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ABSTRACT

The manufacturing sector in Taiwan has a market structure composed of large numbers of small firms, a heavy focus on less capital-intensive industries, and a dense network of firms specializing in subcontracting and trading services. It has been argued that these features lower the start-up costs of new manufacturing firms. Recent theoretical models of market evolution emphasize that low sunk entry and exit costs act to speed firm turnover by facilitating entry and increasing the pressure on inefficient firms to exit. As a result, low cost entry and exit may contribute to aggregate productivity improvements by facilitating the rapid transfer of resources from less to more efficient producers within an industry. Using comprehensive firm-level panel data from the Taiwanese Census of Manufactures for 1981, 1986, and 1991, we measure differences in total factor productivity among entering, exiting, and continuing firms, and quantify the contribution of firm turnover to industry productivity improvements.

We find significant differences in productivity across manufacturing firms that are reflected in turnover patterns in both the domestic and export market. Cohorts of new firms have lower average productivity than incumbents but are themselves a heterogeneous group. The more productive members of the group, on average, survive and in many cases their productivity converges to the productivity level of incumbents. Exiting firms are less productive than survivors. Exporters, including firms that recently exited the export market, are more productive than nonexporters. These patterns are consistent with the view that both the domestic and export market sort out high productivity from low productivity firms and that the export market is a tougher screen. The productivity differential between entering and exiting firms is an important source of industry-level productivity growth in Taiwanese manufacturing, accounting for as much as one-half of industry improvement in some industries and time periods.

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I. Introduction

Recent dynamic models of firm entry and exit emphasize the relationship between a firm's productivity and the decision to enter or exit. If firm turnover is driven by productivity differentials then the reallocation of resources across firms at the micro level can have important implications for aggregate or industry-level productivity change. Using comprehensive firm-level panel data from the Taiwanese Census of Manufactures for the years 1981, 1986, and 1991, this paper documents the extent of firm turnover in both the domestic and export markets, measures differences in total factor productivity between entering, exiting, and continuing firms, and quantifies the contribution of firm turnover to industry productivity improvements.

Our analysis parallels a number of recent studies of firm or plant turnover and productivity growth for manufacturing industries in the United States (Baily, Hulten, and Campbell 1992, and Olley and Pakes 1996), Israel (Griliches and Regev 1995), and Chile and Colombia (Liu 1993, Tybout 1996a, and Liu and Tybout 1996). With the exception of Olley and Pakes (1996), these studies find that entry, exit, and market share reallocations among firms or plants within an industry contribute very little to productivity growth, generally because there are only small productivity differences between entering and exiting plants or these groups account for a very small share of industry output.[1]

In contrast to the relatively slow growth experienced by the manufacturing industries in most of these studies, Taiwan's manufacturing sector had substantial output growth during the 1980's, with much of the supply expansion provided by entering firms. In the nine major manufacturing industries we study, output grew at an average annual rate of 11.4 percent and the total number of firms grew by 7.7 percent

[1] Most of these applications are to industries or time periods in which there are not large changes in market conditions so that there are not strong forces pushing for rationalization of industry structure. The exception is Olley and Pakes (1996) who study the U.S. telecommunications industry in the period surrounding deregulation. They find that the reallocation of output from older, less productive plants that contract or exit to more productive entering establishments is a significant source of industry productivity growth during the period.

per year between 1981 and 1991. Besides being an important country to examine because of its development success and the recent debate regarding the role of productivity growth (Page 1994, World Bank 1993) and capital accumulation (Young 1994, 1995, Krugman 1994, Kim and Lau 1994, and Rodrik 1995) as the source of its success, Taiwan is an interesting case in which to examine the role of firm turnover in productivity growth. Recent research on the institutional environment in Taiwan has emphasized that the low capital intensity of much of the production combined with the manufacturing sector's dense network of subcontracting relationships and trading firms results in low sunk entry and exit costs. Recent theoretical models of firm entry and exit have emphasized that high sunk entry costs act to slow firm turnover, weaken the pressure on inefficient firms to exit, and thus slow or prevent the reallocation of resources from inefficient to more efficient producers and its accompanying productivity gain. Together these factors suggest that, if turnover and market share reallocations reflect productivity differentials across firms, they could be a much more important source of productivity growth in Taiwan than has been found in other countries.

A consistent finding of our study is that there are significant differences in productivity across manufacturing firms and these differences are reflected in turnover patterns. Cohorts of new firms have lower average productivity than incumbents but are themselves a heterogeneous group. The more productive members of the group survive and, in many cases, their productivity converges to the productivity level of incumbents. Exiting firms are also less productive than survivors. Differences in productivity are also reflected in movements of firms in and out of the export market. Firms that remain exporters over multiple years have the highest productivity while beginning exporters, whether they are new firms or older firms, follow behind them. All are more productive, on average, than firms that exit the export market who, in turn, are more productive than firms that never exported. These patterns are generally consistent with the view that both the domestic and export market sort out high productivity from low productivity firms and that only the most efficient firms are able to survive in the export market.

We also find evidence of productivity growth at modest levels (two percent per year) for a number of manufacturing industries. In most industries, the productivity improvement is widespread across the whole distribution of firms, suggesting that it may be less related to individual firm actions than it is to common improvements in worker quality and infrastructure. One implication of this general shift in the firm-level productivity distribution is that entering firms also shared in the higher productivity so that the turnover of firms through entry and exit made a significant positive contribution to industry productivity growth. Productivity growth of incumbent firms also was a significant source of industry productivity growth.

In the next section of the paper we summarize a theoretical model of firm turnover and market selection due to Hopenhayn (1992) with an emphasis on the model's implications for productivity differences between entering, exiting, and continuing cohorts of firms. The third section summarizes the importance of firm entry and exit in both the domestic and export market for nine major manufacturing industries in Taiwan over the 1981-1991 period. Section four describes the index number methods used to measure firm-level total factor productivity and summarizes the cross-sectional productivity distributions and their movement over time. The fifth section of the paper examines the differences in average productivity among entering, exiting, and continuing firms. The final section of the paper combines the productivity and turnover statistics and uses them to disaggregate sectoral productivity growth into components reflecting firm-level productivity improvements and the reallocation of production from less efficient to more efficient producers. Throughout the paper we do not attempt to explain why productivity differs across firms. Our focus instead is on exploiting the longitudinal elements of our data to determine if firm transition patterns in and out of operation or between the export and domestic market reflect underlying differences in firm productivity.

II. A Theoretical Framework Relating Productivity and Turnover

Recent theoretical models of industry dynamics by Jovanovic (1982), Lambson (1991), Hopenhayn (1992), and Ericson and Pakes (1995) have been developed to explain the divergent paths of growth and failure that characterize micro data on individual producers. These models all begin with the assumption that producers within the same industry differ in their productive efficiency and are subject to idiosyncratic shocks or uncertainty. Differences in the evolution of their productivity over time, in turn, lead producers to make different decisions regarding entry, growth, and exit.[2] As a result they provide a very useful framework for organizing micro firm-level productivity and turnover data.

We rely on the model of firm dynamics developed by Hopenhayn (1992) to organize our empirical analysis. In this model an industry is composed of a large number of price-taking firms which produce a homogeneous output. Each firm's output is a function of input levels and a random variable ϕ which is a productivity shock. The productivity shock follows a Markov process that is independent across firms. The conditional distribution function $F(\phi_{t+1} \mid \phi_t)$ is strictly decreasing in ϕ_t, implying that a large productivity shock in period t raises the probability the firm has a large productivity shock in period $t+1$. Each period, before the new productivity shock is observed, incumbent firms may choose to exit the industry and earn zero profits or remain in the industry and pay a fixed cost C_f, after which they observe their productivity shock, and choose their output level for that period. Potential entrants may choose to enter by paying a sunk entry cost C_e, after which they draw their initial productivity level ν from a common distribution function $G(\nu)$, and choose their output level. Output prices are determined competitively to equate industry demand and supply. Hopenhayn demonstrates that equilibrium in this

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[2] The actual source of uncertainty differs across models with Jovanovic emphasizing firm uncertainty about their own productivity level, Lambson focusing on uncertain future market conditions, Hopenhayn emphasizing randomness in productivity changes over time, and Ericson and Pakes modeling uncertainty in the return to firm investments.

model involves the firm using an exit rule of the form: exit after period t if $\phi_t < x_t$ where x_t is the minimum productivity level that results in the firm having positive discounted expected profits over future periods.

One result of this model is that, as long as the sunk entry cost C_e is not too large, industry equilibrium will involve simultaneous offsetting flows of entering and exiting firms. An increase in C_e will raise the level of discounted profits needed to make entry profitable but also lower the minimum productivity level x needed for incumbents to survive, thus reducing the level of firm turnover. In this framework high sunk entry costs provide the barrier to the entry of new firms and insulate incumbents from the effects of market selection. Alternatively, low sunk entry costs produce high levels of firm turnover and demanding requirements on the productivity of incumbent firms. In this way Taiwan's institutional environment with low entry costs can promote the reallocation of resources from low to high productivity firms.

The failure condition implied by this model indicates that firm exit will be concentrated among the least productive firms in the industry. In addition, when sunk entry costs are high, firms will be willing to endure low productivity for longer periods of time before exiting. This could result, depending on the shape of the productivity distribution, in a larger divergence between the average productivity of surviving and failing firms when sunk costs are high. We will examine this by comparing the average productivity of surviving and failing firms.

This framework can also identify the factors leading to differences in the productivity of different cohorts of firms. The distribution function $G(\nu)$ summarizes the heterogeneity in the productivity of entering firms. The distribution function $F(\phi_{t+1} \mid \phi_t)$ determines the evolution of each firm's productivity following entry. Hopenhayn identifies conditions that guarantee that the productivity distribution of incumbents stochastically dominates the productivity distribution of entrants. We will examine this relationship in three ways: by comparing the average productivity of incumbent and entering cohorts at a point in time, by comparing the average initial productivity of the surviving and failing members of an entry cohort, and by examining the productivity of entrants that survive to see if they converge to the level of incumbents.

