Productivity Dynamics of SMEs in Taiwan

Bee Yan Aw

The Pennsylvania State University

November 1999

Productivity Dynamics of SMEs in Taiwan

I. Introduction

Taiwan's real gross national product grew at an average of over 8% per year for three decades beginning in the early 1960s to the early 1990s. Two key features characterize this rapid and sustained growth: an export-oriented trade regime and a market structure based predominantly on small and medium enterprises (SMEs). The former has been part of Taiwan's industrial strategy since the late 1950s while the preponderance of SMEs began around the same time period and persists through the present day. A significant amount of research has focused on the roles of Taiwanese exporters and SMEs in the successful performance of the economy in general. However, the bulk of this research is either at the aggregate level or anecdotal in nature.

The primary goal in this paper is to analyze the dynamic role of SMEs using micro level data in the cross section as well as in the panel data. We quantify the magnitude and nature of turnover among SMEs as well as their level and growth of total factor productivity relative to large firms. It is a well known fact from research using micro data in both developed and developing countries that the levels and growth of productivity are positively correlated with firm size. We examine if this is also true of Taiwanese firms. For the purpose of policy, the critical issue is which comes first: higher productivity (leading to the growth in firm size) or large firms (leading to higher productivity). The first suggests that larger firm size reflects the self selection of more efficient producers that survive over time. The second indicates that larger firms, by virtue of their size and the advantages associated with greater resources or access to more resources, are able to adopt better techniques that result in higher productivity. Both explanations are consistent with the positive correlation between productivity and firm size in the cross section. In this paper we exploit our ability to track firms over time to address the issue of whether high levels of productivity precedes or proceeds from firms that grow significantly in size.

More specifically, we focus on the relationship between productivity and the movement of producers in and out of larger firm size categories. It is productivity differences between producers with different transition patterns, rather than just different firm size status, that are crucial to separating the selection versus size-specific advantage explanations. If self selection is shown to be more important, then policies which strengthens market selection forces are likely to result in the survival of the relatively more efficient producers and thus higher aggregate productivity. Alternatively, if the results suggest that producers' choice to be 'large' leads directly to improvements in productivity over time, then there is some justification for policies supporting the entry and survival of such 'large' firms.

In section II we report the results of a cross-sectional analysis of several key features that characterize SMEs in the Taiwanese manufacturing sector. In sections III we use panel data to focus on the interaction of firm size with total factor productivity in order to arrive at a more complete understanding of the role of SMEs in economic development. Finally we conclude with policy implications of our results in section IV. In the data appendix at the end of the paper, we describe the data set on which this study is based.

II. SMEs: Cross-Sectional Features

A. General Characteristics

First, we document information on some general statistics of the manufacturing sector to provide the context for our analysis of SMEs. In table 1, we note that while the number of firms increased by about 25% in each of the two five-year periods between census years, employment per firm has fluctuated from 20 in 1981 to 24 and 18 in 1986 and 1991 respectively. The aggregate data suggest that if firm size is measured in terms of employment, average firm size underwent a small decline over the ten year period. However, over the first five-year period, average capital stock doubled while average

Table 1: General Characteristics of Manufacturing Sector in Taiwan, 1981-1991

	1981	1986	1991
Number of Firms (number)	88,450	110,818	137,428
Employment per firm (number)	20.12	24.0	18.89
Sales per firm (NT$'000)	17,300	28,800	34,400
Subcontracting expenditure per firm (NT$'000)	116	341	736
Subcontracting revenue per firm (NT$'000)	551	739	1,210
Capital stock per firm (T$'000)	4,900	9,500	14,000

sales rose by 67%. Growth rate in sales per firm in the second five-year period remain positive although at about a third of the level of the 1981-1986 period. In this latter period, there was a 50% growth in the capital stock per firm. It is interesting to note that the rate at which the average firm subcontracted out part of their production increased by 198% between 1981-86 and 116% between 1986-91.

The general impression from the figures in table 1 suggests that while, in terms of employment, firm size has not changed dramatically, in terms of other variables like sales, capital stock and subcontracting activities, the average firm appears to be "bigger" by the end of the ten-year period under study. Nevertheless, even at its largest, whether in terms of average employment or sales, these measures of firm size are smaller than the corresponding figures for other countries at similar levels of development.

While the standard definition of SMEs are firms that employ 300 or fewer workers, over 90 percent of firms in Taiwan are SMEs by this criteria. In the analysis that follows we find it useful to decompose SMEs into micro (less than 5 workers), small (5-99 workers) and medium (100-299 workers) enterprises. Table 2 reports several key shares in each of the nine major industries in the manufacturing sector: those relating to total manufacturing firms, total manufacturing employment, and total value of output by the above firm size categories and year.

Four features stand out in the table. First, the overall average size distribution in each industry is relatively time invariant. The stability of the firm size distribution is especially apparent in several industries. Throughout the decade of the 80's, the fabricated metals and non-electrical industries have the highest concentration of micro-sized firms while chemicals and electric & electronics industries have among the lowest. Second, on average across all 9 industries in the manufacturing sector for all three census years, about 30% of the firms are micro enterprises employing less than 5 workers. Between 1981 and 1991, however, the highest gains have been made by firms classified as small firms (5-99 employees). With the exception of the fabricated metals industry, the share of firms in that size category alone ranged from 64-74% of all firms by 1991. Thus, for Taiwanese firms, it is important that we keep in perspective the use of the standard definition of SMEs as firms employing less than 300 workers.

Third, SMEs in Taiwan, unlike those in developed countries like the U.S., make significant contributions to employment and total sales in the manufacturing sector. On average, more than fifty percent of total manufacturing employment, and at least one third of total sales in every two-digit manufacturing industry come from SMEs. The higher figures for employment share relative to output share that come from SMEs in each of the 9 two-digit industry indicate that compared to their larger counterparts, SMEs are relatively more labor intensive in production. Finally, both output and employment shares of this group of firms are increasing over time, implying their increasing importance over the period from 1981 to 1991.

