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

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Table of Contents

I. Motivation and Objectives

- Industry dynamics depend on plant/firm entry and exit flows $\Rightarrow$ TFP of entering and exiting plants have and impact on industry's long-term productivity levels = turnover effect.

- Turnover analysis $\rightarrow$ to disentangle market share reallocation from less productive firms to more productive firms $\rightarrow$ even if $\dot{A} / A = 0$ industry's TFP > 0 due to reallocation effect.

- International studies on firm entry, exit + turnovers have focuses on OECD cases.

-Roberts & Tybout (1996) is the first comprehensive attempt to gather several studies on for developing economies. They include the cases of Morocco, Chile, Colombia, and Mexico.

- The study of Colombia covers the 1978-1988 period and only focus on turnovers → out to date.

- Other studies → Levinsohn & Petrin (1999) + Pavnick (2002) use the same dataset of Chile from 1980-1986 to evaluate manufacturing TFP using the parametric approach of Olley & Pakes (1996).

- Most recently Melendez et al (2003) provides a measurement of productivity and turnovers in Colombian manufacturing following L&P (1999) semiparametric regression estimation.

- Above studies concerned about estimating TFP dynamics represented by a first order stochastic (Markov) process.

- Aw, Cheng, & Roberts (2001) = TFP differentials and plant turnovers for the Taiwanese industry based on three census years.

- Drawback = studies report generic analyses presenting aggregate measures (ISIC2) + no ∃ specific explanation about the forces behind plant turnover within industries + turnover differences across industries ?

Objectives

1 Present an industry case $\rightarrow$ narrow analysis; links = plant entry + plant heterogeneity $\Rightarrow$ effect on productivity differentials + turnovers + plant entry determinants.

Why petrochemicals ?

a) Industry where barriers to entry may have played a significant role on firm entry (i.e scale economies, high fixed costs, and the spending in patented technologies)

b) Development of the petrochemical industry was conditioned by the initial pathway of inward-looking

c) petrochemical industries belong a complex industrial chain → plant heterogeneity ↑ + ↑ TFP differences.

2. Contribute in providing new evidence about firm entry dynamics through an industry study for a developing economy.

3. Third, the paper looks to test the determinants of plant entry within petrochemicals.

II. Data

- The dataset is an *unbalanced panel* that comes from EAM (1974-1998) → ISIC groups = 13 subgroups that belong to synthetic resins (3513) and plastic (3560) industries.

- Row data = low quality ⚐ 1991-1992 EAM's ID code problem ⇒ data inconsistencies.

