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Entry, Exit, and Aggregate Productivity Growth: Micro Evidence on Korean Manufacturing

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Entry, Exit, and Aggregate Productivity Growth: Micro-evidence on Korean Manufacturing

December 2000

Chin-Hee Hahn

Korea Development Institute

I am very grateful to the Korea Statistical Office for providing relevant data as well as to the World Bank's Global Development Network for its generous research grant. I would like to thank Jeong-sam Yang of KDI for his invaluable contribution to data processing and Hwa-Jung Choi for her helpful research assistance. I also thank the participants of the OECD workshop on economic growth held in Paris in June, 2000 for helpful comments on an earlier version of this paper. All remaining errors are author's own.

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Foreward

It is widely accepted that the growth process in a market economy inevitably requires gradual and constant reallocation of resources from less efficient producers to more efficient ones. As Schumpeter put it, “The fundamental impulse that keeps the capital engine in motion comes from the new consumers’ goods, the new methods of production and transportation, the new markets... [The process] incessantly revolutionizes from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact of capitalism.”

This study by Chin Hee Hahn examines various aspects of the micro-dynamics of plant entry, exit, and productivity in the Korean manufacturing sector using plant-level data, and tries to answer the question of what role the competitive process of entry and exit plays in enhancing aggregate productivity. While there have been empirical studies on this issue for several developing and developed countries, no such study based on plant-level data from the Korean manufacturing sector exists. The findings of this study support the efficiency-enhancing role of the entry and exit or creative-destruction process. In addition, policy implications are drawn.

I hope this study provides a basis for discussions and further research on this topic.

Jin-Soon Lee

President

Korea Development Institute

빈 면

Abstract

Using plant-level panel data on the Korean manufacturing sector during the 1990-98 period, this study tries to assess the role of entry and exit in enhancing aggregate productivity, both qualitatively and quantitatively. The main findings of this study are summarized as follows. First, plant entry and exit rates in Korean manufacturing appear to be quite high - they are higher than in the U.S. and several developing countries for which comparable studies exist. Second, in line with existing studies on other countries, plant turnovers reflect the underlying productivity differential in Korean manufacturing, with the “shadow of death” effect as well as selection and learning effects all present. Third, plant entry and exit account for as much as 45 and 65 percent of manufacturing productivity growth during cyclical upturn and downturn, respectively. The findings of this study show that the entry and exit of plants has been an important source of productivity growth in the Korean manufacturing sector. Plant birth and death are mainly a process of resource reallocation from plants with relatively low and declining productivity to a group of heterogeneous plants, some of which have the potential to become highly efficient in the future. The most obvious lesson from this study is that it is important to establish a policy or institutional environment where efficient businesses can succeed and inefficient businesses fail.

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1. Introduction

The process of economic growth involves the continual cycle of resource reallocation among heterogeneous producers. Even in the same narrowly defined industry, it is common to observe new or expanding producers as well as exiting or contracting ones during regular business cycles or over longer-run frequencies. Motivated by this observation, a growing number of studies try to assess the role played by resource reallocation in enhancing industry or aggregate productivity.¹

In the existing literature that tries to understand the sources of growth of Korea and other East Asian countries, resource reallocation among heterogeneous producers as an inevitable part of the growth process has received little attention. For example, Kim and Lau (1994), Young (1995), and Collins and Bosworth (1996), all of which provided the basis for the so-called TFP controversy, mainly focus on the respective roles of productivity growth and input accumulation using country-or industry-level data. Even though it is well acknowledged that productivity growth is the ultimate driving force for raising our standard of living, the studies based on aggregate data have a limitation for understanding how the productivity growth occurs. This is particularly true if aggregate productivity improvement takes place through a gradual process of resource reallocation among heterogeneous producers.

This study attempts to broaden our understanding of the micro-dynamics of entry, exit, and productivity growth using plant-level data on the Korean manufacturing sector. Specifically, this study has three objectives. The first is to document actual patterns of plant entry and exit. The next seeks to answer whether the plant turnover patterns reflect underlying productivity differential among plants. In order to do so, this study examines the relative total factor productivities of entering and exiting plants, both at a point in time and over a period of time. Also, this study analyzes whether plant productivity is persistent over time. The final objective of this study is to make a quantitative assessment of the contribution from resource reallocation to aggregate productivity

¹ For a recent survey of empirical literature in this vein, see Tybout (1996), Caves (1997), and Foster, Haltiwanger, and Krizan (1998).

growth. To do so, this study decomposes the total factor productivity growth in manufacturing into contributions from three components: productivity growth of continuing plants, entry and exit effect, and market share reallocation among continuing plants. To the best of the author's knowledge, this is the first study examining these issues of Korean manufacturing based on comprehensive plant-level data.

The theoretical framework of this paper is provided by previous studies on industry dynamics with firm heterogeneity.² Motivated by the empirical evidence that smaller firms grow faster and are more likely to fail than large firms, Jovanovic (1982) provides the first industry equilibrium model where firm specific stochastic elements generate observed firm dynamics. In his model, firms are faced with uncertainty about their "true cost" and learn about their relative efficiency as they operate. The equilibrium leads to selection through exit and entry, efficient growth and survival and inefficient decline and fail. Hopenhayn (1992) provides a variant of Jovanovic's model where firms are faced with exogenous productivity shock and make decisions as to when to exit the industry. He shows that there are simultaneous entry and exit in the long-run stationary equilibrium with sufficiently small fixed costs. He also performs steady state comparative static analysis to examine how the structural characteristics of an industry, such as sunk entry costs, demand, and the productivity shock process, affect turnover and distribution of firms. He shows that the high sunk entry costs lead to a lower turnover rate and a larger divergence between surviving and exiting firms, since the cost of entry acts to protect the incumbent firms and exiting firms will endure low productivity for longer period of time before exiting. He also provides conditions where the recent entrants have higher hazard rates and lower productivity than incumbent firms.

The existing empirical findings on the importance of exit and entry or market share reallocation among plants or firms are diverse. In the case of the U.S., Baily, Hulten, and Campbell (1992) find that, while entry and exit plays a minor role, market share reallocation among existing plants are important in aggregate productivity growth.

² The theoretical framework of this type of study is also related to recent endogeneous growth models of learning by doing or creative destruction, such as Stokey (1988), Grossman and Helpman (1991), Aghion and Howitt (1992), and Young (1991). For a detailed survey of the theoretical underpinnings, see Tybout (1996) and Foster, Haltiwanger, and Krizan (1998).

However, Olley and Pakes (1992) report that not only the share reallocation but also entry and exit are important in the U.S. telecommunications equipment industry. Foster, Haltiwanger, and Krizan (1998) conclude that entry and exit plays a significant role, especially in the medium to long run.

The evidence on developing countries is also mixed. Griliches and Regev (1995) analyze Israeli data and find that the effect of entry, exit, and share reallocation explains a very small part of labor productivity growth. One interesting finding, however, is that there is a “shadow of death” effect; firms that will exit in the future have lower productivity performance several years earlier. Using Chilean panel data, Liu (1993) reports a similar effect even though she does not attempt to quantify the contribution of entry and exit. Meanwhile, Aw, Chen, and Roberts (1997) find a significant role of entry and exit in total factor productivity growth of Taiwanese manufacturing industries. They claim that Taiwan’s institutional environment, such as the manufacturing sector’s dense network of subcontracting relationships and trading firms, combined with low capital intensity of much of the production, makes entry and exit of firms relatively easy and inexpensive, allowing the economy to rapidly exploit micro-level differences in productivity.

Even though it is hard to draw a general conclusion on the importance of entry and exit as a process of enhancing aggregate productive efficiency, it is also true that these studies differ in various details that might affect the conclusion, as Foster, Haltiwanger, and Krizan (1998) point out. They emphasize that the measured contribution of such reallocation effects varies over time and across sectors and is quite sensitive to measurement methodology. However, after performing sensitivity analysis on methodological details, they report that a large contribution from efficient entering plants displacing inefficient ones is a clear conclusion, especially when productivity changes are measured over five or ten year horizons. They also show that the large role of entry and exit is not just an artifact of longer-run analysis but also reflect entering plants displacing less productive exiting plants (selection) and entering plants becoming relatively productive over time (learning).

While a detailed summary of the results of this study will be presented at the end of the paper, it might be useful to give a brief overview of the findings of this study here. To begin with, most qualitative findings of this study are in line with those frequently reported for other countries. That is, this study documents that plant turnovers reflect the underlying productivity differential in Korean manufacturing, with the “shadow of death” effect as well as selection and learning effects all present. Also, there is a persistency in plant productivity. Thus, plant exit and entry, particularly birth and death, are mainly a process of resource reallocation from plants with relatively low and declining productivity to a group of heterogeneous plants, some of which have the potential to become highly efficient in future.

However, this study provides several findings that differ quantitatively from existing studies on other countries. Among others, plant entry and exit rates in the Korean manufacturing sector seem quite high. Plants born during the past five-year period account for between 21.5 and 26.2 percent of manufacturing output. A roughly similar portion is attributable to the plants that will die within five years. These figures are higher than those found in the U.S. and several developing countries for which comparable studies exist. However, the importance of entry by birth in Korea is not as pronounced as in Taiwan.

Another finding of interest in Korea comes from the comparison of aggregate productivity decomposition between Korea and the U.S. Entry and exit plays an important role in aggregate productivity growth in Korea while, in the U.S., its role is more modest. In the Korean manufacturing sector, the entry and exit effect accounts for about 45 and 65 percent in cyclical upturn and downturn, respectively. In the reasonably comparable study for the U.S., the entry and exit effect is at best below 40 percent even in the cyclical downturn when the effect tends to get stronger. This seems to reflect not only fast overall productivity shift and high rate of plant turnover but also the strong learning effect in Korea as will be documented in this paper. By contrast, market share reallocation plays a relatively minor role in Korea than in the U.S., which, however, is not unique to Korean manufacturing but in line with other studies on several developing countries.

The remainder of this paper will be organized as follows. The next section describes briefly the patterns of entry and exit. Section three will examine the relation between plant turnover and plant productivity, while section four will assess the contributions from resource reallocation to aggregate productivity growth. As the paper proceeds, the results will be discussed and compared with existing studies on other countries. The final section provides a summary of the empirical results of this paper and discusses the implications of this study. Finally, data and measurement of plant productivity will be described in the appendix.

