firm level productivity dynamics through stochastic processes than about providing a story regarding the effect of entry on local market characteristics and industry development.[3] Aw, Cheng, & Roberts (2001) analyzes productivity differentials and plant turnovers for

[3] There is an ongoing collective study for Latin America on labor turnover productivity leading by Haltiwanger at the IDB. The background paper of Colombia [Melendez et. al (2003)] followed the Olley & Pakes approach to estimate firm productivity and then measure plant turnover across main manufacturing industries at ISIC two-digit levels.

the Taiwanese industry based on three census years. Firm-level productivity is estimated through index number methods.

One general drawback of these studies on firm turnover and productivity excepting Olley & Pakes (1996), is that they report generic analyses presenting aggregate measures at two-digits ISIC code where there is no specific explanation regarding the forces behind plant turnover within industries and, more importantly, on what explains turnover differences across industries.

The objective of this paper is three-fold. First, the paper seeks to present an industry case within a semi-industrialized economy in Latin America such as Colombia. The importance of analyzing the petrochemical industry lays down in three reasons: i) as in any developed or developing country it is an industry where barriers to entry may have played a significant role on entry, in particular, scale economies, high fixed costs, and the spending in patented technologies; ii) the development of the petrochemical industry was conditioned by the initial pathway of inward-looking economic development Colombia pursued since the 1950s until the late 1980s. However, the recent export-orientation the industry followed under the economic openness program boosted plant entry; iii) petrochemical industries are intertwined in what we call the petrochemical chain [Diagram 1] that introduces an element of plant heterogeneity and productivity differences. Moreover, the technological complexity is increased by the different paths of maturity present in the links along with the petrochemical tree.

Second, the paper seeks to contribute in providing new evidence to shed light on the long-term forces behind entry patterns and plant productivity heterogeneity within an industry with the features above-mentioned. It will so present very detailed plant-level productivity estimations that follow state of the art methodologies. Third, the paper looks to test under a variety of econometric specifications what has determined entry in this industry in the long run.

This study makes an effort in analyzing jointly the patterns of entry, the productivity dynamics, and the explanations of what may determine entry in an industry with such special features. To our best knowledge there is no industry study for a developing economy that has tried to put together these three pieces together. Plant-level productivity estimations are less ambitious. They follow standard methodologies following index number methods. Our focus is to provide a complete picture about plant entry and stylized facts, the role of entrants within the industry, plant heterogeneity and productivity differentials, the plant turnover effect on aggregate industry productivity, and the testing of gross entry flows as function of entry barriers and market incentives.

The paper is organized in six additional sections. Section 2 presents an overview of plant entry and survival for a 25 years span in the petrochemical industry. Section 3 reviews the main methodological properties and advantages of using *exact index numbers* in measuring multifactor productivity. Section 4 reports the productivity differentials by market entry dynamics and also across sub-markets. Then it turns attention to the analysis of the sources of growth by incumbent, entrant and exiting plants, as well as across industry sub-markets Section 5 provides the econometric analysis on modeling plant entry determinants following the Orr-type specification. Section 6 concludes.

II. Patterns of Entry and Exit

Empirical research on firm entry, exit and turnovers has been very active since the 70s worldwide. Three comprehensive studies published from 1989 to 1994 present what are the patterns of firm entry and types of competition based on more than 25 case studies. The work of Geroski & Schwalbach (1991) collects 12 studies of firm entry and contestability for OEDC countries and Korea. The 1989 and 1994 special issues of the *International Journal of Industrial Organization* gather 15 studies of entry barriers and post-entry competition for different industries within the OECD economies. Caves (1998) presented a survey on new findings about the turnover and mobility of firms where he reviews some stylized facts and tries to see how they fit with existing theories. Perhaps the largest study on a country firm turnover done so far is the study of Dunne, Roberts & Samuelson (1988) for the case of the U.S. They used information at plant-level data from five Censuses of Manufactures for a 20-year span. Baldwin (1995), Baldwin & Gu (2002) and Baldwin et al (2002) have studied plant turnover and the importance of entry into Canadian manufacturing. Both studies make use of data from census of manufactures. Recently Disney, Haskel & Heden (2003) present new results of the dynamics of entry and exit in the United Kingdom.

The main difficulty to undertake that kind of research has been to collect reliable and comprehensive data to measure firm turnover. Almost all research done on the subject has made use of data collected from National censuses. This study uses plant-level data from the Annual Manufacturing Survey of Colombia [*Encuesta Anual Manufacturera (EAM)*] collected by the Colombian Bureau of Statistics [*Departamento Administrativo Nacional de Estadística-*(DANE)], which covers a 25 year-period ranging from 1974 to 1998.[4]

2.1 The industry structure

Diagram 1 illustrates the petrochemical industry tree from the production of basic materials to their final use in several consumer goods industries. The study sample focuses on two main petrochemical groups that constitute the base of the local industry in the country. They are the manufacture of synthetic resins, plastic materials and man-made fibers except glass, and the manufacture of plastic products. Together they represent 5% of manufacturing plants spread in 13 separate markets and industries at ISIC five digits level.[5]

Upstream industries in petrochemicals are composed of olefins and aromatics where the former are obtained from cracking natural gas or from cracking refined oil. The latter are derived exclusively from oil refinery feed stock. This group includes the main olefins and aromatics like ethylene, propylene, toluene and xilene. In Colombia, however the production of those olefins is very small (or non-existent) relative to a standard worldwide production plant and most of demand must be cleared with imports. The lack of this linkage in the petrochemical chain is perhaps the most important structural weakness of Colombian petrochemicals. The olefins are the main raw

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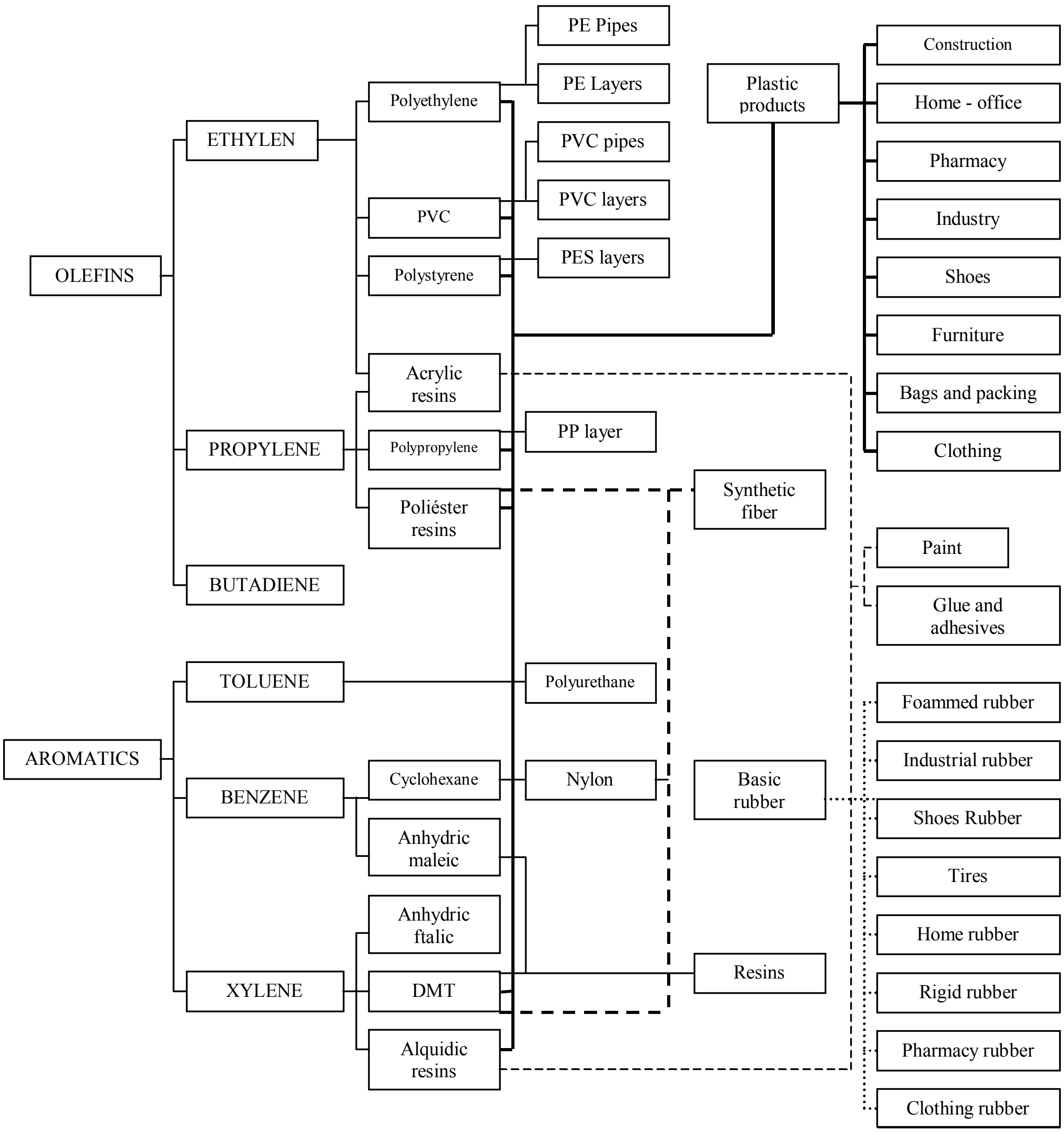
[4] Appendix III presents an overview of the EAM structure explaining what are the main limitations and advantages.

[5] Appendix IV lists the names of each of these 13 manufacturing groups located within synthetic resins and the plastic industries.

DIAGRAM 1 PETROCHEMICAL MANUFACTURING TREE



material in the production of what are called *commodity plastic resins* (third branch in the tree-figure): polyvinyl chloride (PVC), some types of polyethylene (PE), polypropylene (PP) and polystyrene (PS) whose main characteristics are that they are produced in large volumes, have several uses and a low unit value. Regarding a second and third kind of *plastic resins*, engineering plastics and the thermosets, which domestic supply is reduced. Some of these special plastics are: urea formaldehyde (UF), polycarbonate (PC), and polyamide (PA), among others. These materials are manufactured in small volumes, their unit values are very high, and have multiple applications.

The second group is composed by the *end products* in the downstream end of the petrochemical industry (the nodes to the right). This group is very heterogeneous because within it, there are products for the consumer markets as well as for industrial users. These plastics are used in building, packaging (boxes and bottles), pharmaceutical and furniture, toys and leisure and house ware.

Table 1 provides a summary of the number of firms by each of the industry sub-groups as well as for the entire sample period. The number of industrial plants grew from a minimum of 178 in 1975 to a maximum of 507 in 1998. Plastics explain on average 92% of total plants in petrochemicals while the remaining is due to synthetic resins. The petrochemical industry, in turn explains on average 38% of the total plants in the chemical industry and 5% of total manufacturing. The above trends are increasing for all cases.

2.2 ENTRY AND EXIT MEASURES

Different measures of entry and exit have been used trying to approach the patterns of industry turnover. This study follows the methodologies of Dunne et al. (1988), Geroski 1991, Baldwin (1995) and Baldwin et al. (2002). Let

$NE_i(t)$ = number of firms that enter industry *i* between year *t* and *t* - 1;

$NES_i(t+n)$ = number of firms that enter industry *i* between year *t* and *t* – 1 and that survive until year *t* + *n*;

$NT_i(t)$ = number of firms in industry *i* in year *t* ;

$NX_i(t-1)$ = number of firms that exit industry *i* between year *t* and *t* - 1;

$QE_i(t)$ = total output of firms that enter industry *i* between year *t* and *t* - 1;

$QT_i(t)$ = total output of all firms that enter industry *i* in year *t* ;

$QX_i(t-1)$ = total year (*t*-1) output of firms that exit industry *i* between year *t* and *t* - 1;

$LE_i(t)$ = total number of employees of firms that enter industry *i* in year *t* ;

$LT_i(t)$ = total number of employees of all firms in industry *i* in year *t* ;

Geroski (1991) proposes four similar ways to measure entry. The first one is the (gross) number of new firms/plants entering an industry called *gross entry*. A second measure refers to *(gross) entry rates* or, as he says, to "*weigh each entrant by its size relative to the existing firms in the industry*." The third measure tries to tell difference between *net* and *gross* entry rates: that is a measure that takes into account firms exiting the industry. The last measure just considers the entrant firms in an industry that survive the entire sample period. First, let define *entry rate* and *exit rate* for industry i between year *t* and *t* –1 as:

$$ER_i(t) = NE_i(t) / NT_i(t) \tag{1}$$

$$XR_i(t) = NX_i(t-1) / NT_i(t-1) \tag{2}$$

The definition of *entry rate* here is slightly different than the used in Dunne's paper where the denominator of total plants/firms is with respect to *t* -1 instead of *t*. Second, define *net entry* for industry i between year *t* and *t* –1 as:

$$NNE_i(t) = NE_i(t) - NX_i(t) \tag{3}$$

Entry rates are also defined in the literature with respect to employment [Baldwin, Beckstead & Girard (2002)] .[6] This measure of entry captures size effects of entrants. *Entry rate relative to total employment* for a given industry i is

$$ERL_i(t) = LE_i(t) / LT_i(t) \tag{4}$$

TABLE 1

AVERAGE NUMBER OF PLANTS BY FIVE-YEAR PERIODS

	Average Number of Plants					
ISIC Rev 2	**74-79**	**80-84**	**85-89**	**90-94**	**95-98**	**74-98**
35132	13	11	12	14	15	13
35133	1	2	2	2	1	2
35134	3	5	7	5	7	5
35135		4	4	6	4	4
35601	37	47	58	68	84	57
35602	7	12	16	22	31	16
35603	14	19	14	16	20	16
35604	30	43	60	75	96	58
35605	33	41	54	75	79	55
35606	27	32	28	30	41	31
35607	11	18	42	38	36	28
35608	1	2	1	2	2	1
35609	28	40	56	73	80	53
Petrochemicals	204	275	354	425	495	339
Chemicals	680	754	864	1.009	1.162	874
Intermediate Goods	1.980	1.948	2.047	2.272	2.494	2.128
Manufacturing	6.491	6.643	6.978	7.513	8.067	7.075

Source: DANE-EAM
Notes: Petrochemicals = ISICs: 3513 + 3560; Chemicals = ISIC 35

Entry is also measured relative to the gain in output market share. This indicator captures entrants' penetration rates and they can also be defined in gross, net of entrants as well as exiting firms:

$$ESHARE_i(t) = QE_i(t) / QT_i(t) \tag{5}$$

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[6] It is useful to mention some concerns associated to those previous measures of entry. Baldwin, Beckstead and Girard (2002) ask, "When does a new firm becomes a new firm?" The answer is not precise and straightforward. One answer may depend on which stage in the creation of a firm the researcher considers more important. Another answer could be the time when a firm appears in the files of the Statistic Bureau. However, this second answer is by itself problematic if more information is not available. This is so because as we stressed above, for instance, the sole appearance in the files may be an administrative fact but not the actual time of firm existence within an industry. In general, since the availability of plant or firm-level information is hard to get, researchers have adopted the (practical) procedure of choosing the time when the firm appears in the database.

$$NESHARE_i(t) = [QE_i(t) - QX_i(t-1)] / QT_i(t) \tag{6}$$

$$XSHARE_i(t) = QX_i(t) / QT_i(t-1) \tag{7}$$

where Eqs (5) and (6) define the gross and net entrants' penetration rates while Eq. (7) is the market share of exiting firms. Dunne proposes two benchmarking measures that allow comparison of the average size between entrants and incumbents and between surviving and exiting firms:

$$ERS_i(t) = \frac{QE_i(t)/NE_i(t)}{[QT_i(t) - QE_i(t)]/[NT_i(t) - NE_i(t)]} \tag{8}$$

$$XRS_i(t) = \frac{QX_i(t)/NX_i(t-1)}{[QT_i(t-1) - QX_i(t-1)]/[NT_i(t-1) - NX_i(t-1)]} \tag{9}$$

Other important measure of firm dynamics is related to survival rate. This is usually defined as

$$SER_i(t) = NES_i(t+1) / NE_i(t) \tag{10}$$

2.3 ENTRY PATTERNS IN PETROCHEMICALS

Geroski (1995) states that there are empirical regularities regarding firm entry and exit: i) Entry is common. Large numbers of firms enter most markets in most years, but entry rates are far higher than market penetration rates; ii) Entry and exit rates are highly positively correlated, and net entry rates and penetration are modest fractions of gross entry rates and penetration; iii) the survival rate of most entrants is low, and even successful entrants may take more than a decade to achieve a size comparable to the average incumbent; and iv) entry rates vary over time, coming in waves, which often peak early in the life of many markets. Different waves tend to contain different types of entrant. What follows presents a descriptive analysis of the basic entry measures described above and see whether or not the measurements are in accordance with the above stylized facts.

Table 2 reports information on *gross* entry (NE_i) for each of the thirteen petrochemical industry groups. There were 586 plant start-ups during the 25 years span and entry was concentrated in plastics, reflecting the fact that this group of industries requires less amount of capital investment and that the technology to enter is standardized. The entry rate exhibits an increase in plastics and remains constant within resins. There is not enough information to compare the data with that found in international studies.[7]

Three additional comments are necessary. First, *Gross* entry in plastics was concentrated in three sub-industries. They were the manufacture of tubular films and synthetic guts, the manufacture of furniture and plastic products not classified elsewhere and the manufacture of basic plastic shapes, sheets, films and tubing. Almost 300 start-ups took place in them. These are

[7] According to Geroski (1995) gross entry in the US Chemical industry were 322 new firms..

industries with strong links to packing and housing that performed relatively well during all the period. Second, overall entry in the petrochemical industry does *not* appear to be cyclical. Exception made for initial years (1974-79) and the years 1990-91, the number of firms entering the market was quite even and not dependent of the overall business cycle. For instance, in the first years of the 1980's, the Colombian economy suffered a slowdown in its economic growth but the number of entrants kept its pace.