Finally, the framework can be used to suggest ways in which productivity and turnover may differ between the export and domestic market. First, if the profitability of operating in the export market is lower than for the domestic market, either because there are additional costs of transportation to a foreign market or because output prices are lower in the international market, then we will only observe the more efficient producers entering and surviving in the export market. This will lead us to observe higher average productivity among exporting firms relative to firms selling in the domestic market. This difference does not result from the acquisition of knowledge or expertise by firms exposed to the export market but rather that higher productivity is required to survive in the export market. Second, to the extent that sunk entry costs are different for the export and domestic markets we should observe differences in firm turnover rates and the productivity differential between surviving and exiting producers in each market. To explore the importance of these factors we will make comparisons of the productivity of exporting and nonexporting firms at the same point in time, compare the productivity of exiting and continuing firms in the export market, and summarize the productivity change over time for firms that enter the export market.

III. Firm Turnover in the Taiwan Manufacturing Sector

The data set we analyze in this paper includes information on the output and inputs of every Taiwanese manufacturing firm at three points in time 1981, 1986, and 1991. The firm observations have been matched over time so that we can identify two cohorts of entering firms, two exiting cohorts, and the group of firms that continue in operation over two or three time periods. The data set also contains firm exports in 1986 and 1991 so that we can observe one cohort of entrants to the export market, one cohort of firms that exit the export market, a group that does not export in either year, and a group that exports in both years.

To assess the importance of entering and exiting firms to production and exports in Taiwan we provide evidence of their cumulative effects over the 1981-1991 period. Table 1 summarizes the importance of firm entry to the composition of industry output in 1991. In 1991 we can classify each producer into one of three cohorts: observed in operation in 1981, first observed in the 1986 census, and first observed in the 1991 census. The table summarizes the contribution of the 1986 and 1991 entry cohorts to the total number of firms (column 1) and total industry output (column 2) in 1991. For the textile industry the 1986 entry cohort accounted for 23.8 percent of the number of firms in 1991 and 24.2 percent of industry output, while the 1991 entrants accounted for 59.4 and 33.4 percent of the firms and output, respectively.

A similar pattern is reported for every other industry. Across industries, the cohort of 1991 entrants, which, because of the five-year period of our data, includes any firms that enter after 1986, accounts for approximately two-thirds of the number of firms in operation and between one-third and one-half of each industry's production in 1991.[3] The 1986 entry cohort accounts for approximately an additional 20 percent of the firms and 25 percent of industry output in 1991. Taken together, the two cohorts indicate that firms less than 10 years old in 1991 are responsible for at least 50 percent (transport equipment) to much as 78 percent (fabricated metals) of industry output.

Firms that are new to the export market also account for a substantial fraction of total manufactured exports. The last two columns of table 1 summarize the importance of firms that enter the export market between 1986 and 1991 to total industry exports in 1991. Column 3 reports the entrants' share of the total number of exporters and column 4 the entrants' share of the value of exports. In 1991,

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[3] Similar statistics are available for the manufacturing sectors in three countries. Using data for Colombian manufacturing plants, Roberts (1996, Table 10.4) finds that the combined market share of one to five year old plants varies between 18.3 and 20.8 depending on the year. With similar data for Chile, Tybout (1996b, Table 9.5) finds one to five year old plants account for 15.0 to 15.7 percent of manufacturing output. Using data for U.S. manufacturing firms, Dunne, Roberts, and Samuelson (1988, Table 3) find the market share of one to five year old firms varies from 13.6 to 18.5 depending on the year. In Taiwan, comparable aged entrants have approximately two to three times the market share of entrants in these other countries.

between 59.1 percent (textiles) and 73.6 percent (fabricated metals) of each industry's exporters were firms entering the export market after 1986. These entrants accounted for between 38.0 (textiles) and 54.2 (basic metals) percent of the value of 1991 exports.

The importance of entering firms in total production and exports reflects, at least partially, the substantial growth of these industries during the decade of the 80's. The average annual rate of output growth over the 1981-1991 period for these manufacturing industries varied from 3.3 percent in the clothing industry to over 16 percent in basic metals and electrical machinery. It exceeded 11 percent per year in six of the nine industries we examine. The net increase in the number of firms over each of the five-year periods 1981-1986 and 1986-1991 exceeded 25 percent in all but the apparel industry and the textile industry in the 1986-1991 period. Net entry rates of over 65 percent were observed in the electrical machinery and chemicals industries in 1981-1986 and in basic metals in 1986-1991.

However, the overall expansion of the manufacturing industries and the high rates of entry were also accompanied by significant firm exit. Table 2 summarizes the magnitude of firm exit by asking how much of initial-period production and exports was accounted for by firms that later exited. For example, for the textile industry the first two columns of the table show that firms that exited the industry by the 1986 census accounted for 60.9 percent of the number of firms in 1981 and 42.2 percent of 1981 production. Firms that exited textiles between 1986 and 1991 accounted for an additional 17.8 percent and 21.1 percent of the number of firms and value of production, respectively, in 1981. Overall, more than 78 percent of the 1981 textile firms, which accounted for over 63 percent of 1981 output, were not present ten years later. A similar pattern with the number of firms holds for every industry: between 70 and 87 percent of the 1981 producers are not present in 1991. These failing firms' share of output in 1981 is always less than their share of firm numbers, reflecting the fact that the failures are smaller, on average, than the survivors. The amount of 1981 production which these exiting firms account for also varies across industries, from a low of 37.9 percent in transport equipment to a high of 73.2 in fabricated metals, indicating that the average size difference between failing and surviving firms varies across industries.

The market for Taiwan's manufactured exports grew even more rapidly than total production between 1986 and 1991, averaging over 8 percent per year, yet the export market is also characterized by substantial exit over this period. As shown in column 3 of table 2, the exit rate for 1986 exporting firms varies from 52.4 percent in the chemicals industry to 75.7 percent in plastics. Only the chemical industry has an exit rate below 60 percent. These exiting firms account for between 35.7 and 61.1 percent of initial period exports. Overall, even in rapidly expanding markets, there is substantial firm exit.

The high rates of entry and exit documented in tables 1 and 2 indicate substantial simultaneous movement of firms in and out of production or the export market. In most countries in which firm turnover patterns have been quantified, it is not uncommon to find firm entry and exit rates in excess of 10 percent per year. However, because entering and exiting firms are so much smaller, on average, than incumbent or surviving producers, they tend to contribute much less as a share of industry production. While turnover rates in Taiwan are larger than what has generally been found for other countries, the importance of entering and exiting firms to total industry production is unusually high. Entrants over a five-year period account for between one-third and one-half of industry output and exports at the end of the period. Exiting firms over a five-year period account for between one-quarter and one-half of production and one-third to one-half of exports at the start of the period. This reallocation of output among firms has the potential to contribute substantially to sectoral productivity growth if the reallocation is from less efficient to more efficient producers.

A factor which is likely to contribute to the high turnover rate of Taiwanese firms is that the sunk costs of entering or exiting markets are quite low. As demonstrated by Hopenhayn (1992), low sunk entry costs result in higher equilibrium rates of firm turnover because it is more likely that a potential producer can recoup his startup costs, thus encouraging entry, and because market selection forces are stronger, raising the minimum productivity required to survive, thus encouraging exit. Pack (1992), Wade (1990) and Levy (1988, 1991) argue that the dominance of small-scale firms in Taiwan, combined with a well developed network of subcontracting, allows firms to enter production with relatively small amounts of capital, thus lowering the sunk costs of entry. 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. In addition, there is also little emphasis among Taiwan manufactures on brand or product differentiation thus reducing the need for sunk advertising or R&D expenditures by entering firms (Hobday 1995). These authors also document the major role of the numerous export trading companies that act to reduce the transactions costs of entering and leaving the international market. These traders specialize in channeling export orders to Taiwanese manufacturers and thereby reduce the search and negotiation costs often associated with linking up with foreign buyers, costs which are likely to be a particularly large hurdle for smaller firms.[4]

In summary, two of the most striking characteristics of the manufacturing sector in Taiwan are the high rates of entry and exit from production and the export market and the fact that these firms account for significant shares of total output. If these entering firms are, on average, more productive than the firms they replace then this heterogeneity, when combined with the large turnover rate, may be a substantial source of productivity growth.

[4] Roberts and Tybout (1997) discuss survey evidence that shows the lack of an export trading sector in Colombia was viewed as a significant impediment to entry by manufacturers in that country.

IV. Firm Total Factor Productivity

Measurement Issues

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.[5] 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.

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[5] 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.

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:

$$\begin{aligned} lnTFP_{ft} = & \left(lnY_{ft} - \overline{lnY_t}\right) + \sum_{s=2}^{t} \left(\overline{lnY_s} - \overline{lnY_{s-1}}\right) \\ & - \left[\sum_{i=1}^{n} \frac{1}{2}\left(S_{ift} + \overline{S_{it}}\right)\left(lnX_{ift} - \overline{lnX_{it}}\right) \right. \\ & \left. + \sum_{s=2}^{t} \sum_{i=1}^{n} \frac{1}{2}\left(\overline{S_{is}} + \overline{S_{is-1}}\right)\left(\overline{lnX_{is}} - \overline{lnX_{is-1}}\right)\right] \end{aligned} \tag{1}$$

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.

Summary Measures of the Productivity Distribution

One simple way of summarizing the distribution of firm productivity measured by equation (1) is with kernal density estimates. Figure 1 provides density estimates of the three annual cross-sections for the clothing, textile, chemical, and electrical machinery and electronics industries. All of these industries show a clear rightward shift in the productivity distribution over time, indicating productivity improvements that are widespread across all firms. In addition, the textile industry shows a clear narrowing of the productivity differences across firms between 1981 and 1991. This could reflect a narrowing of the range of technologies used by firms in this industry.