2. Patterns of Entry and Exit in Korean Manufacturing

Utilizing the longitudinal aspect of our data set, we can define continuing plants, births, deaths, switch-ins, and switch-outs. For each year, births are defined as plants that first appear in the data set and deaths are defined as plants that disappear the next year. Continuing plants stay within the five-digit industry and are neither births nor deaths. Switch-out plants move to another five-digit industry the next year and are neither births nor deaths. Similarly, switch-in plants move into the industry from another five-digit industry.³

<Table 1> summarizes the importance of plant births. Specifically, it shows what fraction of output or number of plants for each year is attributable to the plants that are grouped by plant age. In 1995, plants between zero and two years of age account for about 17.1 percent of manufacturing output and three to four-year-old plants explain about 9.1 percent. So, the fraction of manufacturing output in 1995 produced by plants less than five years old is as much as 26.2 percent. In 1998, the contribution from those plants drops visibly to 21.5 percent. This is due not only to the fall in birth rate but also to the increase in closing of young plants, reflecting severe economic recession. In terms of number of plants, the importance of births becomes more dramatic. Plants less than five years old account for between 58.1 and 67.5 percent of manufacturing plants depending on the year. The larger contribution of younger aged plants in terms of

³ However, the plant classification depends on the time interval of the analysis. For example, in the five-year transition matrix that will be discussed below, births could be many years old.

number of plants indicates that those plants are usually small ones.

The importance of births in Korea can be assessed by comparison across countries. Aw, Chen, and Roberts (1997) report, after examining nine manufacturing industries in Taiwan, that one to five-year-old firms account for approximately two-thirds of the number of firms in operation and between one-third and one-half of each industry's production in 1991.⁴ They also summarize similar statistics for other countries. Using data for Colombian manufacturing plants, Roberts (1996) finds that the combined market share of one to five-year-old plants varies between 18.3 and 20.8 percent depending on the year. With similar data for Chile, Tybout (1996) 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) find the market share of one to five-year-old firms varies from 13.6 to 18.5 percent depending on the year. Thus, the importance of entry by birth in Korean manufacturing seems to be less pronounced than in Taiwan.⁵ However, entry by birth in Korea seems to be more active than in the U.S. or several developing countries in Latin America.

The plant death rate is also high in the Korean manufacturing sector as shown in <Table 2>. In terms of output, between 13.4 percent and 15.8 percent of plants die within three years depending on the year. Between 19.9 percent and 24.1 percent of a given year's output is produced by plants that will die within five years. The figures for deaths within five years for number of plants are again much larger than for output, indicating that the deaths are concentrated in small plants. In terms of number of plants, the fraction of plants that will survive more than five years is surprisingly as low as 36.1 to 47.4 percent depending on the year. Again, the fraction of plants that will survive more than five years in 1993 drops dramatically due to the high rate of plant closing in 1998.

⁴ This paragraph heavily borrows from Aw, Chen, and Roberts (1997). Explicit quotation has been omitted.

⁵ The fact that the study by Aw, Chen, and Roberts uses firm-level data instead of plant-level data does not affect this statement since plant-level entry and exit rates would be higher than firm-level entry and exit rates.

The plant death rate among births is even higher than the death rate among all plants. <Table 3> shows the distribution of a given year's output or number of plants according to the length of plant life, conditional on birth. The death rate of births is much higher than the unconditional death rate, especially during the first three years of operation, which is in line with the theories of firm dynamics. In terms of number of plants, between 46.4 and 55.9 percent of births die within three years depending on the year, which is much higher than the corresponding numbers in <Table 2>. In terms of output, the difference is even more striking, which seems to be natural since births are usually small plants. However, the death rate of births between three to four years of operation is not much different from the unconditional death rate. Thus, new plants seem to fail easily, especially during the first three years. This might be due, among other factors, to the low productivity of births at the beginning of operation as will be discussed later. After five years, only between 24.0 and 35.8 percent of a given year's birth plants will still be operating. Even among births, smaller plants die more frequently, which can be seen by comparing the shares of deaths in output and in number of plants.

Switch-ins, another type of entry, are also frequently observed in Korean manufacturing. In terms of output, they are almost as important as births. <Table 4> shows that plants that switched into a five-digit industry for the past three years account for between 11.6 and 15.6 percent of manufacturing output depending on the year. In terms of number of plants, however, they represent between 13.1 and 15.3 percent. Plants that switched in during the past five years and survived produce between 18.3 and 22.9 percent of manufacturing output. Compared with births, switch-in plants are generally bigger in size.

Finally, switch-outs are also almost as important as deaths. Again, switch-out plants are larger than deaths in size. Plants that switch out to another industry within three years account for between 8.8 and 12.4 percent of manufacturing output and between 13.1 and 14.8 percent of the number of plants, as shown in <Table 5>. Plants that will be operating in another five-digit industry within five years produce between 14.5 and 16.3 percent of a given year's manufacturing output.

3. Plant Productivity and Turnovers

- Summary Measures of Productivity

The distribution of plant total factor productivity and its changes over time are summarized in <Figure 1>. Data and methodological details of measuring plant total factor productivity are presented in Appendix A. <Figure 1> shows the cross-sectional relative frequencies of plants along equal-length productivity intervals for three years. For both total manufacturing and all disaggregated industries presented here, there exists a large degree of heterogeneity in plant productivity, which provides the background for micro-level analysis of this sort. The distribution of plant productivity moved rightward over time, suggesting that productivity growth is widespread among plants.

<Table 6> provides an alternative summary of plant productivity distribution and its changes over time. It reports the quartiles of cross-sectional productivity distribution for total manufacturing and twelve disaggregated industries in 1990, 1994, and 1998. The table shows that there is a clear rightward shift in the productivity distribution over time. In the case of total manufacturing, the median plant experienced a productivity improvement of about 26 percent over the 1990-98 period, which corresponds to an annual growth rate of about 3.2 percent. All twelve industries show positive productivity growth of the median plant during the 1990-98 period, although the growth rate varies substantially across industries. Communications equipment and transport equipment exhibit the largest median plant productivity improvement of 68 percent and 47 percent, respectively, while wood and pulp (2 percent) and food and beverages (10 percent) show the lowest growth rates. Productivity growth rates by the median plant of the other industries range from 22 percent to 33 percent. The productivity growth of the median plant is accompanied by the roughly similar growth rates of the 25th and 75th percentiles in each of the industries, indicating that the shape of the productivity distribution did not change much during the eight-year period.⁶

⁶ In fact, the interquartile range increases slightly during the 1994-98 period for most industries. However, this phenomenon is largely due to the rapid rightward shift of the 75th percentile relative to 25th percentile in 1998.

The discussion above suggests that plants are heterogeneous in terms of productivity levels. It also suggests that aggregate productivity growth involve the productivity improvement of most plants that are observed. However, this discussion does not shed light on the patterns of micro-plant dynamics underlying the aggregate productivity change. In the previous section, it was shown that there is a substantial amount of entry and exit of plants even at annual frequencies. In addition, plants that stay in the market over a certain time interval could move across the productivity distribution. This suggests that the micro-plant dynamics underlying <Figure 1> might be very complex.

We do not attempt to characterize fully the complex plant dynamics in this paper. Instead, we focus below on a subset of questions, using the data for the Korean manufacturing sector, which have been often raised in the literature. A short list of those questions is as follows. Do plants exit because they are inefficient? Are entrants more or less productive, at the time of entry, relative to continuing or exiting plants? How about switch-ins and switch-outs? How do surviving entrants perform in terms of productivity after entry? What is the pre-exit productivity performance of exiting plants like? How persistent is the productivity differential among plants? As we move along these issues, we hope to determine whether the observed plant turnovers or, more broadly, resource reallocation among plants reflect underlying differences in productivity and whether those differences are an outcome of a transitory or random event.⁷

- Productivity Differential among Entering, Exiting and Continuing Plants

As the first step toward identifying the relationship between plant productivity and plant turnover patterns, we compare productivity levels of continuing plants, entrants, and exiting plants at the time of entry and exit. We also examine the

⁷ The question of persistency in productivity is related to the question of what is the source of the productivity differential among plants. In this paper, however, we do not pursue this question in detail. For a brief review of the theoretical literature on reasons for heterogeneity in plant-level and firm-level outcomes, see Baily, Hulten and Campbell (1992), Davis and Haltiwanger (1998) and Foster, Haltiwanger and Krizan (1998). Baily, Hulten and Campbell also examine this issue empirically in detail.

productivity levels of switch-in and switch-out plants that might be different from birth and death. <Table 7> shows the unweighted mean productivity levels of plants in total manufacturing that are observed at a given year for each of the five plant groups.

The main features of <Table 7> can be summarized as follows. First, deaths in a given year are, on average, less productive than continuing plants in that year. Depending on the year, they are about 3 to 6 percent less productive than continuing plants. This result is consistent with the prediction by models of plant or firm heterogeneity that market selection forces sort out low-productivity plants from high-productivity plants. Also, this result is not unique to the Korean manufacturing data but is reported by many studies for other countries.

Second, births are, on average, less productive than continuing plants in the first year they are observed. They are even less productive than deaths. In fact, the productivity of a typical birth plant is the lowest among all groups of plants in every year. Initial low productivity of birth plants relative to continuing plants or deaths is not consistent with the presence of the simple vintage effect that new plants are more productive than older plants. However, it is not necessarily contradictory to the prediction of several recent models of plant dynamics, such as Jovanovic (1982) and Hopenhayn (1992). Potential entrants who are uncertain about their productivity but hold a positive outlook on their post-entry productivity performance—i.e., those who expect they could catch up with the incumbents in terms of productivity sooner or later—might enter despite their initially low productivity. Of course, birth plants themselves are also heterogeneous in terms of productivity, as will be discussed later.

Initial low productivity of births relative to incumbents is also documented by other studies, although these studies differ from ours in terms of data and methodologies. For example, Aw, Chen, and Roberts (1997), using firm level data on Taiwanese manufacturing industries, reports that entrants in 1986 are, depending on the industry, between 0.6 percent and 6.9 percent less productive than incumbent firms in the same year. Meanwhile, Foster, Haltiwanger, and Krizan (1998), using plant-level data on the U.S. manufacturing sector and based on a ten-year interval analysis, report that there is no statistical difference between continuing plants and entering plants in terms of

multifactor productivity in 1987 (see <Table 10>). However, the same table shows that the cohort of plants that entered during the past five-year period, rather than ten-year period, exhibit lower productivity than continuing plants in 1987.⁸

Third, switch-in or switch-out plants have higher productivity than births or deaths, respectively. The productivity of those plants is roughly comparable to the continuing plants on average. Recalling our definition of plant groups, switch-ins are distinguished from birth in that they have previous experience in another market defined at the five-digit level. Thus, higher productivity of switch-ins relative to births is consistent with the idea that previous experience in a related market helps. It would not be surprising to find higher productivity of switch-outs relative to deaths, since switch-outs are distinguished from deaths in that they continue their operation for the next year in another market. The finding that switch-outs have productivity levels comparable to continuing plants seems to suggest that high-productivity plants have mobility. However, this could also be consistent with the story that multi-product plants have both high productivity and mobility. High productivity could come from the possible spillovers generated by producing multiple related products, and mobility could come from, given the presence of sunk costs, the ease of changing the product mix relative to restarting a business in an entirely new product market.