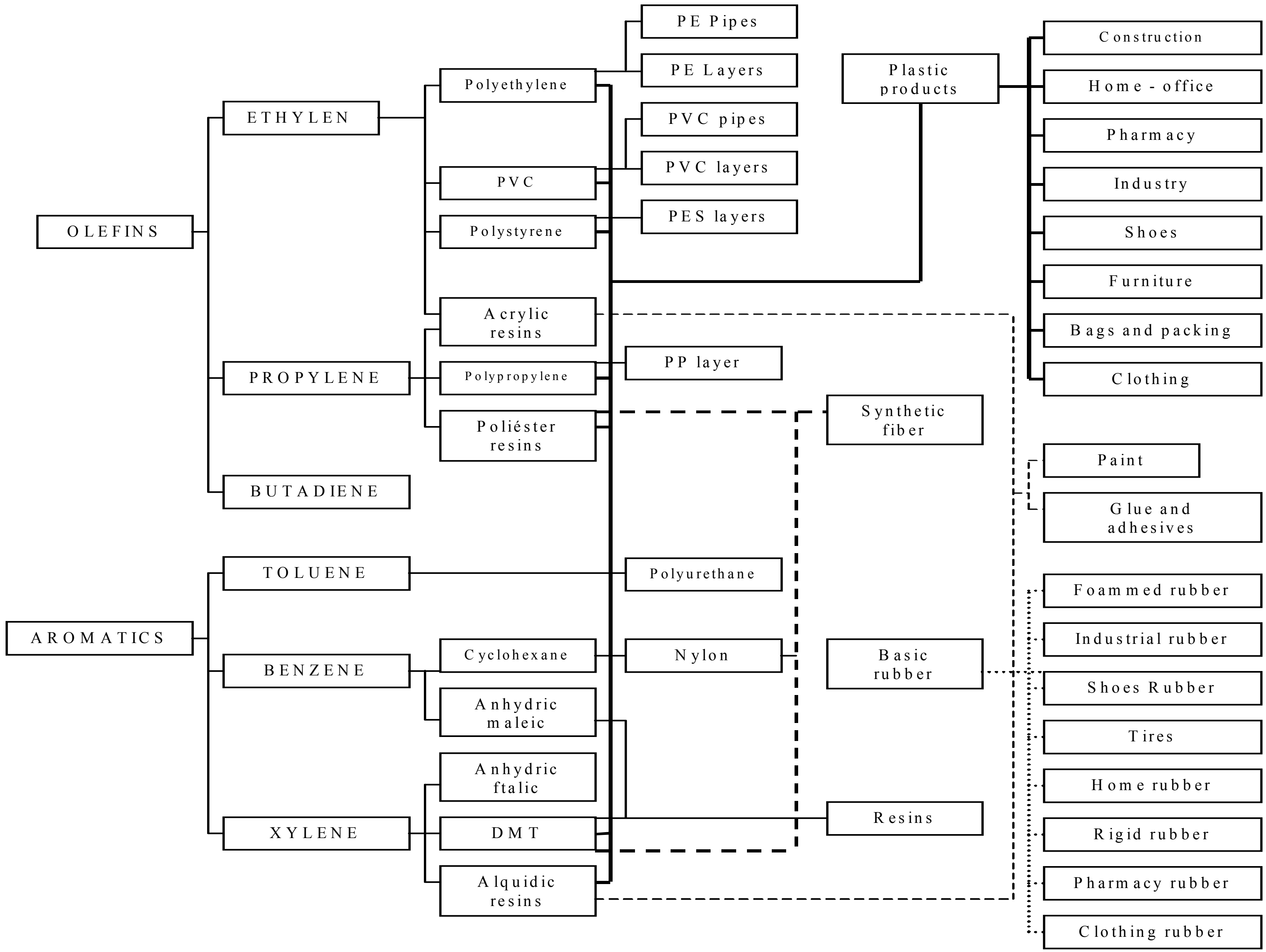
- There were 921plants that had records for the 1974-1998 period. Then 298 plants were dropped and classified as volatiles ⇒ 623 plants = working panel.

Plants classified by market dynamics: incumbents, successful entrants, and exiting plants.

Dataset 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
Plastics	117	183	282	367	431	3,453	4,366	4,050	3,726	4,256
Petrochemicals	127	200	302	391	460	5,198	6,618	6,863	6,276	6,587
	Average capital stock					Average 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
Plastics	1,281	1,525	1,187	1,096	1,136	82	70	50	47	48
Petrochemicals	1,836	2,710	2,388	2,257	2,093	89	84	63	56	53

Petrochemical Manufacturing Tree → Plant Heterogeneity



III. Entry patterns in petrochemicals

Entry + Exit empirical regularities [Geroski (1995)]:

i) Entry is common: entry rates > market penetration rates.

ii) Entry and exit rates are positively correlated.

iii) the survival rate of most entrants is low. It takes >10 years to get average incumbent plant size.

iv) entry rates vary over time (waves) which often peak early in the life of many markets. Different waves tend to contain different types of entrants.

Main Results...