An alternative way of summarizing the movement in the firm productivity distributions, which is more tractable when a large number of industries are involved, is to summarize the quartiles of each cross-sectional distribution. Table 3 reports the 25th, 50th, and 75th percentiles for each of the nine two-digit manufacturing industries in each of the three census years. The table clearly indicates that there has been a systematic shift in the productivity distributions over time in the direction of higher productivity. Three industries, textiles, chemicals and electrical machinery\electronics have increases in productivity for the median firm of at least 32 percent over the ten years. Five of the remaining industries have productivity growth for the median firm of between 11 and 19 percent for the decade. Only one industry, transportation equipment, shows a decline in productivity, in this case with the productivity of the median firm falling 8 percent over the decade.

In the majority of cases the rightward shift of the distribution is not accompanied by a significant change in the shape of the distribution from one census year to the next. In particular, there is no evidence of a substantial narrowing of the cross-sectional distributions over time for most of the industries. The interquartile range (IQR) narrows slightly for all industries except clothing, where the narrowing is more substantial, and chemicals, where there is a substantial increase in the IQR. Clothing is the industry with the lowest output growth over the period and the only industry in which real output actually fell over one of the five year periods. In this case most of the narrowing of the IQR comes from the relatively large increase of the 25^{th} percentile. The 25^{th} percentile increase approximately 17 percent over the decade while the 75^{th} percentile rises only 7 percent. This indicates it is a reduction in the mass of low productivity firms that generates the narrowing of productivity differentials in the industry. In contrast, the chemical industry had the second highest rate of output growth among our nine industries and is the one industry with an increase in the IQR over time. In this case the 75^{th} percentile increases more rapidly than the 25^{th} percentile, indicating that an increase in the mass of high productivity firms accompanies the rapid output growth and results in the increased dispersion.

The comparison of the productivity distributions across years indicates that the productivity increase is widespread across most firms. What the comparison cannot reveal, however, is the movement of individual firms through the distributions over time. The rightward shift in the distribution could reflect, at one extreme, productivity growth for all firms at approximately the same rate, or, at the other extreme, no productivity growth by any firm but rather the exit of all firms in the low productivity tail of the distribution and their replacement by a cohort of new, higher productivity firms. The movements in the productivity distribution also cannot reveal the change in industry-level productivity, which is a size-weighted average of the firm productivities, since the distributions do not take into account differences in the size of the firms. If the size distribution of firms is quite skewed, as is true in most manufacturing industries, then movements of output, or the reallocation of market shares, among firms with different productivity levels can have an impact on industry-level productivity change. In the remaining sections of this paper we exploit the time-series information on our firms to quantify the differences in productivity among entering, continuing, and exiting firms. We then construct an index of aggregate industry productivity and study the importance of firm turnover in its growth over time.

V. Productivity Differentials and Firm Turnover

In this section we relate firm-level productivity and turnover. We focus on documenting whether firms which undergo transitions either in and out of production or in and out of the export market tend to be located in different parts of the productivity distribution. We do this by quantifying (unweighted) mean differences in productivity across groups of firms with different transition patterns. The point of this inquiry is to determine if turnover patterns reflect the underlying differences in productivity as even the simplest models of firm heterogeneity and market selection predict. By relying on transition patterns, that is conditioning on a firm's history in the market, we are able to draw some conclusions about the role of market selection that are not possible with simple cross-section data.

Table 4 begins by comparing the productivity differences among cohorts of continuing, entering, and exiting firms. We estimate a regression in which *lnTFP* for each firm and year is regressed on a set of year dummies and year dummies interacted with dummies for whether the firm is in its first (entry) or last (exit) year. The interaction terms allow the productivity differential between the entering or exiting cohort and the comparison group of continuing firms to vary across the different years. The intercept represents the average productivity in 1981 of the group of firms that will survive until 1986. The year dummies correct for the overall shifts in the productivity distribution over time.

Three features of table 4 should be noted. First, relative to incumbents, entrants in the first year they are observed are less productive on average, although these magnitudes are relatively small. The coefficients reported in column 4 indicate that entrants in 1986 are between .6 percent (fabricated metals) and 6.9 percent (textiles and basic metals) less productive than incumbent firms in the same year. A very similar pattern is also found for the entrants in 1991 (column 5). The hypothesis that entrants are equally productive to incumbents in both years is rejected in seven of the nine industries. The test statistics are reported in the third column of table 5.

Second, the average productivity of exiting firms is less than that of continuing firms for every industry and time period. The regression coefficients for the firms exiting in 1981 indicate that they are between 2.6 percent (chemicals) and 9.8 percent (textiles and electrical machinery\electronics) less productive than the survivors. This differential is smaller, varying from 1.0 to 5.0 percent in 1991. The test statistics for the hypothesis that there are no significant differences between failing and surviving firms are reported in the last column of table 5 and indicate the differences are significant in eight of the nine industries.

The final inference drawn from table 4 is that the entrant-incumbent productivity differential does not vary across years but the exit-survivor differential does. The first column of table 5 reports test statistics for the hypothesis that the entrant-incumbent differential is equal in 1986 and 1991 and the hypothesis is never rejected. The second column reports the same test for the exiting-surviving firm differential and it is rejected in six of the nine industries. It is interesting to note that the exit-survivor differential is narrower in 1986 than in 1981 for all but one industry, implying that exiting firms in the latter year are not as inefficient, relative to the survivors, as they were in the initial year. This could reflect a maturing of the product market so that smaller productivity differentials become sufficient to induce exit.

The results in table 4 document clear substantial *TFP* differences between each entry cohort and the incumbent producers. Why would firms enter when they are at such a productivity disadvantage relative to incumbents? One reason is that the entry cohort itself is heterogenous, with some firms at little or no disadvantage, but the firms are initially uncertain of their own productivity. This should in turn lead to subsequent sorting out of the entrants as they learn about their own productivity, a process which has been modeled by Jovanovic (1982). Alternatively, the firms may be able to improve their productivity following entry through a combination of scale economy exploitation, learning by doing, investments in productivity-enhancing inputs such as R&D, or acquisition of knowledge and information through the export market. These are the type of factors that are captured by the distribution $F(\phi_{t+1}|\phi_t)$ in Hopenhayn's (1992) framework and are the type of investments modeled by Ericson and Pakes (1995). To make some progress in distinguishing these explanations in our data we examine the cohort of entering firms in 1986 and compare their subsequent survival and productivity performance in 1991.

Table 6 reports differences in mean productivity between the members of the 1986 entry cohort that survive until 1991 (column 2) and the members that do not survive (column 3). The *TFP* is measured in the entry year 1986 and expressed relative to the incumbents in that year. The table shows clearly that the surviving members of the entry cohort were at less of a productivity disadvantage than the members of the cohort that would ultimately exit ($|\beta_1| < |\beta_2|$). The differences are significant in seven of the nine industries. Thus the subsequent exit patterns reflect the initial productivity differences among firms in the cohort as predicted by the heterogeneity and selection models.

To assess the productivity improvements of the surviving members of the entry cohort we estimate the productivity differential between them and the incumbent firms to see if it changes over time. Table 7 reports regression results using only the 1986 entering firms that survive until 1991 and a corresponding group of incumbents in 1986 that also survive until 1991. The coefficient β_2, reported in column 3, is the productivity disadvantage of the entrant in the initial year. It is the same as the difference reported in the second column of table 6. The new information in the table is the productivity differential between these same two groups of firms five years after entry, which is reported in column 4. In eight of the nine industries the disadvantage of the entrants has been reduced ($\beta_3 > \beta_2$). Only in the chemical industry was there no improvement in the relative productivity of the entrants as they aged. In five of the industries (textiles, clothing, plastics, nonelectrical machinery, and transport equipment) there is no significant difference between the entrants and incumbents five years after entry. In one case, fabricated metals, the entrants improve until they have significantly higher productivity than the incumbents.

Taken together, the results from tables 4-7 indicate that entrants have lower productivity on average than incumbents but the entry cohort is itself heterogeneous. In the years following entry the cohort members with lower productivity will fail more often and the survivors will improve their productivity until they are approximately equal to incumbent firms. Thus, the three elements of initial heterogeneity, market selection based on productivity, and productivity improvements by survivors are all present in the micro data.

Productivity Differentials and Transitions between the Domestic and Export Market

It is interesting to note that of the five industries for which we find convergence of entrant productivity to incumbent productivity, four (textiles, plastics, fabricated metals, and electric machinery, which includes electronics products) are very export-intensive industries. The relationship between exporting and productivity has long been of interest in development. A positive relationship between exporting activity and productivity could reflect selection forces at work. For example, if the export market is more competitive than the domestic market then we would expect that only the higher productivity producers would enter and survive in the export market. Even if the markets are equally competitive, exporting firms must still incur additional transportation costs for their products that are not incurred by their domestic competitors in the importing countries so that again only the more efficient firms may be viable in the export market. Alternatively, a positive relationship between exporting and productivity may reflect the fact that exporting provides benefits in the form of information on new products and processes that improve productivity.[6] While we cannot resolve the endogeneity issues involved in the productivity-export link we can use our data to explore if the transition patterns of firms between the export and domestic markets are consistent with differences in firm productivity and a more demanding export environment.

We begin by documenting the cross-section differences in *TFP* between exporting and nonexporting firms using the data for 1986 and 1991. Table 8 reports regressions of *lnTFP* on year and export intensity dummies. The dummies distinguish firms with low export intensity (<25 percent of production exported), medium (25 to 75 percent), and high intensity (>75 percent). The positive and significant coefficients on the export intensity dummies indicate clearly higher levels of productivity for exporting firms relative to nonexporters. This finding is consistent with research examining the productivity of exporting firms (Chen and Tang, 1987; Haddad, 1993; Aw and Hwang, 1995, Bernard and Jensen, 1995).

The magnitude of this productivity differential ranges from approximately 11 percent in basic metals to 24 percent in textiles. Two notes of interest emerge from the table. First, the positive correlation of exports and productivity is not limited to Taiwan's highly export-oriented industries but is common to all nine industries under study. Second, the magnitude of the productivity advantage for exporters is not dependent on the export intensity of the firm. Firms which export little of their sales have productivity, on

[6] Clerides, Lach and Tybout (1996) examine the causality between exports and cost changes using annual plant-level data for Colombia, Mexico and Morocco. Their findings suggest that the direction of causality is more likely to run from good performance to exports than the other way around and reinforces the idea that it is the higher productivity firms that enter the export market.

average, that is the same as firms that depend on the export market for a high proportion of their sales. Being an exporter per se signals higher productivity.