Fourth, each new cohort of birth is more productive than its previous cohorts. This fact conforms well with the presumption of recent R&D-based endogenous growth models, such as Grossman and Helpman (1991), that potential entrants receive externalities from previous innovation.

The above discussion suggests that observed patterns of plant turnovers reflect the underlying productivity differential. In order to examine the statistical significance of the productivity differential among plant groups, we also present the results from dummy variable regressions which are similar to the regressions in Aw, Chen, and Roberts (1997). <Table 8> reports the regression results using the pooled 1990-98 data. The measured plant level productivity is regressed on a set of dummy variables

⁸ They report, however, that in terms of labor productivity entering plants have lower productivity than continuing plants even at ten-year intervals.

indicating whether the plant is a birth, switch-in, death, or switch-out, and year dummies (not reported). Thus, the estimated coefficients can be interpreted as the average productivity differential between each group of plants and continuing plants, which is assumed to be common across years.

The regression for total manufacturing shows that the difference in productivity between continuing plants and each of the other groups of plants is statistically significant. Births and deaths are less productive than continuing plants by 6.3 percent and 4.2 percent, respectively. Switch-ins and switch-outs are statistically more productive than continuing plants, although the differences are small. The fifth column of <Table 8> tests the hypothesis that there is no productivity differential between births and deaths. The reported F-statistic shows that the hypothesis is rejected at the usual significance level. We also tested the hypothesis that there is no productivity differential between births and switch-ins and it was rejected. The hypothesis of there being no productivity differential between deaths and switch-outs was also rejected.

We then ran the same regression separately for each of the twelve industries. The estimated coefficients show that in every industry births and deaths are significantly less productive than continuing plants. The productivity differential between births and continuing plants ranges from 3 percent (medical and precision instruments) to 13 percent (food and beverages). In the case of deaths, the differential is also the smallest for medical and precision instruments at 2 percent and the largest for food and beverages at 10 percent. The hypothesis of there being no productivity differential between births and deaths is rejected at the 1 percent significance level in nine of the twelve industries.

The column two and four in <Table 8> reveal that the high productivity of switch-ins and switch-outs relative to continuing plants estimated for total manufacturing masks the industry differences. It turns out that, depending on the industry, the productivity of switch-ins and switch-outs can be either higher or lower than continuing plants. However, in all of the twelve industries, switch-ins and switch-outs are significantly more productive than births and deaths, respectively.

The analysis so far reveals that plant turnovers, especially entry by birth and exit by death, are not random events. In other words, the productivity of birth and death

plants are more likely to be located at the lower part of the cross-sectional productivity distribution shown in <Figure 1>. In particular, lower productivity of deaths relative to continuing plants indicates that market selection forces are at work as predicted by theoretical models of plant or firm dynamics. Market selection of low productivity plants from surviving high productivity plants is a process that enhances the aggregate productive efficiency level.

Even though lower productivity of births relative to continuing plants, or even deaths is not inconsistent with the prediction of theoretical models and is often found for other countries, it could cast doubts on the positive role of exit and entry on aggregate efficiency gain. That is, it suggests that the *instantaneous* effect of resource reallocation by plant deaths and births on aggregate productivity growth might be very small or even negative, which might be true especially if the resources released by deaths are entirely used up by births. If this is the end of the story, then any positive role of plant turnovers on improvement of aggregate productivity measured at a certain time interval will be an accounting result arising from current births having higher productivity than past deaths.

However, this is not the end of the story. The literature points out that the benefits of the resource reallocation by exit and entry are realized *over time*. First, examination of post-entry performance of entrants reveals that entrants are a heterogeneous group going through the process of market selection themselves. More importantly, it is frequently documented that the surviving members of entrants experience fast productivity improvement or rapid learning and catch up to the incumbents after a certain period from the entry. In other words, plant exit and entry is a process of resource reallocation from inefficient plants to a group of heterogeneous plants, some of which have the potential to become highly efficient in the future. Second, it has also been noted that exiting plants are less productive than continuing plants, not just at the time of exit but also for a certain period before exit. That is, there is a “shadow of death” effect. The productivity gap between exiting and continuing plants often widens over time before exit.⁹ In other words, the process of plant productivity is not purely random but highly persistent over time, indicating the presence of plant-specific effects. Then,

⁹ See Liu (1993) for evidence on Chilean manufacturing.

plant death or survival might reflect not just temporary misfortune but also plant-specific factors that will be fixed over time, such as managerial ability. Thus, we examine below post-entry and pre-exit performance of plants, focusing on market selection, learning, and persistency of plant productivity using the data on the Korean manufacturing sector.

- Post-Entry Performance: Market Selection and Learning

We examine whether the market selection forces sort out low productivity plants among births. In our sample, there are eight cohorts of birth according to birth year (1991 to 1998). Focusing on a particular birth-year cohort has the advantage that possible age effect on survival is controlled for. Specifically, we examine whether plants that belong to the 1991 birth cohort but die in 1993, for example, have lower productivity at the time of death than the other surviving members of the birth cohort. In order to do this, plant productivity is regressed on a set of year dummies (not reported) and a dummy variable denoting whether the plant that died after birth within the sample period interacted with year dummies. Thus, the estimated coefficients denote the productivity differential between deaths and survivors at the time of death. The regression results for three birth cohorts are reported in <Table 9>.

The table clearly shows that, for each birth-year cohort reported here, exiting plants have lower productivity than surviving plants at the time of exit, even after controlling for the birth year. Also, the differences are highly significant. Depending on cohort year or death year, deaths are less productive than surviving plants by about 3 to 6 percent. Thus, the results strengthen the conclusion drawn earlier that markets sort out plants on the basis of productivity.

Next, we examine the productivity performance of the surviving members of the entrants relative to continuing plants. <Figure 2> and <Table 10> show the average productivity of birth cohorts that survived until 1998 by birth year, in comparison with continuing plants in 1991 that also survived until 1998. Continuing plants have increased their productivity steadily and improved their average productivity by about 23 percent during the 1991-98 period. Each birth-year cohort starts with a productivity

disadvantage relative to continuing plants at the year of entry.

However, each birth cohort shows very rapid productivity improvement following entry, and catches up with continuing plants in terms of productivity level after several years. The productivity differential between births and continuing plants at the time of entry ranges from 6 to 10 percent depending on the birth year. In the second year after entry, the productivity differential narrows to only about 0 to 3 percent. The productivity growth by births between the first and the second year is very large, between 6 percent (1995 birth cohort) and 13 percent (1994 birth cohort). In the third year after entry, the productivity level of births is roughly the same as, or even slightly higher than, continuing plants. The 1991 birth cohort in particular, which has the longest time series, maintains higher average productivity than continuing plants three years after entry. For some years these differences are statistically significant. A similar conclusion also holds for the 1992 birth cohort, which is shown in <Table 10>. Thus, the results are clearly supportive of the presence of rapid learning by surviving members of births, especially during the first several years after entry.

<Table 11> examines the convergence in productivity of surviving births to continuing plants for each of the twelve disaggregated industries. Specifically, it compares the average productivity levels of continuing plants and births as of 1991 that did not exit the five-digit industry, either by death or switch-out, until 1998. The reported coefficients are the average productivity differential between the two groups. Overall, the results indicate that the experiences of the twelve industries are consistent with the initial productivity disadvantage and subsequent learning of surviving births. The coefficients on the dummy variable for 1991 are negative and significant in most industries. However, the coefficients tend to become insignificant or turn positive as years go by.

Of course, the experiences of the twelve industries are diverse. In some industries, surviving births either catch up or overtake the continuing plants in terms of productivity levels. In non-metallic mineral product and machinery and equipment industries, the productivity advantage of surviving births over continuing plants is statistically significant. There are also industries, however, where the surviving births

never catch up with continuing plants, such as food and beverages and communication equipment industries. Even in these industries, the productivity disadvantage of surviving births in later years is smaller than in earlier years.

The examination of post-entry performance of births using the plant-level Korean manufacturing data reveals the presence of both market selection and learning process. Births are a heterogeneous group themselves, among which low productivity plants die over time. Surviving members of births experience fast productivity improvement or rapid learning after entry and catch up with continuing plants in terms of productivity level within approximately three years. Examination of early year birth cohorts with longer time series reveals that those plants overtake continuing plants in productive efficiency in relatively short period of time. These results are broadly consistent with those reported by studies on other countries. Thus, it is strongly supported by the present study that plant exit and entry is a process of resource reallocation from inefficient plants to a group of heterogeneous plants, some of which have the potential to become highly efficient in the future.

- Productivity Performance by Exiting Plants

So far it has been found that there are certain patterns (market selection and learning) in the post-entry performance of births. Here, we examine another dynamic aspect of our data set, pre-exit performance of deaths, in order to understand the role of plant exit and entry on aggregate productivity growth.

<Figure 3> and <Table 12> show the time series of average productivity of plants that existed in 1990 grouped by the death-year cohort, in comparison with plants that survived throughout the sample period. As could be expected from the previous discussion, with the exception of the 1993 death cohort, the average productivity of each death cohort in the last year it is observed is the lowest among all cohorts. For example, the productivity of the 1997 death cohort is the lowest in 1997, and the productivity of the 1996 death cohort is the lowest in 1996, and so on. There are two additional points to be noted.

First, there is a significant productivity gap, not only at the time of death but also for years before death, between each death cohort and the group that survived until 1998, even though each death cohort experienced productivity gain over time. This phenomenon suggests that plant deaths reflect underlying productivity differences that have existed for quite a long period of time. In other words, those differences are not just an outcome of random or transitory bad luck. Taking the 1997 death cohort as an example, the productivity disadvantage relative to the surviving group is about 6.5 percent in 1997. However, the productivity differential is evidenced as early as 1990, when it already was as large as 3.7 percent. Similar results hold for other death cohorts. Thus, plant deaths seem to reflect not only point-in-time productivity disadvantage around death but also persistently bad productivity performance.

Second, the productivity differential between deaths and surviving plants tends to widen, especially during the period close to death year. Take again the example of the 1997 death cohort. The productivity differential fluctuates between 3.5 and 4.7 percent during the 1990-96 period, but in 1997 it rises to 6.5 percent. Similar patterns are found for other death-year cohorts.