Table 2 : Distribution of Firms among Taiwan's SMEs and their Output and Employment Share in Total Manufacturing

Industry	1981			1986			1991		
	Micro	Small	Medium	Micro	Small	Medium	Micro	Small	Medium
Textiles: Firm Share	.27	.58	.10	.21	.65	.10	.24	.68	.03
Output Share	.45			.56			.63		
Labor Share	.52			.66			.70		
Clothing: Firm Share	.29	.60	.08	.16	.71	.10	.21	.72	.06
Output Share	.70			.68			.79		
Labor Share	.67			.72			.81		
Chemicals: Firm Share	.22	.69	.05	.26	.67	.04	.21	.72	.04
Output Share	.34			.28			.28		
Labor Share	.37			.33			.35		
Plastics: Firm Share	.37	.55	.06	.25	.67	.06	.30	.68	.02
Output Share	.59			.61			.67		
Labor share	.74			.73			.84		
Basic Metal: Firm Share	.29	.66	.05	.26	.69	.04	.26	.70	.03
Output Share	.83			.64			.59		
Labor Share	.87			.76			.72		
Fabr. Metal: Firm Share	.57	.42	.01	.50	.49	.01	.48	.51	.01
Output Share	.90			.88			.88		
Labor Share	.94			.92			.94		
Non-Elec. Mach:Firm Sh.	.48	.51	.01	.37	.62	.01	.35	.64	.01
Output Share	.81			.82			.83		
Labor Share	.88			.90			.90		
Elec. Mach: Firm Sh.	.28	.62	.06	.18	.71	.07	.19	.74	.04
Output Share	.32			.38			.42		
Labor Share	.40			.47			.55		
Transportation: Firm Sh.	.33	.60	.05	.23	.71	.05	.24	.72	.04
Output Share	.39			.43			.38		
Labor Share	.70			.65			.66		

Note: Definition of Size categories: Micro = <5 workers; Small = 5-99 workers; Medium = 100-299 workers.

It is clear from table 2 that over 90 percent of firms in all principal manufacturing industries in Taiwan employ less than 100 workers. This feature is a result of very rapid turnover of firms in general and firms in these size categories in particular. Table 3 summarizes the size distribution of the entrants and exits into and out of the manufacturing sector, respectively. Over the decade between 1981 and 1991, between three-quarters and four-fifths of the total number of entering and exiting firms in Taiwan are SMEs. In a separate paper by Aw, Chen and Roberts (1998) they document that the pattern of turnover in Taiwan's manufacturing sector is closely reflected in systematic productivity differences across firms.

They conclude that, unlike the finding in other countries, the turnover of Taiwanese enterprises through entry and exit play a significant role in explaining the increase in aggregate productivity growth, generally because there are significant productivity differences between entering and exiting firms and these groups account for a substantial share of total industry output. Thus results together with the observed high concentration of SMEs among entrants and exits imply that the productivity dynamics of the manufacturing sector in Taiwan is driven significantly by the contribution of a constantly evolving group of small businesses.

Table 3: Size Distribution of Entering, Exiting and Surviving Firms, 1981-86, 1986-91

Share of	1981-1986			1986-1991		
	Micro/Small (1-99)	Medium (100-299)	Large (>300)	Micro/Small (1-99)	Medium (100-299)	Large (>300)
Total Entrants	.77	.19	.04	.79	.17	.04
Total Exits	.79	.17	.05	.78	.17	.05

The dominance of small scale firms in Taiwan allows firms to enter production with relatively small amounts of capital, thus lowering the sunk costs of entry. Absent from the manufacturing landscape are large companies with big advertising budgets. In fact, there is little emphasis among Taiwan manufactures on brand or product differentiation thus reducing the need for such sunk advertising or R&D expenditures by entering firms (Hobday 1995).[1] Anecdotal evidence emphasize the infinitely flexible characteristic of Taiwan's SMEs, adapt at switching businesses as market conditions dictate. This evidence further documents the fact this group of SMEs, by their sheer numbers, can collectively create a critical mass by exploiting the niches in a particular industry and by so doing, compensate for the marketing inefficiencies of each undersized member. The specific feature that much of the evidence points to as being responsible for the flexible and efficient response to global shocks in demand and supply in Taiwan is the preponderance of its dense network of SME subcontractors.[2] The subcontracting activity itself is related closely with the ease of entry and exit and therefore low barriers to entering and exiting the business of producing in an industry.[3]

Thus in our analysis of the relationship between firm size and the growth in TFP in section IV, we incorporate information on firm level subcontracting activity into the regressions to proxy the flexibility of these firms over time.

---

[1] This is evidenced by the common observation that most people would be hard pressed to name a single Taiwanese firm. The bulk of Taiwanese producers operate in small, young and often obscure firms making seemingly obscure products such as small metal fittings or machine tools that eventually end up as a branded product sold by large enterprises in the international market.

[2] In a field survey, Levy and Kuo (1991) find evidence that firms entering the electronics industry are often characterized by little up-front investment and that they subcontract the manufacture of a substantial number of components of the finished product. They find that it is not uncommon for firms to have as many subcontractors as employees. In fact, it is believed that the business network in Taiwan is so dense that local subcontractors can usually be found for everything a particular firm needs to begin production of its speciality, enabling firms to horizontally integrate across the entire industry.

[3] The other side of the coin to a firm spending on subcontracting out some component in the middle of a long supply chain is the firm providing subcontract services which earns the firm revenue.

B. Firm-Size and Total Factor Productivity

To measure productivity at the firm level we use a modification of the multilateral index developed by Caves, Christensen, and Tretheway (1981). In appendix II at the end of the paper, we describe the measure in detail both for the firm and for the industry. We construct this index of firm-level total factor productivity (*TFP*) for each firm in each of the three census years 1981, 1986, and 1991.[4]

Table 4 reports the results of the regression of firm productivity on year and firm size dummies for each of the nine two-digit industries. We also include a variable that measures the age of the firm. This variable accounts for the length of time that the firm has been in the market. Older firms have more experience in production and have also survived competition from other firms. Both these factors imply that age is positively correlated with TFP. However, younger firms may have higher productivity levels if they have newer and better technology, which would result in a negative correlation between age and TFP level. The net effect will depend on which of these forces is stronger. In table 4, the figures in the second to last column indicate that in every industry, productivity is positively and significantly correlated to firm age.