This general pattern is reflected again when we analyze the productivity differentials in 1991 between exporters and non-exporters who are also distinguished by their export history. The purpose here is to recognize that entry into the export market may involve sunk entry costs. If it does then the firm's decision to export in a given year is a function of both its current and expected future profits from exporting, of which its productivity is an important component, as well as its past export status.[7] When examining productivity differentials we want to distinguish firms based on their current and past export market participation. The regressions reported in Table 9 compare the productivity of all firms in 1991 to the base group of firms that operated in both 1986 and 1991 but solely in the domestic market (column 1). Among the firms that do not export in 1991 they could be (in addition to the base category) either new firms that are first observed in 1991 (column 3) or continuing firms that exported in 1986 but exited the export market (column 2). Among the firms that export in 1991 they could be new firms first observed in 1991 (column 6), continuing firms that did not export in 1986 but enter in 1991 (column 4), or continuing firms that remained in the export market both years (column 5).

The positive coefficients in the last three columns indicate that firms that exported in 1991 had higher productivity in that year than the base group of firms that were present in both 1986 and 1991 but did not export in either year. For example, textile firms that exported in both years had 21.5 percent higher *TFP* than the base group, on average, in 1991. Besides summarizing exporter-nonexporter productivity differentials, table 9 also summarizes mean productivity differences between entering, or exiting firms, and incumbents. For example, the small and often insignificant coefficients in column 3 indicate that, among non-exporting firms in 1991, those that just entered the industry have average productivity levels similar to

[7] See Roberts and Tybout (1997) for a theoretical and empirical model of the decision to export. Sunk entry costs into the export market result in the firm's previous export status being an important determinant of the decision to export.

the continuing firms in their industry that have never been in the export market at all. In eight of the nine industries, both of these groups are less productive than firms that exit the export market. These results suggest that in the bulk of the industries, firms that were efficient enough to compete in the export market in the past but left are still superior in terms of efficiency to their counterparts, new and old, that never entered the export market in the first place. This evidence taken together with the fact that exporters have higher average productivity than non-exporters is consistent with the process of self-selection of more efficient firms into the export market in which the export market is characterized by more competitive pressure than the domestic market.

The finding that firms exiting the export market have higher productivity, on average, than non-exporters differs from findings of studies for Colombia, Morocco, and Mexico by Clerides, Lach and Tybout (1996) and the U.S. by Bernard and Jensen (1996). They find that firms exiting the export market are among the worst performers. One explanation may be that the sunk costs involved in re-entry into the export market in Taiwan are sufficiently low that firms do not hesitate to exit the market in the face of low productivity. In contrast if the export market entry costs are higher in the other countries, firms will be more willing to continue in the export market in the face of low productivity and profits and wait to see if productivity improves in order to avoid the reentry costs. Only the firms with very low productivity will choose to exit when the entry costs are high. This interpretation is also consistent with the pattern observed among exporters in 1991 in columns 4-6 in Table 9.

Firms that are continuous exporters (column 5) have average productivity levels that are significantly higher than new firms that are exporters (column 6) or continuing firms that became exporters (column 4). Except for the clothing industry, there is little productivity differential between the latter two groups. These findings suggest that entry into the export market may be associated with low sunk costs, as documented by Levy (1991), that enables firms to easily and inexpensively enter the international market. Alternatively, it may reflect the fact that the most efficient firms are already in the export market and that their high productivity cannot be imitated by new entrants.

Finally, we examine whether the high efficiency that we observe among firms that export precedes their entry into the export market. Table 10 reports the 1986 and 1991 productivity differentials between the firms that entered the export market in 1991 and those that did not. Their 1986 productivity differential varies from 4.8 to 14.8 percent. That is, firms that eventually entered the export market were more productive than their non-entering counterparts in the years prior to their entry. This is similar to a finding of Bernard and Jensen (1996) using U.S. data. It is also consistent with the findings of Clerides, Lach and Tybout (1996) that entry into the export market largely reflects productivity differences and there is little direct productivity improvement that follows from the act of exporting.

The productivity differentials observed for these same groups after their entry into the export market remained at about the same level as the pre-entry differential for four industries (basic metals, chemicals, transportation and fabricated metals) and fell for one industry (clothing). However, in the other four industries, we find evidence to suggest that the productivity differential after entry is substantially higher than the pre-entry figures. This result suggests that there may be some productivity improvement that is associated with exporting in Taiwan, although the exact mechanism cannot be identified here. We note that three of these four industries, electrical machinery\electronics, textiles, and plastics, are among Taiwan's top three export-oriented industries, raising the possibility that in well-established export markets, firms may potentially be able to make productivity improvements by learning from their export activity. While this possibility cannot be ruled out, identification of the direction of causality depends critically on whether the export activity affects the stochastic process that governs their productivity growth, an issue that would require longer time-series data than is available for Taiwan.

VI. Implications for Industry Productivity Growth

The results from sections II and III indicate that there is substantial firm turnover and that entering, exiting, and continuing cohorts differ systematically in their average productivity. In this section we measure what effect this within-industry resource reallocation has on productivity growth at the industry level. We begin by defining industry productivity 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. As shown by Olley and Pakes (1996, eq. 16), we can rewrite industry productivity in year t as:

$$lnTFP_t = \overline{ln\,TFP_t} + \sum_f \Delta\,\theta_{ft} \, \Delta\, ln\, TFP_{ft} \tag{3}$$

where $\overline{lnTFP_t}$ is the unweighted mean productivity over all firms in year t and the Δ is used to represent a deviation from the unweighted mean in year t. The second term in equation (3) is the sample covariance between firm productivity and market share in year t, multiplied by the number of firm observations in the year. The larger this covariance, the higher the share of output that is allocated to more productive firms and the larger is industry productivity.

Table 11 reports the aggregate productivity level for each of the nine industries in the three Census years and its two components. Two main features stand out in the table. First, the unweighted mean level of productivity increases over time for every industry except transportation equipment, where there is a decline in productivity. The increase over the decade is largest for the electric and electronics, textiles, and chemicals industries. This pattern is consistent with that observed for the median of the productivity distributions reported in table 3. Second, in every industry there is a positive covariance between firm productivity and market share indicating that a larger share of industry output is concentrated in the more productive firms and thus industry productivity is higher than the unweighted firm mean. The positive covariance is present in every year and, unlike the unweighted mean productivity, its magnitude does not vary greatly or systematically over time indicating that shifts in the productivity distribution rather than market share reallocations are likely to be the main source of industry productivity growth.

We next decompose the change in industry productivity over time into contributions due to the productivity growth of continuing firms, the difference in average productivity between entering and exiting cohorts of firms, and the reallocation of market shares among all firms. We define industry productivity growth as the change in equation (2) between two time periods. As shown by Griliches and Regev (1995), the contribution of a single firm f to the change in the weighted sum in equation (2) between years t and $t+1$ can be written as:

$$\theta_{ft+1}\, lnTFP_{ft+1} - \theta_{ft}\, lnTFP_{ft} = \left(\frac{\theta_{ft} + \theta_{ft+1}}{2}\right)\left(lnTFP_{ft+1} - lnTFP_{ft}\right) + \left(\frac{lnTFP_{ft+1} + lnTFP_{ft}}{2}\right)\left(\theta_{ft+1} - \theta_{ft}\right) \tag{4}$$

This equation shows that any firm's contribution to industry productivity growth is the combination of its own productivity growth between the two years, weighted by the firm's average market share in the two years, and the change in its market share, weighted by its average productivity. If there were no entry or exit, then industry productivity growth would equal the sum of equation (4) over all the firms and would rise if individual firm productivity increased or if there was a reallocation of market shares from low productivity to high productivity firms.

While this contribution can be constructed for any firm f that remains in operation in both years t and $t+1$, it cannot be constructed for any firm that enters or exits between the two years. To incorporate entry and exit, we follow Griliches and Regev (1995) and aggregate all firms that exit following year t into a single exiting firm with market share θ_{Xt} and productivity level $lnTFP_{Xt}$ where the latter is a share-weighted sum over the productivity of all exiting firms. Similarly, we aggregate all new firms in year $t+1$ into a single entrant with market share θ_{Et+1} and productivity level $lnTFP_{Et+1}$. Denoting all firms that remain in operation in both years as $f \in C$ we can write the growth in industry productivity as:

$$\begin{aligned} dlnTFP &= lnTFP_{t+1} - lnTFP_t \\ &= \sum_{f \in C}\left[\left(\frac{\theta_{ft} + \theta_{ft+1}}{2}\right)\left(lnTFP_{ft+1} - lnTFP_{ft}\right)\right] \\ &+ \left(\frac{\theta_{Xt} + \theta_{Et+1}}{2}\right)\left(lnTFP_{Et+1} - lnTFP_{Xt}\right) \\ &+ \sum_{f \in C}\left[\left(\frac{lnTFP_{ft} + lnTFP_{ft+1}}{2}\right)\left(\theta_{ft+1} - \theta_{ft}\right)\right] \\ &+ \left(\frac{lnTFP_{Et+1} + lnTFP_{Xt}}{2}\right)\left(\theta_{Et+1} - \theta_{Xt}\right) \end{aligned} \tag{5}$$

This decomposition consists of four parts. The first two lines summarize the productivity growth of continuing firms and the difference in productivity between the entering and exiting cohort, respectively. The third and fourth lines capture the reallocation of market shares. The third line is between the continuing firms and the fourth is between the entrants and exits. Griliches and Regev (1995) combine the last three components into a single measure of the contribution of firm "mobility" and distinguish it from the "within firm" productivity improvements captured by the first term. Tybout (1996a) reports a three-term decomposition in which the last two terms of equation (5) are combined into a single market share reallocation term that captures the shift of market shares among all three categories of firms.[8]

Table 12 reports the growth rate of industry *TFP*, its components in equation (5) (where we have aggregated the third and fourth terms into a single market share reallocation term) and, for comparison, the growth in industry labor productivity.[9] As reported in column 1, over the five-year interval real output per worker grew for all but the transportation equipment industry, between 15.7 percent (clothing) and 74.3 percent (electrical machinery). A weighted average of the industry growth rates for the five-year intervals is 39.5 percent for an average annual growth rate in labor productivity of 7.9 percent.[10] In contrast, *TFP* growth rates are much more modest, with a weighted average of the industry rates equaling 9.4 percent for the five-year interval or 1.9 percent per year.[11]

Table 12, however, provides evidence that some of the manufacturing industries have experienced high rates of *TFP* growth during at least one of the time periods. Textiles, chemicals, and electrical machinery each have at least one of the five-year periods in which they average over 3 percent annual productivity growth. In contrast, several industries including transport equipment, clothing, and non-electrical machinery had periods of negative productivity growth.