In order to examine whether the persistent and widening productivity gap before death reflects industry differences, we also compared, for each of the twelve industries, the average productivity level of the 1997 death cohort with the surviving group among the plants observed in 1990. Here, plants that switched out after 1990 were removed from both groups. <Table 13> shows the regressions of productivity on a set of year dummies (not reported) and a dummy variable denoting that the 1997 death cohort interacted with year dummies. Thus, the reported coefficient indicates the average productivity differential between the 1997 death cohort and the group of plants that survived until 1998.

Most coefficients reported in <Table 13> are negative and frequently significant, consistent with our previous results. The productivity of deaths is lower than survivors in 1997 and the differences are statistically significant at the 5 percent level in eight of the twelve industries. In basic metals and machinery and equipment industries, it is significant at the 10 percent level. Seven industries show productivity difference

significant at the 5 percent level in 1995 out of those eight industries. In addition, seven industries show significant productivity differential as early as 1990. Finally, ten industries show larger productivity differential in absolute terms in 1997 compared with 1995.

So far we have examined pre-death productivity performance of death cohorts relative to surviving groups of plants and observed large and persistent productivity differences that often widen over time during the period close to death year. Such large and persistent productivity differences observed in <Figure 3>, however, might reflect not only whether or not plants survive but also other factors that differ between survivors and deaths, such as plant age. That is, younger plants are less productive and die more frequently than older plants. In order to control for this possible age effect on productivity and survival, we also looked at pre-death performance of plants that are born in the same year.

<Figure 4> shows the pre-death productivity performance of the 1991 birth cohort that is further divided by the death year, compared with the 1991 births that survived until 1998. For comparison purposes, the productivity performance of 1991 continuing plants that survived until 1998 is also shown. As expected, the persistence of productivity differential among 1991 births is somewhat weaker than suggested by <Figure 3>. That is, the 1991 births that die before 1998 do not show noticeable productivity disadvantage in the early years of their beginning of operation compared with the surviving group. Especially in the first year of operation, 1991, there is virtually no productivity differential among them, except the 1996 deaths. Moreover, for the several years after entry, the productivity differential between 1991 births and 1991 continuing (and surviving until 1998) plants narrows over time.

However, as surviving members of 1991 births improve their productivity at a fast pace, the productivity gap begins to develop and persists over time. In addition, for each death-year cohort among 1991 births, the productivity disadvantage relative to the continuing group becomes the largest in the last year they are observed. Thus, even if the possible age effect on productivity and survival is controlled for, it still holds that plant deaths reflect a somewhat persistent productivity disadvantage, which often

widens during the period close to death.

If the productivity differential between deaths and survivors are persistent, then it is expected that the initial productivity of a plant at a point in time is correlated with whether that plant dies within certain period or not. To examine this, we first chose plants in 1993 that belong to the group of continuing plants, births, or switch-ins. Then we further divided these groups according to whether the plants survived until 1998. <Table 14> shows the average productivity of each group, expressed as the difference of the productivity of continuing plants that died within five years and statistical test results on equal productivity between survivors and deaths. We report the results for 1993 only since the results for other years are qualitatively similar. Thus, the table shows any productivity differential between plants that survived more than five years and those that did not, conditional on 1993 status.

Within continuing plants, those that survived until 1998 had clearly higher productivity in 1993 than those that died before 1998. The average productivity differential for total manufacturing is about 4 percent and it is statistically significant. Out of twelve disaggregated industries, ten industries show productivity differences that are statistically significant at the 1 percent level.

Within births, however, there is no clear initial productivity differential between survivors and deaths, even though the average productivity of the former is higher than the latter in many industries. The F-test statistics show that the difference is significant in only two of the twelve industries. This result is consistent with the previous result from <Figure 4>, which shows that the first year productivity of births does not differ much across death-year cohorts. Similar results hold for switch-ins, which is not surprising since both births and switch-ins are newcomers in the five-digit industries.

At first sight, the observation that there is no clear initial productivity differential among births between survivors and deaths over the five-year period seems to run counter to the results by Aw, Chen, and Roberts (1997). For seven out of nine Taiwanese manufacturing industries, they found that there exists a significant productivity differential in 1986 among 1981-86 entrants between survivors and deaths over the subsequent five-year period. However, the two studies differ in that, among other ways,

the average age of births in our study is only 0.5 year while the average age of entrants in their study is about 2.5 years.

Motivated by this observation, we decided to examine whether there is a productivity differential among births after several years following entry, depending on whether those plants survive or not over the subsequent period. Specifically, we examined the productivity differential as of 1994 among 1990-94 births between plants that survived until 1998 and those that did not. <Table 15> shows that the productivity differential is significant for total manufacturing. In addition, five out of twelve industries show clear productivity differential among birth between survivors and deaths. Thus, comparison of the results in <Table 14> and <Table 15> indicates that even though there may not be a clear productivity differential within a birth-year cohort in the first year of entry, the productivity differential arises over the years. This is also consistent with <Figure 4> where the surviving members of the 1991 birth cohort differentiates themselves from others in terms of productivity after several years following entry. Thus, the results found in this study for Korean manufacturing are not at odds with those for Taiwan.

In short, the patterns of plant survival or exit reflect productivity differential at an earlier year in Korean manufacturing. In other words, plant death or survival might not be an outcome of random productivity shock, but rather, reflect persistent productivity differential.

- Transition Matrix Analysis

We have presented above quite a few pieces of evidence consistent with market selection, learning, and persistence of plant productivity by focusing on the *average* productivity differentials among various plant groups. However, there could be high as well as low productivity entrants. The same can be said about exiting plants. Even among continuing plants, there might be movement of plants across productivity distribution over time. One useful way of summarizing the above features of our data and complementing our previous analysis is to rely on transition matrix analysis.

We set up transition matrices for various time intervals following Baily, Hulten, and Campbell (1992) (BHC henceforth), but focus primarily on the five-year transition during the 1990-95 period. The primary reason for our interest in the five-year transition is to make our results comparable to theirs, so that any similarities or differences between Korean and U.S. manufacturing might be found.

In order to do this, the plants within each five-digit industry are ranked according to their relative productivity in each year and divided into quintiles. Then, for each quintile in 1990, we calculate what fractions of those plants are in each quintile in 1995 in their own industry and what fractions have either died or switched out to another industry. Among the plants that are observed in 1995, there are also births and switch-ins during the 1990-95 period. We can also examine where in the productivity distribution the births and switch-ins started by calculating the fractions of those plants that are in each quintile in 1995. <Table 16> shows the transition matrix which has been weighted by employment size measured by number of workers. For entrants in 1995 and exits in 1990, the weights denote number of workers in the year they are observed. For continuing plants that are observed in both years, the weights are the average number of workers in the two years.

Starting from the first row of the table, of the plants that were in the top quintile in 1990, about a weighted 28.5 percent of them are again in the top quintile in 1995. However, the fractions of those plants that experience downward movement in relative productivity ranking decrease monotonically. The drop in the percentage as we move rightward along the first row is so huge that only about 3 percent of those plants were in the bottom two quintiles in 1995. Among the plants that were in the second quintile in 1990, 16.6 percent of them stayed in the second quintile and roughly an equal fraction of them moved up to the first quintile in 1995. However, the percentage decreases rapidly and monotonically as we move off the diagonal to the right.

When there is a persistency in productivity it is expected that the relative productivity rankings does not change much over time and the diagonal numbers of the transition matrix tend to be bigger than the off-diagonal members. The discussion above suggests that plant productivity in the Korean manufacturing sector is very persistent,

especially in the top of the productivity distribution. Similar results are also reported by BHC for U.S. manufacturing.

However, the persistency is less visible in the middle and bottom of the productivity distribution. Of the plants that were in the third quintile in 1990, only about 7.7 percent stayed in the same quintile. In this case, about 28.7 percent move up to the top two quintiles, while only about 10.1 percent moved down to the bottom two quintiles in 1995. There is also somewhat lower persistency in the bottom two quintiles in 1990. Most of those plants either move up in the productivity distribution or exit the industry by switch-out or death. Especially in the case of the bottom quintile in 1990, a weighted 12.7 percent moved into the third quintile while only 6 percent stayed in their own quintile in 1995. Of course, a huge fraction of them (68.7 percent) either exited the industry either by switch-out or death.

We also calculated the unweighted transition matrix during the 1990-95 period, which is reported in <Table 17>, where the numbers denote percentages in terms of number of plants. In the unweighted matrix, all of the diagonal numbers are bigger than off-diagonal numbers. In this case again, however, the persistency is marked in the top of the productivity distribution.

Based on the U.S. manufacturing data, BHC reports that there is not much evidence of a systematic plant vintage effect. In our data as well, the systematic evidence in favor of plant vintage effect is hard to find. If a plant vintage effect is present, then it is expected that older plants move down the productivity distribution over time. Among the plants in the second quintile in 1990, more of them moved up to the first quintile than down to the third quintile. In the third quintile again, there were by far more plants that moved up than those that moved down over time.

The transition matrix also shows the percentage of plants for each quintile in 1990 that exited their own industry. As expected, the percentage of death conditional on the 1990 productivity quintile gets higher as we go down the productivity quintiles. In the top quintile, about 22.6 percent of the plants, weighted by employment, died within five years, while as many as 43.5 percent died in the bottom quintile during the same period. If we look at the unweighted matrix, the same pattern exists but the numbers get

higher. Even in the top quintile, about 46.0 percent did not exist after five years, while in the bottom quintile the corresponding number is as large as 57.0 percent. The larger percentage of deaths in the unweighted matrix indicates that plants that die during the period are usually small plants. One interesting observation here is that there are many high-productivity deaths that are small in size. A similar result is reported by BHC for the U.S.

The percentages of switch-outs are roughly even across the 1990 productivity quintiles. In fact, the weighted matrix shows that the switch-outs are more frequent in the top and bottom of the productivity distribution. Not only high-productivity but also low-productivity plants are more likely to move to another industry. The unweighted matrix shows, however, that, in terms of the number of plants, high-productivity are more likely to switch out than low-productivity plants. As discussed before, it is not clear whether this phenomenon reflects the general mobility of high-productivity plants or the advantage of multi-product plants coming from the technological spillovers and the ease of entry by changing product mix.

The transition matrix also shows the relative productivity of entrants during the 1990-95 period. Here, births and switch-ins that died during the period are not included in the sample. Thus, the entrants in the sample are relatively successful in partly going through the process of market selection and learning, with average experience in the industry of 2.5 years. The table shows that both switch-ins and births are moderately concentrated in the high productivity quintiles. Relatively high productivity of birth does not contradict our previous result that births have lower productivity than continuing plants in the first year they are observed. In fact, we already showed in <Figure 2> that it does not take many years for the surviving births to catch up with continuing plants in terms of productivity in the Korean manufacturing sector. Thus, it would not be surprising to find higher productivity of births relative to continuing plants that have gone through market selection and experienced learning for 2.5 years on average. Meanwhile, in terms of number of plants, births are slightly concentrated in the lower quintiles. This implies that birth plants in the top productivity quintiles are bigger in size by 1995 than those in the bottom quintiles.