Third, it is worthwhile comparing the period 1974-89 with the period 1990-98. The rationale is that during the first period there was a standing policy to protect national industry from foreign competition. The data seems to confirm the hypothesis that plant entry was boosted after the economic liberalization of 1991. The annual number of start-ups was 35 between during the decade against the average of 18 startups between 1974 and 1989.

TABLE 2
ENTRY PLANTS (UNITS) AND GROSS ENTRY RATES (PERCENTAGES)

		Gross Entry Rates (averages)				
ISIC Rev 2	**Entrants**					
	74-98	**74-79**	**80-84**	**85-89**	**90-94**	**95-98**
35132	15	1,5	1,0	1,5	1,7	3,0
35133	2	1,0	1,0	-	-	-
35134	4	-	1,0	-	1,0	-
35135	4	-	3,0	-	1,0	-
35601	90	2,3	2,0	4,6	6,8	5,8
35602	29	1,0	2,3	1,3	1,8	2,3
35603	26	1,3	1,5	1,0	3,5	1,5
35604	105	2,5	5,3	5,3	10,3	8,0
35605	95	2,3	3,0	4,6	6,2	4,8
35606	50	2,0	2,0	1,8	4,0	3,3
35607	60	2,0	1,8	5,0	4,0	2,5
35608	3	-	-	1,0	-	1,0
35609	103	3,0	3,4	5,6	4,2	8,5
3513	25	1,3	2,0	1,5	2,3	3,0
3560	562	6,6	17,8	27,2	31,2	37,0
Petrochemicals	586	8,0	18,8	27,8	33,0	37,8

Source: Own estimations based on DANE-EAM

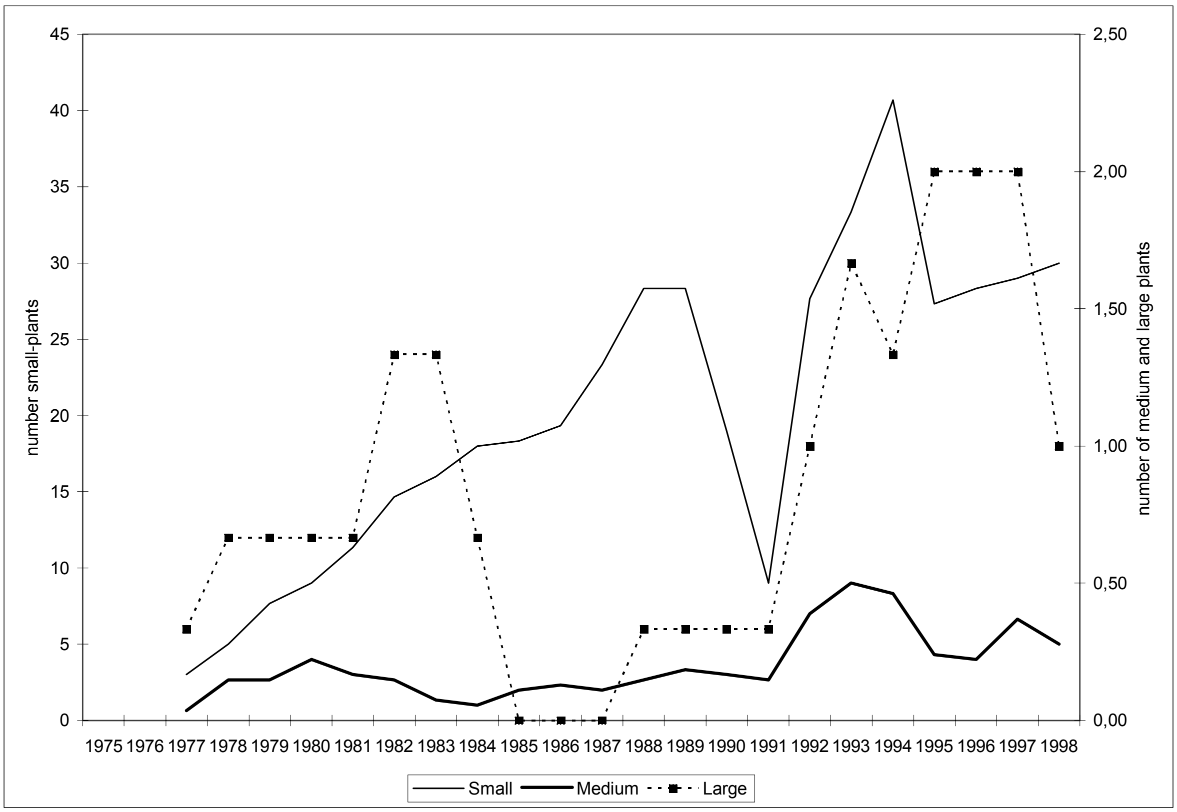
Figure 1 illustrates gross entry by plant *size* for overall the period. The main feature is that the larger proportion of firms entering the industries was composed of small and medium size plants.[8] After 1994 entry flows apparently recovered. Table 3 summarizes the measures of penetration rates. The measures indicate low penetration rates. The long run average for the entire industry is 6.8% when rates are weighted by plant output market share. The plastic industry exhibit rates, where on average entrants explain 5% of its group output. In resins

[8] The 1992 peak reflects the EAM's coding problem of 1992-1993. Further details are in Appendix III.

despite the lower entry rates new plants explain 16% of its sector output. These numbers are consistent with findings of other studies on firm entry. For instance, Cable & Schwalbach (1991) reports penetration rates for seven OECD countries and Korea across manufacturing groups covering different periods in the 70s and 80s. For the chemical industry Portugal has a 33% penetration rate, followed by the US with a rate of 19%.

FIGURE 1

GROSS ENTRY BY PLANT SIZE MA(3)



Source: Own estimations based on DANE-EAM

For the remaining cases, entry penetration rates range for 1.5% to 6%. Therefore, one can claim that the first stylized fact applies to the petrochemical industry. Gross entry is a common economic force, averaging 24 firms during 1974-1998, and entry rates are larger than penetration rates.

Survival and post-entry performance of entering plants is another feature that characterizes entry patterns within an industry. Figure 2 shows the evolution of survival rates with plant ageing. Complementary information concerning survival by cohorts is in Appendix I. The figure was reached by summing up the number of firms that survive across each cohort, and dividing it by the total number of entrants. It is clear that as firms age their survival likelihood declines. Some facts can be noticed. First, a very low number of firms/plant die during the first two years of birth, meaning that new firms adopt tough competition strategies. The average life span of new firms is high. It takes about seven years to get a survival indicator of less than 50%. Mata (1995) shows a figure of the survival schedule of new plants in Portugal. The shape of the function is convex, which implies an increasing rate of firm deaths. In a similar way, the shape of the function for the samples of Colombian petrochemicals firms is also convex, implying the same behavior.[9]

TABLE 3
ENTRANT MARKET SHARE

ISIC Rev 2	74-79	80-84	85-89	90-94	95-98	74-98
35132	0,0865	0,0094	0,1480	0,0577	0,0016	0,0726
35133	0,8667	0,0149	.	.	.	0,4408
35134	.	.	.	0,0320	.	0,0408
35135	.	0,9980	.	0,0268	.	0,5124
35601	0,0582	0,0056	0,0141	0,0801	0,0332	0,0346
35602	0,0143	0,0343	0,0607	0,0091	0,0351	0,0336
35603	0,1728	0,0662	0,0277	0,0112	0,0137	0,0590
35604	0,0237	0,0423	0,0248	0,0728	0,0784	0,0504
35605	0,0573	0,0146	0,0375	0,0440	0,0657	0,0416
35606	0,0233	0,0400	0,0456	0,1214	0,0235	0,0531
35607	0,0181	0,0066	0,0184	0,0559	0,1193	0,0465
35608	.	.	.	.	0,0801	0,0801
35609	0,0874	0,1112	0,0408	0,0145	0,0902	0,0641
Unweighted rates						
3513	13,1%	12,2%	9,0%	2,7%	0,1%	8,1%
3560	2,7%	2,3%	2,5%	4,6%	5,3%	3,4%
Petrochemicals	5,3%	4,7%	3,1%	3,5%	3,3%	4,0%
Weighted rates						
3513	34,7%	19,5%	14,8%	3,9%	0,2%	16,0%
3560	5,3%	3,9%	3,3%	4,5%	5,8%	4,5%
Petrochemicals	13,6%	6,1%	4,0%	4,6%	5,6%	6,8%

Source: Own estimations based on DANE-EAM
Methodology: Entrant Market Share (Penetration rate): ESH(t) = QE(t)/QT(t)

Another fact is that for firms/plants that passed the rule, their survival was high. To illustrate this, about 80% survived on average between five to ten years, and almost 61% survive between ten to fifteen years. Appendix 1 [Table A1] provides a complementary insight of the survival patterns, which shows plant life span by cohorts. Plants that belong to the 1975-1979 cohorts had a lower percentage of continuing firms. Plants born in the 1980s had a superior performance. It is still too early to evaluate comparatively the survival of the cohorts born in the 1990s; the data seems to show a slightly lower pattern. One important feature of survival that is not generally shown in international studies on entry and exit dynamics is the extent to which small-size plants are more likely to fail than larger-size firms. Figure 3 gives the survival patterns across plants of three different sizes.

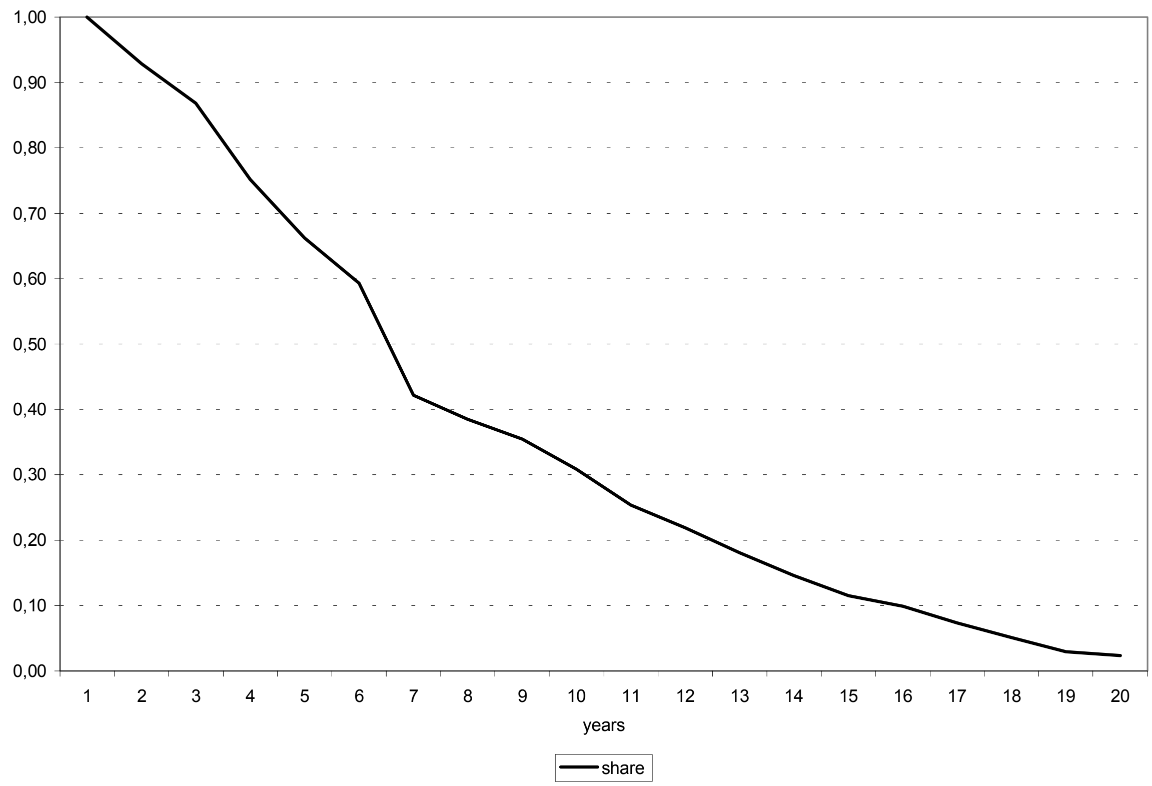
[9] Two caveats are important to have in mind. Since we ruled out all firms that did not report information for at least four years, many small starts-up that fell into that classification actually could have survived and so the survival indicator may be understated. Second, the percentage of firms surviving more than fifteen years may be understated given the changes in the ID code number and the high gross exit that occurred in 1991 and 1992.

The survival of medium size plants is longer as expected. Indeed they had a remarkable consistency and resiliency. On average, their survival rate was greater than 90% per cent for all cohorts. On the other hand, small-size plants face more trouble trying to survive as can be noted from their consistently lower proportion within plant population ageing.

In sum the highlighted entry patterns indicate that the results fit along the expected direction and magnitudes, relative to what other studies have found within the chemical industry. Thus, the gross entry penetration rates are low. The analyzed sample gives no evidence of the existence of either entry or exit waves (shake-out). Firm survival indicates that the medium-size plants accommodate to post-entry competition exhibiting the highest survival rates. The petrochemical industry as a whole tends to reduce plan size over time, which gives firms more flexibility for plant restructuring. The next section turns attention to productivity analysis by entry dynamics.

FIGURE 2

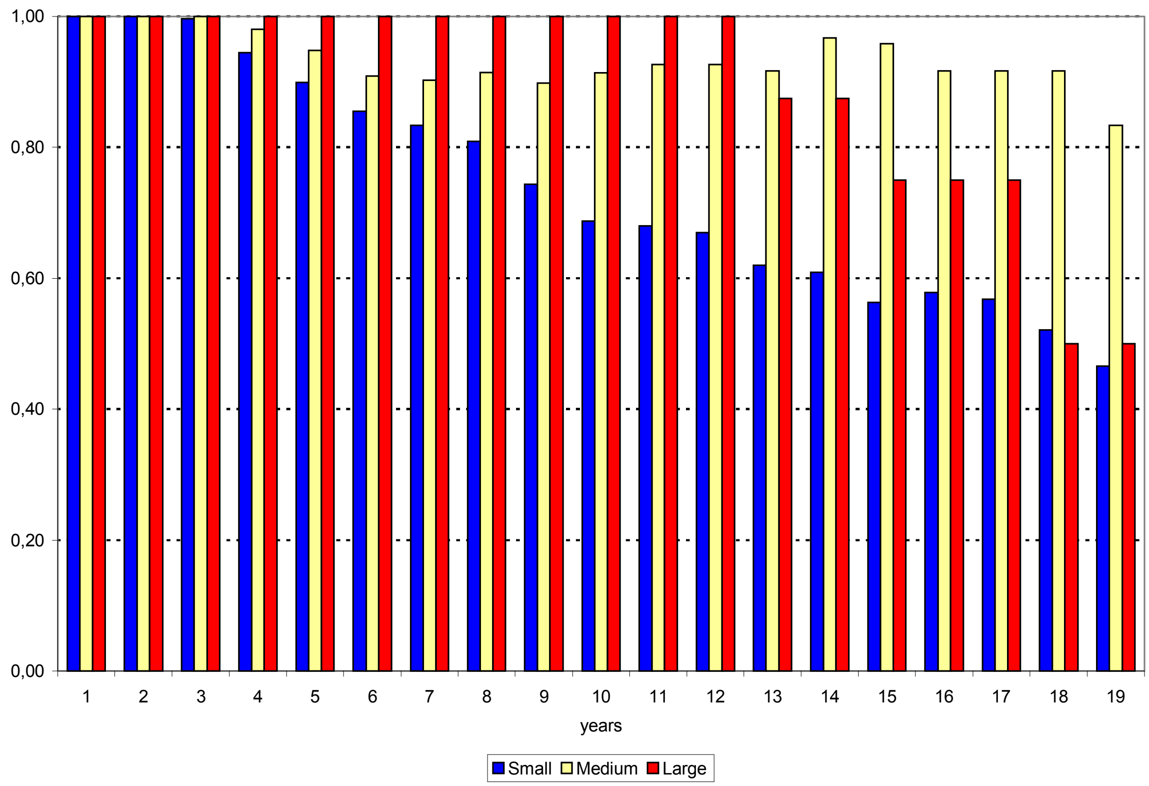
PLANT SURVIVAL RATES



Source: Own estimations based on DANE-EAM

FIGURE 3

SURVIVAL RATES BY PLANT SIZE



Source: Own estimations based on DANE-EAM

III. PLANT LEVEL TOTAL FACTOR PRODUCTIVITY AND ENTRY DYNAMICS

This section presents the results of measuring productivity and technical change within a panel of industrial plants that belong to the plastics and synthetic resins industries. These specific groups form the petrochemical sector in Colombia as depicted by diagram1. The exercise looks to establish whether there are productivity differentials across type of firms according to their entry status and asks the question of whether entrants do better than incumbent firms within the market. The section is divided in three parts. It begins presenting the methodology for measuring total factor productivity following the *Divisia* index approach. Then it turns to specific data issues on the format of the longitudinal dataset, and finishes presenting an analysis of sources of productivity growth.

3.1 TRANSLOG INDICES OF TOTAL FACTOR PRODUCTIVITY GROWTH

Growth accounting exercises measures total factor productivity (TFP) under the traditional assumptions of constant returns to scale (CRTS), perfect competition, equal efficiency across capital equipment vintages, non-externalities, and long-run firm optimization. The index number approach relies on the usage of exact indices [Diewert (1976)] that are derived from specific production functions. By far the most used in productivity studies [Jorgenson et. al (1987)] is the translog index of TFP growth, also known as the Tornqvist-Theil index. The technology behind such index is the transcendental logarithmic production function [Christensen et. al. (1971)] restricted to constant returns to scale. A common refinement to the Tornqvist index is to take into account the effects of changes in quality in inputs [Jorgenson and Griliches (1967)], in which aggregate inputs follow a translog specification in each one of its components.