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[8] Bailey, Hulten, and Campbell (1992), and Haltiwanger (1997) report alternative decompositions. As suggested by Haltiwanger's decomposition we can further disaggregate the first term in (5) into two components:

$$\sum_{f \in C} \theta_{ft}(\ln TFP_{ft+1} - \ln TFP_{ft}) + \tfrac{1}{2} \sum_{f \in C} (\theta_{ft+1} - \theta_{ft})(\ln TFP_{ft+1} - \ln TFP_{ft}).$$

The first component reflects the productivity improvements of incumbents with fixed, initial period weights, while the second term captures the comovement of incumbent firm productivity and market share. The second term will be positive if incumbents with higher rates of productivity improvement also expanded their market share and thus contributed to aggregate productivity improvement. This indicates that the "within-firm" productivity term in Griliches-Regev decomposition also captures market share reallocations among incumbents.

[9] The growth in industry labor productivity is also constructed as a market-share weighted sum of the firm labor productivities.

[10] Each industry is weighted by its share of manufacturing value of shipments in 1986. The industries with the largest shares are electrical machinery (.238), textiles (.154), and plastics (.135).

[11] The *TFP* growth rates are even more modest than those reported by Young (1995). Using aggregate data for the whole manufacturing sector, he reports (Table VIII) that Taiwan's manufacturing output grew at an average annual rate of 7.2 percent from 1980-90. Labor productivity grew 5.1 percent and *TFP* grew 2.8 percent per year during the decade.

The decomposition of *TFP* growth is reported in the last three columns of table 12. The first component indicates that *TFP* growth of continuing firms is a significant source of industry productivity growth. In every industry and time period the industry *TFP* reflects what happens to the continuing firms. Thus the shifts in the productivity distributions documented in table 3 appear to characterize the experience of continuing firms. The importance of this term growth mirrors the findings of virtually all other productivity studies that report this type of decomposition.[12]

In contrast to the other studies, we find that differences in productivity between entering and exiting firms (column 4) are frequently an important source of industry productivity growth. The sign of this effect is virtually always the same as the sign of the continuing firm effect, indicating that the average productivity of entering cohorts is rising over time. In other words, the rightward shift in the productivity distributions found for most industries in table 3 result from higher levels of productivity among the entering cohort, relative to the failing cohort from the previous year, as well as higher productivity of the continuing firms. The higher productivity levels in the second year of each pair of years reflect widespread productivity improvements across all producers in the latter year. This pattern is unusual, as most other studies find that entering firms have approximately the same productivity levels, on average, as exiting firms so that the differential contributes little to industry productivity growth.[13]

The final column of table 12 reports the effect of changing market shares. The total contribution of market share reallocation is very close to zero in most cases. For example, in the high productivity industries of textiles, chemicals, and electrical machinery the total contribution of changing market shares

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[12] Further disaggregating the continuing firm term into the two components identified in footnote 8 we find the productivity improvement with initial period weights to be negative for the fabricated metal, nonelectrical machinery, and transportation industries in all years and the clothing industry in 1981-86. It is positive in all other cases and generally the dominant source of the incumbent firm change reported in column 3 of table 4. The comovement of incumbent productivity and market share makes a positive contribution to the aggregate in all cases except the chemical industry.

[13] The difference may also arise because of the five-year interval between our entering cohorts, so that the entrants are, on average, 2 ½ years old when we first observe them. The studies for Israel, Colombia, and Chile use annual data. Productivity improvements that occurred following entry would appear as continuing firm productivity improvements in those studies but as more productive entrants in our data.

is never more than 2.2 percent over any five year period and is generally much smaller.[14] This mirrors findings for Israel, Colombia, and Chile. Bailey, Hulten, and Campbell (1992) and Haltiwanger (1997) report a much larger role for output reallocations among producers, accounting for as much as one-half of productivity change in U.S. manufacturing.

Overall, the decomposition in table 12 indicates that the productivity growth of incumbents and the productivity differential between entering and exiting firms are both major sources of sectoral productivity growth in Taiwan manufacturing. Market share reallocations, in total, contribute little to productivity change in most industries. The most unusual feature of this decomposition is the substantial role which entry and exit play. The fact that, on average, entering cohorts are more productive than the exiting cohorts they replace contributes significantly to aggregate productivity growth in many industries. In the high productivity growth sectors of textiles, chemicals, and electrical machinery, the entry-exit differential contributes between 2.3 and 11.6 percentage points of *TFP* growth over a five-year interval.

VII. Summary and Conclusions

In this paper we use micro panel data for Taiwan's manufacturing sector to measure each firm's total factor productivity, to study the movement of the productivity distribution over time, to examine if patterns of firm turnover in the domestic and export market are related to productivity differences, and to measure the contribution of firm turnover to industry productivity growth.

A broad conclusion from our examination of the data is that there are significant differences in *TFP* across firms and that these differences are reflected in turnover patterns. Cohorts of new firms have

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[14] As shown in equation 5 the market share reallocation term can be further divided into changes in incumbent market shares and the difference in the share of the entering and exiting cohort with average productivities as weights. These separate components are heavily affected by the substantial net expansion in the number of Taiwanese manufacturing firms. This expansion results in a decline in the incumbent firm market share over time and an entrant market share that is greater than the exiting firm market share. As a result, the market share reallocation among incumbents always makes a negative contribution to aggregate productivity growth and the difference between entering and exiting firm market share always makes a positive contribution. The magnitudes of these two effects largely offset each other and generate the small market share reallocation term in table 12.

lower average productivity than incumbents but are themselves a heterogeneous group. On average, the more productive members of the group survive and, in many cases, their productivity converges to the productivity level of incumbents. Exiting firms are also less productive, on average, than survivors. Differences in productivity are also reflected in movements of firms in and out of the export market. Firms that remain exporters over multiple years have the highest productivity while beginning exporters, whether they are new firms or older firms, follow behind them. All are more productive on average than firms that exit the export market who, in turn, are more productive than firms that never exported. These patterns are generally consistent with the view that both the domestic and export market sort out high productivity from low productivity firms and that the export market is a tougher screen.

We also find evidence of productivity growth at modest levels (two percent per year) for a number of manufacturing industries over the decade of the 80's. In most industries, the productivity improvements are widespread across the whole distribution of firms, suggesting that it may be less related to individual firm actions than it is to common improvements in worker quality and infrastructure. One implication of this general shift in the firm-level productivity distribution is that entering firms also shared in the higher productivity so that the turnover of firms through entry and exit made a significant positive contribution to industry productivity growth. Productivity growth of incumbent firms also was a significant source of industry productivity growth.

Taken together, the above results differ in two ways from previous findings on how producer turnover relates to productivity growth. First, firm entry and exit, has been a significant source of productivity growth in Taiwan unlike other developing and developed countries. Second, and more specific to the export activity, firms that exit the export market, on average, are more productive than firms that have never been in the that market, while firms that newly entered the export market are not as productive as firms that have stayed in the export market continuously. Both of these characteristics are consistent with low threshold entry and exit costs made possible by the presence of a dense network of subcontractors and export traders in the Taiwanese manufacturing sector. The transition patterns of firms in and out of production and the export market, combined with the systematic differences in average productivity among the transiting groups, suggest that the activities or institutions in Taiwan that make entry and exit of firms into markets relatively easy and inexpensive may allow the economy to rapidly exploit micro-level differences in productivity.

Data Appendix

The data used in this paper are a compilation of the last three Industrial and Commercial Census collected by the Statistical Bureau of Taiwan's Executive Yuan. They cover 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.

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.[15] The 1986 and 1991 censuses also disaggregate each firm's total sales into domestic and export sales and we will use this to measure firm turnover in the export market and the firm's export exposure.

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

[15] 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).

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 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.[16]

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[16] 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.

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 and Amy Hwang (1995), "Productivity and the Export Market: A Firm-Level Analysis," *Journal of Development Economics*, 47, 313-332.

Aw, Bee Yan and Mark J. Roberts (1987), "Price and Quality Comparisons for US Footwear Imports: An Application of Multilateral Index Numbers," *Empirical Methods for International Trade,* Robert C. Feenstra (ed), Cambridge: MIT Press.

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

Bernard, Andrew B. and J. Bradford Jensen (1995), "Exporters, Jobs, and Wages in U.S. Manufacturing, 1976-1987," *The Brookings Papers on Economic Activity: Microeconomics 1995,* 67-112.

Bernard Andrew B. and J. Bradford Jensen, (1996), "Facts on the 'Export Boom' in US Manufacturing: The Role of Entry Costs, Productivity, and Terms of Trade," Manuscript, MIT and Carnegie Mellon University.

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 W. Tretheway, (1981) "U.S. Trunk Air Carriers, 1972-1977: A Multilateral Comparison of Total Factor Productivity," in *Productivity Measurement in Regulated Industries*, edited by Thomas G. Cowing and Rodney E. Stevenson, Academic Press.

Chen, Tain-Jy and De-Piao Tang (1987). " Comparing Technical Efficiency between Import Substituting and Export-Oriented Foreign Firms in a Developing Country," *Journal of Development Economics*, 26, 277-289.

Clerides, Sofronis, Saul Lach, and James Tybout (1996). "Is 'Learning-by-Exporting' Important? Micro-Dynamic Evidence from Colombia, Mexico and Morocco," NBER Working Paper 5715.