We also examined transition matrices for various time periods. Since the results are not much different from the five-year transition matrix discussed here, we do not present all of them. However, even in the eight-year transition matrix (1990-98 period) reported in Appendix B, we could observe a moderate degree of persistency in productivity. Of course, the shorter-period transition matrix tended to show stronger persistency. Also, the longer-period transition matrix showed larger selection and learning effect of successful births.

So far we have examined the transition matrices of plant-relative productivity and discussed the results, which are similar to those for the U.S. manufacturing sector. However, it might be useful to summarize this section by pointing out several aspects of the Korean data that apparently differ from Baily, Hulten, and Campbell (1992). First, even though the data are consistent with persistency of productivity, the degree of persistency seems to be weaker in Korea than in the U.S. To take one example, the weighted 60.8 percent of the plants in the top quintile in 1972 were again in top quintile in 1977, while only 14.9 percent of them moved down to the second quintile in U.S. manufacturing (Table 3 of BHC). However, the corresponding numbers are 28.5 and 13.4, respectively, in the Korean manufacturing sector.

Second, the fractions of entrants and exits are much larger in Korea than in the U.S., during the five-year interval. In BHC, only 11.2 percent of the bottom quintile in 1972 either switched out (5.5 percent) or died (5.7 percent), while the corresponding number is as large as 68.7 percent (25.3 percent for switch-outs and 43.5 percent for deaths) in Korea. Plant turnovers are much more frequent in Korean manufacturing than in the U.S.

Finally, the time it takes for surviving entrants as a group to become as productive as continuing plants seems to be somewhat shorter in Korean manufacturing than in the U.S. For example, in the case of Korea, the weighted 25.6 percent of births during 1990-95 period were in the top quintile and only 16.5 percent of them were in the bottom quintile in 1995. However, the corresponding numbers for the U.S. are 20.8 percent and 29.3 percent, respectively, indicating that low productivity entrants were the largest even at the five-year interval. This might be related to both high frequency of

death by unproductive plants and fast learning in Korea.

4. Exit, Entry and Aggregate Productivity Growth

In this section, we examine what effect the entry and exit of plants, or more broadly, the resource reallocation among plants, has on aggregate productivity growth. In order to do this, we begin by defining the level of industry total factor productivity in year t as follows.

$$\ln TFP_t = \sum_i \theta_{it} \ln TFP_{it},$$

where θ_{it} is the market share of the i th plant in five-digit level industry and $\ln TFP_{it}$ is plant total factor productivity calculated as described in Appendix A. Then, the industry TFP growth rate between year t and $t-\tau$ is

$$\Delta TFP_t = \sum_i \theta_{it} \ln TFP_{it} - \sum_i \theta_{i,t-\tau} \ln TFP_{i,t-\tau}.$$

Following Baily, Hulten, and Campbell (1992), we can decompose the industry TFP growth as follows.

$$\begin{aligned} \Delta TFP_t = & \sum_{i \in S} \theta_{i,t-\tau} \Delta \ln TFP_{it} + \sum_{i \in S} (\theta_{it} - \theta_{i,t-\tau}) \ln TFP_{it} \\ & + \sum_{i \in N} \theta_{it} \ln TFP_{it} + \sum_{i \in X} \theta_{i,t-\tau} \ln TFP_{i,t-\tau}, \end{aligned} \quad (1)$$

where S , N , and X denote the set of continuing plants that operated in both year t and $t-\tau$, entrants, and exits during the period, respectively. Among the entrants, there are births and switch-ins. Similarly, there are deaths and switch-outs among the exits. Thus, the first term in equation (1) represents the “within” component that comes from the improvements in each plant separately, weighted by initial shares in the industry. The second term represents the share effect, i.e., the contribution from changes in the output

shares.¹⁰ The last two terms represent the contribution of entrants and exits, respectively. The net effect of the entrants and exits will reflect any differences in the levels of productivity between the groups and any differences in the output shares.

<Table 18> shows the results of the decomposition for Korean manufacturing for the 1990-95 and 1995-98 periods. The manufacturing-average figure weights each five-digit industry result by its share of nominal gross output, averaged over the beginning and ending years of the period. The results for twelve disaggregated industries are presented in Appendix B. The sample period is divided into the two distinct sub-periods, as described above, for the following reasons. First, the literature suggests that the relative contribution of each component varies systematically over the business cycle (e.g., Baily, Hulten, and Campbell (1992) and Foster, Haltiwanger, Krizan (1998)). The first five-year period is intended to capture the patterns observed in the cyclical upturns, even though it does not exactly coincide with the officially reported period.¹¹ The second reason for dividing the sample period as above is to focus on five-year changes, which will make our results more comparable to other results in the literature.

To begin with, the TFP growth in Korean manufacturing is as high as 23.0 percent during the 1990-95 period, or roughly 4.6 percent per annum, but is only 4.7 percent during the 1995-98 period (about 1.5 percent per annum). Thus, the measured TFP growth shows well-known procyclicality.

Overall, the decomposition yields strikingly different results between the two sub-periods of cyclical upturn and downturn. The contribution from the within effect is 13.2 percent during the 1990-95 period, accounting for as much as about 60 percent of

¹⁰ The second term can be further decomposed into a between-plant component and cross term, as shown in Foster, Haltiwanger, and Krizan (1998). They point out that when there are random measurement errors in output it will generate an upward bias in the correlation between productivity growth and output growth, making the cross term spuriously high in the output-weighted industry productivity growth decomposition. In this paper, we combine the between-plant and cross term into share effect term as in Baily, Hulten, and Campbell (1992) in order to make our results comparable to theirs.

¹¹ The National Statistical Office defines 1989 and 1993 as cyclical troughs and 1992 and 1996 as cyclical peaks. Nevertheless, the business conditions improved significantly over the 1990-95 period as a whole so that the decomposition results during this period are expected to show overall patterns observed in upturns, which seems to be supported by our results.

manufacturing TFP growth. However, the within effect falls to slightly below zero during the 1995-98 period. The larger role of the within effect on aggregate TFP growth during the period of cyclical upturns is consistent with the results for the U.S. manufacturing sector as reported by BHC and Foster, Haltiwanger, and Krizan (1998) (FHK hereafter).

The effect of entry and exit on aggregate TFP growth in Korea is very large. It is as large as 10.5 percent (2.1 percent per annum) during the 1990-95 period, accounting for more than 40 percent of manufacturing average TFP growth during the same period. The effect of entry and exit also falls in the 1995-98 cyclical downturn to about 3.1 percent (1.0 percent per annum). The diminished effect of entry and exit during this period suggests that the productivity improvements of the entrants also slowed down together with the overall productivity slowdown. However, in percentage terms, the effect of entry and exit rises during the 1995-98 downturn. It accounts for more than 65 percent of the manufacturing aggregate TFP growth. Thus, entry and exit plays a greater role in aggregate productivity growth in cyclical downturns.

Again, this cyclical pattern is consistent with the results for U.S. manufacturing by FHK. After performing various sensitivity analyses, they report that while the contribution of net entry is sensitive to time period, the pattern is regular in the sense that the contribution of net entry is greater in cyclical downturns. In addition, they also report that the contribution of net entry is robust to the alternative measurement method. This suggests that the large role of entry and exit and its greater role in downturns found in this paper are not likely to result from the use of a particular decomposition methodology.

The contribution of market share reallocation among the continuing plants also varies over the periods. During the 1990-95 period, this share effect is negative even though it is small in magnitude. However, during the 1995-98 downturn period, the share effect turns positive at 1.8 percent. In terms of percentage contribution, it accounts for about 38 percent of manufacturing TFP growth during that period. It helps offset the productivity decline of the continuing plants between 1995 and 1998. The greater contribution of reallocation among continuing plants during the period of cyclical

downturn accords well again with the results for the U.S. manufacturing sector as reported by BHC and FHK.

Taken together, the above discussions suggest that the role of resource reallocation in aggregate productivity growth, by entry and exit or by market share reallocation among continuing plants, tends to be greater during cyclical downturns. During the 1995-98 period, the entry and exit and share effect together explains virtually all of the aggregate TFP growth. In the case of Korean manufacturing, the role of entry and exit seems to be particularly large. Even though the entry and exit effect is smaller and the share effect is larger during the 1995-98 period compared with the previous five-year period, the former effect is still greater than the latter.

While the cyclical pattern of each component of aggregate TFP growth in Korean manufacturing is quite similar to the U.S., the relative importance of each component seems very different between the two countries, controlling for the cyclical factors. <Table 19> compares the decomposition results of this study with two of the studies for the U.S., Baily, Hulten, and Campbell (1992) and Foster, Haltiwanger, and Krizan (1998), which are reasonably comparable to this study in terms of methodology and data. The second column of <table 19> shows that the relative contribution of the within effect for Korea is quite similar to that of the U.S. (by FHK) in both business upturn and downturn. The within effect by BHC seems to be greater than this study in absolute terms, indicating that it is cyclically more volatile than ours.

However, the relative contribution of the entry and exit effect in the Korean manufacturing is larger than the U.S., regardless of the business condition. In the Korean manufacturing sector, the entry and exit effect accounts for about 45 and 65 percent in cyclical upturn and downturn, respectively. In the case of the U.S., the entry and exit effects from both studies are at best below 40 percent even in the cyclical downturn when the effect tends to get stronger.¹² The larger role of entry and exit in Korean

¹² The two studies differ in their assessment of the importance of entry and exit effect. Baily, Hulten, and Campbell (1992) conclude that, even though there is an apparent cyclical pattern, the net effect of entry and exit is not great because the relative productivities of the entrants are not much different from the relative productivities of the exits. By contrast, Foster, Haltiwanger, and Krizan (1998) conclude that the contribution from the replacement of less productive exiting

manufacturing seem to reflect not only a fast overall productivity shift and high rate of plant turnover but also a strong learning effect as documented in this paper.

By contrast, the relative contribution of the share effect in Korea is smaller than in the U.S., although there is also a cyclical pattern. Even in the 1995-98 downturn period when the share effect tends to get larger, the share effect, 0.38, is much smaller than corresponding figures for the U.S., where it accounts for most of the manufacturing productivity growth. However, the relative minor role of the share effect is frequently reported by studies on developing countries, such as Taiwan, Israel, and Chile and Colombia.¹³

To summarize, the cyclical patterns of the contributions from within, entry and exit, and share effect in Korean manufacturing mirror those found for U.S. manufacturing. However, in terms of relative importance of each component, the results for Korea differ from the U.S. Among others, entry and exit plays an important role in aggregate productivity growth in Korea while, in the U.S., its role is more modest. On the contrary, the aggregate productivity growth attributable to market share reallocation is smaller in Korea than in the U.S., where much of the productivity growth coming from efficient plants gets bigger. However, the relatively minor role of the share effect is not unique to Korean manufacturing but frequently reported for developing countries as well.