The translog index has some desired economic properties such as being an *exact* transformation of a translog production technology. The index is also time-chained, which allows factor shares to change over time. This feature makes it unnecessary to assume *neutrality* in technical progress under the hypothesis of perfect *competition*. Changes in input value shares will be the result of changes in factor marginal rates of substitution.[10] The *Translog* index of TFP growth for any given firm is

$$Ln\frac{A_t}{A_{t-1}} = \ln\frac{Y_t}{Y_{t-1}} - \frac{1}{2}\cdot\sum_{i=1}^{n}(S_{it}+S_{it-1})\cdot(\ln x_{it} - \ln x_{it-1}) \tag{11}$$

where: s_i = factor i's share in gross output at time t; x_i = type of input i; A_t = Hicks-neutral index of technical change at time t; and Y_t = firm gross output at time t.

It follows that under the classical assumptions the rate of growth of TFP is equivalent to the rate of technical progress. The underlying technology of (11) is the *restricted Translog production function* under constant returns to scale. The used translog function includes four types of inputs for every industry sector i: capital, labor, materials, and energy. Let

$$Y_i = A_i \cdot F(K_i, L_i, M_i, E_i) \tag{12}$$

denotes firm i's production function, and

$$\ln Y(X,t) = b_0 + \sum_i b_i \cdot \ln x_i + \frac{1}{2}\sum_i\sum_j b_{ij}\ln x_i \ln x_j + b_t t + \frac{1}{2}b_{tt}t^2 + \sum_i b_{it} t\cdot \ln x_i \tag{13}$$

be the translog specification of (12), where X and t denote the vector of inputs and time argument respectively. Factor elasticities in (13) are equal to

$$\frac{\partial \ln Y}{\partial \ln x_i} = V_{x_i} = b_i + \sum_j b_{ij}\ln x_j + b_{iT}t \tag{14}$$

On the other hand, the rate of technical change is equal to the growth of output holding all inputs constant, which is given by

$$\frac{\partial \ln Y}{\partial t} = V_T = b_T + \sum_j b_{Tj}\ln x_j + b_{TT}t \tag{15}$$

[10] The observed changes in factor shares are explained also by changes in factor prices that are not related to changes input marginal productivities, but with distortions and rigidities in the labor and capital markets. Therefore, the observed productivity growth rates might be or not neutral.

Necessary conditions for producer equilibrium imply that factor elasticities are equal to the value shares of inputs in gross output if the technology exhibits constant returns to scale (CRTS), and inputs are paid by their marginal products. Since the production function (13) is assumed linearly homogeneous, applying Euler's *theorem* implies

$$\sum_i^n \frac{\partial Y}{\partial x_i} \cdot x_i = Y \tag{16}$$

The above identity is known in production analysis as the *adding up condition* implying that output is fully accounted by all input payments. To satisfy (16) the value of inputs must sum to 1, hence

$$\sum_i V_{xi} = \sum_i b_i + \sum_i \sum_j b_{ij} \cdot \ln x_j + t \cdot \sum_i b_{it} \text{ amd } \sum_i V_{x,i} = 1 \tag{17}$$

For this restriction to apply globally, it follows

$$\sum_i b_i = 1; \quad b_{ij} = bji \text{; and } \sum_j b_{ij} = 0 \tag{18}$$

The translog function can be evaluated to express the growth rate of output as the weighted sum of the growth rates in inputs plus the rate of productivity growth in two discrete points in time,[11] as

$$\ln Y(T) - \ln Y(T-1) = \frac{1}{2} \cdot \sum_i \left[V_{Xit} + V_{Xit-1} \right] \cdot [\ln x_{iT} - \ln x_{it-1}] + \frac{1}{2} [V_T + V_{T-1}] \tag{19}$$

Finally, if restrictions (18) are imposed on the above growth decomposition equation, factor elasticities are equivalent to input shares, and Eq. (19) becomes the translog index given by formula (11). In other words, this index represents the rate of technical change for a plant i, when the current technology can be approximated by a translog production function. Regarding input capital, labor, and materials, they also follow a translog specification on their components. Under the assumption of CRTS, the translog index for each input i becomes

$$\text{Ln} \frac{K_t}{K_{t-1}} = \frac{1}{2} \cdot \sum_{j=1}^n (\theta_{jt} + \theta_{jt-1}) \cdot (\ln k_{jt} - \ln k_{jt-1}) \tag{20}$$

$$\text{Ln} \frac{L_t}{L_{t-1}} = \frac{1}{2} \cdot \sum_{j=1}^n (\theta_{jt} + \theta_{jt-1}) \cdot (\ln l_{jt} - \ln l_{jt-1}) \tag{21}$$

$$\text{Ln} \frac{M_t}{M_{t-1}} = \frac{1}{2} \cdot \sum_{j=1}^n (\theta_{jt} + \theta_{jt-1}) \cdot (\ln m_{jt} - \ln m_{jt-1}) \tag{22}$$

---

[11] Because the translog function is a special case of the generalized quadratic function, using the quadratic approximation lemma does this discrete evaluation.

where θ_j denotes the share of each component in input's total payments. Equations (20) to (22) express the growth rate of aggregate capital, labor, and materials by the sum of growth rates of each sub-input weighted by its average marginal product, under the assumption input and output competitive markets. The weighted sum among inputs represents the correction by *improvements in the quality of inputs* that are embodied in the process of technical change itself. [12] Thus, formulas (11) and (11)-(22) constitute the benchmark for measuring total factor productivity across plants in our study panel.

3.2 Data

The analysis of plant productivity is based on a longitudinal dataset that includes all plants that report consistently at the Colombia's Annual Manufacturing Survey [*Encuesta Anual Manufacturera (EAM)*] for the 1975-1998 period. There were 921 identified plants that at some point have records at the survey within the plastic and synthetic resins sectors. Nonetheless, 298 plants were dropped form the panel for several data inconsistencies and then were classified as *volatiles*. The exclusion of those plants reduces the number of plants to 623 in the working panel. This final panel is slightly different from the one used in section II to measure entry and exit rates. The objective here is to work with individuals that have consistent records in the basic variables of output, investment, labor input, materials and power consumption that allow to get accurate measures of input demands and total factor productivity.[13]

The EAM until 1977 published the variable of plant startup year. Later we consider as the startup year the first record that shows up in the panel. The exit date is the year by which there are no records afterwards. Therefore, plants were classified according to entry dynamics. Incumbents are plants that show records for the entire period, entrants are surviving plants that begun operations after 1977 and are still active in 1998, and the existing plants are those founded before 1977 or entrants after 1977 that exit the market before 1998.

Table 4 depicts the average number of industrial plants and the average plant output, capital stock, and employment within the petrochemical industry by five-year periods. There are several plant characteristics worth to highlight. To begin with there is a notorious difference in capital intensity between the two industry branches. On average, the capital stock per plant in synthetic resins moved 6.3 in the 70s to 14.2 times at the end of the 1990s. Plant size is on average 3.5 times larger in resins, given by the number of employees. In both cases plant size started decreasing since 1990 in both sectors. This adjustment suggests labor restructuring

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[12] Among many studies on productivity, this correction has been applied in the works of Jorgenson *et al,* (1987) for the U. S, and Young A., (1994) for East Asian countries. An application for the manufacturing sector in Colombia is in Pombo (1999a).

[13] The plants in the panel fulfill the following requirements in order of not being classified as volatile plants: i) plants most have at least 4 consecutive observations within the 1974-1998 period in their main variables excepting gross investment; and ii) plant basic series must be continuous or exhibit a discontinuity for a maximum of three (3) years. In these cases, we perform an interpolation across observations. The difference between the unbalanced panel with the 623 plants and the one used in section II is explained by the inclusion of plants that do report for the 1997-1998 period and for the productivity panel they do not fulfill condition i). This avoids truncation in entry rates series. The above implies a difference of 150 plants between the two panels.

within plants to minimal efficiency scales. The above differences also hold for type of plants according to entry dynamics. Incumbents tend to use more capital-intensive technologies and plants are larger in size and in their operative scale. On average, plant output for incumbent plants is 2.5 times larger than for entering plants. In contrasts, exiting plants show decreasing patterns in their characteristic variables.

3.3 Sources of productivity growth and entry dynamics

The first step in analyzing productivity and market entry is to answer two basic questions: i) How is the performance of total factor productivity across plants by type entry dynamics? That is, do entrants perform better than incumbents?, and does productivity slowdown influence market exit, and ii) if so, does productivity drive output growth?

Total factor productivity is measured using translog indices given by Eq. (11). Positive changes in those indices reflect productivity gains due to technical change. Table 5 synthesizes the results about the measurement of the sources of growth, the contribution of technical efficiency to output growth, and the quality input effect. The measurement of TFP was done for all 623 plants of the panel. Afterwards inputs and output variables were weighted and grouped according to ISIC-specific group within the synthetic resins and plastic industries and market entry dynamics. That is plants/firms were coded as surviving entrants, incumbents and exiting firms. Then the translog decomposition of industry productivity follows.

The first fact worth noticing is that the measurement is consistent with the expected direction in accordance with plant entry. Entrants are more efficient than incumbents and dying plants are the least efficient. In particular, productivity grew at an average rate of 4.9% per year within entrants, incumbents at 1.8%, while dying plants showed a negative rate of -1.7% per year during the 1975-1998 period.

Regarding industry groups the plastic industry pulls productivity. Productivity grew on average at 2.3% rate per year while resins suffered from a productivity loss of -2.8% per year. As noted in the previous section, plastics is an industry that grew and consolidated in the 1980s while resins such as polymers and aromatics were industries that were born in the 1950s promoted in many cases under the corporate structure of state or mixed capital enterprises. Those are capital-intensive plants that experienced diseconomies of scale due to i) domestic demand shrinkage, and ii) over investment during the 70s where output growth did not compensate the capital accumulation rates. These elements punished capital productivity drastically. This phenomenon was not unique within petrochemicals or the chemical industries. A recent study of privatization in Colombia showed this drastic fall during the 1979-1986 period in the privatized manufacturing firms which were located in intermediate and capital intensive industries such as steel, paper, rubber, and transportation equipment industries.[14] Figure 4 traces the divergent paths of TFP indices within petrochemicals and contrasts them with performance of the chemical industry. Despite the non- recovery of plant productivity within resins, entry in plastics has pushed up overall productivity in petrochemicals as Figure 5 suggests.

[14] See Pombo & Ramirez (2003) for further details.

TABLE 4

PRODUCTIVITY ANALYSIS: PANEL DATA CHARACTERISTICS

Entry/ISIC	Average Number of plants					Average output per plant				
classification	74-79	80-84	85-89	90-94	95-98	74-79	80-84	85-89	90-94	95-98
Entrants	4	46	115	228	367	2.049	7.698	5.791	5.216	5.082
Incumbents	74	78	78	78	78	5.456	8.142	12.460	12.996	14.654
Exiters	49	76	109	85	15	5.123	4.512	4.059	2.722	1.117
Resins	10	18	21	24	29	25.381	29.960	45.408	44.763	40.860
35132	6	9	11	13	17	23.269	27.212	45.819	44.695	43.715
35133	2	3	3	2	2	40.323	28.084	38.982	26.998	13.086
35134	2	2	3	4	6	21.538	17.009	17.694	12.174	14.219
35135	1	3	4	5	4	744	42.692	69.465	83.818	82.585
Plastics	117	183	282	367	431	3.453	4.366	4.050	3.726	4.256
35601	24	33	51	65	80	7.124	11.917	10.200	7.922	8.113
35602	6	11	16	19	25	1.683	1.959	2.668	3.530	3.163
35603	8	13	13	15	18	1.159	1.790	2.680	5.472	6.681
35604	21	33	51	69	88	2.423	2.716	3.019	2.793	2.862
35605	24	36	52	70	79	2.197	2.723	2.823	3.036	4.025
35606	14	21	23	30	38	1.840	1.966	2.524	3.737	3.876
35607	4	10	27	35	34	13.177	8.352	3.438	850	1.087
35608				1	3			896	1.370	954
35609	15	28	48	62	66	1.660	1.978	2.179	2.442	3.489
Petrochemicals	127	200	302	391	460	5.198	6.618	6.863	6.276	6.587
	Average capital stock					Average number of employees per plant				
Entrants	4.312	3.989	2.276	2.232	1.703	45	72	54	52	48
Incumbents	2.060	3.442	4.266	4.056	4.260	82	88	80	84	80
Exiters	1.339	1.361	1.157	708	370	102	86	61	40	23
Resins	8.170	14.946	18.699	19.809	16.177	164	231	240	199	124
35132	9.599	18.251	20.785	21.117	16.042	124	143	135	118	85
35133	7.891	8.978	12.171	7.866	3.982	375	295	345	215	105
35134	5.827	5.412	3.757	2.254	3.372	105	97	83	59	42
35135	122	16.754	29.699	38.948	42.026	25	442	554	540	428
Plastics	1.281	1.525	1.187	1.096	1.136	82	70	50	47	48
35601	2.527	4.196	2.973	2.837	2.894	106	95	64	58	51
35602	195	198	188	263	199	43	38	29	37	30
35603	677	783	1.880	1.946	1.942	48	53	48	64	65
35604	981	804	696	700	550	55	44	36	39	36
35605	1.219	1.478	1.028	1.041	1.162	71	60	50	50	61
35606	427	443	523	608	606	49	48	39	55	55
35607	4.349	2.586	1.279	429	232	406	254	104	33	28
35608			211	360	260			24	33	21
35609	448	517	525	457	704	71	55	42	43	55
Petrochemicals	1.836	2.710	2.388	2.257	2.093	89	84	63	56	53

Source: Own estimation based on DANE-EAM;
Notes: ISIC 3513 = Synthetic Resins; ISIC 3560 = Plastics; Petrochemicals = 3513 + 3560; value series are in millions of pesos at 1998 prices.

The analysis of sources of growth shows that the petrochemical industry had a modest rate of TFP growth. The long rung growth rate is 0.92%, which is similar to rates estimated in other studies for total manufacturing that is around 0.8% per year.[15] Output growth in petrochemicals was sustained by capital accumulation up to 1985 where capital stock rate of growth is 14% per year. Then there was a drastic slowdown in capital accumulation. The average rate during the 1990s dropped to 1.5% per year. The contribution of TFP to output growth in contrast increased

[15] For more details see Pombo (1999b). The estimates of this study are based on ISIC 4-digits groups and do not count for turnover effects on productivity.

TABLE 5

SOURCES OF GROWTH, TFP INDICES, QUALITY INPUT EFFECT BY ENTRY DYNAMICS AND INDUSTRY GROUPS

ISIC/Entry	75-79	80-85	85-89	90-94	95-98	75-98	75-79	80-85	85-89	90-94	95-98	75-98
Output Growth							**Fixed Capital Growth**					
Entrants	0,6908	0,5461	0,0932	0,1235	0,0335	0,2320	-0,0424	0,2552	0,1160	0,0946	0,0379	0,1219
Incumbents	0,0951	0,0695	0,0658	0,0050	0,0010	0,0492	0,1074	0,0884	0,0249	-0,0397	-0,0096	0,0361
Exiters	0,1579	0,0300	0,0221	-0,2768	-1,6270	-0,2268	0,1399	0,0651	0,0224	-0,3721	-1,1098	-0,1762
Resins	0,1360	0,1472	0,1000	0,0030	-0,0270	0,0760	0,3417	0,2107	0,0659	0,0052	0,0012	0,1301
Plastics	0,1180	0,1074	0,0378	0,0585	0,0350	0,0729	0,1075	0,0673	0,0546	0,0166	0,0330	0,0567
TOTAL	0,1244	0,1229	0,0660	0,0331	0,0107	0,0740	0,1568	0,1246	0,0602	0,0110	0,0180	0,0764
Labor Growth							**Materials Growth**					
Entrants	0,1940	0,3949	0,1048	0,1313	0,0236	0,1722	0,5367	0,5837	0,0936	0,1095	-0,0119	0,2212
Incumbents	0,0652	-0,0099	-0,0211	0,0141	-0,0573	0,0005	0,0757	0,0521	0,0281	0,0051	-0,0272	0,0290
Exiters	0,1042	0,0219	-0,0139	-0,2404	-1,3532	-0,2044	0,0859	0,0270	0,0083	-0,2414	-1,6045	-0,2354
Resins	0,2138	0,1357	0,0209	-0,0394	-0,0580	0,0593	0,1466	0,1739	0,1074	0,0208	-0,0381	0,0871
Plastics	0,0732	0,0319	0,0212	0,0497	-0,0116	0,0347	0,0672	0,1009	0,0076	0,0518	-0,0213	0,0438
TOTAL	0,0913	0,0539	0,0211	0,0302	-0,0195	0,0377	0,0871	0,1248	0,0504	0,0372	-0,0288	0,0576
Electricity Growth							**TFP growth corrected by input efficiency**					
Entrants	0,5065	0,6154	0,0799	0,1527	0,0846	0,2542	0,4188	0,0856	-0,0088	0,0143	0,0179	0,0493
Incumbents	0,1081	0,1247	0,0524	0,0097	0,1109	0,0799	0,0065	0,0061	0,0439	0,0221	0,0174	0,0182
Exiters	0,2485	0,0677	0,0364	-0,2615	-1,4953	-0,1752	0,0456	-0,0112	0,0103	0,0181	-0,1928	-0,0173
Resins	0,2071	0,2411	0,0438	0,0175	0,0481	0,1142	-0,1153	-0,0403	0,0232	-0,0048	-0,0071	-0,0285
Plastics	0,1423	0,0885	0,0776	0,0742	0,1107	0,0982	0,0351	0,0272	0,0066	0,0208	0,0247	0,0233
TOTAL	0,1675	0,1683	0,0574	0,0435	0,0810	0,1045	**0,0074**	**0,0052**	**0,0146**	**0,0076**	**0,0134**	**0,0092**
Input Contribution to Output Growth							**TFP contribution to Output Growth**					
Entrants	0,3938	0,8433	1,0943	0,8843	0,4655	0,7873	0,6062	0,1567	-0,0943	0,1157	0,5345	0,2127
Incumbents	0,9321	0,9115	0,3332	-3,4631	-15,738	0,6307	0,0679	0,0885	0,6668	4,4631	16,7376	0,3693
Exiters	0,7111	1,3728	0,5318	1,0654	0,8815	0,9238	0,2889	-0,3728	0,4682	-0,0654	0,1185	0,0762
Resins	1,8474	1,2740	0,7677	2,6119	0,7377	1,3757	-0,8474	-0,2740	0,2323	-1,6119	0,2623	-0,3757
Plastics	0,7029	0,7469	0,8254	0,6447	0,2931	0,6807	0,2971	0,2531	0,1746	0,3553	0,7069	0,3193
TOTAL	0,9407	0,9574	0,7795	0,7717	-0,2574	0,8758	**0,0593**	**0,0426**	**0,2205**	**0,2283**	**1,2574**	**0,1242**
TFP Translog Indices (1974 = 100) corrected by input efficiency							**Quality Input Effect**					
Entrants	108,4	191,0	210,6	207,0	232,9	188,2	0,1736	-0,0217	0,0080	0,0062	0,0199	0,0128
Incumbents	98,8	100,3	123,9	131,5	138,1	117,7	0,0363	0,0483	0,0197	0,0178	0,0212	0,0279
Exiters	121,0	117,4	126,2	136,0	94,5	120,1	0,0248	0,0084	0,0122	-0,0040	-0,0439	0,0031
Resins	81,4	60,2	67,4	64,5	66,5	68,1	0,0390	0,0282	0,0027	0,0003	0,0093	0,0174
Plastics	111,1	123,8	142,4	144,9	158,1	135,1	0,0262	0,0119	0,0127	0,0009	0,0222	0,0149
TOTAL	**103,5**	**100,3**	**114,8**	**113,3**	**121,2**	**110,2**	**0,0298**	**0,0227**	**0,0080**	**0,0004**	**0,0169**	**0,0152**