Gross entry- entry rates, entry penetration

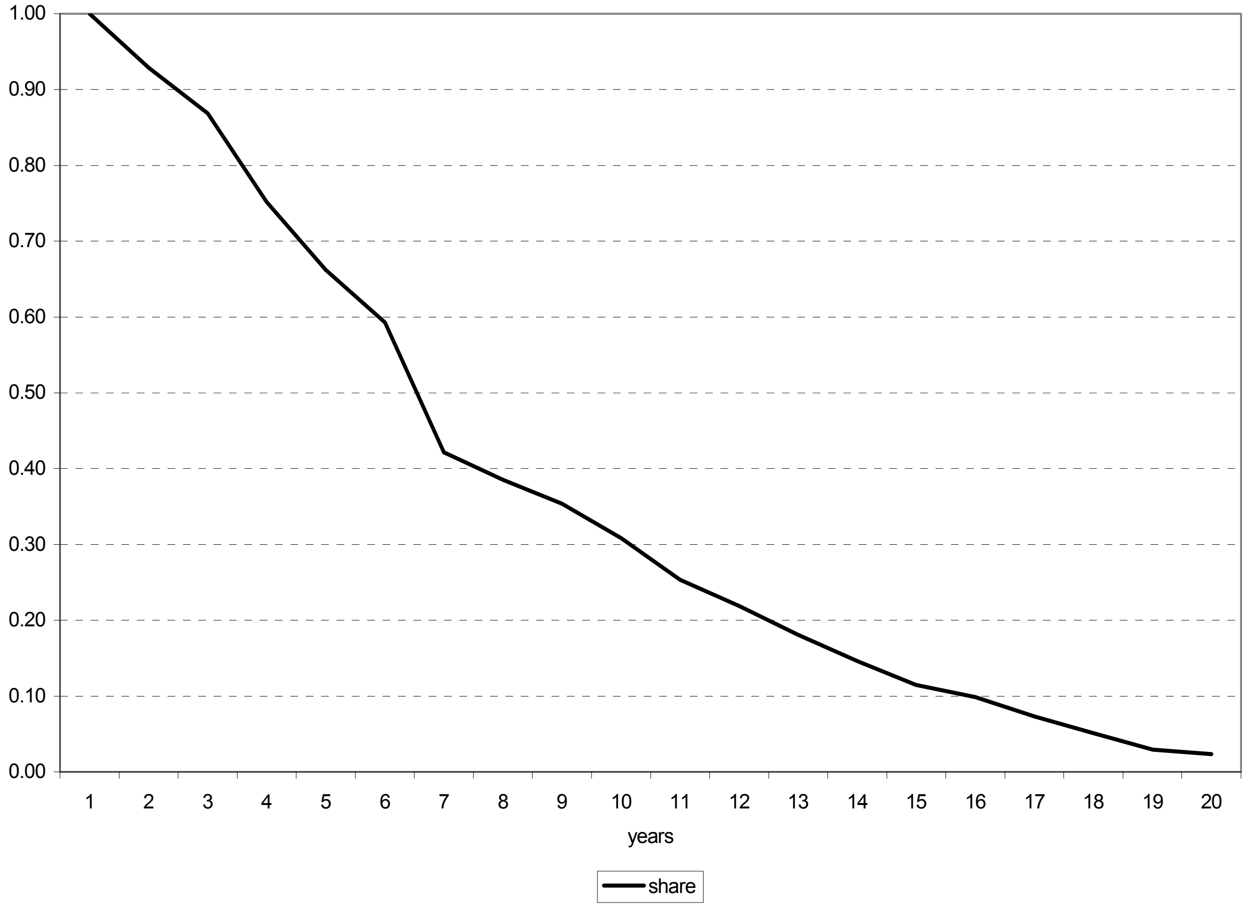
ISIC	Entrants 74-98	Gross Entry (averages) 74-79	80-84	85-89	90-94	95-98
3513	25	1.3	2.0	1.5	2.3	3.0
3560	562	6.6	17.8	27.2	31.2	37.0
Petrochemicals	586	8.0	18.8	27.8	33.0	37.8
		Gross Entry Rates				
3513		7.3%	9.2%	6.0%	8.1%	9.4%
3560		3.0%	6.4%	7.6%	7.0%	7.5%
Petrochemicals		3.1%	6.3%	7.3%	7.0%	7.3%
		Entry Penetration Rates				
3513		13.1%	12.2%	9.0%	2.7%	0.1%
3560		2.7%	2.3%	2.5%	4.6%	5.3%
Petrochemicals		5.3%	4.7%	3.1%	3.5%	3.3%

Entry Rate: ER(t)=[NE(t)]/[NT(t)]; Gross Entry: NE(t)