The intercept in column 1 of the table represents the mean productivity of the base group of firms, that is, those that employ less than 5 workers (micro-sized). The remaining coefficients from columns 2-4 measure the percentage difference in average productivity between these micro-sized firms and small (5-99 workers), medium (100-299 workers) and large (300+ workers) firms, respectively. The positive and significant coefficients on the firm-size dummies for all nine industries indicate clearly

[4] Tybout (1996a) discusses alternative productivity measures based on econometric estimation of production functions and summarizes the literature on the sources of productivity differences across producers. Olley and Pakes (1996) develop an econometric methodology for estimating production functions that is consistent with a dynamic, stochastic model of industry development and use it to study productivity growth in the U.S. telecommunications industry.

Table 4: Mean Productivity Differences Across Firms Based on Firm Size

Industry	Firm Size Categories [a]				Age	Test Results [c]
	Intercept	Small	Medium	Large		
Textiles	-.277* (.008)	.222* (.007)	.409* (.012)	.438* (.018)	.001** (.0005)	1
Clothing	-.245* (.010)	.197* (.009)	.376* (.016)	.389* (.027)	.001 (.0007)	1
Paper/Publ.	-.187* (.005)	.151* (.004)	.370* (.019)	.471* (.032)	.001* (.0003)	1,2
Chemicals	-.227* (.016)	.163* (.013)	.278* (.029)	.271* (.033)	.002** (.0008)	1
Plastics	-.188* (.005)	.146* (.004)	.304* (.009)	.337* (.017)	.004* (.0003)	1
Basic Metal	-.215* (.009)	.137* (.007)	.217* (.018)	.232* (.038)	.002* (.0005)	1
Fabricated Metal	-.165* (.003)	.138* (.003)	.296* (.013)	.313* (.030)	.001* (.0002)	1
Machinery	-.115* (.004)	.137* (.004)	.304* (.016)	.338* (.034)	.002* (.0003)	1
Electric/Electronics	-.214* (.006)	.145* (.005)	.226* (.010)	.238* (.012)	.004* (.0004)	1
Transportation Equipment	-.196* (.008)	.158* (.007)	.287* (.015)	.382* (.027)	.002* (.0005)	1,2

[a] Definition of Size Categories: Small = 5–99/Medium = 100–299/Large = 300+
[b] All regressions include year dummies
[c] 1. Reject equality of small and medium sized firms' coefficients at α = .05 level.
2. Reject equality of medium and large sized firms' coefficients at α = .05 level. Even at the cross-sectional level of analysis, the above results present a non-linear relationship between productivity and firm size. There is a steep increase in total factor productivity from micro to small firms, which in turn are only slightly less productive than medium firms. Large firms do not have productivity levels that are significantly different from medium firms.
* Statistically significant at 1%.
** Statistically significant at 5%.

higher levels of productivity of small, medium and large firms relative micro-sized firms. What is more interesting is that the largest increase in efficiency is in the movement from micro to small firms ranging from a 13.7% gain in non-electrical machinery and basic metals to 22.2% gain in textiles. The difference between small and medium firms is slightly less ranging from 8% gain in basic metal and electric/electronics to 21.9% gain in paper and publishing. The difference is even less between medium and large firms. In the last column of the table, we report the results of the tests of equality between the coefficients between small and medium sized firms and then between medium and large firms. For all 9 industries, we reject that the coefficients of small firms equal to those of medium firms and on for seven of the nine industries, it is not possible to reject the hypothesis that average productivity is the same across the medium and large. Thus, the gains in productivity, at least in the cross section, flattens out significantly after firms reach medium size.

To summarize, the productivity advantage of increasing firm size is significant only among SMEs that employ less than 100 workers. Given that firm size is endogenous to various government policies as well as market selection mechanisms, a firm that is classified as a micro-sized firm today may very quickly exit/fail or grow into a medium/large firm tomorrow. As such, rather than treat firm size as given and examining how performance of firms vary with size at a given point in time, it is important to understand the interaction of firm size with productivity as well as the interaction of firm size with employment generation over time.

In the next section of this paper, we exploit information in the panel data to more precisely separate the sources higher levels and growth of total factor productivity, taking into account firms that not only continue production but those that fail and those that are new entrants into production.

III. The Productivity Dynamics of SMEs

Recent theoretical models of industry dynamics all begin with the assumption that producers within the same industry are heterogeneous in their productive efficiency. Another common thread running through the models is that differences in the evolution of productivity over time result in the divergent paths of growth and failure of producers within the same industry. These models provide a very useful way in which to organize and view firm-level productivity and its interaction with firm size. We begin with a simple analysis of relating firm growth as measured by changes in employment at the firm-level with the productivity and size of the firm as measured in the initial time period. We then use the results obtained from this exercise to explore further the pattern of relationship between firm size and productivity change.

Table 5 displays the results of the regression of employment growth on productivity level and firms size in the initial period and a year dummy. The results indicate that initial levels of TFP are positively related to firm growth and the relationship is statistically significant in all but two of the nine industries. Initial firm size is negatively correlated to firm growth, implying that larger firms have smaller growth in employment. Given that the regression focuses on growth rates in employment as the dependent variable, the regression does not include firms that are new entrants or exits in the industry. In order to have a clearer understanding of the relationship among the variables, information on firms that enter and exit the industry should be incorporated into the analysis.

Table 5: Regression of Employment Growth by Industry

	Constant	Initial Firm Size	Initial TFP	Year Dummy
Textiles	1.775** (.128)	-.378** (.032)	.665** (.166)	-.405** (.094)
Apparel	2.111** (.249)	-.388** (.066)	.787 (.336)	-.642** (.184)
Chemicals	1.359** (.194)	-.250** (.049)	.367 (.296)	-.424** (.157)oobb
Plastics	1.908** (.077)	-.400** (.023)	.782** (.123)	-.674** (.061)
Basic Metals	1.740** (.199)	-.342)** (.053)	.735* (.291)	-.425** (.147)
Fabricated Metals	1.398** (.047)	-.395** (.019)	1.266** (.082)	-.284** (.042)
Machinery	1.262** (.055)	-.359** (.021)	.485** (.090)	-.075 (.045)
Electric/Electronics	2.920** (.167)	-.500** (.041)	2.114** (.250)	-1.093** (.138)
Transportation	1.841** (.155)	-.332** (.043)	.125 (.241)	-.574** (.116)

* Statistically significant at 1%.