Methodology: Input quality effect = TFP growth corrected - TFP growth simple
Source: Own Estimations based on DANE-EAM

since 1985. Technical change arose as source of output growth during the 1090s. The contribution of TFP to output growth was 74% while the reminder 16% were allocated among inputs. This scenario was opposite in the 1970s where inputs contributed 94% to output growth.

There are at least three facts worth mentioning if one breaks the industry by entry dynamics. First, industry growth is based on the entry flows. This fact is clear in plastics where entry rates steadily increased over time [Table 1]. Entrants as defined for this exercise are surviving plants that enter in the market after 1977. This implies that the first cohorts of those firms after 20 years became the dominant ones in the industry. In fact, entrants ended up demanding more capital or labor inputs. Thus, younger firms gain over time market share and generated more employment. This implies a positive trend of birth cohorts where new firms shape the industry in the long run.

FIGURE 4
TRANSLOG INDICES OF TFP (1974=100) - CHEMICALS VS. PETROCHEMICAL INDUSTRIES

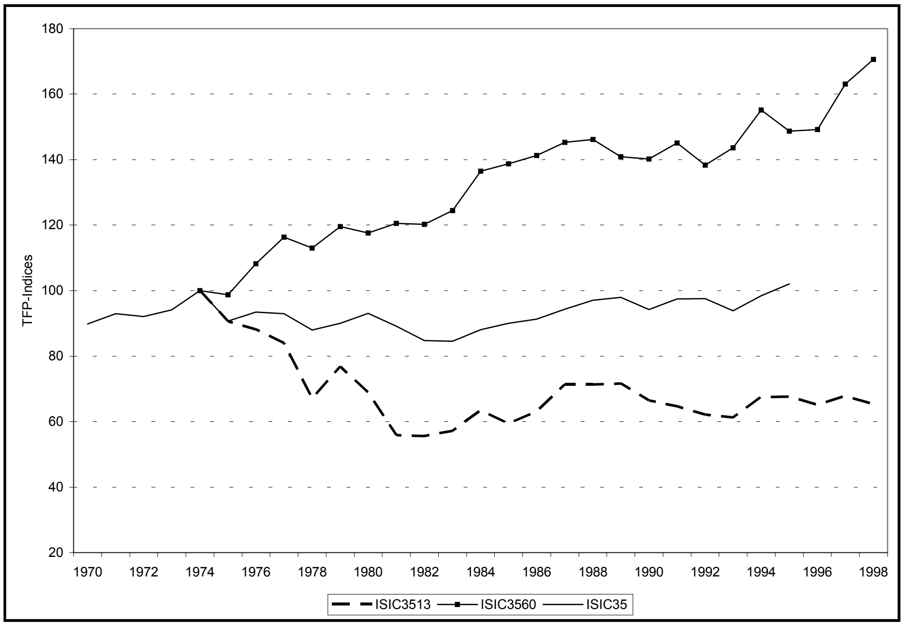
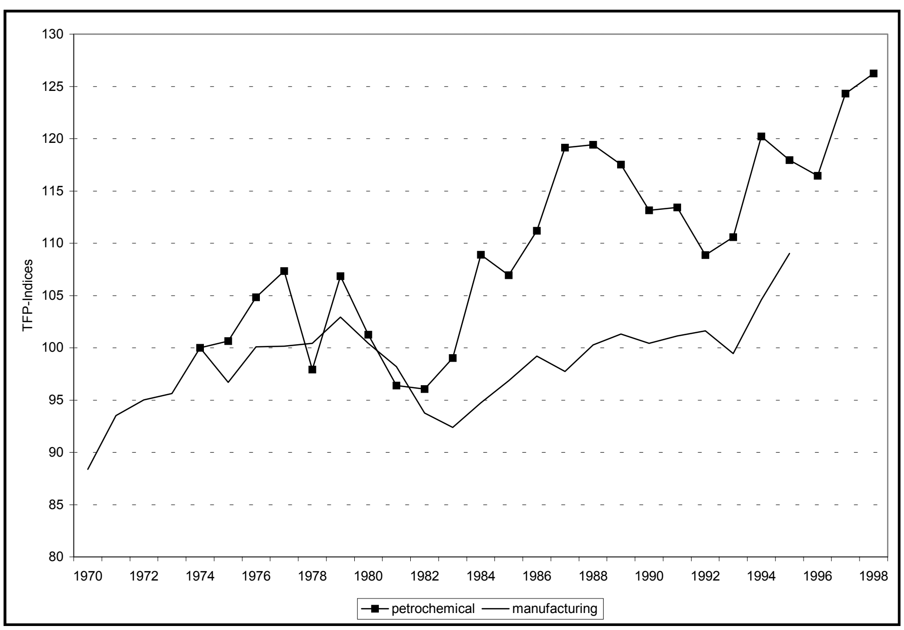


FIGURE 5
TRANSLOG INDICES OF TFP (1974=100) - PETROCHEMICALS VS. MANUFACTURING



Notes: ISIC 3513 = Synthetic Resins; ISIC 3560 = Plastics; Petrochemicals = 3513 + 3560; Chemicals ISIC 35
Sources: Own estimations based on DANE-EAM; Pombo (1999b)

Second, there is a catching-up in productivity growth between the surviving entrants and incumbents according to the table. The first cohorts were on average highly productive. TFP growth was on average 42% per year in the late 1970s and 8.5% during the first half of the 1980s. The catching up of TFP growth is evident for the late 1990s where either entrants or incumbents plants had on average 1.7% productivity growth. Third, incumbent firms accommodated to market entry. TFP contribution to output growth is higher than input contribution among entrants for the first cohorts, but this was not the case after 1980. The numbers for incumbent firms suggest that the loss in market share with respect to entrants induced plant restructuring since the mid 1980s. TFP growth confirms partly this observation. The average rate for the second half of the 1980s was 4.4% and 2.2% for the first years of the 1990s. Entrants showed no productivity growth during the late 1980s and 1.4% in the early 1990s. The demand for capital input was drastically reduced after 1985. The annual accumulation rate moved from 8.8% to 2.5% in the 1980s. After 1990 it turned negative. Entrants in contrast kept positive growth rates in their capital stock, although they exhibit a decreasing trend over time.

The demand for labor input across incumbents was on average negative since 1980, reaching a minimum of –5.7% for the second half of the 1990s. In contrast, entrants displayed a 17% long run rate in labor input. The above numbers, together with the null growth in output for incumbent plants during the 1990s, imply an outlier TFP contribution to output growth of 4.4 and 16.7 times offsetting the drastic reduction of aggregate inputs contribution to growth. Intermediate consumption gathers the demand for raw materials, and the consumption of fuels, lubricants, repairing services, and machinery parts. Electricity demand is excluded because it is treated separately as an input.

Savings in materials spending is a source of efficiency gains. Consumption growth in intermediate materials decreased for incumbents as well as for entering plants since the late 1970's. Nonetheless, efforts on saving in material spending were very evident for entrants. They could diminish by 48 percentage points the spending in intermediate materials, moving from 58% to 10% growth rates from 1980 to 1994. For the same period incumbents, reduced them in 4.7% moving from 5.2% to 0.5% annual growth rate. Technical change became a source of growth within plastics since the mid-1980s when entry within this industry took off.

Last, the change in quality of inputs is an important source of productivity gains in this industry. On average, there is a difference of 1.5% TFP growth per year. This effect is important within all subgroups in the petrochemical industry. The difference in resins is 1.7% while in plastics is on average 1.5% per year in TFP growth.

Summing up, firm entry in petrochemicals induced plant restructuring within incumbents, although they did not deter entry because gross entry rates rose in plastics during the analyzed period, and at the same time promoted plant shakeout in both industries according to exit rates reported in the previous section. The next section turns attention to the analysis of productivity differentials testing changes in means and medians of plant TFP and labor productivity by surviving and exiting plants, incumbent versus entrant plants, and between birth-cohort plants.

IV. PRODUCTIVITY DIFFERENTIALS AND PLANT TURNOVER

The main shortcoming of following an index approach methodology to measure technical change and total factor productivity is that it does not account for the effect of market entry and exit in industry productivity. Firm entry is an endogenous flow that shifts either plant or industry-group productivity. The literature on index numbers and productivity measurement has developed methodologies since the 1970s relaxing the core assumptions that are behind the traditional TFP decompositions.[16]

The analysis of plant turnover has attracted attention within the productivity literature in recent years because economies around the world have engaged in a series of structural market reforms that have implied market deregulation, elimination of entry barriers and promotion of market competition since the 1990s. Firm entry has an effect on plant reallocation and shakeout of inefficient firms. These effects in fact might induce plant restructuring. Thus, entry and exit flows force firms to become more productive over time in order to survive. Enterprises that cannot make it fail end exit the market.[17] The non-parametric estimation of a given industry group productivity index level can be defined as the weighted sum of firm productivity level at year *t*:

$$\mathrm{LnTFP}_t = \sum_{i=1,n} \theta_{it} \ln \mathrm{TFP}_{it} \tag{23}$$

where *i* indices plants, TFP is the translog index derived from Eq. (11), and θ_{it} is plant weight in industry-ISIC specific gross output. This formulation is interesting from the view of output reallocation across firms. In particular, if high productivity firms gain participation this will contribute positively to industry productivity growth even if no individual firm experiences a productivity increase. Following Olley & Pakes (1996), given any particular estimation of plant productivity levels, Eq. (23) decomposes in two terms:

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16 On this particular, productivity studies at firm or industry levels have introduced market failures and measured TFP through the inclusion of markups and imperfect competition [Hall (1988)], output scale [Nadiri & Schankerman (1981)], rate of return of regulation [Denny, Fuss, & Waverman (1981)], factor demand endogeneity and quasi-fixed inputs [Morrison (1986, 1988, 1992)], rate of installed capacity utilization [Fuss & Berndt (1986)], and entry, exit and turnovers [Olley & Pakes (1996), Griliches & Regev (1995), and Foster, Hatinwanger & Krisan (2001)]. For the case of Colombia a non-parametric measurement of TFP introducing imperfect competition through mark-ups and variable returns to scale for ISIC-group in manufacturing is in Pombo (1999b).

17 Melendez et al (2003) presents a TFP parametric estimation at plant level and groping results at 2-digits ISIC industry following Olley & Pakes methodology in Colombian manufacturing, which follows closely the study of Pavnick (1997) for Chile. These studies have the shortcoming of assuming continuous investment spending series at plant level that follows a first order Markov-process in firm's investment decisions given preceding shocks in productivity. This outcome is delivered implied in the parametric approach of Olley & Pakes. This methodology was designed to characterize the telecom equipment industry in the US where the assumption of continuous investment is realistic, in particular after market deregulation of the 1980s in the telecom industry. One fact that is common in manufacturing in developing economies is the deterministic characteristic of investment in fixed assets. The non-parametric approach overcomes the above problem although this methodology is less robust than any parametric estimation based on costs or production functions, because one is deriving the *dual* rather than the *primal* rate of technical change.

$$\text{LnTFP} = \sum_{i=1}^{N} [\bar{\theta}_t + (\theta_{it} - \bar{\theta}_t)][\overline{\ln \text{TFP}_t} + (\ln \text{TFP}_{it} - \overline{\ln \text{TFP}_t})$$

$$\text{LnTFP} = N_t \bar{\theta}_t \cdot \overline{\ln \text{TFP}_t} + \sum_{i=1}^{N_t} \Delta\theta_{it} \Delta \ln \text{TFP}_{it}$$

hence, $$\text{LnTFP} = \overline{\ln \text{TFP}_t} + \sum_{i=1}^{N_t} \Delta\theta_{it} \Delta \ln \text{TFP}_{it} \tag{24}$$

where $\overline{\ln \text{TFP}_t}$ is the mean productivity over all plants in year t and $\bar{\theta}_t$ is the plant share in year t. The second term of Eq. (24) represents the sample covariance between plant productivity and output. It follows that the larger the covariance is, the larger the share of more productive plants and therefore the higher industry-group productivity will be.

An alternative TFP decomposition focuses on the measurement of productivity growth according to entry dynamics following Griliches & Regev (1995). This decomposition defines the contributions of continuing firms, the difference in average between entering and exiting cohorts and reallocation of market shares into the TFP residual among all plants. In particular, if high productivity firms gain participation this will contribute positively to industry productivity growth even if no individual firm experiences a productivity increase. Taking differences of (13) one can express changes in productivity over time for a single plant *i* as

$$\theta_{t+1} \ln \text{TFP}_{t+1} - \theta_t \ln \text{TFP}_t = \left(\frac{\theta_t + \theta_{t+1}}{2} \right) \cdot \left(\ln \text{TFP}_{t+1} - \ln \text{TFP}_t \right) + \left(\frac{\ln \text{TFP}_{t+1} + \ln \text{TFP}_t}{2} \right) (\theta_{t+1} - \theta_t) \tag{25}$$

Eq. (25) says that the contribution of plant i to an industry productivity growth is the sum of two components: i) the weighted own productivity growth by market share, and ii) the change in its market share weighted its productivity average. If there is no entry or exit at time t and t+1, this implies that industry productivity will equal the sum of productivities over all plants given Eq. (4). An increase in market reallocation from low productivity to high productivity firms and/or a single firm productivity increase will explain industry productivity growth under this decomposition. Now, if entry or exit occurs the above-mentioned set up is not longer useful. The shortcut that Griliches & Regev (1995) proposed is to aggregate in a given two-year period all entrants (E) at year t+1 and all dying plants (D) at year t as a single firm with weight in output or sales $\theta_{E,t+1}$ and $\theta_{D,t}$ respectively. Aggregating over continuing firms and adding firm entrant and exit effects, industry productivity growth can be approximated by the following TFP decomposition equation:[18]

[18] We follow the notation used in the study of Aw, Cheng, & Roberts (2001).

$$\Delta \ln TFP = \left(\frac{\theta_{D,t} + \theta_{E,t+1}}{2}\right)\cdot\left(\ln TFP_{E,t+1} - \ln TFP_{D,t}\right) + \sum_{i=1,n}\left[\left(\frac{\theta_{it} + \theta_{i,t+1}}{2}\right)\cdot\left(\ln TFP_{i,t+1} - \ln TFP_{it}\right)\right]$$
$$+\left(\frac{\ln TFP_{E,t+1} + \ln TFP_{D,t}}{2}\right)\cdot\left(\theta_{E,t+1} - \theta_{D,t}\right) + \sum_{i=1,n}\left[\left(\frac{\ln TFP_{it} + \ln TFP_{i,t+1}}{2}\right)\left(\theta_{i,t+1} - \theta_{it}\right)\right] \quad (26)$$

The above formula decomposes an industry ISIC-group productivity growth in four parts: i) the turnover effect between entrants and dying firms, ii) the contribution of continuing plants, iii) the market share reallocation among entrants and existing firms, and iv) the market share reallocation from low to high productivity of continuing firms. The last two terms can be simply added to denote market share reallocation effect.