5. Summary and Concluding Remarks

In this study, we examined the micro-dynamics of entry, exit, and productivity growth using plant-level data on the Korean manufacturing sector. In order to do this, we documented the patterns of plant entry and exit, examined the relation between plant productivity and turnovers, and assessed the contribution from plant turnovers or resource reallocation among producers to the aggregate productivity change. The following summarizes the main findings of this study.

plants with more productive entering plants over a five or ten year horizon is large, not only due to the overall productivity change but also due to selection and learning effect.

First, there is a large amount of resource reallocation going on in Korean manufacturing through plant births, deaths, switch-ins and switch-outs. Plants born during the past five-year period account for between 21.5 and 26.2 percent of manufacturing output. A roughly similar portion is attributable to the plants that will die within five years. They account for a much larger fraction of the total number of manufacturing plants, indicating that those plants are usually small ones. Switch-ins and switch-outs are almost as important as births and deaths, respectively, in terms of output contribution. Those plants are, on average, bigger in size than births and deaths. Cross-country comparison of plant birth rate indicates that the turnover rate in Korean manufacturing is higher than in the U.S. and several developing countries for which comparable studies exist. However, the importance of entry by birth in Korea is not as pronounced as in Taiwan.

Second, examination of the data on Korean manufacturing reveals that plant turnovers reflect systematic differences in underlying productivity as found in many other countries. Deaths are, on average, less productive than continuing plants, consistent with the prediction by models of plant or firm dynamics that market selection forces sort out low-productivity plants from high-productivity plants. Births are less productive than not only continuing plants but also deaths in the first year they are observed. However, the productivity levels of switch-ins and switch-outs are higher than births or deaths and comparable to continuing plants.

The post-entry performance of births shows the presence of both market selection and learning process. Births are a heterogeneous group themselves, among which low productivity plants die over time. Surviving members of births experience rapid productivity improvement or learning, especially during the first several years after entry, and catch up with continuing plants in terms of productivity level in approximately three years.

Meanwhile, deaths are less productive than continuing plants not just at the time of death but also for a certain period before death. In other words, plant deaths, on

¹³ See Aw, Chen, and Roberts (1997), Griliches and Regev (1995), Liu and Tybout (1996) for results on Taiwan, Israel, and Chile and Colombia, respectively.

average, reflect not just temporary misfortune but persistent productivity disadvantage, which seems to indicate the existence of plant-specific effects on plant productivity.

In order to examine whether the persistent productivity differential between deaths and survivors arises from the age differential, i.e., younger plants are less productive and die more frequently than older plants, we also examined the pre-death performance of plants in the same birth-year cohort. As expected, the persistence of productivity differential between survivors and deaths within the same birth-year cohort was somewhat weaker. Especially in the early years of the beginning of operation, there was not a noticeable productivity differential between survivors and deaths within births. However, as surviving members of births improve their productivity at a fast pace, the productivity gap begins to develop and persists over time.

Recognizing the possibility that the analysis based on the average productivity differential might mask the diversity that exists within the same plant categories, we also utilized the transition matrices. Similar to the results reported by Baily, Hulten, and Campbell (1992) for the U.S., the persistence of productivity was noticeable, especially in the top of the productivity distribution. In addition, while the plants in low productivity quintiles were more likely to die within five years, there were many high productivity deaths that are small in size. Likewise, the diversity in productivity was present for other plant groups.

Comparison of transition matrices between Korea and the U.S., however, revealed not only similarities but also differences. First, the degree of persistency was somewhat weaker in Korea than in the U.S. This might be partly due to the fact that there is a higher percentage of young plants that show weaker persistency in productivity in Korea, as has already been documented. Second, the fractions of entries and exits are much larger in Korea than in the U.S. Even though the sources of cross-country variation of the turnover rate are not well understood yet, this might be related, for example, to factors such as differences in the growth rate and the pace of structural change of the economy and the development of financial market. Third, the time it takes for surviving entrants as a group to become as productive as continuing plants seems to be somewhat shorter in Korea. This might be related to both high frequency of death by

unproductive plants and fast learning in Korea.

Finally, we decomposed the productivity growth in manufacturing into the within effect, the entry and exit effect, and the share effect for the periods of 1990-95 and 1995-98. It was found that the cyclical patterns of the contribution from each component in Korea are very similar to those found for the U.S. That is, the resource reallocation effect, i.e., the entry and exit effect and the share effect, plays a larger role during cyclical downturns. During the 1995-98 period, for example, the combined effect of entry and exit and market share reallocation more than explains away the aggregate productivity growth in manufacturing.

However, in terms of relative importance of each component, the results for Korea differ from the U.S. Among others, entry and exit plays an important role in aggregate productivity growth in Korea while, in the U.S., its role is more modest. This seems to reflect not only fast overall productivity shift and high rate of plant turnover but also the strong learning effect in Korea as documented in this paper. By contrast, market share reallocation plays a relatively minor role in Korea. This finding, however, is not unique to Korean manufacturing but is in line with other studies on several developing countries.

Taken together, the evidence presented in this study confirms that the entry and exit of plants has been an important source of productivity growth in Korean manufacturing. Plant birth and death is mainly a process of resource reallocation from plants with relatively low and declining productivity to a group of heterogeneous plants, some of which have the potential to become highly efficient in future. Thus, much of the benefit from the resource reallocation by entry and exit on aggregate productivity growth will be realized over time even though the instantaneous gain might be small.

The most obvious lesson from this study is that it is important to establish a policy or institutional environment where efficient businesses can succeed and inefficient businesses fail. In other words, policies that hinder the processes of entry and exit of businesses are likely to be inefficient. Considering the persistently low and declining productivity of deaths and the rapid learning opportunities of births as documented in this paper, the cost of such policies is likely to be very large.

This point would be particularly relevant these days for Korea, which is going through a process of large-scale corporate sector restructuring. Maintaining exit barriers for firms simply because they are large is highly likely to make matters worse. The evidence of this study suggests that, even though the cost of such policies might not be evident momentarily, it will show up and grow over time in the form of foregone aggregate efficiency gain. Of course, removing all entry and exit barriers *per se* is not likely to guarantee that the outcome is efficient when there are market imperfections for a variety of reasons.¹⁴ However, the existence of market failures or poor institutions would not justify the barriers to entry and exit, especially if the creative destruction process is an inescapable and essential element of improving aggregate productive efficiency.

¹⁴ Market imperfections can arise for the following reasons, as discussed in Haltiwanger (2000). First, there might be externalities involved in innovation activity. In creative destruction models such as Aghion and Howitt (1992) and Grossman and Helpman (1991), agents do not internalize the impact of their decisions on others so that the resulting pace of creative destruction and, hence, the rate of aggregate growth may not be optimal. Second, Caballero and Hammour (1996) emphasize that the specific investments that firms and workers make combined with contracting difficulties in the formation of production units can disrupt the timing and volatility of creative destruction and hamper the pace of renovation in the economy. Third, and related to the second, markets may be incomplete due to a missing insurance and contingent claim market, as Haltiwanger (2000) points out. He argues further that the inability of losers in the reallocation process to insure against idiosyncratic risks can be a source of distortion. That is, barriers to the reallocation process can emerge through a variety of interventions in product, labor, trade, and credit markets that are rationalized in terms of protecting against the potential losses to those that would be adversely affected in the reallocation process.

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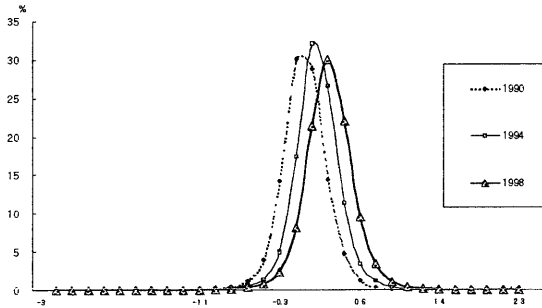
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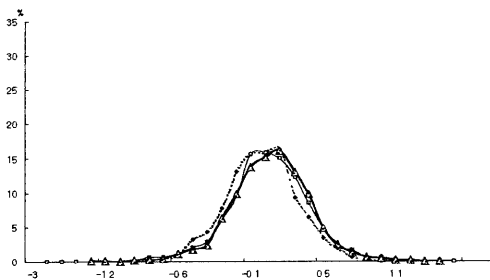
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<Figure 1> Plant Productivity Distribution and its Changes over Time