** Statistically significant at 5%.

We make use of some of the cross-sectional results reported in section III as a basis of our analysis of how the relationship between firm size and productivity varies in the panel data. To organize the analysis, we separate firms into 6 cohorts based on the size of the firm as measured by employment between year t and year t+1:

Firm Status	**Year t**	**Year t+1**
1. Stay micro	<5 workers	<5 workers
2. Grew	<5 workers	>=5 workers
3. Stay SML	>=5 workers	>=5 workers
4. Entered micro	Does not exit	<5 workers
5. Entered SML	Does not exist	>=5 workers
3. Exit	<5 workers	Ceased production

Given that the largest increase in TFP, as found in the regression of mean productivity levels on categories of firms of different sizes (table 3), is between firms that have less than 5 workers (micro) and small firms (5-99 workers), we define a firm as having grown in size as one that was observed to employ less than 5 workers in year t and more than 5 workers by year t+1. Moreover, in many countries, micro-sized firms are usually defined as those with under 5 workers. The literature with respect to these micro-sized firms also suggests that micro firms are often distinctive in their organizational structure. For all these reasons, the choice of 5 workers as the cut-off between firms that grew and those that did is of most interest. Later in the paper, we will show that the regression results are independent of the exact definition of what constitutes micro-sized firms.

Firms in cohort 1 are those that stayed at employment levels of less than 5 workers (stay micro). Similarly, those that employed 5 workers or more in both year t and year t+1 are classified under cohort 3 (stayed small or medium or large). New entrants are firms that observed for the first time in year t+1 and are classified under cohort 4 if they started production with less than 5 workers(entered micro), but are under cohort 5 if they started production at levels of employment greater than 5 workers (entered small, medium or large). Cohort 6 consists of firms that employed less than 5 workers in year t but ceased production five years later.

Several of the cohorts consists of firms that are likely to be very heterogeneous. For example, firms that we observe for the first time in 1991 could vary from 1 to 4 years old given the five-year intervals in our observations in the Census data. In order to control for this dimension of the heterogeneity problem, we include the age variable in the relative productivity regressions.

In Table 6 we begin by comparing the productivity of the first five transition groups in year t+1 to see if the transition patterns of firms is reflected in underlying productivity differences, after accounting for firm age. The base category are the firms that stayed micro-sized throughout the period, that is, category 1 firms. The constant term represents that average productivity of this base group of firms. Columns 2-5 measure the percentage deviation in average productivity between the base group and each of the other four categories. Not surprisingly, firms that stayed micro-sized over time is also the group with the lowest productivity. The magnitudes range from -.281 in the clothing industry to -.088 in chemicals. These are followed, in order of increasing productivity, by firms that are micro-sized entrants, firms that graduated from micro to SML enterprises, firms that entered as (larger than micro-sized) SML enterprises and firms that remained SMLs over time.

Column 4 indicates that in only two of the nine industries, micro-sized entrants were, on average, not significantly different than firms that stayed micro-sized over time. In the other industries they were marginally (1.6-7.4%) more efficient than firms in the base category. In contrast, firms that made the transition from micro to one of the larger size categories (cohort 2) had average productivity levels that were 8-20% higher than those that stayed as micro-sized firms. The figures in the second to last column

Table 6: Mean Productivity Differences Across Firms Based on transitions In and Out of Firm Size Categories[a]

	Differential for Firms That:					
	Constant	Grew	Stay SML[b]	Micro Entrants	SML Entrants	Age
Textiles	-.193* (.018)	.192* (.028)	.343* (.018)	.074* (.018)	.284* (.017)	.003* (.001)
Clothing	-.281* (.027)	.080** (.040)	.273* (.027)	.032 (.028)	.250* (.026)	.003* (.001)
Paper/Publ.	-.209* (.008)	.110* (.012)	.193* (.008)	.025* (.008)	.167* (.008)	.002* (.000)
Chemicals	-.088** (.038)	.164* (.056)	.267* (.038)	.066 (.038)	.229* (.037)	.002* (.001)
Plastics	-.118* (.010)	.120* (.014)	.222* (.010)	.044* (.010)	.187* (.009)	.004* (.000)
Basic Metal	-.140* (.023)	.200* (.034)	.245* (.024)	.061* (.023)	.191* (.023)	.002* (.001)
Fabricated Metal	-.146* (.005)	.117* (.008)	.182* (.005)	.016* (.005)	.148* (.004)	.001* (.000)
Machinery	-.104* (.008)	.095* (.012)	.184* (.009)	.020** (.008)	.149* (.008)	.001* (.000)
Electric/Electronics	-.134* (.015)	.100* (.022)	.206* (.015)	.030** (.016)	.176* (.015)	.004* (.000)
Transportation Equipment	-.275* (.021)	.097* (.029)	.225* (.029)	.035** (.021)	.187* (.021)	.002* (.001)

[a] All regressions include year dummies
[b] This represents small (5-99 workers), medium(100-299 workers) and large(300+ workers) firms.
* Statistically significant at 1%.
** Statistically significant at 5%.

of the table represent firms that entered as SML enterprises (cohort 5). On average, these firms were about 15-28% more productive than firms that stayed micro. One possible explanation for the similarity in these magnitudes with firms that grew from micro to SML firms is that firms lumped together under cohort 5 are likely to be heterogeneous in characteristics, even after accounting for when they began business. In particular, some of the firms that technically entered as SML firms may be very similar to the ones that "grew" from the smallest size category by the time this latter group is first observed.

The size category that records the highest difference in productivity levels from the base category are those in cohort 3 (Stay SML). The figures in column 3 indicate that the average productivity of this group range from gains of 18% to 34% compared to firms in the base category of firms.

In order to show that the above results are insensitive to the specific cut-off size in employment used to determine firms that grow and those that do not, the above regressions were repeated using the higher threshold levels of 10 as well as 20 workers in firm employment rather than 5 workers to determine which firms stayed the same size and which firms grew. With the cut-off at 10 or 20, the results essentially remains qualitatively unchanged.[5] In the case of the 20-worker cut-off, with the sole exception of the chemicals industry, the magnitude of the intercept terms for the other eight industries average about 10% higher compared to the 5 worker cut-off. Given the higher cut-off, this is reasonable and consistent with the strong positive relationship between size and productivity in the cross-section. The same qualitative results continue to hold in all nine industries under study: that firms which grew from micro/small size to medium/large firms have average productivity levels that are significantly higher than those that stayed micro/small and that these magnitudes in turn are only slightly smaller than the cohort of firms that either entered as medium/large firms or stayed in those size categories.