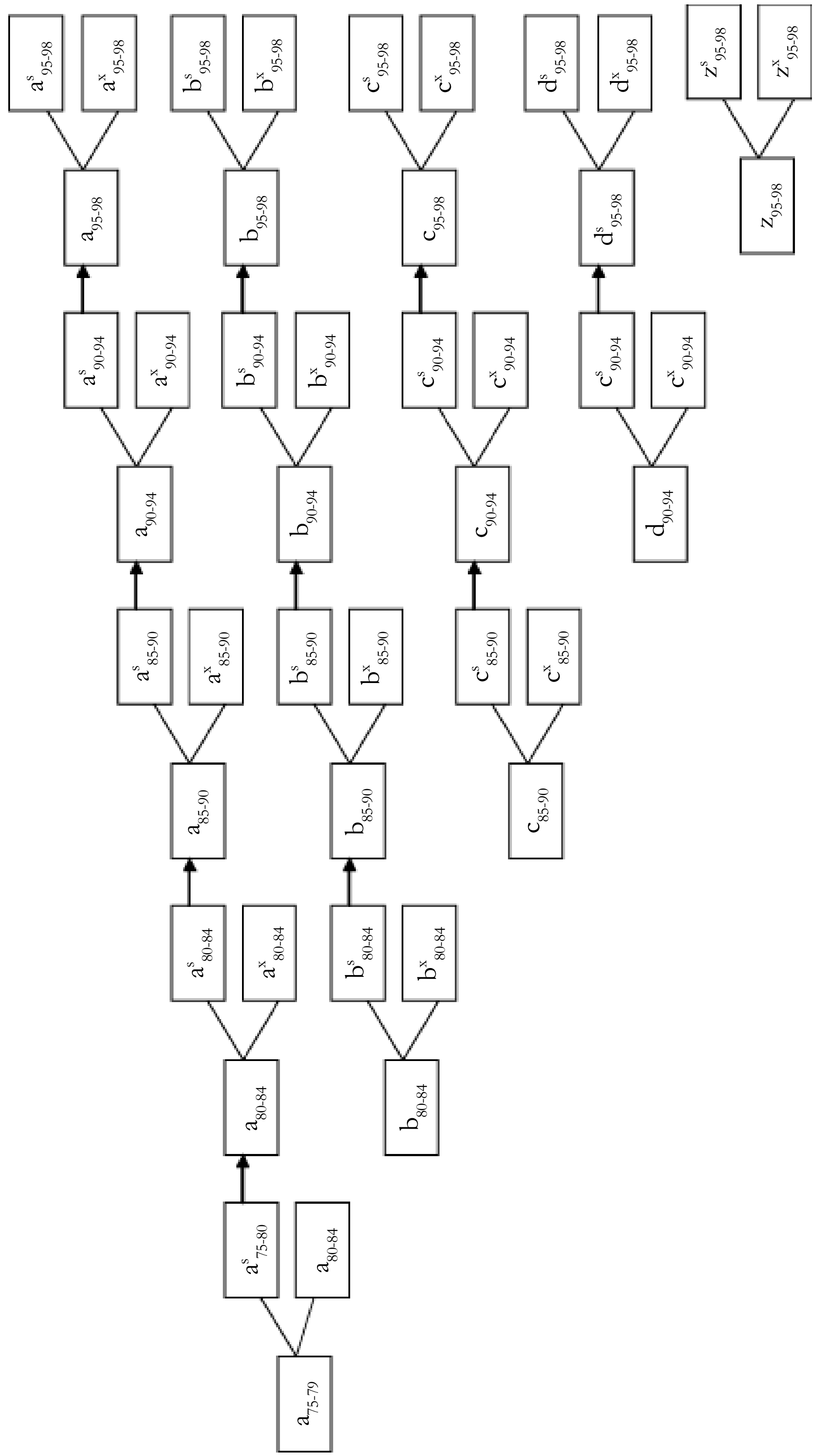
4.2 PRODUCTIVITY DIFFERENTIALS

Market entry influences industry cycles, restructuring processes, and transitions. This section presents a comparative analysis of productivity differentials between entering, incumbents, and dying plants, and across birth cohorts with the purpose of shedding light at the role of entrants in industry productivity. The goal is therefore to determine if productivity differentials reveal turnover patterns. The working panel, as mentioned, has a total of 623 petrochemical plants distributed between plastics and synthetic resins. The older plant in the panel started operations in 1933 and the younger ones did in 1995. Because we are working with continuous information since 1974 it was necessary to classify plants according to birth cohorts by five-year periods to simplify the analysis.

Diagram 2 draws the map of industrial plants based on the five-year period, entry cohort and transition status. There are five working cohorts from 1975 to 1998. The chart flow has five layers indicating what the plant cohorts are. Plants might belong to cohorts *a, b, c, d*, and *z*. Each cohort has assigned a subscript of five-year period. Thus plants belonging to the first cohort (*a*) are those plants founded before 1979. They split in two groups. The surviving plants that report data for the next period, and the dying plants that exit the market during the period. They are marked with the superscript *S* and *X* respectively. The second layer indicates the plants that were born between 1980 and 1984. Thus the staked data in the panel within this period have records from plants from the first and second cohorts (*a* and *b*). Again plants might survive or exit the market regardless their cohort. Surviving plants from the cohorts (*a*) and (*b*) will have records in the next period [1985-1989]. At the same time new plants enter in the market within the period and are grouped as cohort (*c*). The reading of the entry and exit flows continues in the same manner up to the last cohort/period, which has plants from all five cohorts.

Testing productivity differentials lead to contrasting differences in total factor productivity and labor productivity based on the above-mentioned structure of plant cohorts and entry status. Firm selection theory [Jovanovic (1982), Audretsch (1995)] predicts that entrants are more productive than incumbents and they catch-up minimal efficiency scales to industry benchmarks. Thus, TFP levels in the short-run must be higher for entrants and these are the hypotheses behind the structure of Diagram 2. We carried out three exercises. The first one contrasted productivity between surviving and exiting plants that belong to the same birth-cohort by means

Diagram 2 - Entry cohorts and transition status



of testing changes in means and medians. These tests depict the direction that a firm performance variable such as productivity takes within a given sample. The test on medians evaluates proxy distribution shape through the non-parametric Wilcoxon rank-sum test.[19]

Table 6 summarizes the results of this exercise. The sample size (N) is equal to plant-year observations according to birth cohort. Incumbents are individuals that report for the entire period, entrants are successful births for any given period that are still active by 1998, and exiting plants are those that shut down operations within a given period. Thus, incumbents and entrants in this context form the surviving plants.[20] Differences in total productivity levels given by the TFP translog indices are statistically significant at 1 percent level for the first three cohorts. The mean (median) difference between surviving and exiting plants is 17 (11.5) points for cohort I, 42 (13.2) points for cohort II, and 26 (6.3) for cohort III. In contrast, for cohort IV we cannot reject the hypothesis of no productivity differentials. The outcomes for labor productivity are robust and go in the same direction. On average labor productivity is higher in surviving plants but the difference tends to close over time. For instance the mean (median) is $26.9 ($7.1) millions per worker/year for cohort I, $8.4 ($2.6) millions for cohort II, and $2.8 ($2.3) millions for cohort III. The mean labor productivity differential for cohort IV raises but not its median, which remains almost constant ($2.9 millions).[21] The differences are significant at 5% level.

The second implication of the firm selection model further restricts the test on productivity differentials. In particular, if surviving firms are in fact more efficient over time, is there a difference between incumbents and successful entrants? TFP growth showed a long run rate of 5% per year for entrants and 1.9% per year for incumbent plants. From the perspective of entry flows they indicate that a successful entrant at time t becomes an incumbent firm at time $t+1$. Then with time passing older entrants' productivity first catch up with industry benchmarks and then turn into newly incumbents. This process characterizes the formation of generations of entrepreneurs. In the case of petrochemicals in Colombia it is clear that the industry entry patterns indicate that at least two generations of entrepreneurs were created. The older incumbents that started up from the 1950s to the 1970s and the successful entrants after 1980 located mainly within the plastic industry.

Table 7 presents the results of testing productivity differentials between entrants and incumbents plants by cohort that takes into account entry dynamics where entrants at period t, turn out incumbents at period $t+1$. The sample size (N) consists of plant-year observations where the maximum number of records for each plant within a given cohort/period, are 5

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[19] Wilcoxon's test has several versions. The one that is implemented in STATA software is the extension of Mann-Whitney (1947) about rank sum tests. See Sprent & Smeeton (2001) for further explanation on tests for two independent samples.

[20] For instance, the table report 2195 plants for cohort I. Among them there are plants founded since 1933 up to 1979. Plants founded in 1978 or 1979 that are still reporting by 1998 are the entrants of this cohort. Plants that report from or before 1977 to 1998 are the incumbents. Exiting plants are the units that fail within the 1974-1979 period. Recall that in all cases the first observation is 1974. The total number of surviving plants of this cohort are 91 while dying plants are 61.

[21] Notice that there is not exiting plants for cohort V. This is a result of the truncation derived from the conditions imposed to all units in the final-panel in order of not being classified as a volatile plant as explained in section 3.2.

TABLE 6

PRODUCTIVITY LEVEL DIFFERENTIALS BETWEEN EXITING AND SURVIVING PLANTS BY COHORT PEARSON AND WILCOXON RANK-SUM TESTS

Cohorts	N^X plants^X	N^S plants^S	TFP^X mean median	TFP^S mean median	t-stat z-stat	N^X plants^X	N^S plants^S	PPL^X mean median	PPL^S mean median	t-stat z-stat
Cohort I										
1974-1979	903	2.195	126,1	143,1	-5,47 [a]	902	2.196	22.561	49.533	-5,85 [a]
	61	91	110,5	122,0	-5,08 [a]	61	91	15.169	22.270	-10,65 [a]
Cohort II										
1980-1984	391	934	125,9	167,8	-4,97 [a]	385	935	20.108	28.529	-2,42 [a]
	39	55	109,8	123,1	-5,99 [a]	39	55	13.000	15.640	-5,39 [a]
Cohort III										
1985-1989	346	989	106,7	132,8	-4,03 [a]	344	993	19.647	22.451	-1,21
	54	84	100,0	106,3	-4,22 [a]	54	84	10.923	13.241	-2,64 [a]
Cohort IV										
1995-1998	69	969	125,7	118,0	1,17	69	968	13.762	27.032	-2,04 [b]
	15	147	100,1	104,9	-0,70	15	147	10.626	13.516	-2,40 [b]
Cohort V										
1995-1998		273		109,6			272		26.932	
		77		100,0			77		14.930	

Notes: X= exiting plants; S=surviving plants. TFP is the translog index of TFP where entry date = 100, PPL = PPL= VA/L, in thousand of pesos at 1998 prices per worker per year. N= Number of observations are firm-year observations. The panel is an unbalanced time series-cross section dataset. Plants= Number of plants or individuals within the panel by cohort and entry dynamics; a= statistically significant at 0.01; b= statistically significant at 0.05; c= statistically significant at 0.1; DUM1= dummy variable to test changes in average TFP and labor productivity between exiting and surviving plants by cohort. The variable takes the value of 1 if marked as an exiting plant. They can be either former incumbents for the first cohort or entrants in successors cohorts. Survival firms are plants, which are successful entrants or survival incumbents. Incumbents in the study are defined as reporting plants for the 1974-1998 period. Methodology: t-tests = Ho: mean(x)-mean(s) =difference=0; z-test= Ho: median(x)=median(s)

observations, where the number of incumbents increases over time. It began with 78 plants for cohort I, and ends up with 377 plants in the last cohort. Three results are worth mentioning. First, productivity levels given by the average value across plants of the TFP translog indices follow a concave function reaching a local maximum with an index value of 154 during the 1990-1994 period.

This means that TFP in surviving plants grows faster during their first years of operations and then slows down. New firms shift out industry TFP levels but the productivity growth exhibits decreasing rates because of productivity decreases with entrants' ageing. Second, total factor or labor productivity differences between new-births and incumbents become significant after the effect of firm entry of the first cohorts takes place on overall industry productivity. That is, entry penetration induces productive plants to lead industry productivity and to generate a reallocation effect toward younger firms in the industry. The result also suggests that there is an initial disadvantage in scale efficiencies of new plants with respect to incumbents. They are smaller plants that cannot exploit internal economies of scale. The above differences are significant at 5% level. Third, the hypothesis of no entry differentials is consistently rejected across cohorts at 1% level.

TABLE 7

PRODUCTIVITY LEVEL DIFFERENTIALS BETWEEN INCUMBENT AND ENTERING PLANTS BY COHORT AND YEAR

PEARSON, WILCOXON RANK-SUM, AND F-TESTS

Cohorts	N^E	N^I	TFP^E	TFP^I	t-stat	N^E	N^I	PPL^E	PPL^I	t-stat	F-Statistic	
	$plants^E$	$plants^I$	mean	mean	z-stat	$plants^E$	$plants^I$	mean	mean	z-stat	No entry differential	
			median	median				median	median		TFP	PPL
Cohort I												
1974-1979	25	442	116,7	112,6	0,53	25	442	15.588	22.212	-1,15	2.116,0 [a]	143,4 [a]
	13	78	100,0	104,1	-0,31	13	78	12.880	12.817	0,09		
Cohort II												
1980-1984	164	454	121,5	126,1	-0,85	165	455	33.106	23.578	-0,29	1.342,5 [a]	83,5 [a]
	55	91	102,1	118,4	-2,52 [b]	55	91	22.826	13.068	-7,07 [a]		
Cohort III												
1985-1989	233	730	109,2	153,8	-6,81 [a]	237	730	14.791	43.766	-3,48 [a]	1.322,5 [a]	58,4 [a]
	84	146	100,0	129,4	-9,83 [a]	84	146	10.429	19.896	-11,12 [a]		
Cohort IV												
1990-1994	381	1.150	107,1	153,9	-6,87 [a]	380	1.150	21.350	43.766	-3,12 [a]	1.195,0 [a]	114,3 [a]
	147	230	100,0	129,4	-9,41 [a]	147	230	11.554	19.896	-8,90 [a]		
Cohort V												
1995-1998	273	1508	109,6	153,9	-5,52 [a]	272	1.508	26.932	44.542	-2,36 [a]	1.338,4 [a]	119,5 [a]
	77	377	100,0	122,7	-6,98 [a]	77	377	14.930	20.032	-6,03 [a]		

Methodology

DUM2 = Dummy to test changes in means by cohort between successful entrants and incumbents by cohort. The dummy variable that takes the value of 1 if the plant is marked as an ENTRAND, 2 if is an INCUMBENT in the sample for the T-tests evaluations. Entrants t-1 = Incumbents t by five year period. The observations are 5 per plant. E= entrants; I=Incumbents; TFP = translog index of total factor productivity where entry date = 100, PPL = Labor partial-productivity expressed in thousand of pesos at 1998 prices per worker per year; N= Number of observations are firm-year observations. The panel is an unbalanced time series-cross section dataset; Plants= Number of plants or individuals within the panel by cohort and entry dynamics. a= statistically significant at 0.01; b= statistically significant at 0.05; c= statistically significant at 0.1; T-tests = Ho: mean(E)-mean(I) =difference=0; z-test= Ho: median(E)=median(I). F-test:

$$Y = \beta_1 DUMMY1_{it} + B_2 DUMMY2_{it} + \varepsilon_{it}$$

where: Y = TFP or PPL; Dummy1 = 1 if i is an entrant, zero otherwise; dummy2 = 1 if i is an incumbent, zero otherwise.

The null is:

$$H_0 : \beta_t^I = \beta_t^E = \beta_{t-1}^I = \ldots\ldots = \beta_{t-5}^I = \beta_{t-5}^E$$

Source: Own estimations based on DANE-EAM

The third exercise in testing productivity differentials focuses on the role of turnovers of industry productivity. Table 8 reports the results of TFP level decomposition between the unweighted average productivity and sample covariance between productivity and output following the methodology of Eq. (25). This measurement is done for the 13 five-digit groups within petrochemicals. The covariance term captures the reallocation of fixed factors toward more productive plants. Thus, the larger this covariance is, the higher the share of more productive plants/firms in industry output, and the higher industry productivity becomes.