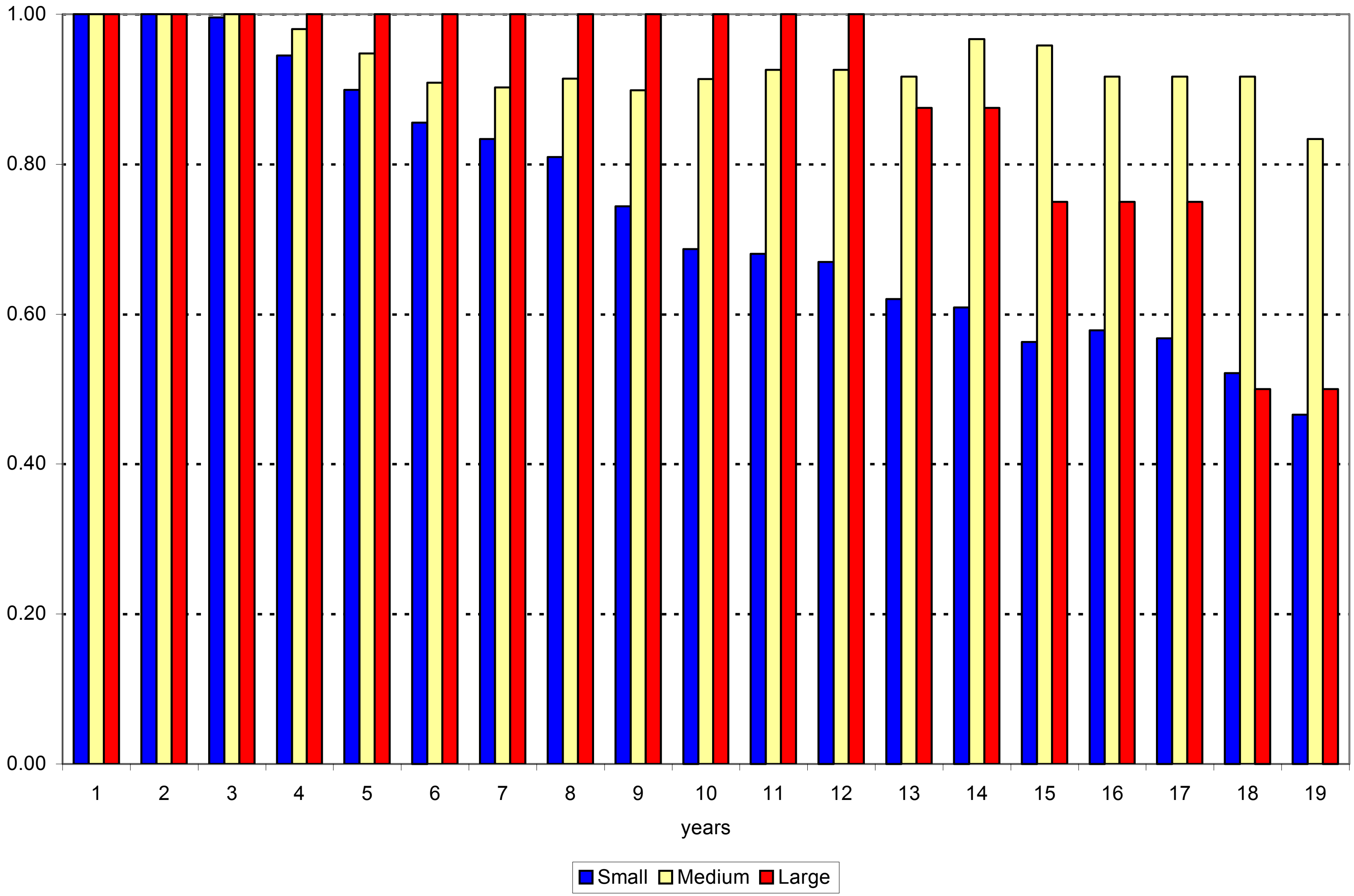
Penetration rate: ESHARE(t) = QE(t)/QT(t)

Regarding Survival.........

Plant Survival Rates



Survival rates by plant size and cohort



IV. TFP growth by market status

Growth accounting exercise → sources of growth

TFP measures follow an index number approach → measurement of Solow's residual through Translog Indices of TFP, which under CRTS TFP growth becomes for any given plant/firm/industry :

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

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.*

Further, if inputs follow a translog specification:

$$\mathrm{Ln}\frac{x_t}{x_{t-1}} = \frac{1}{2}\cdot\sum_{j=1}^{n}(\theta_{jt}+\theta_{jt-1})\cdot(\ln x_{jt}-\ln x_{jt-1}) \qquad (2)$$

where θ_j = *the share of each component in input's total payments* → *TFP corrected by improvement in the quality of inputs.*

Applied Eq. (1) and (2) to generate translog productivity indices across 623 plants, markets, and entry dynamics.

Main results can be summarized ......

Entry/ISIC	75-79	80-85	85-89	90-94	95-98	75-98
TFP growth corrected by input efficiency						
Entrants	0.4188	0.0856	-0.0088	0.0143	0.0179	0.0493
Incumbents	0.0065	0.0061	0.0439	0.0221	0.0174	0.0182
Exiters	0.0456	-0.0112	0.0103	0.0181	-0.1928	-0.0173
Resins	-0.1153	-0.0403	0.0232	-0.0048	-0.0071	-0.0285
Plastics	0.0351	0.0272	0.0066	0.0208	0.0247	0.0233
TOTAL	**0.0074**	**0.0052**	**0.0146**	**0.0076**	**0.0134**	**0.0092**
TFP contribution to Output Growth						
Entrants	0.6062	0.1567	-0.0943	0.1157	0.5345	0.2127
Incumbents	0.0679	0.0885	0.6668	4.4631	16.7376	0.3693
Exiters	0.2889	-0.3728	0.4682	-0.0654	0.1185	0.0762
Resins	-0.8474	-0.2740	0.2323	-1.6119	0.2623	-0.3757
Plastics	0.2971	0.2531	0.1746	0.3553	0.7069	0.3193
TOTAL	**0.0593**	**0.0426**	**0.2205**	**0.2283**	**1.2574**	**0.1242**
TFP Translog Indices (1974 = 100) corrected by input efficiency						
Entrants	108.4	191.0	210.6	207.0	232.9	188.2
Incumbents	98.8	100.3	123.9	131.5	138.1	117.7
Exiters	121.0	117.4	126.2	136.0	94.5	120.1
Resins	81.4	60.2	67.4	64.5	66.5	68.1
Plastics	111.1	123.8	142.4	144.9	158.1	135.1
TOTAL	**103.5**	**100.3**	**114.8**	**113.3**	**121.2**	**110.2**