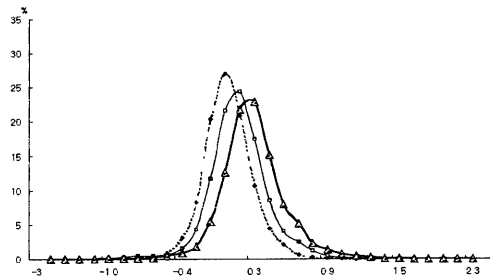
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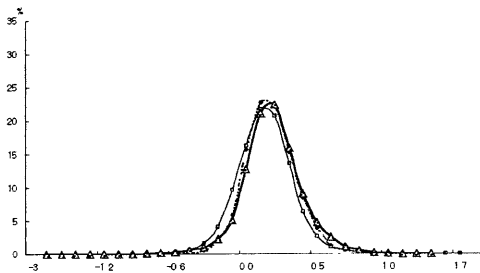
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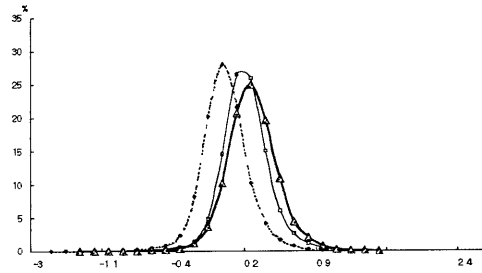
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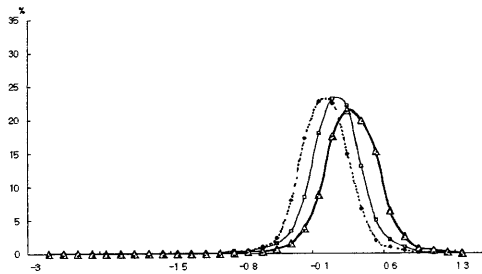
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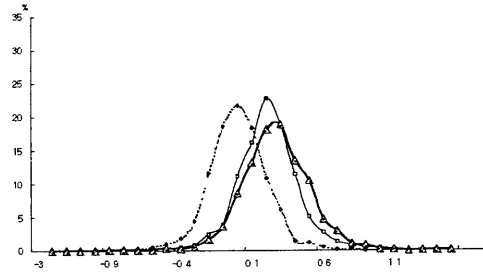
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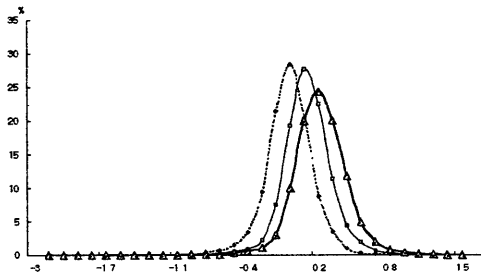
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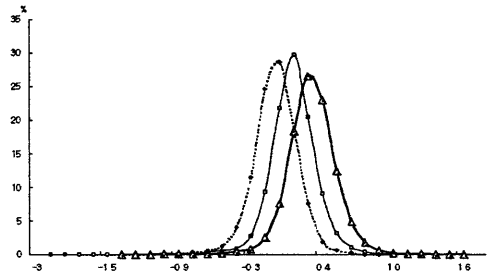
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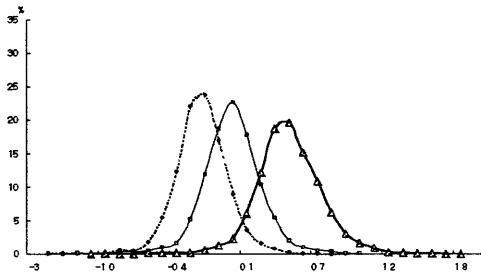
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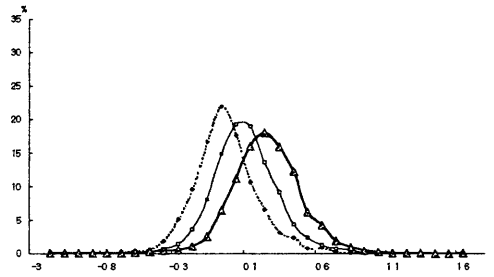
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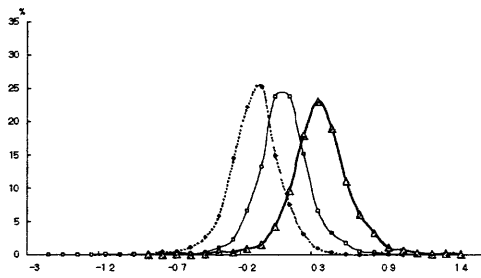
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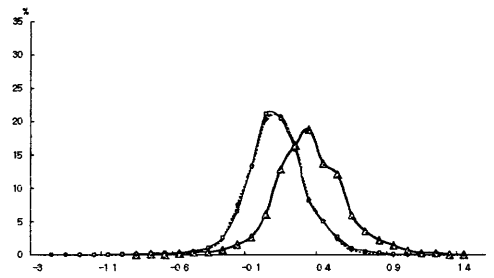
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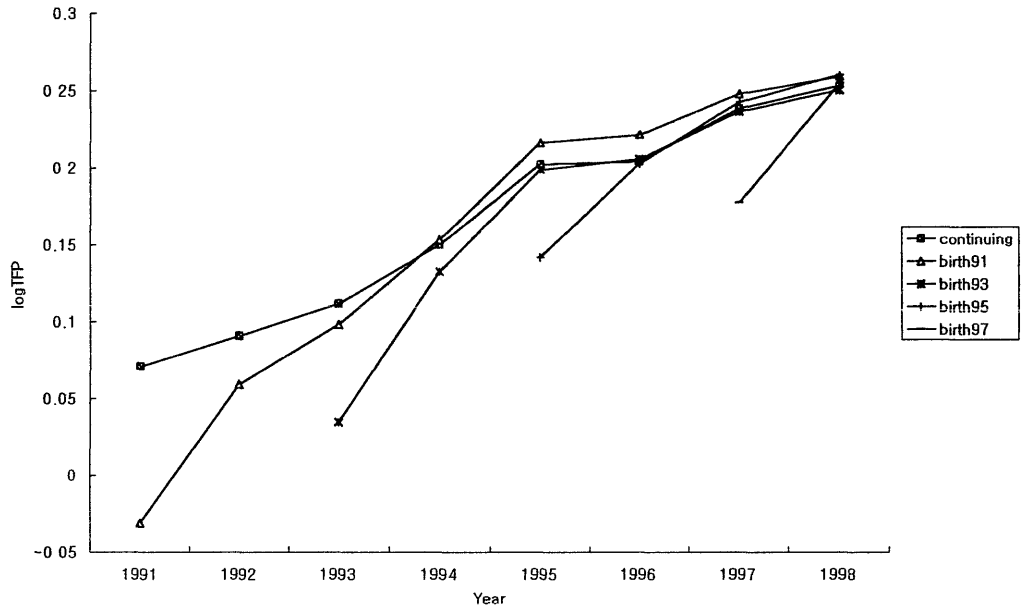
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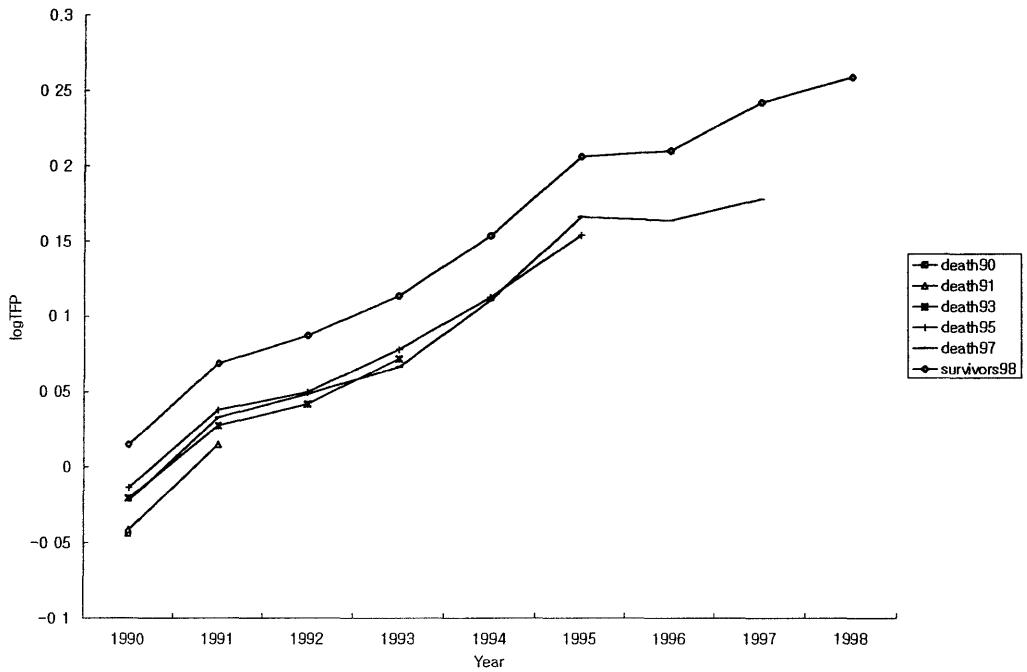
Others



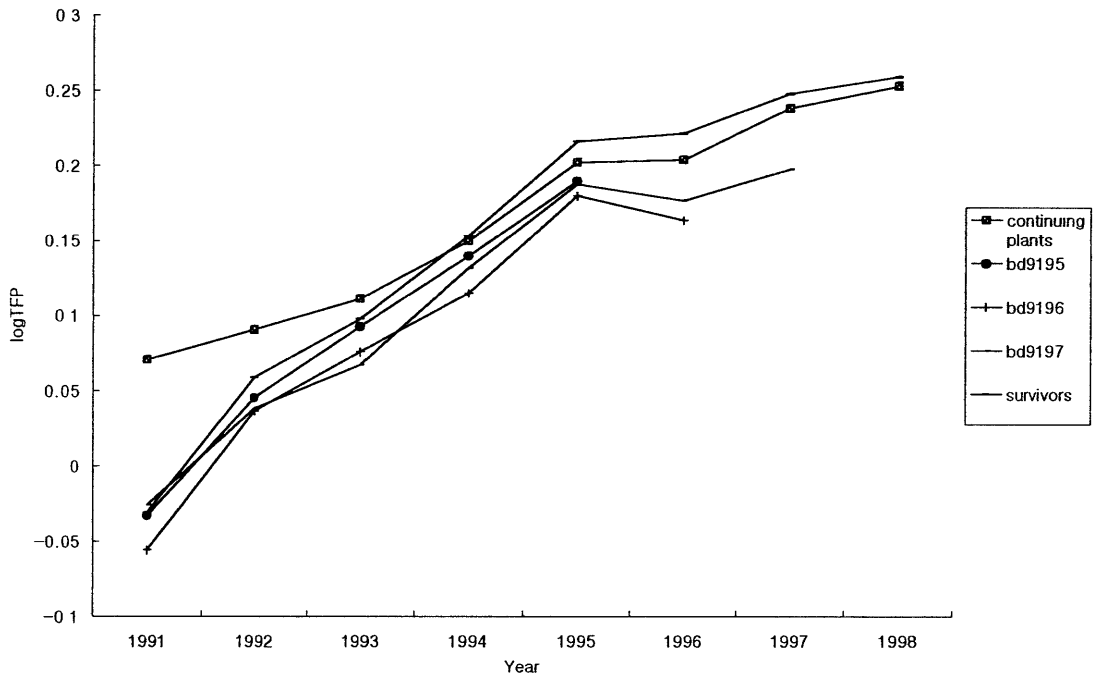
<Figure 2> Post-entry Productivity Performance of Surviving Births



<Figure 3> Pre-Exit Productivity Performance of Deaths



<Figure 4> Pre-exit Productivity Performance of Deaths among 1991 Births



<Table 1> Contribution of Plant Births

(Unit: %)

Year	Under 5 years						Over 5 years	
	1-3		4-5		Total		Number of plants	Current Output
	Number of plants	Current Output	Number of plants	Current Output	Number of plants	Current Output		
1995	53.32	17.13	14.22	9.09	67.54	26.22	32.46	73.78
1996	47.60	15.36	18.68	11.11	66.29	26.46	33.71	73.54
1997	45.40	14.77	18.67	10.63	64.08	25.40	35.92	74.60
1998	39.45	12.77	18.63	8.68	58.08	21.45	41.92	78.55

<Table 2> Contribution of Plant Deaths

(Unit: %)