TABLE 8

OLLEY AND PAKES PRODUCTIVITY LEVELS DECOMPOSITION BY PERIODS AND INDUSTRY GROUPS

ISIC Group	Period	Aggregate Level	Unweighted Mean Level	Covariance	ISIC Group	Aggregate Level	Unweighted Mean Level	Covariance
		Ln TFP	$\overline{\ln TFP_t}$	$\sum_f \Delta\theta_{ft}\cdot\Delta LnTFP_{ft}$		Ln TFP	$\overline{\ln TFP_t}$	$\sum_f \Delta\theta_{ft}\cdot\Delta LnTFP_{ft}$
Synthetic Resins								
3513	75-79	0,0030	-0,0223	0,02527	35603	-0,0016	0,0220	-0,0236
	80-89	0,1353	0,1196	0,01566		0,2585	0,2586	-0,0001
	90-98	0,2649	0,2623	0,00257		0,8282	0,7568	0,0714
	75-98	**0,1581**	**0,1453**	**0,01275**		**0,4274**	**0,4056**	**0,0218**
35132	75-79	0,0055	-0,0083	0,01379	35604	0,0647	0,0208	0,0439
	80-89	0,1807	0,1843	-0,00361		0,3167	0,3038	0,0129
	90-98	0,2607	0,2561	0,00461		0,2770	0,2805	-0,0035
	75-98	**0,1774**	**0,1743**	**0,00310**		**0,2621**	**0,2489**	**0,0132**
35133	75-79	0,0668	0,0892	-0,02240	35605	0,0040	-0,0061	0,0101
	80-89	0,1725	0,1633	0,00922		0,2218	0,1528	0,0690
	90-98	0,1521	0,1581	-0,00593		0,2470	0,2575	-0,0105
	75-98	**0,1492**	**0,1523**	**-0,00305**		**0,1920**	**0,1650**	**0,0269**
35134	75-79	-0,2032	-0,2033	0,00016	35606	0,0119	-0,0061	0,0180
	80-89	-0,1554	-0,1624	0,00693		0,1609	0,1528	0,0081
	90-98	0,4624	0,4311	0,03135		0,2592	0,2575	0,0018
	75-98	**0,0594**	**0,0447**	**0,01468**		**0,1728**	**0,1650**	**0,0078**
35135	75-79	-0,0131	-0,0131	0,00000	35607	0,1216	0,1140	0,0076
	80-89	0,0947	0,0660	0,02872		0,1978	0,1918	0,0060
	90-98	0,0622	0,0569	0,00525		0,2941	0,2739	0,0203
	75-98	**0,0606**	**0,0467**	**0,01393**		**0,2232**	**0,2115**	**0,0117**
Plastics								
3560	75-79	0,0895	0,0751	0,01440	35608	.	.	.
	80-89	0,2800	0,2696	0,01039		-0,0967	-0,0967	0,0000
	90-98	0,3637	0,3529	0,01076		0,1215	0,1147	0,0069
	75-98	**0,2815**	**0,2701**	**0,01136**		0,0788	**0,0762**	0,0026
35601	75-79	0,0974	0,0939	0,00355	35609	0,1004	0,0813	0,0191
	80-89	0,2272	0,2259	0,00127		0,1778	0,1885	-0,0107
	90-98	0,2875	0,2731	0,01435		0,2570	0,2519	0,0051
	75-98	**0,2322**	**0,2256**	**0,00665**		0,1951	**0,1937**	0,0014
					Petrochemicals			
35602	**75-79**	**0,2167**	**0,1575**	**0,05915**		0,0888	0,0677	0,0211
	80-89	0,3687	0,3896	-0,02098		0,2672	0,2587	0,0086
	90-98	0,6567	0,6346	0,02208		0,3589	0,3475	0,0114
	75-98	0,4603	**0,4485**	0,01186		**0,2736**	**0,2614**	**0,0122**

Methodology: Olley & Pakes (1996) total productivity levels decomposition.
Sources: Own estimations based on EAM-DANE

Several comments stand out. First, the *unweighted mean* or *between* productivity level increases over the 25 years span within all sub-groups in plastics and synthetic resins. As long as group-specific TFP average levels increase, this indicates that productivity improves across plants generating a rightwards movement of industry's TFP distribution.[22] Second, there are more

[22] These results are not strictly comparable with the traditional TFP translog indices by ISIC five-digits groups because they are weighted by construction. The weights differ because for the traditional growth accounting decomposition output weights are relative to input spending at plant or ISIC group levels. The Olley & Pakes (1996) decomposition as well as similar methodologies such as Foster, Haltinwanger, & Krizan (2001) TFP indices are weighted by plant output or sales market shares at specific industry sub-group level.

cases where the covariance term is positive across petrochemical groups/periods than there are negative. In particular, 40 out of 63 group five-digits/periods had positive covariance rates, meaning that output reallocation within more productive plants took place in this industry. The average covariance level for petrochemicals for the 1975-1998 period was 1.2%. The highest covariance level took place in the plastic bottles, packaging, and boxes industry (ISIC-35605) with 2.7% long run covariance level. The second highest was located in the plastic products for house ware uses industry (ISIC-35603) with 2.3% covariance level. The lowest was located in manufactures of cellulose and vulcanize-fibers industry (ISIC-35133) with a -0.3% covariance level. These numbers are low in contrast to results of other case studies. For instance, Aw, Cheng & Roberts (2001) found for the Taiwanese chemical industry for three census years (1981, 1986, 1991) an average covariance level of 14.8%. Pavnick (2002) reports for the chemical industry in Chile an average covariance level 21.8% for the 1979-1986 period. Olley & Pakes (1996) report for the telecommunication equipment industry in the US for the 1974-1987 period an average covariance level of 17.3%.

Third, the covariance explained, on average across sub-groups/periods, 10% of total factor productivity level. The remaining 90% is the contribution of mean productivity level. For the chemical industry in Taiwan the distribution was 57% for covariance and 43% the mean TFP, while in Chile the contribution of the covariance was greater than the mean TFP to total productivity level in the chemical industry. Olley & Pakes (1996) report a covariance contribution of 18% to total productivity levels within the telecommunication equipment industry.

Table 9 reports the results of technical change decomposition exercise following Griliches-Regev methodology [Equation 26]. This decomposition captures the contribution of continuing plants, the net entry effect and market share reallocation into the TFP growth rates. Each component is reported in the last four columns in the table. Several are the results worth mentioning. First, productivity of continuing firms is the main source of TFP growth across petrochemical industry-groups. Their contribution is in both directions. Improvements in incumbent's efficiency will reflect gains in overall industry productivity as well as productivity deterioration will end up in industry's efficiency losses. The former is the case for plastics and its products, while the latter describes the case of synthetic resins.

The minimum contribution of continuing plants to the TFP growth industry within plastics was 55% located in the manufacture of plastic shoes ant their parts [ISIC 35607].

The other plastic industry-groups the contribution is greater than 87% of TFP growth. In most cases the sign of TFP growth rate of continuing firms matches to industry-specific productivity growth. In contrasts, productivity deterioration of incumbent plants shifted down productivity within the synthetic resins industry. Efficiency of continuing plants decreases in all four groups exhibiting long run negative growth rates.

The above results are consistent with other international studies of productivity that use similar decompositions. For instance, Aw, Cheng & Roberts (2001) report an average accumulated TFP growth rate for the plastic industry of 12% and 11.8% between census periods of 1981, 1986 and 1991. Continuing plants contribution were 7.1 and 8.0 percentage points respectively. That is an average contribution of 63%. Liu & Tybout (1996) report technical effi-

TABLE 9

GRILICHES - REGEV TFP GROWTH DECOMPOSITION BY FIVE-YEAR PERIODS

ISIC Period	TFP Growth	Continuing Plants	Entrants vs Exiters Cohorts	MSR Continuing Plants	MSR Entrants vs Exiters	TFP Growth	Continuing Plants	Entrants vs Exiters Cohorts	MSR Continuing Plants	MSR Entrants vs Exiters
ISIC-35132						**ISIC-35605**				
75-79	0,0017	-0,0208	0,0000	0,0161	0,0064	0,0576	0,0471	0,0036	0,0041	0,0027
80-84	0,0056	-0,0004	0,0000	0,0059	0,0001	0,0354	-0,0555	-0,0035	0,0931	0,0014
85-89	0,0235	0,0473	-0,0097	-0,0128	-0,0013	-0,0217	0,0168	-0,0013	-0,0416	0,0044
90-94	-0,0049	-0,0124	0,0038	-0,0010	0,0048	-0,0599	0,0211	-0,0242	-0,0568	0,0000
95-98	-0,0249	-0,0432	-0,0001	0,0182	0,0003	0,0077	-0,0124	-0,0053	0,0231	0,0023
75-98	0,0013	-0,0044	-0,0013	0,0047	0,0021	0,0036	0,0041	-0,0062	0,0036	0,0022
ISIC-35133						**ISIC-35606**				
75-79	0,0172	0,0208	0,0000	-0,0058	0,0022	0,0416	0,0339	0,0007	0,0072	-0,0002
80-84	-0,0436	-0,0519	0,0000	0,0083	0,0000	-0,0150	-0,0173	0,0026	0,0001	-0,0004
85-89	0,0124	0,0074	0,0000	0,0050	0,0000	0,0156	0,0261	-0,0033	-0,0016	-0,0056
90-94	0,0456	-0,0248	0,0109	0,0594	0,0000	0,0340	0,0440	0,0021	-0,0215	0,0094
95-98	-0,0534	-0,0491	0,0000	-0,0044	0,0000	-0,0040	-0,0229	0,0000	0,0189	0,0000
75-98	-0,0023	-0,0183	0,0023	0,0132	0,0005	0,0152	0,0143	0,0004	-0,0002	0,0007
ISIC-35134						**ISIC-35607**				
75-79	-0,0764	-0,0753	0,0000	-0,0011	0,0000	0,0368	0,0368	0,0000	0,0000	0,0000
80-84	-0,0644	-0,0761	0,0000	0,0116	0,0001	-0,0116	-0,0128	0,0001	0,0009	0,0002
85-89	0,0094	0,0027	0,0000	0,0067	0,0000	0,0367	0,0120	0,0288	0,0450	-0,0492
90-94	0,1327	0,0153	0,0000	0,1169	0,0004	0,0019	0,0132	-0,0388	0,0416	-0,0141
95-98	-0,0958	0,0127	0,0000	-0,1087	0,0002	0,0237	-0,0040	0,0032	-0,0008	0,0253
75-98	-0,0157	-0,0257	0,0000	0,0099	0,0001	0,0172	0,0096	-0,0015	0,0181	-0,0089
ISIC-35135						**ISIC-35608**				
75-79	-0,0252	-0,0213	0,0000	-0,0026	-0,0013	.	.	.	.	.
80-84	0,0461	-0,0053	0,0000	0,0489	0,0024	.	.	.	.	.
85-89	-0,0037	-0,0025	0,0000	-0,0012	0,0000	-0,1000	-0,0274	0,0000	-0,0484	-0,0242
90-94	-0,0124	-0,0205	0,0003	0,0078	-0,0001	0,0280	0,0280	0,0000	0,0000	0,0000
95-98	0,0236	0,0120	0,0215	-0,0087	-0,0012	0,1129	0,0837	0,0036	0,0215	0,0041
75-98	-0,0026	-0,0169	0,0001	0,0141	0,0002	0,0356	0,0382	0,0013	-0,0010	-0,0029
ISIC-35601						**ISIC-35609**				
75-79	0,0416	0,0300	0,0047	-0,0013	0,0082	0,0216	0,0138	-0,0013	0,0101	-0,0009
80-84	0,0279	0,0293	0,0007	-0,0020	-0,0001	-0,0065	0,0264	0,0056	-0,0310	-0,0076
85-89	-0,0051	0,0000	0,0012	-0,0063	0,0001	0,0212	0,0209	-0,0021	-0,0016	0,0039
90-94	-0,0258	-0,0107	-0,0117	-0,0046	0,0012	0,0417	0,0300	0,0000	0,0116	0,0002
95-98	0,0421	0,0210	0,0002	0,0208	0,0001	0,0236	0,0120	0,0215	-0,0087	-0,0012
75-98	0,0151	0,0136	-0,0010	0,0005	0,0020	0,0202	0,0210	0,0040	-0,0037	-0,0011
ISIC-35602						**Resins (3513) Cross Industry Average**				
75-79	0,1023	0,0653	0,0000	0,0413	-0,0043	-0,0207	-0,0242	0,0000	0,0017	0,0018
80-84	-0,0054	0,0249	0,0012	-0,0314	0,0001	-0,0141	-0,0334	0,0000	0,0187	0,0007
85-89	-0,0024	0,0180	0,0002	-0,0206	-0,0001	0,0104	0,0137	-0,0024	-0,0005	-0,0003
90-94	0,0730	0,0385	0,0008	0,0338	-0,0001	0,0402	-0,0106	0,0038	0,0458	0,0013
95-98	-0,0724	-0,0776	0,0001	0,0051	0,0000	-0,0376	-0,0169	0,0053	-0,0259	-0,0002
75-98	0,0228	0,0176	0,0005	0,0056	-0,0009	**-0,0048**	**-0,0163**	**0,0003**	**0,0105**	**0,0007**
ISIC-35603						**Plastics (3560) Cross Industry Average**				
75-79	-0,0125	0,0236	-0,0053	-0,0295	-0,0013	0,0391	0,0316	0,0004	0,0066	0,0006
80-84	-0,0226	0,0118	-0,0046	-0,0291	-0,0006	0,0028	0,0011	0,0003	0,0023	-0,0008
85-89	0,0919	0,0946	-0,0040	0,0023	-0,0010	0,0077	0,0219	0,0022	-0,0084	-0,0079
90-94	0,2180	0,1087	-0,0010	0,1103	0,0001	0,0267	0,0286	-0,0111	0,0090	0,0001
95-98	-0,0130	-0,0105	0,0007	-0,0034	0,0002	0,0173	0,0025	0,0025	0,0086	0,0036
75-98	0,055092	0,047975	-0,003	0,010691	-0,00057	**0,0213**	**0,0197**	**-0,0012**	**0,0038**	**-0,0009**
ISIC-35604										
75-79	0,0237	0,0020	0,0006	0,0207	0,0003					
80-84	0,0204	0,0023	0,0002	0,0176	0,0004					
85-89	0,0334	0,0361	0,0001	-0,0031	0,0003					
90-94	-0,0708	-0,0154	-0,0268	-0,0332	0,0046					
95-98	0,0348	0,0335	-0,0014	0,0014	0,0013					
75-98	0,0072	0,0108	-0,0056	0,0006	0,0014					

Source: Own estimations base on Dane-EAM
Methodology: Griliches-Regev (1995) productivity decomposition

ciency decomposition between incumbent and turnover effect in five major ISIC 2-digits manufacturing groups for Colombia during the 1979-1986 period. The cross industry average of TFP growth across was 1.63% per year. Incumbents grew 1.49% and the remainder is due the turnover effect.[23] Griliches & Regev (1995) report a labor productivity (LP) growth decomposition between the within effect (incumbents) and the mobility effect (market share reallocation) for the Israeli manufacturing by industry-specific 3 digits-ISIC codes for the 1979-1988 period. For instance, the average growth of LP for other chemical was 7.1%. The within effect accounted for 6.8% percentage points out the total growth.[24]

Balwing & Gu (2002) present an analysis of labor productivity growth decomposition for Canadian manufacturing following Griliches-Regev (1995) approach. They report an average labor productivity growth and its components for two periods: 1979-1988 and 1988-1997. Average LP growth and the within-plant effect in each of these periods were: 1.16% (1.10%), 1.13% (1.09%) for plastics, and 2.41(1.40%), and 2.74% (2.59%) for the chemical industry. Baily, Hulten & Campbell (1992) undertook a complete analysis of productivity dynamics at plant level for 23 US industries based on five manufacturing census years (1972, 1977, 1982, 1987). They broke TFP growth as the sum of continuing plants, output reallocation across incumbents and net entry (turnover). They found for instance that for all industries the growth of TFP and the incumbent effects between censuses were: 7.17% (5.04%), 2.39 (-1.09), and 15.63% (13.52%) respectively.[25]

Second, market share reallocation across continuing plants constitutes an important source of productivity growth. This outcome implies that there was an effective substitution of resources toward more productive plants across petrochemical-groups. This source was more dynamic within synthetic resins in contrast to plastics subgroups. The long run growth rate was 1.1% within resins and 0.4% within plastics per year. This finding is important because in the former case TFP growth across subgroups had a negative rate of –0.48% per year for the entire period of 1975-1998. In this case productivity deterioration would have been greater if there were not such increase in market share of the more productive plants.

Third, the contribution of the turnover effect to TFP growth is low across petrochemical groups. The growth rate differentials in productivity between entering and exiting plants across periods/groups range from –0.09% (2.1%) in resins and –3.8%(2.8%) in plastics. This outcome reflects two facts. On one hand, there are not significant productivity differentials between entry and exiting plants. The result is consistent with the results of section 4.2;

[23] The manufacturing sectors included in Liu & Tybout (1996) study for Colombia were: Food (0.63%; 0.60%), Textiles (6.4%; 6.5%), Footwear (2.1%; 1.7%), Wood Products (-0.14%; -0.30%), Metal Products (-0.92%, -1.01%). Numbers in parenthesis indicate the average industry-specific TFP growth rate and continuing plants TFP growth rate for the whole period. For more details see table 4.2.

[24] Average labor productivity growth and the within effect were 0.04% (-1%) for plastics, and 5.3% (4.5%) for basic chemicals for the same period (figure 5, pp. 185). It is implicit that other chemicals include the petrochemical branches excepting plastics.

[25] The only chemical subgroup included in this study was inorganic or basic chemicals that include the manufacture of acids, urea, sulfates, etc. TFP growth and incumbents' TFP growth across censuses were: 5.7% (1.28%), -13.24% (-19.96%), and 10.57% (7.75%).

entrants (exiters) tend to have less scale economies than incumbents. Once entrants become incumbents or survive as time passes they do a catching up with industry's productivity benchmarks. The result in the plastic industry for instance was that successful entrants shaped plant minimal efficient scales as well as total productivity. Nonetheless, this happened once entrants matured and became new established firms. In other words, productivity improvements that occurred following entry showed up as productivity improvements of the continuing plants.[26] This result also reflects the low entry penetration rate documented in the first section. It is a common fact that entrants for any given year have a low market share with respect to the incumbent plants.

On the other hand, differences in market shares between entrants and exiters is also negligible, therefore their contribution to TFP growth is too low in most petrochemical groups. The cross industry average for the entire period of this component is 0.07% in resins, and in plastics is –0.09% per year. Despite the above, the turnover effect is important across subgroups for specific periods. There are 10 out of 43 periods were the negative rates of TFP growth were partially offset by positive changes in turnovers within the plastic industry. For instance, productivity growth in the manufacture of plastic shoes industry group [ISIC 35607] was 2.37% for the 1995-1998 period. The differential in market shares explained 2.53% points for that period.

Summarizing, the effect of output reallocation to enhance total factor productivity levels and growth in petrochemicals was low for the analyzed period. This is a consequence of low entry penetration rates. The share of entrants into industry output was less than 10% for all sub-groups excepting in ISIC-35135 [Table 3]. Nonetheless, the measurement of the TFP translog indices showed a substantial difference in productivity levels and growth rates between incumbents and successful entrants as a whole. Plants that were born after 1977 shaped industry productivity levels by the 1980s and 1990s but once they became incumbents the output share of new plants did not steadily increase over time to boost penetration rates. The next section presents the econometric analysis of entry rates determinants in the petrochemical industry as a function of entry barriers and market incentives to entry.