Dunne, Timothy, Mark J. Roberts, and Larry Samuelson (1988), "Patterns of Entry and Exit in U.S. Manufacturing Industries," *The Rand Journal of Economics*, 19, 495-515.

Ericson, Richard and Ariel Pakes (1995), "Markov-Perfect Industry Dynamics: A Framework for Empirical Work," *Review of Economic Studies*, 62, 53-82.

Good, David H., M. Ishaq Nadiri, and Robin Sickles (1996), "Index Number and Factor Demand Approaches to the Estimation of Productivity," NBER Working Paper 5790.

Griliches, Zvi and Haim Regev (1995). "Firm Productivity in Israeli Industry, 1979-1988," *Journal of Econometrics,* 65, 175-203.

Haddad, Mona (1993), "How Trade Liberalization Affected Productivity in Morocco," Policy Research Working Paper 1096, Policy Research Department, The World Bank, Washington, D.C.

Haltiwanger, John C. (1997), "Measuring and Analyzing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence," *Review of the Federal Reserve Bank of St. Louis,* May/June, 1-23.

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.

Jovanovic, Boyan (1982), "Selection and the Evolution of Industry," *Econometrica,* 50, 649-670.

Kim, Jong-Il and Lawrence J.Lau (1994). "The Sources of Economic Growth of the East Asian Newly Industrialized Countries," *Journal of the Japanese and International Economies,* 8, 235-271.

Krugman, Paul (1994). "The Myth of Asia's Miracle," *Foreign Affairs*, November/December 1994, 62-78.

Lambson, Val E. (1991), "Industry Evolution With Sunk Costs and Uncertain Market Conditions," *International Journal of Industrial Organization*, 9, 171-196.

Levy, Brian (1988), "Korea and Taiwan as International Competitors: The Challenges Ahead," *The Columbia Journal of World Business*, 23.

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.*

Liu, Lili (1993). "Entry-exit, Learning and Productivity Change: Evidence from Chile," *Journal of Development Economics,* 42, 217-242.

Liu, Lili and James R. Tybout (1996). "Productivity Growth in Chile and Colombia: The Role of Entry, Exit, and Learning," 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.

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

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

Page, John (1994). "The East Asian Miracle: Four Lessons for Development Policy," *NBER Macroeconomics Annual* 1994, Cambridge, MA: MIT Press.

Roberts, Mark J. (1996). "Colombia, 1977-85: 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 University Press.

Roberts, Mark J. and James R. Tybout (1997). "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, 87.

Rodrik, Dani (1995). "Getting Interventions Right: How South Korea and Taiwan Grew Rich," *Economic Policy*, 20, 55-107.

Tybout, James R. (1996a). "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.

Tybout, James R. (1996b). "Chile, 1979-86: 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.

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

World Bank (1993). *The East Asian Miracle: Economic Growth and Public Policy*, Oxford University Press for the World Bank, Washington, DC.

Young, Alwyn (1994). "Lessons from the East Asian NICs: A Contrarian View." *European Economic Review*, 38, 964-973.

Young, Alwyn (1995). "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience." *Quarterly Journal of Economics*, 641-680.

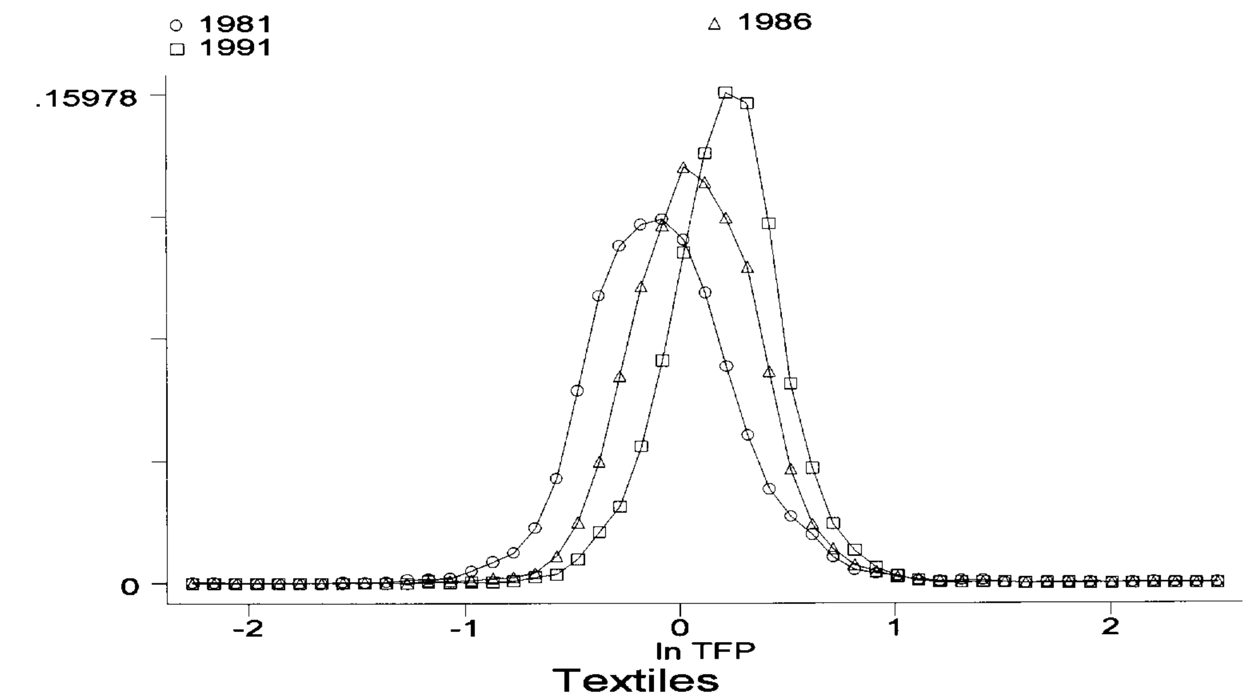
Table 1 : Contribution of Entry Cohorts in 1991

Industry / Entry Cohort	Production - 1991		Exports - 1991	
	Share of Number of Firms	Share of the Value of Production	Share of the Number of Exporters	Share of the Value of Exports
Textiles				
1986 Entry Cohort	.238	.242	-	-
1991 Entry Cohort	.594	.334	.591	.380
Clothing				
1986 Entry Cohort	.221	.234	-	-
1991 Entry Cohort	.635	.455	.649	.392
Chemicals				
1986 Entry Cohort	.198	.292	-	-
1991 Entry Cohort	.640	.401	.667	.445
Plastics				
1986 Entry Cohort	.215	.200	-	-
1991 Entry Cohort	.648	.332	.705	.399
Basic Metals				
1986 Entry Cohort	.162	.233	-	-
1991 Entry Cohort	.743	.377	.722	.542
Fabricated Metals				
1986 Entry Cohort	.217	.279	-	-
1991 Entry Cohort	.664	.506	.736	.482
Non Electrical Machinery				
1986 Entry Cohort	.193	.240	-	-
1991 Entry Cohort	.666	.473	.723	.395
Electrical Machinery				
1986 Entry Cohort	.200	.270	-	-
1991 Entry Cohort	.686	.310	.660	.390
Transportation Equipment				
1986 Entry Cohort	.201	.264	-	-
1991 Entry Cohort	.669	.245	.689	.398

Table 2 : Contribution Of Exiting Cohorts

Industry / Exit Cohort	Production- 1981		Exports-1986	
	Share of Number of Firms	Share of the Value of Production	Share of the Number of Exporters	Share of the Value of Exports
Textiles				
1986 Exit Cohort	.609	.422	-	-
1991 Exit Cohort	.178	.211	.684	.532
Clothing				
1986 Exit Cohort	.737	.502	-	-
1991 Exit Cohort	.138	.161	.748	.501
Chemicals				
1986 Entry Cohort	.564	.223	-	-
1991 Entry Cohort	.142	.361	.524	.403
Plastics				
1986 Exit Cohort	.622	.362	-	-
1991 Exit Cohort	.161	.233	.757	.611
Basic Metals				
1986 Exit Cohort	.671	.376	-	-
1991 Exit Cohort	.149	.122	.672	.462
Fabricated Metals				
1986 Exit Cohort	.655	.548	-	-
1991 Exit Cohort	.167	.184	.735	.510
Non Electrical Machinery				
1986 Exit Cohort	.611	.473	-	-
1991 Exit Cohort	.161	.127	.609	.363
Electrical Machinery				
1986 Exit Cohort	.588	.300	-	-
1991 Exit Cohort	.160	.149	.605	.357
Transportation Equipment				
1986 Exit Cohort	.620	.223	-	-
1991 Exit Cohort	.157	.156	.653	.437