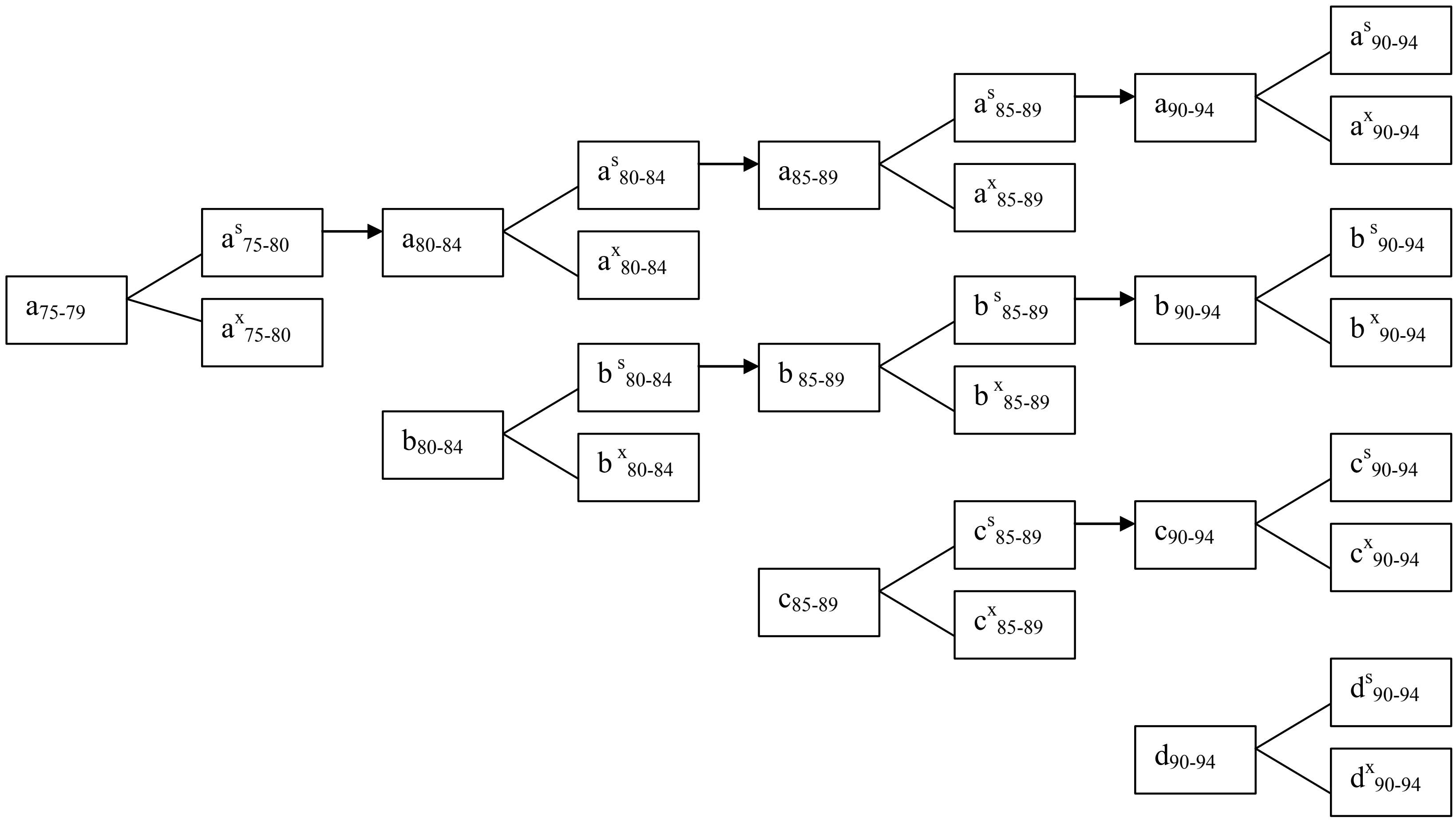
V. Productivity differentials and plant turnovers

- Plant heterogeneity → TFP differentials ≡ undertake a comparative analysis by type of firms according to their market status + across birth cohorts.