V. THE ECONOMETRICS OF INDUSTRY ENTRY RATES

The general model used in this work to explain the determinants of plant entry in the petrochemical industry is borrowed from Orr's seminal paper. That approach has been extensively employed in international research on determinants of entry.[27] Following Khemani & Shapiro (1986), the entry equation is given by

$$\text{LogEntry}_{it} = f(X_{1,i,t-1_{it}}, \text{BTE}_{i,t-1}, X_{2;i,t-1}) + \varepsilon_{it} \tag{27}$$

[26] These results mirror previous ones that use annual data such as the studies for Israel, Canada, Chile and Colombia. Inter-census studies also confirm that the incumbent effect dominates the turnover effect. The exception is the study for Taiwan where productivity differentials between entrants and exiters constitute and important source of TFP growth. For instance, Aw et al. (2001) report for the Taiwanese chemical industry an accumulated TFP growth of 11.9% among censuses. Productivity differentials account for 3.85% out of this total.

[27] Appendix 2 [Table A2.1] lists the main econometric studies on firm entry done since Orr's 1974 paper.

where: *Log Entry* is the gross number of plant/firms that entered each petrochemical group between 1975 and 1998. However, we do not do not observe the type of entry due to new startups, new plant acquisitions, or mergers. Following Mata (1993) and Roberts & Thompson (2003), we add one to the number of (gross) entrants before doing the logarithmic transformation.[28] X_1 is a vector of variables that controls for incentives to enter, *BTE* stands for those variables that are barriers to entry, and X_2 is a vector of complementary variables that have been found to be important in explaining entry in international studies. Again all variables are at 12 ISIC specific petrochemical groups for the 1975-1998 period.[29] Further variable definitions and their expected signs are shown in Appendix 2 [Table A2.2].

The vector of X_1 regressors is composed mainly by two variables, commonly used in the literature. The first one is the annual growth of the price-cost margin (*gPCM*) of industry lagged one period. It proxies observed profitability, and as Orr (1974) stated, it reflects the extent to which economic rents have been captured by existing firms. The second variable is the market room (*MROOM)*. It captures the effect that entry is more likely to occur whenever there have been industry growth. We follow the definition of Rosenbaum & Lamort (1992). The *BTE*-vector is composed of some variables used in Orr-type models and one should expect all of them to be negatively related to entry. The first one is advertising intensity. It is measured as the ratio of the spending in advertising to value added. The second barrier to entry variable is a proxy for technology. It is defined as the ratio of expenses of royalties paid by firms in industry *i* to the value added of that industry (*ROY*). BTE variables that are determined by structural characteristics were also included. The first one is called *Scale*, and proxies the extent of economies of scales in industry *i*. It is a composed variable defined as the ratio of minimum efficient scale over the cost-disadvantage ratio. A second structural variable is the log of the capital-to-output ratio *(Log KOR)*. The last variable is the dependence of imported raw material (*DMRM*). This proxy is included because the domestic petrochemical industry has been heavily dependent on imported raw material despite the fact they were thought to be substituting petrochemical inputs. It is not a variable included in any of the studies reported in appendix 2, and since the access and the associated costs of imported inputs have been commonly difficult, one should expect it to be negatively correlated with entry.

The X_2 vector is formed mainly by idiosyncratic variables as well as other variables found relevant in the mainstream literature. The first idiosyncratic is the building and construction GDP growth (*GROCONS*). The two 4-digit petrochemical industries represent the upstream and downstream links of a branch of petrochemicals. Their main user of those (final) goods has been the Colombian building and construction industry. Then, one should expect that as the rate of growth of building increases, so does entry and vice versa. The second variable included in this set is the translog indices of total factor productivity (*TFP*), which captures industry weighted average productivity levels. Although not idiosyncratic to petrochemicals, it is a variable that has not been employed previously in any of the studies above reported. The insight

[28] A total of 120 cases of no entry were recorded during the period under study.

[29] The number of ISIC-five-digits industries is 12 since ISIC 35608 was excluded from the sample. The main reason is that the number of plants in this plastic-subgroup is extremely low (three) and in fact is an outlier. In addition, times series start after 1987.

with TFP indices is that industries with better total factor productivity are those where inefficient firms are very likely to drop the market and then open room to new entrants. Three additional variables are the proxy for risk, an industry concentration index, and a measure of the fringe in each industry *i*. For the first one, we employ the standard deviation of the price-cost-margin (*RISK*), the second the Herfindal concentration index (*HH*), and the last one is fringe competition (FRINGE) that is constructed following the methodology of Rosenbaum & Lamort (1992): the percentage of firms with fewer than 50 employees. This variable is meant to capture the relative size of the fringe in an industry and it is expected that the larger the fringe the higher the entry. Last, since the study by Shapiro & Khemani (1987), it has been acknowledged that the displacement effect (or the effect that new entry generates exit and vice versa) must be included in the determinants of entry. In that direction, recently, Roberts & Thompson (2003) introduced both past exit (NX_{t-1}) and past entry (NE_{t-2}) into the determinants of entry. The rationale is that past exit open room while past entry could "*capture some omitted height of entry barriers effect*". Therefore, the expected sign of those variables is positive. All the variables were lagged one period.

The studies listed in appendix 2 [Table A2.1] show that regressions follow standard specifications. Most of the studies just run OLS, and since they had information about the whole manufacturing industries, some do pooled cross-section and time series, others rely on to 2SLS, and the rest employ FGLS and panel data. We run the above specifications, due to the working panel is an unbalanced matrix of 12 petrochemical industries (individuals) with time span for about 24 years (within observations). Tobit regressions were included because the dependent variable is censored at value of cero. Appendix 2 also reports the variables main statistics [Table A2.3] and the variables correlation matrix [Table A2.4].

Table 9 reports the main findings about the determinants of entry in Colombian petrochemical industries. There, the reader can notice the five different econometric specifications we ran. For each of them there appear two equations. The only difference is the inclusion of gross entry lagged two periods and the exit variable to account for the potential room that exits open to new entrants. The results running OLS, Tobit, 2SLS and FGLS are very similar and with an acceptable global significance of the model and goodness of fit. On average the model explains 47% of gross entry flows. The panel data random effect model gets similar results but the Breusch-Pagan test clearly rejects the hypothesis of that specification.

The first striking result is the fact that regardless of the econometric specification both the lagged growth in price margin and market room, proxy of industry *i* dynamics, were found either not to be significant in the first case, (although with the right expected sign), or significant some times but with the wrong sign in the second one. Although at odds with the theoretical arguments, the no significance of profit cost margin was also found in Orr's paper and others as the table A2.1 in appendix 2 shows.

TABLE 10

REGRESSION ANALYSIS

POOLED, GLS, RANDOM EFFECTS AND TOBIT ESTIMATIONS

DEPENDENT VARIABLE: LOG OF GROSS ENTRY

Independent Variables	Eq 1 Pooled OLS[1]	Eq 2 Pooled OLS[1]	Eq 3 Tobit	Eq 4 Tobit	Eq 5 2SLS[1]	Eq 6 2SLS[1]	Eq 7 Panel FGLS	Eq 8 Panel FGLS	Eq 9 Panel RE	Eq 10 Panel RE
GPCM, $_{t-1}$	0,0073	0,0070	0,0883	0,0731	0,0147	0,0153	0,0162	0,0167	-0,0080	-0,0125
	(1.10)	(1.00)	(0.26)	(0.22)	(0.36)	(0.37)	(0.12)	(0.13)	(-0.04)	(-0.06)
Mroom, $_{t-1}$	-0,00053[b]	-0,00069[b]	-0,18718	-0,20019	-0,00066[b]	-0,00067[b]	-0,00042	-0,00042	-0,00068	-0,00070
	(-2.46)	(-2.22)	(-0.51)	(-0.55)	(-2.12)	(-2.16)	(-0.58)	(-0.58)	(-0.53)	(-0.55)
Fringe, $_{t-1}$	0,5519[a]	0,4800[c]	0,9031[b]	0,9422[b]	0,4635[b]	0,4813[b]	0,8314[a]	0,8329[a]	0,4604[c]	0,4776[c]
	(2.81)	(1.96)	(2.19)	(2.25)	(1.98)	(1.97)	(4.61)	(4.51)	(1.86)	(1.89)
Scale, $_{t-1}$	0,0349[c]	0,0582	0,0565	0,0596	0,0578	0,0594	0,0244	0,0241	0,0560	0,0576
	(1.79)	(1.51)	(0.61)	(0.64)	(1.52)	(1.55)	(0.67)	(0.66)	(1.05)	(1.07)
Log KOR, $_{t-1}$	0,3608[c]	0,3294	0,4206	0,4480	0,3178	0,3307	0,6212[a]	0,6233[a]	0,3151	0,3278
	(1.68)	(1.39)	(1.22)	(1.29)	(1.39)	(1.40)	(3.22)	(3.18)	(1.35)	(1.39)
HH, $_{t-1}$	-2,3159[a]	-2,6302[a]	-2,7684[a]	-2,9401[a]	-2,5342[a]	-2,6216[a]	-2,0168[a]	-2,0148[a]	-2,5471[a]	-2,6340[a]
	(-3.75)	(-3.45)	(-2.99)	(-3.03)	(-3.48)	(-3.41)	(-3.28)	(-3.10)	(-4.08)	(-3.98)
ROY, $_{t-1}$	-4,5303[c]	-5,2655[c]	-10,4883	-10,3350	-5,5461[c]	-5,5290[c]	-3,6284	-3,6390	-5,1002	-5,0788
	(-1.71)	(-1.90)	(-1.26)	(-1.25)	(-1.93)	(-1.92)	(-1.41)	(-1.42)	(-1.21)	(-1.20)
ADV, $_{t-1}$	9,8876 [b]	11,3584 [b]	14,0518 [b]	14,6790 [b]	10,9478[b]	11,2721[b]	11,0935 [b]	11,0663 [b]	11,0760 [b]	11,3929 [b]
	(2.28)	(2.38)	(1.98)	(2.04)	(2.34)	(2.36)	(2.47)	(2.44)	(2.31)	(2.34)
TFP, $_{t-1}$	0,0049 [a]	0,0046 [a]	0,0059 [a]	0,0060 [a]	0,0046 [a]	0,0046 [a]	0,0054 [a]	0,0055 [a]	0,0046 [a]	0,0046 [a]
	(3.95)	(3.55)	(2.75)	(2.79)	(3.60)	(3.55)	(4.58)	(4.52)	(3.16)	(3.17)
Grocons, $_{t-1}$	1,0684 [a]	0,8507 [c]	1,3362 [c]	1,3960 [c]	0,8265 [c]	0,8528 [c]	0,5702	0,5746	0,8213 [c]	0,8467 [c]
	(2.62)	(1.87)	(1.95)	(2.02)	(1.84)	(1.87)	(1.62)	(1.62)	(1.82)	(1.86)
DMRM, $_{t-1}$	-0,0483	-0,0589	-0,0892	-0,0892	-0,0590[c]	-0,0587	0,0060	0,0058	-0,0595	-0,0593
	(-1.47)	(-1.64)	(-1.19)	(-1.19)	(-1.66)	(-1.64)	(0.23)	(0.22)	(-1.36)	(-1.36)
RISK, $_{t-1}$	3,5809 [a]	4,0462 [b]	2,0663	2,3930	3,8417 [b]	4,0137 [b]	3,4765 [a]	3,4753 [b]	3,8924 [a]	4,0631 [a]
	(2.58)	(2.37)	(0.92)	(1.04)	(2.35)	(2.33)	(2.57)	(2.46)	(2.71)	(2.71)
NX, $_{t-1}$	0,0677[a]	0,0676[a]	0,0698[b]	0,0717[b]	0,0667[a]	0,0678[a]	0,0682[a]	0,0679[a]	0,0664[a]	0,0675[a]
	(3.18)	(3.12)	(2.16)	(2.21)	(3.06)	(3.10)	(2.65)	(2.62)	(2.87)	(2.90)
NE, $_{t-2}$		-0,0060		-0,0121		-0,0060		0,0001		-0,0060
		(-0.41)		(-0.58)		(-0.41)		(0.01)		(-0.40)
Constant	0,3238	0,4524[c]	-0,0533	-0,0415	0,4456 c	0,4515[c]	0,0905	0,0902	0,4472[c]	0,4531[c]
	(1.47)	(1.86)	(0.13)	(0.10)	(1.82)	(1.85)	(0.43)	(0.43)	(1.70)	(1.72)
Regression Statistics										
R^2	0,4789	0,4717			0,4713	0,4716			0,4713	0,4716
P-seudo R^2			0,2681	0,2686						
Num of groups							12	12	12	12
Num Obs	273	261	261	261	261	261	261	261	261	261
Obs per Group: Min							19	19	19	19
Max							22	22	22	22
F-test	51,95	50,79			55,25	51,07				
	[0.0000]	[0.0000]			[0.0000]	[0.0000]				
LR-Chi2(k-1)			184,24	184,58						
			[0.0000]	[0.0000]						
Wald-Chi2(k-1)							316,95	317,26	220,18	219,59
							[0.0000]	[0.0000]	[0.0000]	[0.0000]
Breusch-Pagan									1,71	2,03
Chi 2 (k-1)									[0.1907]	[0.1547]
Variance Matrix Residuals										
Homocedastic panels							no	no	no	no
Instrumental Variables					Yes	Yes	no	no	no	no
RHS Endogenous Variables					GPCM	GPCM				

Notes: The table reports results from OLS, Two-stage least squares (2SLS), feasible generalized least squares (FGLS), Tobit and random effects (RE) estimations. The dependent variable in all equations is log of gross entry.
1:/ White-Hubert robust heteroskedastic standard errors; t student appears in parentheses; and p-values in square brackets.
Definitions of each variable and its methodology can be found in Appendix 2 [table A2.2].
a = Significant at 0.1; b = significant at 0.05; c = significant at 0.1

Second, BTE barriers show mixed results. Neither scale (SCALE) nor the log of capital-to-output ratio (LOG KOR) were significant, and all cases with the opposite sign. The result could be explained by the real development in plastics took place since the 1980s where entry occurred and plant scale were low. The licensing indicator (ROY) turned out a robust entry barrier. If continuer firms invest in leasing patented technologies it constitutes a fix cost that will deter entry. On average, if incumbents increase 1% their licensing spending entry flows will fall in around 5%. Advertising intensity (ADV) is also a robust regressor although it exhibits a positive relationship with entry. The variable was significant under all the econometric specifications. From theory, advertising intensity is expected to be a barrier to entry if it just conveys a persuasive goal. In that case, expenses in advertising create a barrier to entry since new potential entrants must waste huge amount of money to gain (small) market participation. What can then explain the positive relationship? Some studies have found also a positive correlation between entry and advertising. Among them, Telser (1962), Hirschey (1981) and MacDonald (1986) present evidence that advertising may facilitate entry and new product innovations. The theory behind this explanation may be borrowed from Schmalensee (1978) who presents some arguments about the positive relationship between profitability and entry. Advertising plays an informative role and when incumbent firms advertise, they create or strengthen market demand. Then the existence of such spillovers makes entry easier. However, it is expected that advertising has a role only for consumer goods and lesser degree for intermediate goods. Plastic products satisfy that condition since most of them manufacture -in some way- consumer goods. Las, the dependence of imported raw materials ratio (*DMRM*) is significant and with the right sign for 2SLS without the exit variable and has the expected sign for most of the regressions but not statistically significant. Despite that it shows that when studying entry researchers should pay attention to variables like the dependence of raw material that in certain specific situations may be relevant.

Third, regarding the complementary variables, the *Herfindal* concentration ratio is significant in all regression equations with the expected negative relationship. On average, an increase in 1% in the market concentration entry drops in 2.5%. Hence, industry concentration deters entry. Productivity levels (TFP) turn out a robust determinant with the expected sign. As long as productivity raises due to market reallocation effects will induce entry. On average, the regression coefficients indicate that an increase in 10 points on TFP indices entry will increase in 0.46%. The annual growth rate of the building and construction GDP (GROCON) also turn out a significant regressor. This variable captures the macro effect that tends to facilitate entry. Only in a couple of regressions, it falls short of getting the ten per cent significance. As in the paper by Orr and others, the proxy for risk is included in the estimations. Under the assumption that the greater the risk firm could face, the lower the incentives to enter and then the lower would be entry. However, almost all the equations show a positive and significant relationship between the measure of risk (the standard deviation of the PCM) and the level of entry. Recently, Roberts and Thompson (2003) also found a similar positive association. They conjecture here is that if one considers the variability of past profitability as "*a measure of intra-industry heterogeneity, hence an indicator of the potential for niche entry, the significant positive coefficient appears sensible*" [(Roberts & Thompson 2003, p 241, italics added]. That interpretation is more sensible if one notices that Fringe competition that controls for how small firms are represented in the industry is always positive and significant. On average, as the competitive fringe raises 1% entry will boost in 0.65%. This result is consistent with the fact that entry in plastics is formed by medium-size plants with an average less 50 employees since the 1985.

Finally, the regressions include the test of whether the displacement effect has any effect on the level of entry and if past entry could deter or facilitate entry. The past exit variable XN, is in all equations significant averaging a positive effect of 6% on entry if the exit rate increases in 10%. Thus, plant exit induce entry through increments in market room. Past entry (NE_{t-2}) exhibits the correct sign although this variable is not statistically significant in the regression equations.

Summing up, the determinants of entry have been tested for developed economies and more recently for transition economies. Some general specifications borrowed from Orr's model have been used and tested, and the main variables employed to explain entry are commonly known. In this paper based on that research, we tested the determinants of entry for an industry case in a developing economy. The appealing of the above-explained results is that the basic Orr-type model holds for this case study as predicted in theory, and with the previous findings in the international literature on firm entry.