While the information from examining Table 6 reinforces the cross-sectional results that micro-

[5] We do not report any of these results in detail but they are available from the author.

sized firms suffer the greatest productivity disadvantage, it is also clear that those that survived and grew into larger firms have productivity levels that are significantly higher than those that did not. The important question from the above results is does higher productivity precede or proceed from a larger firm size? We address this issue by focusing on firms that are micro-sized in year t and compare the average productivity in t and t+1 between those that grew larger (cohort 2) and those that stayed micro-sized (cohort 1). If self-selection is important then a producer's transition into or out of a larger size category should be reflected in initial productivity. If being in a larger size category is important, then those that grew should have subsequent productivity changes that are different from producers that do not grow. As before, in order to account for the degree of heterogeneity within each cohort, we include the age variable in the regression results reported in Table 7.

The second column in the table provides the percentage difference between these two groups in year t and column 3 reports the changes in the productivity differential in year t+1. In every industry those firms that eventually grew from micro to small, medium or large firms, have significantly higher average productivity prior to this growth than those that did not grow and stayed micro. The differential varies from 6.5-17% across the nine industries. These deviations are statistically significant in all but one industry. In fact, if we compare the magnitudes column 2 with those in column 2 of Table 6, we find that, with the exception of the basic metal industry, the coefficients are not significantly different. This suggests that the bulk of the productivity advantage that the firms that grew larger existed in the pre-growth period. This result is consistent with the self-selection hypothesis. Column 3 shows that the initial difference between the two groups does not widen in all the industries. This latter result indicates that there is little evidence that being 'larger' per se leads to higher productivity.

Table 7: Mean Productivity Differences in Initial Productivity and Subsequent Productivity of Firms that Grew and Those that Stayed Micro (< 5 workers)

	Intercept	Before Growth	After Growth	Age	Year Dummy
Textiles	-.126*	.169*	-.058	-.002	-.013
	(.024)	(.032)	(.045)	(.002)	(.027)
Clothing	-.158*	.073	-.046	-.003	-.066
	(.035)	(.047)	(.067)	(.002)	(.043)
Paper/Publ.	-.206*	.103*	-.007	-.001	.008
	(.009)	(.012)	(.018)	(.001)	(.011)
Chemicals	-.045	.144**	-.042	.0002	-.028
	(.066)	(.074)	(.106)	(.005)	(.069)
Plastics	-.126*	.094*	-.033	.003*	.042**
	(.012)	(.015)	(.022)	(.001)	(.014)
Basic Metal	-.128*	.114**	.066	.0003	.017
	(.034)	(.040)	(.057)	(.003)	(.037)
Fabricated Metal	-.131*	.092*	-.016	.0002	-.003
	(.005)	(.008)	(.011)	(.0004)	(.006)
Machinery	-.127*	.086*	-.033	.0002	.053*
	(.009)	(.012)	(.017)	(.001)	(.011)
Electric/Electronics	-.074*	.071**	-.005	.004*	-.023
	(.020)	(.024)	(.035)	(.002)	(.025)
Transportation Equipment	-.236*	.065**	-.040	-.005*	.037
	(.025)	(.030)	(.043)	(.002)	(.030)

* Statistically significant at 1%.

** Statistically significant at 5%.

Table 8 summarizes the difference in productivity between micro firms that fail (cohort 6) and those that survived but stayed micro (cohort 1). The second column reports the productivity differential in year t when all micro-sized firms are in production. A negative and significant coefficient indicates that firms that fail (exit production after year t) are less productive than their counterparts that survived but stayed the same size, a pattern consistent with productivity-driven selection on the exit side of the market. We observe this pattern in three major industries in Taiwanese manufacturing (textiles, plastics and electric/electronics). The productivity gap varies from 3 to 7%. The coefficient is not significantly different than zero in the rest of the other industries. We conclude that the selection mechanism on the exit side is rather industry-specific.

In summary, one of the key sources of the low productivity of micro firms that we observed in the cross section in Table 4 is that the figure is an average of four different types of micro firms in that year: those that failed in year t+1, those that survived but stayed micro, those that entered as micro-sized firms and finally, those that grew bigger. Tables 5-7 imply that those micro firms that failed have the lowest productivity followed, in order of increasing productivity, by those that survived but stayed micro, those that entered as micro firms and those that grew. More importantly, our results indicate very clearly that the higher productivity of firms that grew relative to those that did not existed in the period before growth occurred. This pattern is exactly what one would expect in the context of strong self selection forces, suggesting that it is not their size per se that dooms a micro firm to low productivity. Those that are more productive among them survive and are more likely to grow bigger and have average productivity levels that converge to those of larger firms. We next analyze the relationship between firm size and productivity growth.

Table 8: Mean Productivity Differences in Initial Productivity of Firms that Exited and Firms that Stayed Micro (<5 workers)

	Intercept	Before Exit	Age	Year 75
Textiles	-.203*	-.046**	-.003*	.116*
	(.029)	(.027)	(.001)	(.019)
Clothing	-.229	.006	-.002	-.007
	(.048)	(.044)	(.002)	(.024)
Paper/Publ.	-.216*	.011	-.0003	.016
	(.012)	(.012)	(.001)	(.010)
Chemicals	-.209**	.032	.001	.185*
	(.091)	(.086)	(.004)	(.044)
Plastics	-.165*	-.025**	.003*	.092*
	(.016)	(.014)	(.001)	(.010)
Basic Metal	-.210*	.023	-.003**	.136*
	(.051)	(.049)	(.002)	(.020)
Fabricated Metal	-.156*	-.002	-.0002	.032*
	(.007)	(.007)	(.001)	(.006)
Machinery	-.187*	-.007	.001	.068*
	(.013)	(.012)	(.001)	(.009)
Electric/Electronics	-.151*	-.067**	.003**	.129*
	(.027)	(.025)	(.002)	(.015)
Transportation Equipment	-.226*	.038	-.001	-.025
	(.034)	(.033)	(.002)	(.017)

* Statistically significant at 5%.