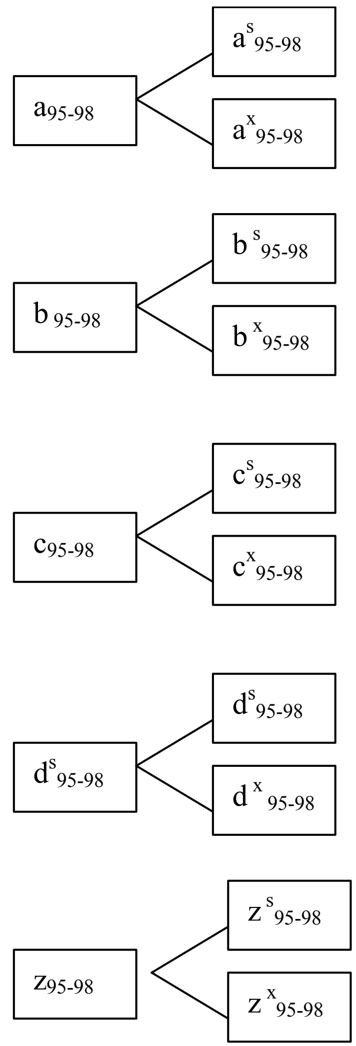
- The exercise looks to highlight the role of entrants in industry's productivity + if TFP differentials reflects turnovers patterns.

The dataset → time series rather than inter-censuses data ⇒ too many cohorts. Then plants were grouped by five year periods to define entry cohorts and transition status.

Entry cohorts and transition status



Entry cohorts and transition status (cont..)



Two exercises:

1. TFP differentials (means, medians) between surviving and exiting plants $\in$ birth-cohort.

Firm selection theory $\rightarrow$ [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 surviving plants

The main results were:

TFP differentials - exiting and surviving plants by cohort

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	

2. TFP differentials (means, medians) between incumbent and entering plants by cohorts

Firm selection model further restricts the test on TFP differentials → 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.

Main results .....

Productivity level differentials between incumbent and entering plants by cohort and year

Cohorts	N^E plants^E	N^I plants^I	TFP^E mean median	TFP^I mean median	t-stat z-stat	F-Statistic No entry differential TFP
Cohort I						
1974-1979	25	442	**116.7**	**112.6**	0.53	2,116.0 [a]
	13	78	**100.0**	**104.1**	-0.31	
Cohort II						
1980-1984	164	454	**121.5**	**126.1**	-0.85	1,342.5 [a]
	55	91	**102.1**	**118.4**	-2.52 [b] [a]	
Cohort III						
1985-1989	233	730	**109.2**	**153.8**	-6.81 [a] [a]	1,322.5 [a]
	84	146	**100.0**	**129.4**	-9.83 [a] [a]	
Cohort IV						
1990-1994	381	1,150	**107.1**	**153.9**	-6.87 [a] [a]	1,195.0 [a]
	147	230	**100.0**	**129.4**	-9.41 [a] [a]	
Cohort V						
1995-1998	273	1508	**109.6**	**153.9**	-5.52 [a] [a]	1,338.4 [a]
	77	377	**100.0**	**122.7**	-6.98 [a] [a]	

the results suggest 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 TFPg ↓ because TFP decreases with entrants' ageing.

- ↑ TFP differences between new-births and incumbents become significant after the effect of firm entry of the first cohorts → Entry penetration induces productive plants to lead industry productivity + reallocation effect toward younger firms = evidence of plant turnovers

Turnover analysis $\rightarrow$ the role of entering + exiting plants in industry's TFP:

1. Levels $\rightarrow$ Olley+Pakes (1996) decomposition

2. Growth rates $\rightarrow$ Griliches + Regev (1995) decomposition

The idea of this measurement is

$$\text{LnTFP}_t = \sum_{i=1,n} \theta_{it} \ln \text{TFP}_{it} \qquad (3)$$

where θ_{it} = *weight, plant i's market share.*

Eq (3) $\rightarrow$ shifts in firm's output from low to high TFP $\rightarrow \uparrow \theta_i^H \Rightarrow \uparrow$ industry's TFP even if no individual firm experiences a efficiency gain.