VI. Conclusions

This paper has conducted an in-depth study of plant entry within the petrochemical industry in Colombia. The importance of this study within an international context is that there are few case studies on specific industries and entry dynamics for developing economies that cover long-run trends and, more importantly, within formerly protected industries that were set up during the import substituting industrialization phases. As was the case in other Latin American countries, the Colombian petrochemical industry was seen as a strategic industry to promote and deepen domestic industrialization five decades ago.

This study shows that entry was a common regularity during the analyzed period, which covered the mixed strategy of import protection and export promotion of the 1970s and 1980s, as well as the economic liberalization strategy of the 1990s. Gross entry in the industry was located in the plastics industry and to a much lesser extent within synthetic-chemical resins, in spite of the trade regime. Moreover, firm/plant entry accelerated since the mid-1980s and in the plastic industry during the 1990s. The plastics sector is mainly composed of medium-size enterprises while resins are made up of capital-intensive plants. The inverse relation between entry and plant capital-intensity is a finding consistent with theory and other international studies. The existence of high survival rates (of above 90%) for medium-size plants is without doubt an interesting finding that becomes a distinctive feature of petrochemical markets in developing economies.

Productivity differentials were a constant regularity between surviving and exiting plants, as well as incumbents versus entrants. Successful entrants shaped industry productivity. Total factor productivity measures showed that this group of firms/plants had 2.1 times the average productivity level of old firms, which started commercial operations before 1977. At the same time, employment generation was upheld in this group within petrochemicals. TFP growth decomposition showed that the incumbent effect dominates the turnover effect. Total factor productivity growth decomposition showed that the continuing plants productivity drives industry efficiency. There was also an important contribution to productivity growth due to market reallocation toward more productive plants across incumbents and surviving entrants. On the other hand there were not large differential between entering and exiting plants as well as differences in market shares. Thus, the turnover effect between entrants and dying firms was low in the 13 studied petrochemical branches. This result is correlated with the low penetration rates on entering plants within any given year, which in turn is a common result according to the evidence reported by entry studies for OECD economies.

The econometric exercises corroborate that the Orr-type model explains in certain degree the entry rates within petrochemicals. The regression results are mixed. On one hand the pure incentive to market variables turn out no significant variables in the regressions. Barriers to entry played important role in deter entry through technology licensing, market concentration, and dependence from imported materials. Surprisingly the advertising indicator showed the opposite sign. This result has been found in other studies. The complementary variables turned out robust determinants. Increases in industry TFP and GDP growth in housing construction boost entry. The risk proxy reported the opposite sign in accordance with findings in recent studies of firm entry. There is a spillover that potential entrants foresee new market niches because the existence of firm/industry heterogeneity. Last, plant exit induces ex-post entry meaning that the replacement effect holds in the model.

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APPENDIX I

SECTION I - COMPLEMENTARY TABLES

SURVIVAL RATES BY BIRTH-COHORTS

Cohort Year	Entrants By Cohort	Age																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1975	2	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%	-	-	-	-
1976	2	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	50,0%	50,0%	50,0%	50,0%	50,0%	50,0%	-	-	-	-	-
1977	8	100,0%	100,0%	100,0%	100,0%	100,0%	87,5%	87,5%	87,5%	62,5%	62,5%	62,5%	62,5%	62,5%	62,5%	37,5%	37,5%	37,5%	37,5%	25,0%	-
1978	15	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	93,3%	86,7%	86,7%	86,7%	86,7%	86,7%	86,7%
1979	9	100,0%	100,0%	100,0%	80,0%	80,0%	70,0%	70,0%	70,0%	60,0%	50,0%	50,0%	50,0%	30,0%	20,0%	20,0%	20,0%	20,0%	10,0%	10,0%	-
1980	16	100,0%	100,0%	100,0%	100,0%	100,0%	93,8%	93,8%	93,8%	93,8%	93,8%	93,8%	81,3%	81,3%	75,0%	68,8%	68,8%	68,8%	68,8%	-	-
1981	19	100,0%	100,0%	100,0%	94,7%	84,2%	84,2%	84,2%	78,9%	73,7%	73,7%	73,7%	73,7%	68,4%	63,2%	63,2%	57,9%	57,9%	-	-	-
1982	21	100,0%	100,0%	100,0%	95,2%	95,2%	90,5%	90,5%	90,5%	90,5%	81,0%	76,2%	76,2%	66,7%	61,9%	61,9%	61,9%	-	-	-	-
1983	16	100,0%	100,0%	100,0%	93,8%	93,8%	93,8%	93,8%	93,8%	62,5%	56,3%	56,3%	50,0%	50,0%	43,8%	43,8%	-	-	-	-	-
1984	22	100,0%	100,0%	100,0%	100,0%	100,0%	100,0%	95,5%	81,8%	77,3%	72,7%	68,2%	63,6%	59,1%	59,1%	-	-	-	-	-	-
1985	23	100,0%	100,0%	100,0%	100,0%	95,7%	91,3%	87,0%	69,6%	65,2%	60,9%	60,9%	56,5%	56,5%	-	-	-	-	-	-	-
1986	20	100,0%	100,0%	100,0%	100,0%	95,0%	85,0%	85,0%	80,0%	80,0%	75,0%	75,0%	75,0%	-	-	-	-	-	-	-	-
1987	33	100,0%	100,0%	97,0%	97,0%	69,7%	63,6%	57,6%	54,5%	48,5%	42,4%	42,4%	-	-	-	-	-	-	-	-	-
1988	41	100,0%	100,0%	100,0%	80,5%	78,0%	75,6%	73,2%	68,3%	68,3%	68,3%	-	-	-	-	-	-	-	-	-	-
1989	22	100,0%	100,0%	95,5%	95,5%	90,9%	81,8%	72,7%	68,2%	68,2%	-	-	-	-	-	-	-	-	-	-	-
1990	4	100,0%	100,0%	100,0%	75,0%	75,0%	75,0%	75,0%	75,0%	-	-	-	-	-	-	-	-	-	-	-	-
1991	10	100,0%	100,0%	100,0%	100,0%	90,0%	70,0%	70,0%	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	93	100,0%	100,0%	100,0%	95,7%	93,5%	93,5%	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	29	100,0%	100,0%	100,0%	89,7%	82,8%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	29	100,0%	100,0%	100,0%	100,0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1995	43	100,0%	100,0%	100,0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	31	100,0%	100,0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	39	100,0%	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1998	38	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Across Cohorts		100,0%	100,0%	99,6%	94,8%	90,7%	86,4%	84,4%	82,0%	73,4%	66,9%	66,1%	65,7%	61,3%	57,9%	53,5%	54,7%	54,2%	50,7%	40,6%	86,7%

Source: Own-estimations based on DANE-EAM

Appendix II

Table 2A.1- The Econometrics Studies on Entry Rates

variable	UK Gerosky	USA D&R /1	USA R&L /2	USA E&S /8	USA AUD /9	Canada Orr	Canada Deutsch	Canad K&S	Canad K&S /6	FRG	Norway /3	Portugal /4	Portugal /5	Belgium	Korea /10	Japan	Greece /7	Poland
ENTRY	**Net entry rate**	**Gross entry & share rate**	**entry rate**	**Gross entry rate**		**Gross entry**	**Net entry**	**Gross entry**	**Gross entry**	**Gross entry rate**	**Gross entry**	**Share rate**	**Gross entry**	**Gross entry rate**	**Net entry rate**	**Net entry rate**	**Gross entry & gross entry rate**	**Gross entry**
expected profits	+	+	+	+ NS		+ NS	+	+	+	+	+	+ c	+ NS	NS	+	+ NS	+	-
industry size	NS	-	+		+		+	+	+	- NS	+	+	+	+				+
industri growth	-	+			+ NS	+	+	+		+	+ NS	+	+ NS	+	+	+	+	+ NS
scale economies		-		+	+		- NS	-	-	+	+	-	- NS	+ NS	- NS	-	-	
product differentiation / advertising			-	- NS		-	+ NS	-	-	+		- c	-	-	-	+	-	-
capital requirements / MES		+ NS	- NS		+	-	-	-	-	+ NS	+	- c	- NS	+ NS	-		- NS	-
Concentration			+ NS				+ NS	-	-		-				+			-
sunk costs			- NS										- NS	-				
equipment											- NS	-E						
new												-E						
exit			+	+							+			+			+	+
risk				+		-		- NS			-							+
patents/R&D						-		- NS	- NS	- NS	+	-	-	+ NS				
diversification												- c	-					
exports/GDP											-							
macro variables					+											+		
multiplant operations							-											
fringe																	+	
innovation rate by small firms					+													
econometric specification	lineal model	lineal model	lineal model	lineal model	lineal model	Semi Log	Semi Log	Semi Log	Semi Logarithmic	lineal model	Semi Log	Semi Log	Semi Log	lineal model	lineal model	lineal model	lineal model	Semi Log
econometric method	Cross section	OLS & Panel Fixed effects	OLS I3SLS & SURE	2SLQ	Pooled corss section	2SLQ a	OLS	2SLQ a	SURE & FIML	2SLQ a	OLS	OLS	OLS & Tobit	Weighted least squares	2SLQ a	Pooled Time Series & Cross-Section	OLS & SURE	OLS

Sources: Geroski (1991), Dunne & Roberts (1991), Rosenbaun & Lamort (1992), Evans & Siegfred (1992), Audretsch (1995), Orr (1974), Deutsch (1984),ñ Matta (1993), Khemani & Saphiro (1993), Fotopoulus & Spence (1999), Jeon & Mason (1991), Yamawaki (1991); Roberts & Thompson (2003).

Notes: /1: Entry rates and FE equations; /2: Equations Table 3; /3 De novo form equation; /4 Mata 1991; /5 Mata 1993; /6 Displacement effect; /7 F&S (1998) OLS Interaction; /8 De novo firm-equation; 9/ Audretsch (1995) Eq. 1; Table 3.2 + = positive related; - = negatively related; NS = statistically non-significant.

TABLE A2.2

INDEPENDENT VARIABLES DEFINITIONS USED IN THE REGRESSION EQUATIONS

Variable	Exp sign	Definition
gPCM	+	PCM is the price-cost margin. It is calculated as the ratio of the difference between the valued added and wages and salaries to the difference between the valued added and raw materials. gPCM is the annual growth rate of PCM.
MROOM	+	Market room. It is calculated, following Rosenbaum and Lamort (1992), as market growth in industry j divided by minimum efficient scale.
Fringe	+	Percentage of small firms. In our sample we defined a small firm, a firm with fewer than 50 employees.
KOR	-	Capital ot output ratio.
Scale	-/+	it is defined as the ratio of minimum efficient scale over the cost-disadvantage ratio (CDR).
CDR		It is defined as the ratio of the value added per worker in the group of firms of lower size of industry *j* to the value added per worker in the group of firms of industry *j* .
HH	-	Hirschman-Herfindahl index.
TFP	+	Total factor productivity
Risk	-	It is calculated as the standard deviation of the firms' price-cost margin in industry j.
Grocons	+	Rate of growth of GDP of building and housing. It is hypotezised to incentive the consumption of plastics.
Adv	-	Advertising Intensity. It is the ratio of advertising expenses in industry *j* to value added in industry *j*.
Roy	-	Royalty. It is the ratio of royalties expenses in industry *j* to value added in industry *j*.
DMRM	-	Dependence of Imported Raw Materials. It is defined as the ratio of imported raw materials to domestic raw materials.
Grocons	+	Rate of growth of GDP of building and housing. It is hypotezised to incentive the consumption of plastics.

TABLE A2.3

SUMMARY OF STATISTICS – INDEPENDENT VARIABLES IN REGRESSION EQUATIONS

Variable	Obs	Mean	Std. Dev.	Min	Max
ADV	285	0,0111	0,0105	0,0001	0,0550
DMRM	285	0,8716	1,1147	0,0000	7,1630
Fringe	285	0,6096	0,2601	0,0000	1,0000
gPCM	285	1,0007	1,1781	-0,9538	19,2260
Grocons	285	0,0367	0,0880	-0,1307	0,1923
HH	285	0,3070	0,2464	0,3375	1,0000
Log KOR	285	0,5484	0,2300	-1,2765	-0,0162
Mroom	285	1,8496	29,2340	-0,4342	493,4170
NE	285	3,0456	3,0778	1,0000	23,0000
NX	285	0,7298	1,7281	0,0000	11,0000
RISK	285	0,0802	0,1075	0,0018	0,4060
ROY	285	0,0038	0,0098	0,0000	0,0479
Scale	285	0,7860	1,3554	0,0184	12,2230
TFP	285	121,63	40,95	45,03	221,05

TABLE A2.4

CORRELATION MATRIX

	NE	Mroom	GPCM	Fringe	Scale	Log KOR	HH	NX	Grocons	ADV	ROY	DMRM	TFP	RISK
NE	1													
Mroom	0,0168	1												
GPCM	-0,0418	-0,0161	1											
Fringe	0,3359	-0,0853	-0,1322	1										
Scale	-0,2960	0,2148	0,0204	-0,3422	1									
Log KOR	-0,0797	0,0347	0,0016	-0,3720	0,1705	1								
HH	-0,4741	0,0604	0,1470	-0,6150	0,6199	0,0932	1							
NX	0,6075	-0,0267	-0,0219	0,2528	-0,2170	-0,0534	-0,3210	1						
Grocons	0,0510	0,0204	-0,0953	-0,0442	-0,0116	-0,0121	0,0233	0,0276	1					
ADV	0,1446	0,0081	-0,0465	0,2521	-0,2953	-0,2034	-0,2555	0,0449	0,0215	1				
ROY	-0,1003	0,1923	-0,0448	-0,2954	0,2450	0,1752	0,2809	0,0348	-0,0407	-0,1582	1			
DMRM	-0,3278	0,0249	0,0109	-0,4984	0,2781	-0,0655	0,4272	-0,2508	-0,0658	-0,2897	0,0226	1		
TFP	0,3880	-0,0588	-0,0197	0,3811	-0,5717	-0,4828	-0,5693	0,3251	-0,0172	0,2610	-0,2293	-0,2444	1	
RISK	-0,3877	0,0625	0,1753	-0,6600	0,5567	0,1019	0,9487	-0,2593	0,0105	-3912,0	0,3002	0,4186	-0,5144	1

Appendix III

The Annual Manufacturing Survey: An overview

The Annual Manufacturing Survey of Colombia [*Encuesta Anual Manufacturera (EAM)*] is in practice a census of medium and large enterprises in manufacturing. The EAM has undergone three methodological changes affecting the following time periods, respectively: i) 1970–1991, ii) 1992–1993, and iii) 1994 to date. The changes have been addressed toward: i) the inclusion or exclusion of variables within chapters; ii) the addition or suppression of new information across chapters; iii) modification of the format or variable classification criteria; and iv) the rescaling of the sample cohorts.

Some specific examples are the changes of the payroll classification, the inclusion of temporary workers after 1987, the exclusion of direct exports as a component of firm's sales, the elimination of the direct tax variables after 1991, the redefinition of large enterprise according to number employees, and the addition of new components for fixed investment after 1992, among many others.

Despite the format modifications, the survey has kept the basic variables and structure across time. The database clean up process was a two-step procedure. First, we worked with the basic variables of the 1970-1991 survey. Second, all basic series were overlapped and grouped keeping the original definitions of the older survey.[30] The manufacturing survey offers five types of variables:

1. *Identification variables:* Location (blue-park district), specific ISIC group, firm's legal capital structure, and size classification.

2. *Labor variables:* Wages, benefits, permanent and temporary employees, administrative employees, workers, technicians, and gender statistics.

3. *Output-related variables:* Gross output, value added, intermediate consumption components, industrial expenditures, and inventories of final products and raw materials.

4. *Finance-related variables:* Fixed asset investment, accounting depreciation, sales, marketing spending, paid royalties, and other general expenditure variables.

5. Consumption, generation, and sales of electricity.

The survey recorded data for 133 variables from 1970 to 1991. The survey recorded 380 variables during 1992 and 1993. From 1994 to date, the survey has worked with 200 variables. The 1992–1993 period is problematic because the survey included information that was not comparable with previous data. However, the core variables were recorded.

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[30] The main problem of the above methodological changes was the modification in the basic plant ID variable from 1991 to 1992, and 1993. This is troublesome if one wants to track the information at plant level. We ran a cross matching program throughout plant commercial names, recorded at the industrial directories, and generated an *identification key* for the ID variables in the 1991–1992 and 1992–1993 surveys.

APPENDIX IV

PETROCHEMICAL INDUSTRY ISIC-GROUPS FIVE DIGITS-LEVEL

TABLE A4.1

5-Digits ISIC Revision 2	Colombian Petrochemical Industry Groups
35131	Manufacture of synthetic resins of non-saturated polyester, and silicon.
35132	Manufacture of synthetic resins by polymerization and co-polymerization.
35133	Manufacture of regenerated cellulose, its chemicals by products and vulcanized fibers.
35134	Manufacture of other resins and man-made chemical products.
35601	Manufacture of basic plastic shapes, sheets, films and tubing.
35602	Manufacture of foamed plastic and products of foamed plastic.
35603	Manufacture of plastic products for house ware uses.
35604	Manufacture of tubular films and synthetic guts.
35605	Manufacture of plastic packaging, boxes, and bottles.
35606	Manufacture of plastic parts and accessories for industrial use, including
35607	Manufacture of plastic shoes, their parts and plastic lasts.
35608	Manufacture of products of plastic material for health, pharmaceutical and ...purposes
35609	Manufacture of furniture and plastic products not elsewhere classified.