** Statistically significant at 10%.

IV. TFP Growth and Firm Size

One of our key findings in this paper provides further insight into the nature of the interaction between firm size and productivity growth. That is, good performance in the form of high levels (and growth) of productivity is clearly not the prerogative of large firms, a very common result in numerous countries for which micro-level analysis have been performed. Micro-sized producers (< 5 workers) that eventually cross this employment threshold are shown to have, in the pre-growth time frame, levels of productivity that are only at a small disadvantage to their larger, more resource-filled counterparts. The same holds true for small firms employing from 5 to 100 workers. A related point is that, of the heterogeneous group of producers in both these size categories, the ones with low productivity levels generally end up exiting the industry, leaving behind the relatively more efficient firms. As pointed out in section II, the reason for the apparent strong market selection forces is likely to be related to low sunk costs of entry and exit due to the dense network of subcontractors in the economy.

For subcontracting to play an important role in lowering the sunk costs of entry for potential entrants into an industry it must be the case that potential entrants into an industry can start up production at a small scale as subcontractors for other firms, making some component in the middle of a long chain of supply. Alternatively, the network of subcontract services available must be available to all firms, large and small, so that it is feasible for potential entrants to start production with very small investments of their own, relying on other firms for part of the production process. These views are consistent with our findings that entrants (and exits) are concentrated among micro to small firms and that the rapid growth of the value of subcontract services in the manufacturing sector of Taiwan between 1981 and 1991 is also increasingly concentrated among firms in the same size category.

In the TFP growth regression, in addition to the firm size dummies, we also include firm age and the share of firm revenue that comes from the firm's subcontracting activity. The age of the firm not only reflects the firm's experience in production but also the vintage of the firm's capital and technology. Clearly, productivity growth and firm access and use of modern technology are likely to be positively correlated. Table 9 reports the results of this regression. As before, the base category are continuing micro-sized firms and columns 2-4 display the coefficients as deviations of average TFP growth of continuing firms in the small, medium and large size categories from the average TFP growth of continuing micro firms.

Table 9: Regression of TFP Growth on Firm Size, Age and Subcontracting Activity by Industry

	Constant	Small	Medium	Large	Year Dummy	Age	Subcontra-cting
Textiles	-.141* (.070)	.174* (.064)	.313* (.068)	.324* (.074)	.012 (.032)	-.006* (.002)	-.357** (.164)
Apparel	-.548* (.108)	.425* (.108)	.484* (.111)	.545* (.122)	.109** (.045)	.001 (.004)	-.304 (.269)
Chemicals	.197 (.411)	.132 (.312)	-.141 (.462)	.013 (.320)	-.205 (.314)	-.001 (.016)	-1.673 (5.299)
Plastics	-.145 (.070)	.089 (.063)	.099 (.072)	.125 (.086)	.098* (.038)	-.002 (.003)	.194 (.237)
Basic Metals	.367** (.153)	-.218 (.140)	-.050 (.154)	-.064 (.174)	-.145** (.067)	-.001 (.004)	.316 (.613)
Fabricated Metals	-.109** (.046)	.064** (.032)	.055 (.058)	.277** (.110)	-.006 (.038)	-.0004 (.002)	-.020 (.166)
Machinery	-.104 (.062)	.008 (.042)	-.013 (.092)	-.042 (.179)	.021 (.049)	.003 (.003)	.059 (.192)
Electric/Electronics	-.075 (.073)	.089 (.062)	.177** (.071)	.173** (.079)	.135** (.043)	-.005 (.003)	.237 (.254)
Transportation	-.161 (.092)	-.017 (.075)	.152 (.091)	.296** (.151)	.069 (.071)	-.004 (.004)	.285 (.283)

Note: the definition of size are as follows: small (5-99 workers), medium(100-299 workers) and large(300+ workers) firms.

The results on the correlates of TFP growth are much more mixed than the ones relating to levels of productivity. They indicate that, conditional on survival, in four (chemicals, plastics, basic metals and machinery) of the nine industries, there is no statistically significant relationship between TFP growth and firm size. The productivity growth of micro sized firms are not significantly different from their larger counterparts. However, in the other five industries there is a positive relationship between firm size and productivity growth. In textiles and apparel, this relationship is monotonic with TFP growth progressively increasing with each firm size category. In the remaining industries, the positive relationship is statistically significant only in firms employing 100 or more workers (electric/electronics) or 300 or more workers (fabricated metals and transportation equipment). Except for the textiles industry, firm age and the degree of subcontracting activity by the firm are not significantly correlated with TFP growth. It is very possible that the share of subcontracting in firm revenue is too aggregate a measure to proxy for the degree of flexibility possessed by the firm in responding to exogenous changes.

V. Conclusions

There are two main findings from this study on SMEs in the manufacturing sector in Taiwan. The first is that firms with higher initial levels of productivity are more likely to survive and grow in size. This pattern is consistent with models of self selection. Our findings indicate that it is the process of survival and growth rather than the absolute size to which firms grow into that appears to be important. For example, firms that graduate from micro to small firms are just as likely to achieve productivity levels that converge towards those of large firms as firms that graduate from small to medium firm size.

The second finding is that the growth in productivity in several of Taiwan's major industries is positively related to firm size, suggesting that in these industries, micro firms that survive and grow bigger have higher growth in TFP.

It is quite clear that in general, incentives that target a specific firm size are likely to be ineffective in encouraging higher productivity. The highest levels of productivity are achieved by firms that survive and grow in size over time. This observation applies equally to firms which employ less than five workers as to those with many times more employees. These results reflect strong market selection forces that are in place in Taiwan where we find that these forces are clearly important in explaining high aggregate productivity growth. For Taiwan, further strengthening market selection forces may require reducing the imperfections in the capital market to allow all firms access to loans at market interest rates.

For other countries, strengthening the process of market selection may involve reducing barriers to entry into and exit from an industry in production as well as in the export market. This process of creative destruction requires that the economy be flexible in the sense that it is easy for new companies to start up and existing ones which are no longer competitive to fail. Our finding of extremely high turnover among firms in Taiwan, especially among small businesses, is consistent with low costs of entering and exiting production and the export market. Part of the explanation for these low costs rests with the small scale, low capital -intensive industries in which firms often cluster around. Entrants can easily startup business as subcontractors for other firms and in so doing have a ready market for their output without developing brands of their own. This reduces the need for expensive advertising and research.