Taking differences = changes in TFP for a single plant i over time. However, if $\exists$ plant entry or exit the formula is no longer true $\Rightarrow$ G&R's shorcut = add Entering plants at *t* and Exiting plants at *t-1* within a single firm, Eq (3) becomes:

$$
\begin{aligned}
\Delta \ln TFP = & \left(\frac{\theta_{D,t} + \theta_{E,t+1}}{2}\right) \cdot \left(\ln TFP_{E,t+1} - \ln TFP_{D,t}\right) + \sum_{i=1,n} \left[\left(\frac{\theta_{it} + \theta_{i,t+1}}{2}\right) \cdot \left(\ln TFP_{i,t+1} - \ln TFP_{it}\right) \right] \\
& + \left(\frac{\ln TFP_{E,t+1} + \ln TFP_{D,t}}{2}\right) \cdot \left(\theta_{E,t+1} - \theta_{D,t}\right) + \sum_{i=1,n} \left[\left(\frac{\ln TFP_{it} + \ln TFP_{i,t+1}}{2}\right) \left(\theta_{i,t+1} - \theta_{it}\right) \right] \qquad (4)
\end{aligned}
$$

Eq. (4) expresses TFPg into four terms:

1) TFP differences between entrants and dying plants.
2) Contribution of continuing plants.
3) Market share reallocation among entering and exiting plants.
4) Market share reallocation from low to high productivity of continuing firms.

Main results...

Griliches - Regev TFP growth decomposition

ISIC Period	TFP Growth	Continuing Plants	Entrants vs Exiters Cohorts	MSR Continuing Plants	MSR Entrants vs Exiters
Resins (3513) Cross Industry Average					
75-79	-0.0207	-0.0242	0.0000	0.0017	0.0018
80-84	-0.0141	-0.0334	0.0000	0.0187	0.0007
85-89	0.0104	0.0137	-0.0024	-0.0005	-0.0003
90-94	0.0402	-0.0106	0.0038	0.0458	0.0013
95-98	-0.0376	-0.0169	0.0053	-0.0259	-0.0002
75-98	**-0.0048**	**-0.0163**	**0.0003**	**0.0105**	**0.0007**
Plastics (3560) Cross Industry Average					
75-79	0.0391	0.0316	0.0004	0.0066	0.0006
80-84	0.0028	0.0011	0.0003	0.0023	-0.0008
85-89	0.0077	0.0219	0.0022	-0.0084	-0.0079
90-94	0.0267	0.0286	-0.0111	0.0090	0.0001
95-98	0.0173	0.0025	0.0025	0.0086	0.0036
75-98	**0.0213**	**0.0197**	**-0.0012**	**0.0038**	**-0.0009**

The results suggest:
1. TFPg of continuing plants is the main source of growth in both directions → Plastics (+); Resins (-)

2. MSR of continuing plants (+) for both industries → substitution of resources toward more productive plants across petrochemical groups; MSRc (3513) > MSRc (3560).

3. Turnover effect is low → consistent with other international studies that report measures in chemicals i.e Baily et al (1992); G&R (1995); Aw,Cheng,&Roberts (2001)

The last result is due to i) low entry penetration, ii) small TFP differences between entering vs exiting plants because the MES disadvantages of the former and the diseconomies of scale of the last ones relative to incumbents.

VI. Econometric Analysis

Objective is to test if the Orr-type model holds.

Approach has been used extensively in research on firm entry determinants.

The entry Eq. is given by [Khemani & Saphiro (1986)]:

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

where: ***Log Entry*** = number entering plants per year/ISIC group ; ***X1*** = incentives to enter (+); ***BTE*** = barriers to entry (−); X2 = complementary variables (+/−).

The main results of the regression analysis were ...