Figure 1: Kernel Density Estimates for ln TFP



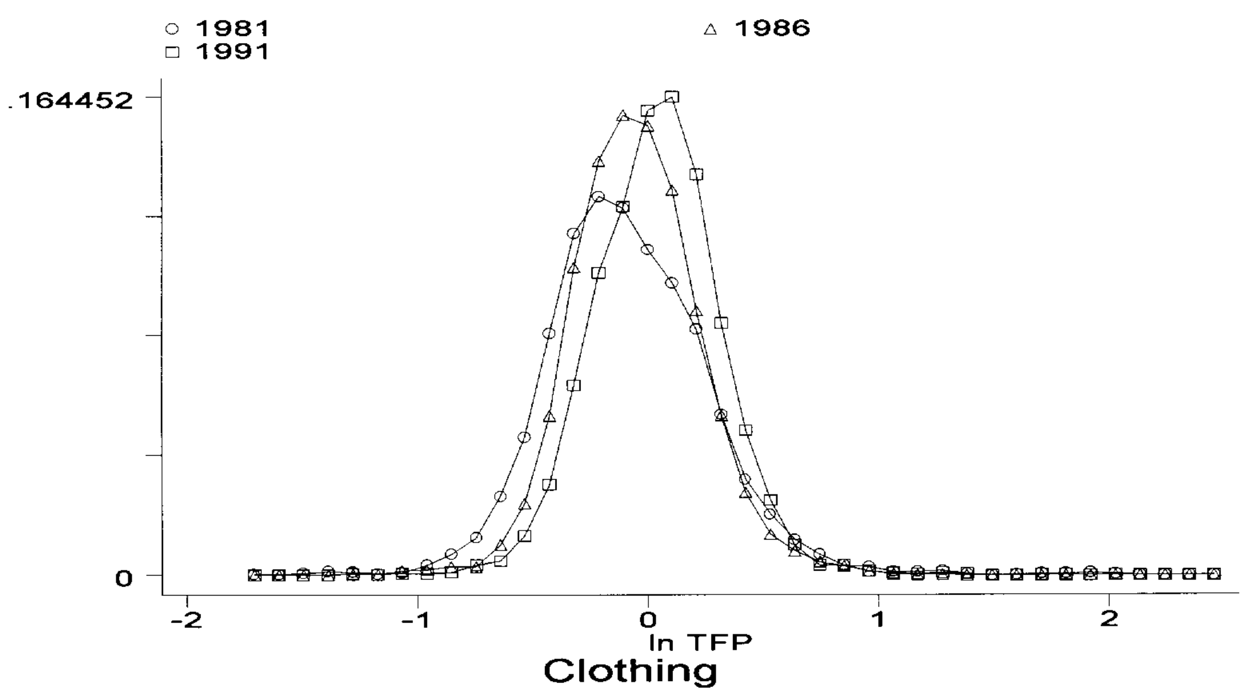
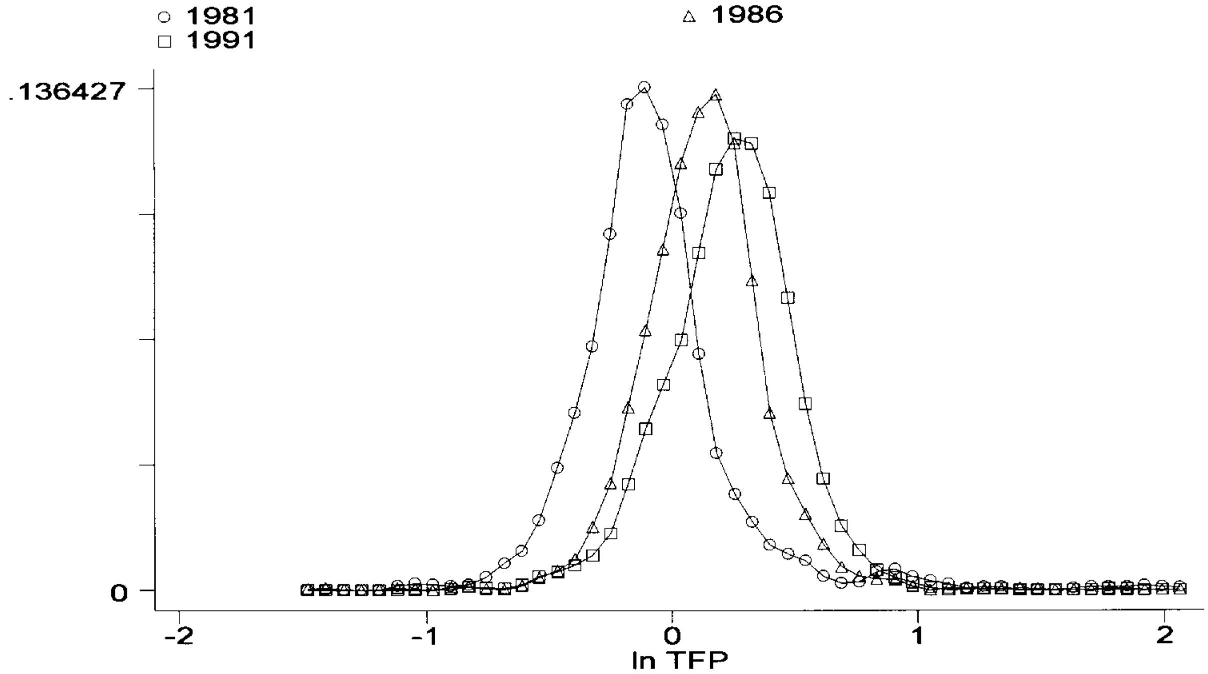
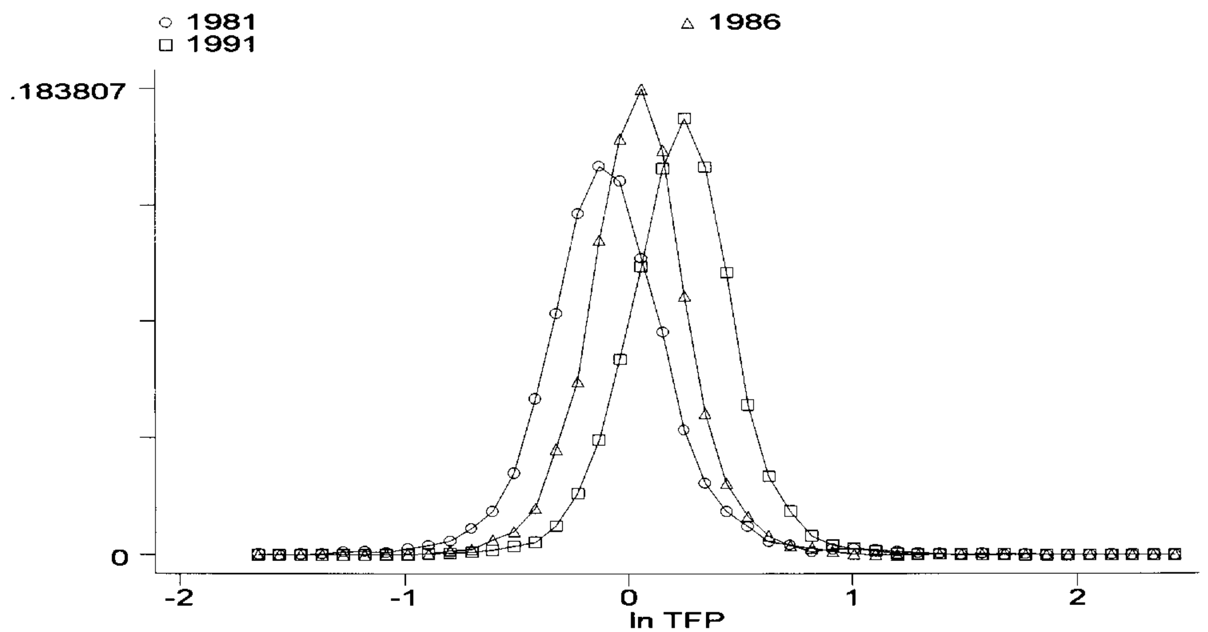


Figure 1 (cont.): Kernel Density Estimates for ln TFP



Chemicals



Electrical Machinery and Electronics

Table 3: Percentiles of the Distribution of lnTFP across Firms

	1981	1986	1991
Textiles - number of firms	2359	3270	3535
25th percentile	-.312	-.122	.043
Median	-.099	.072	.220
75th percentile	.120	.273	.372
Clothing - number of firms	1788	1980	2036
25th percentile	-.314	-.232	-.139
Median	-.114	-.059	.043
75th percentile	.132	.117	.210
Chemicals - number of firms	470	801	990
25th percentile	-.238	-.017	.081
Median	-.108	.131	.247
75th percentile	.034	.264	.400
Plastics - number of firms	4634	6617	8967
25th percentile	-.243	-.088	-.052
Median	-.089	.053	.101
75th percentile	.094	.203	.249
Basic Metals - number of firms	1294	1981	3338
25th percentile	-.280	-.085	-.085
Median	-.126	.040	.071
75th percentile	.022	.158	.203
Fabricated Metals - number of firms	10,914	14,651	19,615
25th percentile	-.261	-.199	-.153
Median	-.121	-.067	-.005
75th percentile	.057	.081	.141
Non Electrical Machinery - number of firms	4987	6215	9664
25th percentile	-.238	-.136	-.129
Median	-.088	.006	.027
75th percentile	.073	.146	.169
Electrical Machinery & Electronics - number of firms	3218	5378	8050
25th percentile	-.254	-.099	.539
Median	-.097	.044	1.00
75th percentile	.073	.180	1.49
Transportation Equipment - number of firms	1603	2357	3243
25th percentile	-.244	-.240	-.325
Median	-.082	-.097	-.162
75th percentile	.092	.030	-.005

Table 4: Productivity Differences Among Entering, Exiting and Continuing Firms
(absolute value of t-statistics in parentheses)

	Intercept	Year Dummies		Entrant-Year Effects		Exit-Year Effects	
	β_0	β_{86}	β_{91}	γ_{86}	γ_{91}	σ_{81}	σ_{86}
Textiles	-.019 (1.82)	.173 (11.29)	.262 (19.85)	-.069 (5.70)	-.060 (5.65)	-.099 (7.59)	-.046 (4.16)
Clothing	-.032 (2.23)	.006 (0.28)	.080 (4.31)	-.022 (1.35)	-.010 (0.73)	-.065 (3.94)	-.010 (.69)
Chemicals	-.060 (3.15)	.249 (8.99)	.329 (13.65)	-.049 (2.14)	-.051 (2.81)	-.026 (1.05)	-.047 (2.33)
Plastics	-.036 (5.74)	.129 (13.78)	.161 (20.26)	-.039 (5.31)	-.040 (6.85)	-.047 (5.89)	-.013 (1.95)
Basic Metals	-.060 (4.77)	.181 (9.75)	.167 (10.77)	-.069 (4.81)	-.062 (5.89)	-.061 (4.02)	-.050 (4.17)
Fabricated Metals	-.094 (20.98)	.050 (7.42)	.094 (16.60)	-.006 (1.05)	-.011 (2.58)	.018 (3.25)	-.015 (3.17)
Non Electrical Machinery	-.034 (5.78)	.077 (8.64)	.072 (9.44)	-.024 (3.38)	-.022 (3.80)	-.059 (7.79)	-.033 (4.96)
Electrical Machinery	-.024 (3.31)	.131 (12.16)	.290 (31.80)	-.053 (6.23)	-.049 (7.56)	-.098 (10.33)	-.041 (5.6)
Transportation Equiment	-.020 (1.90)	-.042 (2.65)	-.116 (8.60)	-.023 (1.86)	-.047 (4.77)	-.078 (5.83)	-.042 (3.77)