Our findings also indicate that even small businesses are able to subcontract the production of many of their components. This means that they do not need to spend much on fixed assets such as machinery, which in turn, reduces the costs of exiting the market. Thus the low costs of entry and exit made possible by this dense network of subcontracting relationships among firms in a given industry means that the economy is in a good position to respond to demand and supply shocks in the global economy. For instance, during a boom in demand, firms are likely to use more subcontractors which in turn encouraging more of them to enter the industry. Conversely during recessions, firms cut down on the amount of subcontracting work encouraging some to exit the market. Thus, the network can be a great absorber of domestic and global shocks and allows the economy to adjust to both rapid growth as well as to sudden economic contraction.

References

Aw, Bee Yan, Geeta Batra and Mark J. Roberts (1997), "The Sources of Export-Domestic Price Differentials,." *Working Paper, The Pennsylvania State University.*

Aw, Bee Yan, Xiaomin Chen, and Mark J. Roberts (1997), "Firm-Level Evidence on Productivity Differentials, Turnover and Exports in Taiwanese Manufacturing," *NBER working paper No. 6235.*

Aw, Bee Yan, Sukkyun Chung and Mark J. Roberts (1998), "Productivity and Turnover in the Export Market: Micro-Evidence From Taiwan and South Korea," *NBER Working Paper 6558.*

Baily, Martin Neil, Charles Hulten, and David Campbell (1992), "Productivity Dynamics in Manufacturing Plants," *Brookings Papers on Economic Activity: Microeconomics 1992,* 187-267.

Caves, Douglas W., Laurits Christensen, and Erwin Diewert (1982), "Output, Input, and Productivity Using Superlative Index Numbers," *Economic Journal*, 92, 73-96.

Caves, Douglas W., Laurits Christensen, and Michael Tretheway (1981), "US trunk Air Carriers, 1972-1977: A Multilateral Comparison of Total Factor Productivity," *in Productivity Measurement in Regulated Industries,* edited by Thomas Cowing and Rodney E. Stevenson, Academic Press.

Good, David H., M. Ishaq Nadiri, and Robin Sickles (1997), "Index Number and Factor Demand Approaches to the Estimation of Productivity," in Hashem Pesaran and Peter Schmidt, *Handbook of Applied Econometrics*, Volume II: Microeconometrics, Basil Blackwell.

Hobday, Michael (1995), *Innovation in East Asia: The Challenge to Japan,* Edward Elgar Publishing Limited.

Hopenhayn, Hugo (1992), "Entry, Exit, and Firm Dynamics in Long-Run Equilibrium," *Econometrica,* 60, 1127-50.

Levy, Brian (1991), "Transactions Costs, the Size of Firms and Industrial Policy: Lessons from a Comparative Case Study of the Footwear industry in Korea and Taiwan," *Journal of Development Economics*, 34, 151-178.

Levy, Brian and Wen-Jeng Kuo (1991), "The Strategic Orientation of Firms and the Performance of Korea and Taiwan in Frontier Industries," *World Development.*

Pack, Howard (1992), "New Perspectives on Industrial Growth in Taiwan," in Gustav Ranis (ed.), *Taiwan From Developing to Mature Economy*, Westview Press.

Olley, G. Steven and Ariel Pakes (1996), " The Dynamics of Productivity in the Telecommunications Equipment Industry," *Econometrica*, 64, 1263-1297.

Roberts, Mark J. (1996), *"* Colombia, 1977-1985: Producer Turnover, Margins and Trade Exposure*," in Industrial Evolution in Developing Countries*: *Micro Patterns of Turnover, Productivity, and Market Structure*, edited by Mark J. Roberts and James R. Tybout, Oxford: Oxford University Press.

Tybout, James R. (1996a), "Chile, 1976-86: Trade Liberalization and its Aftermath," in *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity, and Market Structure*, edited by Mark J. Roberts and James R. Tybout, Oxford University Press.

Tybout, James R. (1996b), "Heterogeneity and Productivity Growth: Assessing the Evidence," in *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity, and Market Structure*, edited by Mark J. Roberts and James R. Tybout, Oxford University Press.

Wade, Robert (1990), *Governing the Market: Economic Theory and Taiwan's Industrial Policies*. Princeton, NJ: Princeton University Press.

Appendix I

Our data base is a compilation of the last three Industrial and Commercial Census collected by the Statistical Bureau of Taiwan's Executive Yuan. It covers the years 1981, 1986 and 1991. The Statistical Bureau collects detailed data on each of the firms in operation in the manufacturing sector, which is more than 88,000 firms in 1981 and over 100,000 manufacturing firms in each of the latter two Census years. The firm observations not only provide complete cross-sectional coverage of the manufacturing sector but are matched across the censuses so that individual firms can be followed over time, allowing measurement of firm turnover and firm growth. The panel data is unbalanced so that we have information on cohorts of firms that survive across census years, enter as new firms or exit the industry in a given census year.

All three Industrial Censuses provide information on the output and input variables that are necessary to measure total factor productivity at the firm-level: sales, employment, book value of the capital stock, and expenditures on labor and different types of intermediate inputs.[6]

Firm output is defined as total firm sales deflated by a wholesale price index defined at the two-digit industry level. There are two weaknesses to this measure. First, we are not able to measure the firm's inventories of final output in each census year so we are not able to distinguish firm sales from firm production in the year. The latter is preferable in productivity studies. The second weakness is that there is no information on firm-level output prices to use in deflating firm sales. While this is a limitation of virtually all productivity studies, it does create the possibility that *TFP* estimates at the firm level will be biased in a way that is related to firm size. If large firms have lower (higher) output prices than small firms, then the use of a common industry price deflator will underestimate (overestimate) the real output of large producers and overestimate (underestimate) the output of small firms, leading to a systematic bias in firm *TFP* across the firm size distribution. In a separate project (Aw, Batra, and Roberts (1997)) we have been

[6] The type of data collected in the Taiwan manufacturing census is very similar to what is collected in the United States (see Baily, Hulten, and Campbell (1992) for its use in productivity measurement) or in the developing countries analyzed in Roberts (1996) and Tybout (1996).

able to analyze firm-level output prices for Taiwan's electronics producers and, while prices do vary across firms, we have found no systematic relationship between output price and firm size or the output market, export versus domestic, in which the output is sold.