Regression Analysis - Dependent Variable: Log of Gross Entry

Independent Variables	Eq 1 Pooled OLS[1]	Eq 3 Tobit	Eq 5 2SLS[1]	Eq 7 Panel FGLS	Eq 9 Panel RE
GPCM, $_{t-1}$	0.0073	0.0883	0.0147	0.0162	-0.0080
	(1.10)	(0.26)	(0.36)	(0.12)	(-0.04)
Mroom, $_{t-1}$	-0.00053 [b]	-0.18718	-0.00066 [b]	-0.00042	-0.00068
	(-2.46)	(-0.51)	(-2.12)	(-0.58)	(-0.53)
Fringe, $_{t-1}$	0.5519 [a]	0.9031 [b]	0.4635 [b]	0.8314 [a]	0.4604 [c]
	(2.81)	(2.19)	(1.98)	(4.61)	(1.86)
Scale, $_{t-1}$	0.0349 [c]	0.0565	0.0578	0.0244	0.0560
	(1.79)	(0.61)	(1.52)	(0.67)	(1.05)
Log KOR, $_{t-1}$	0.3608 [c]	0.4206	0.3178	0.6212 [a]	0.3151
	(1.68)	(1.22)	(1.39)	(3.22)	(1.35)
HH, $_{t-1}$	-2.3159 [a]	-2.7684 [a]	-2.5342 [a]	-2.0168 [a]	-2.5471 [a]
	(-3.75)	(-2.99)	(-3.48)	(-3.28)	(-4.08)
ROY, $_{t-1}$	-4.5303 [c]	-10.4883	-5.5461 [c]	-3.6284	-5.1002
	(-1.71)	(-1.26)	(-1.93)	(-1.41)	(-1.21)
ADV, $_{t-1}$	9.8876 [b]	14.0518 [b]	10.9478 [b]	11.0935 [b]	11.0760 [b]
	(2.28)	(1.98)	(2.34)	(2.47)	(2.31)
TFP, $_{t-1}$	0.0049 [a]	0.0059 [a]	0.0046 [a]	0.0054 [a]	0.0046 [a]
	(3.95)	(2.75)	(3.60)	(4.58)	(3.16)
Grocons, $_{t-1}$	1.0684 [a]	1.3362 [c]	0.8265 [c]	0.5702	0.8213 [c]
	(2.62)	(1.95)	(1.84)	(1.62)	(1.82)

Regression Analysis (cont.)

Independent Variables	Eq 1 Pooled OLS[1]	Eq 3 Tobit	Eq 5 2SLS[1]	Eq 7 Panel FGLS	Eq 9 Panel RE
DMRM, $_{t-1}$	-0.0483	-0.0892	-0.0590 [c]	0.0060	-0.0595
	(-1.47)	(-1.19)	(-1.66)	(0.23)	(-1.36)
RISK, $_{t-1}$	3.5809 [a]	2.0663	3.8417 [b]	3.4765 [a]	3.8924 [a]
	(2.58)	(0.92)	(2.35)	(2.57)	(2.71)
NX, $_{t-1}$	0.0677 [a]	0.0698 [b]	0.0667 [a]	0.0682 [a]	0.0664 [a]
	(3.18)	(2.16)	(3.06)	(2.65)	(2.87)
Constant	0.3238	-0.0533	0.4456 c	0.0905	0.4472 [c]
	(1.47)	(0.13)	(1.82)	(0.43)	(1.70)
Regression Statistics					
R^2	0.4789		0.4713		0.4713
P-seudo R^2		0.2681			
Num of groups				12	12
Num Obs	273	261	261	261	261
F-test	51.95		55.25		
	[0.0000]		[0.0000]		
LR-Chi2(k-1)		184.24			
		[0.0000]			
Wald-Chi2(k-1)				316.95	220.18
				[0.0000]	[0.0000]
Breusch-Pagan					1.71
Chi 2 (k-1)					[0.1907]
Variance Matrix Residuals					
Homocedastic panels				no	no
Instrumental Variables			yes	no	no
RHS Endogenous Variables			GPCM		

Several are results worth mentioning:

1. Fringe competition is the only Market Incentive Variable that is stat significant with the expected sign.

2. BTE → mixed results: HH (-), ROY(-), DMRM(-), ADV(+) are in most cases statistically significant. ADV shows up with the opposite sign → other studies have found a similar result (counterintuitive) i.e MacDonald (1986), Hirschey (1981).

3. Complementary variables are important in the model:

TFP(+), GROCON(+), RISK(+), NX(+)

- Risk shows the opposite sign (counterintuitive). However, this result is found in other studies such as Robert &Thompson (2003) → consequence intraindustry heterogeneity ⇒ potential for niche entry

- Replacement effect is robust regressor meaning that firm shakeout (t-n) induces or eases firm entry.

Conclusions

1. Plant entry is a common regularity within the industry regardless the business cycle.

2. TFP differences common regularity, where successful shaped industry productivity.

3. TFPg decomposition shows the incumbent effect dominates the turnover effect.

4. MSR within incumbents was important source of productivity growth →evidence of reallocation of resources toward more productive firms.

5. The econometric exercise corroborate that Orr-type model partially holds $\Rightarrow$ consistent with findings in other international studies on firm entry. The hypothesis that entry barriers have deterred entry is is confirmed.