Table 5: Hypothesis F-Test Statistics
(* = Reject Ho at the α = .01 significance level)

	Common Entrant Differential $\gamma_{86} = \gamma_{91}$	Common Exit Differential $\alpha_{81} = \alpha_{86}$	No Entrant Differential $\gamma_{86} = \gamma_{91} = 0$	No Exit Differential $\alpha_{81} = \alpha_{86} = 0$
Textiles	0.32	9.50*	32.22*	37.46*
Clothing	0.30	6.16*	1.18	7.99*
Chemicals	0.00	0.43	6.22*	3.26
Plastics	0.01	10.89*	37.52*	19.21*
Basic Metals	0.13	0.34	28.93*	16.76*
Fabricated Metals	0.64	20.45*	3.87	10.29*
Non Electrical Machinery	0.08	6.66*	12.94*	42.68*
Electrical Machinery	0.18	22.27*	11.13*	48.01*
Transportation Equiment	2.21	4.46	13.10*	24.09*

Table 6: 1986 Productivity Differences Within Entry Cohort
(absolute value of t-statistics in parentheses)

	Intercept β_0	Survive β_1	Do Not Survive β_2	F-statistic $\beta_1 = \beta_2$
Textiles	.148 (11.14)	-.060 (3.60)	-.112 (7.27)	16.44*
Clothing	-.031 (1.69)	-.015 (0.69)	-.029 (1.45)	0.78
Chemicals	.206 (9.73)	-.079 (2.86)	-.109 (4.43)	1.82
Plastics	.081 (10.68)	-.022 (2.31)	-.044 (5.08)	10.72*
Basic Metals	.121 (8.02)	-.068 (3.80)	-.118 (7.12)	17.58*
Fabricated Metals	-.042 (7.45)	-.010 (1.42)	-.022 (3.50)	7.02*
Non Electrical Machinery	.045 (6.25)	-.028 (3.15)	-.059 (6.80)	17.34*
Electrical Machinery	.114 (13.22)	-.065 (6.13)	-.100 (10.05)	20.35*
Transportation Equipment	-.052 (4.09)	-.039 (2.49)	-.072 (4.99)	8.18*

Table 7: Convergence of Productivity Levels Between Entrants and Incumbents
(absolute value of t-statistics in parentheses)

	Intercept β_0	1991 Dummy β_1	Entrant*1986 Dummy β_2	Entrant*1991 Dummy β_3	F-statistic $\beta_3 = \beta_2$
Textiles	.148 (11.96)	.098 (5.59)	-.060 (3.86)	-.004 (0.27)	6.43*
Clothing	-.031 (1.75)	.085 (3.45)	-.015 (0.71)	-.010 (0.48)	0.03
Chemicals	-.206 (9.88)	.109 (3.69)	-.079 (2.91)	-.078 (2.87)	0.00
Plastics	.081 (10.83)	.038 (3.56)	-.022 (2.35)	.010 (1.09)	5.91*
Basic Metals	.121 (7.97)	.013 (0.62)	-.068 (3.77)	-.037 (2.03)	1.52
Fabricated Metals	-.042 (7.45)	.016 (2.04)	-.010 (1.42)	.037 (5.53)	24.17*
Non Electrical Machinery	.045 (6.23)	-.008 (0.74)	-.028 (3.14)	.000 (0.04)	5.05*
Electrical Machinery	.114 (13.75)	.164 (13.94)	-.065 (6.38)	-.019 (1.89)	10.08*
Transportation Equipment	-.052 (3.89)	-.081 (4.31)	-.039 (2.37)	-.005 (0.31)	2.13

Table 8: 1986 and 1991 Productivity Differences Among Exporting and Non-Exporting Firms

			Export Intensity Dummy		
	Intercept	1991 Dummy	Low	Medium	High
Textiles	-.012 (2.20)	.156 (23.86)	.236 (16.98)	.212 (18.03)	.244 (27.83)
Clothing	-.142 (21.09)	.121 (14.80)	.181 (6.62)	.193 (10.77)	.233 (24.93)
Chemicals	.093 (10.20)	.106 (9.12)	.173 (9.32)	.165 (7.46)	.057 (1.62)
Plastics	.012 (3.89)	.059 (15.29)	.145 (14.92)	.141 (15.88)	.170 (29.05)
Basic Metals	.020 (3.52)	.029 (4.22)	.122 (8.80)	.114 (6.43)	.107 (4.44)
Fabricated Metals	-.077 (38.06)	.055 (21.11)	.168 (18.05)	.167 (20.72)	.176 (30.95)
Non El. Machinery	-.014 (4.40)	.017 (4.30)	.141 (15.45)	.133 (16.21)	.134 (15.22)
Electrical Machinery	-.007 (1.79)	.199 (45.82)	.145 (16.64)	.129 (18.14)	.131 (22.14)
Transport Equipment	-.140 (26.06)	-.060 (9.10)	.179 (12.27)	.121 (8.83)	.133 (13.14)

Table 9: 1991 Productivity Differentials Based on Entry Status and Export Status

	Non Exporters in 1991			Exporters in 1991		
	Intercept	Exit Export Market	New Firms	Enter Export Market	Stay In	New Firms
Textiles	.158 (15.59)	.095 (4.18)	-.010 (0.92)	.143 (5.44)	.215 (12.81)	.170 (10.60)
Clothing	-.042 (3.02)	.088 (2.86)	.033 (2.00)	.122 (2.55)	.244 (10.47)	.222 (11.09)
Chemicals	.223 (12.65)	-.010 (0.19)	-.032 (1.56)	.093 (1.85)	.175 (5.15)	.117 (4.10)
Plastics	.077 (13.89)	.074 (5.07)	-.011 (1.64)	.137 (8.52)	.189 (14.71)	.127 (12.56)
Basic Metals	.075 (7.25)	.132 (4.30)	-.039 (3.41)	.068 (1.63)	.137 (4.93)	.086 (4.27)
Fabricated Metals	-.029 (8.57)	.103 (8.13)	.008 (1.88)	.160 (11.51)	.200 (16.86)	.162 (19.07)
Non El. Machinery	-.006 (1.18)	.065 (3.94)	.009 (1.44)	.139 (9.22)	.188 (13.93)	.132 (12.53)
Electrical Machinery	.197 (25.19)	.033 (2.10)	-.014 (1.56)	.108 (6.34)	.156 (13.20)	.131 (12.47)
Transport Equipment	-.201 (18.93)	.075 (3.01)	-.006 (0.46)	.124 (4.28)	.207 (10.13)	.130 (7.79)

Table 10: 1986 and 1991 Productivity Differentials Between 1991 Entrants and Non Entrants to Export Market

	1991 Differential	1986 Differential
Textiles	.143 (5.39)	.060 (2.35)
Clothing	.122 (2.76)	.148 3.42
Chemicals	.093 (1.63)	.089 1.97
Plastics	.137 (8.73)	.076 5.24
Basic Metals	.068 (1.67)	.068 1.72
Fabricated Metals	.160 (11.75)	.131 9.76
Non Electrical Machinery	.139 (9.40)	.069 4.86
Electrical Machinery	.108 (6.66)	.048 2.94
Transportation Equipment	.124 (4.19)	.099 3.85

Table 11: Decomposition of Industry Productivity Levels

Industry	Year	Aggregate Level *ln TFP*	Unweighted Mean $\overline{lnTFP}$	$\sum_f \Delta\theta_{ft}\ \Delta\ ln\ TFP$
Textiles	1981	.202	-.079	.281
	1986	.350	.077	.273
	1991	.456	.207	.249
Clothing	1981	.223	-.081	.304
	1986	.175	-.050	.225
	1991	.265	.041	.225
Chemicals	1981	.027	-.075	.101
	1986	.358	.124	.234
	1991	.416	.235	.181
Plastics	1981	.209	-.066	.274
	1986	.290	.056	.234
	1991	.398	.098	.301
Basic Metals	1981	.039	-.101	.139
	1986	.123	.036	.087
	1991	.269	.060	.209
Fabricated Metals	1981	.162	-.083	.244
	1986	.161	-.057	.217
	1991	.209	-.007	.216
Non-Electrical Machinery	1981	.217	-.071	.288
	1986	.193	.008	.185
	1991	.210	.022	.188
Electrical Machinery	1981	.162	-.083	.245
	1986	.204	.043	.161
	1991	.440	.231	.209
Transportation Equipment	1981	.313	-.070	.383
	1986	.149	-.104	.253
	1991	.194	-.170	.364

Table 12: Decomposition of Industry Productivity Growth

Industry/Years	Labor Productivity Growth	TFP Growth	Sources of TFP Growth		
			Continuing Firms	Entry vs. Exit	Market Share Reallocation
Textiles					
1981-86	.514	.148	.095	.054	.000
1986-91	.437	.106	.069	.023	.014
Clothing					
1981-86	.157	-.048	-.027	-.025	.003
1986-91	.352	.091	.048	.041	.002
Chemicals					
1981-86	.515	.331	.213	.116	.003
1986-91	.194	.058	.023	.035	.000
Plastics					
1981-86	.268	.081	.054	.029	-.002
1986-91	.420	.108	.069	.024	.016
Basic Metals					
1981-86	.369	.085	.094	-.009	.000
1986-91	.299	.146	.111	.0282	.007
Fabricated Metals					
1981-86	.266	-.001	-.007	.007	-.002
1986-91	.371	.048	.016	.037	-.004
Non Electrical Machinery					
1981-86	.220	-.024	-.004	-.021	.001
1986-91	.404	.017	.013	-.001	.006
Electrical Machinery					
1981-86	.368	.042	.026	.037	-.022
1986-91	.743	.236	.142	.085	.009
Transportation Equipment					
1981-86	-.047	-.164	-.086	-.049	-.030
1986-91	.468	.045	.018	.005	.023