We model each firm as using four inputs in production: labor, capital, materials, and subcontracting services. The labor input is measured as the number of production plus non-production workers. We do not have information on the mix of worker skills in the firm and so are not able to account for improvements in labor quality over time. Total payments to labor are measured as total salaries to both groups. We do not have data on non-wage benefits paid by the firm.

The measure of capital input is the book value of capital stock of the firm. To attempt to control for price level changes in new capital goods that will cause the book value of firms to change over time as they invest in new equipment, we deflate the change in each firm's book value by a price index for new capital goods. For example, to convert the firm capital values in 1991 to the same basis as reported in 1986, we calculate the change in each firm's reported book value between 1986 and 1991, deflate this using an industry-specific price index for new capital goods and then add this deflated value to the firms reported book value in 1986. While much cruder than constructing perpetual inventory capital stocks, this procedure does recognize both the level differences in the firms' capital, which are important in the cross-section, and the fact that latter additions to each firm's capital stock partly reflect general price level increases. A similar procedure is used to scale the 1981 book values to the 1986 basis. Finally we note that price changes for new capital goods are generally small, averaging less than one percent per year for most industries, so that comparisons of book values over time probably do not greatly distort the growth in capital stocks. The firm's expenditure share on capital is calculated as the residual after subtracting the expenditure on labor, material inputs, and subcontracting from the firm's sales.

The material input includes the raw materials, fuel, and electricity used by the firm. Expenditures on these categories are converted to 1986 dollars. Raw material expenditures are deflated by a general producer price index which covers both manufacturing and nonmanufacturing output in the country. Fuel and electricity expenditures are deflated by an energy price index. These deflators are the same for all industries.

The subcontracting input is included as a separate factor because, while small as a share of a typical firm's total cost, it has risen in importance over the time period we study. This input is not used by all firms, although it has become more widely used over time, and failing to account for it would mean that we systematically underestimate the inputs used by firms that hired subcontractors relative to those that did everything internally. The would lead us to overestimate *TFP* for firms that used subcontractors relative to those that did not. In the census data a firm that out-sources some of the production steps to a subcontractor generally transfers material inputs to the subcontractor. The value of these transferred material inputs are not reported separately but are included with the hiring firm's expenditure on materials. The hiring firm also reports its payments to subcontractors, which effectively represents the cost to the hiring firm of using the labor and equipment services of the subcontractors as well as the latters' expenses for fuel and electricity. To construct a subcontracting input we deflate the firm's payments to subcontractors by the output price of the industry in which the firm operates. If we had information on the precise step of the production process in which the subcontractor was involved and more disaggregated price deflators it might be possible to use a more accurate price deflator for the subcontracting input. Neither of these pieces of information is available. Our correction, however, attempts to recognize that the inputs of firms which subcontract some of the production steps to others need to be increased, and thus their *TFP* reduced, relative to the firms that do not subcontract.[7]

[7] The firms which engage in subcontracting are not included in the set of firms whose productivity we study. The census data reports a zero value of sales for these firms. Also, most of the material inputs they use are not reported by the subcontracting firm but instead are reported as material purchases by the firm that hires the subcontractor. Thus there is no way to construct productivity measures for subcontractors that are comparable to the measures we construct for the firms we analyze.

Appendix II

Measurement of Firm and Industry Total Factor Productivity

Using the Taiwanese manufacturing data we construct an index of firm-level total factor productivity (*TFP*) for each firm in each of the three census years 1981, 1986, and 1991.[8] A multilateral index which is useful for measuring inputs, outputs, and *TFP* in firm-level panel data sets was developed by Caves, Christensen, and Diewert (1982). It has been used to measure productivity in U.S. airlines by Caves, Christensen, and Tretheway (1981) and to measure import prices by country-of-origin by Aw and Roberts (1987). The multilateral index relies on a single reference point that is constructed as a hypothetical firm with input revenue shares that equal the arithmetic mean revenue shares over all observations and input levels that equal the geometric mean of the inputs (which is equivalent to the arithmetic mean of the log of the inputs) over all observations. Each firm's output, inputs, and/or productivity in each year is measured relative to this hypothetical firm and the multilateral index provides transitive comparisons between any subset of the observations.

Good, Nadiri, and Sickles (1996) discuss an extension of the multilateral index that uses a separate hypothetical-firm reference point for each cross-section of observations and then chain-links the reference points together over time in much the same way as the conventional Tornqvist index of productivity growth. This productivity index is particularly useful in our application because it provides a consistent way of summarizing the cross-sectional distribution of firm productivity, using only information specific to that time period, and how the distribution moves over time.

Let each firm *f* produce a single output Y_{ft} using the set of inputs X_{ift} where i=1,2,...n. The total factor productivity index for firm *f* in year *t* is defined as:

---

[8] Tybout (1996a) discusses alternative productivity measures based on econometric estimation of production functions and summarizes the literature on the sources of productivity differences across producers. Olley and Pakes (1996) develop an econometric methodology for estimating production functions that is consistent with a dynamic, stochastic model of industry development and use it to study productivity growth in the U.S. telecommunications industry.

$$lnTFP_{ft} = \left(lnY_{ft} - \overline{lnY_t}\right) + \sum_{s=2}^{t} \left(\overline{lnY_s} - \overline{lnY_{s-1}}\right)$$

$$- \left[\sum_{i=1}^{n} \frac{1}{2}\left(S_{ift} + \overline{S_{it}}\right)\left(lnX_{ift} - \overline{lnX_{it}}\right) \right. \tag{1}$$

$$\left. + \sum_{s=2}^{t} \sum_{i=1}^{n} \frac{1}{2}\left(\overline{S_{is}} + \overline{S_{is-1}}\right)\left(\overline{lnX_{is}} - \overline{lnX_{is-1}}\right)\right]$$

In this formula the input weights S_{ift} are the share of the firm's total revenue attributable to input X_i. The overbars denote the average value over all firms in year t. The index provides a measure of the proportional difference in *TFP* for firm f in year t relative to the hypothetical firm in the base time period. In our application we will use 1981 as the base time period.

Industry productivity is defined as the market-share weighted sum of the firm productivity levels:

$$lnTFP_t = \sum_f \theta_{ft}\, lnTFP_{ft} \tag{2}$$

where firm productivity is defined in equation (1) and θ_{ft} is the value of firm f sales relative to total industry sales in year t.