Year	Within 5 years						Survive more than 5 years	
	1-3		4-5		Total		Number of plants	Current Output
	Number of plants	Current Output	Number of plants	Current Output	Number of plants	Current Output		
1990	36.85	13.36	15.71	6.48	52.57	19.85	47.43	80.15
1991	37.41	14.52	17.11	7.62	54.52	22.14	45.48	77.86
1992	39.28	15.08	16.72	7.77	56.00	22.85	44.00	77.15
1993	43.71	14.92	20.23	9.13	63.93	24.05	36.07	75.95

<Table 3> Contribution of Exits within Births

(Unit: %)

Year	Within 5 years						Survive more than 5 years	
	1-3		4-5		Total		Number of plants	Current Output
	Number of plants	Current Output	Number of plants	Current Output	Number of plants	Current Output		
1991	47.41	40.15	16.84	13.51	64.25	53.65	35.75	46.35
1992	46.38	36.03	17.10	12.20	63.49	48.23	36.51	51.77
1993	55.90	38.58	20.06	12.75	75.96	51.33	24.04	48.67

<Table 4> Contribution of Switch-Ins

(Unit: %)

Year	Within 5 years						Before 5 years	
	1-3		4-5		Total		Number of plants	Current Output
	Number of plants	Current Output	Number of plants	Current Output	Number of plants	Current Output		
1995	13.09	12.61	5.16	5.72	18.25	18.33	-	-
1996	13.92	11.57	4.47	7.30	18.39	18.88	2.44	3.28
1997	15.32	15.60	4.47	7.29	19.78	22.89	3.44	4.62

<Table 5> Contribution of Switch-outs

(Unit: %)

Year	Within 5 years						After 5 years	
	1-3		4-5		Total		Number of plants	Current Output
	Number of plants	Current Output	Number of plants	Current Output	Number of plants	Current Output		
1991	14.29	12.36	3.80	3.92	18.09	16.28	2.61	4.60
1992	14.82	10.90	3.46	5.24	18.29	16.14	2.20	1.60
1993	13.08	8.79	4.47	5.68	17.55	14.47	-	-

<Table 6> Distribution of Plant Productivity by Industry

	1990	1994	1998
Total	43,259	72,286	62,462
25 th percentile	-0.153	-0.017	0.099
Median	-0.018	0.117	0.245
75 th percentile	0.122	0.254	0.399
Food and beverages	1,929	3,359	3,303
25 th percentile	-0.170	-0.111	-0.103
Median	0.012	0.065	0.085
75 th percentile	0.190	0.258	0.274
Textiles and apparel	4,470	8,548	6,840
25 th percentile	-0.112	-0.029	0.083
Median	0.012	0.108	0.226
75 th percentile	0.143	0.252	0.384
Wood and pulp	5,622	8,857	7,147
25 th percentile	0.005	0.069	0.022
Median	0.126	0.203	0.146
75 th percentile	0.258	0.335	0.286
Chemical products	6,090	7,958	7,835
25 th percentile	-0.150	0.049	0.097
Median	-0.019	0.175	0.236
75 th percentile	0.109	0.308	0.390
Non-metallic mineral products	2,066	3,965	3,036
25 th percentile	-0.170	-0.057	0.077
Median	-0.022	0.090	0.233
75 th percentile	0.131	0.237	0.406
Basic metals	1,761	1,868	1,878
25 th percentile	-0.120	0.094	0.137
Median	0.003	0.217	0.270
75 th percentile	0.132	0.341	0.420
Fabricated metal products	4,234	8,490	7,604
25 th percentile	-0.188	-0.026	0.073
Median	-0.065	0.096	0.211
75 th percentile	0.058	0.221	0.357
Machinery and equipment	10,078	15,623	14,520
25 th percentile	-0.167	-0.001	0.157
Median	-0.046	0.117	0.284
75 th percentile	0.075	0.233	0.416
Communications equipment	1,555	3,243	2,742
25 th percentile	-0.347	-0.116	0.309
Median	-0.228	0.015	0.452
75 th percentile	-0.097	0.149	0.618
Medical and precision instruments	634	1,375	1,710
25 th percentile	-0.142	-0.035	0.098
Median	-0.042	0.091	0.233
75 th percentile	0.090	0.227	0.380
Transport equipment	2,593	3,450	3,319
25 th percentile	-0.246	-0.034	-0.223
Median	-0.128	0.076	0.343
75 th percentile	-0.023	0.190	0.472
Others	2,227	5,523	2,528
25 th percentile	-0.083	-0.078	0.125
Median	0.043	0.040	0.265
75 th percentile	0.173	0.171	0.437

Note: The figures in the first rows for each industry denote the number of plants.

<Table 7> Average Productivity of Plant Groups, 1990-1998

	Continuing	Entry		Exit		Total
		Births	Switch-ins	Deaths	Switch-outs	
1990	-0.005			-0.044	-0.026	-0.016
1991	0.046	-0.031	0.041	-0.003	0.050	0.026
1992	0.061	-0.005	0.061	0.018	0.068	0.046
1993	0.087	0.030	0.096	0.051	0.101	0.072
1994	0.132	0.056	0.141	0.101	0.144	0.118
1995	0.190	0.132	0.199	0.150	0.202	0.174
1996	0.197	0.143	0.208	0.160	0.214	0.185
1997	0.239	0.177	0.252	0.182	0.245	0.218
1998	0.256	0.200	0.267			0.249

Note: Unweighted averages.

<Table 8> Relative Productivity of Plant Groups by Industry

	Birth (α)	Switch- in(β)	Death (γ)	Switch- out(δ)	F-Statistics		
					$\alpha=\gamma$	$\alpha=\beta$	$\gamma=\delta$
All	-0.063 (0.001)	0.007 (0.001)	-0.042 (0.001)	0.006 (0.001)	325.1	2598.1	1599. 2
Food and beverages	-0.127 (0.007)	-0.009 (0.008)	-0.098 (0.007)	-0.019 (0.007)	10.8	140.7	75.5
Textile and apparel	-0.075 (0.003)	0.019 (0.004)	-0.026 (0.003)	0.015 (0.004)	154.3	404.3	100.2
Wood and pulp	-0.052 (0.003)	-0.001 (0.003)	-0.040 (0.002)	-0.006 (0.003)	15.8	183.5	114.0
Chemical products	-0.086 (0.003)	-0.016 (0.003)	-0.067 (0.003)	-0.021 (0.003)	28.4	349.9	202.9
Non-metallic mineral products	-0.088 (0.005)	0.055 (0.007)	-0.083 (0.004)	0.035 (0.007)	0.8	321.5	258.5
Basic metals	-0.084 (0.006)	-0.003 (0.006)	-0.052 (0.005)	-0.014 (0.005)	21.8	129.0	39.7
Fabricated metal products	-0.056 (0.003)	0.008 (0.003)	-0.034 (0.002)	0.015 (0.003)	55.4	338.8	249.6
Machinery and equipment	-0.050 (0.002)	-0.003 (0.002)	-0.031 (0.002)	-0.001 (0.002)	87.5	387.0	211.3
Communications equipment	-0.088 (0.005)	-0.018 (0.006)	-0.060 (0.005)	-0.010 (0.005)	22.5	105.8	74.5
Medical and precision instruments	-0.029 (0.006)	0.019 (0.007)	-0.024 (0.006)	0.023 (0.007)	0.5	32.1	34.7
Transport equipment	-0.071 (0.004)	-0.008 (0.005)	-0.044 (0.004)	0.006 (0.004)	37.2	144.1	123.7
Others	-0.042 (0.004)	0.005 (0.006)	-0.035 (0.003)	0.010 (0.005)	2.4	54.1	69.0

Note: Numbers in parentheses are standard errors.

<Table 9> Market Selection among Birth Cohorts

	Births 1991	Births 1993	Births 1995
Deaths 1992	-0.065 (0.005)		
Deaths 1993	-0.044 (0.004)		
Deaths 1994	-0.036 (0.004)	-0.042 (0.003)	
Deaths 1995	-0.032 (0.004)	-0.032 (0.003)	
Deaths 1996	-0.048 (0.004)	-0.030 (0.003)	-0.053 (0.003)
Deaths 1997	-0.038 (0.003)	-0.044 (0.002)	-0.039 (0.002)

Note: Numbers in parentheses are standard errors.

<Table 10> Productivity Performance of Surviving Births Relative to Continuing Plants

	1991	1992	1993	1994	1995	1996	1997	1998
Continuing Plants	0.071	0.091	0.111	0.150	0.202	0.204	0.238	0.253
Births 1991	-0.031	0.059	0.098	0.153	0.216	0.221	0.248	0.259
Births 1992		0.006	0.090	0.150	0.219	0.219	0.246	0.263
Births 1993			0.034	0.132	0.199	0.206	0.236	0.250
Births 1994				0.057	0.190	0.209	0.247	0.261
Births 1995					0.142	0.203	0.242	0.260
Births 1996						0.149	0.241	0.270
Births 1997							0.177	0.255
Births 1998								0.200

<Table 11> Productivity Performance of Surviving Births by Industry

	Births 1991							
	1991	1992	1993	1994	1995	1996	1997	1998
Food and beverages	-0.238 (0.037)	-0.122 (0.036)	-0.138 (0.038)	-0.088 (0.038)	-0.116 (0.042)	-0.036 (0.040)	-0.103 (0.036)	-0.119 (0.035)
Textile and apparel	-0.136 (0.023)	0.009 (0.023)	0.019 (0.023)	0.005 (0.022)	0.037 (0.022)	0.038 (0.022)	0.021 (0.023)	0.013 (0.022)
Wood and pulp	-0.091 (0.019)	-0.045 (0.019)	-0.016 (0.019)	0.015 (0.019)	0.002 (0.019)	-0.003 (0.019)	-0.004 (0.019)	-0.014 (0.019)
Chemical products	-0.168 (0.024)	-0.097 (0.024)	-0.051 (0.024)	-0.030 (0.024)	-0.005 (0.024)	-0.039 (0.024)	-0.025 (0.024)	-0.026 (0.023)
Non-metallic mineral products	-0.095 (0.020)	0.036 (0.020)	0.041 (0.020)	0.063 (0.020)	0.065 (0.020)	0.048 (0.020)	0.062 (0.020)	0.08 (0.02)
Basic metals	-0.161 (0.041)	0.014 (0.044)	0.018 (0.044)	0.040 (0.043)	0.059 (0.044)	0.037 (0.044)	0.053 (0.043)	0.071 (0.043)
Fabricated metal products	-0.034 (0.022)	0.011 (0.022)	0.013 (0.022)	0.009 (0.023)	0.034 (0.023)	0.054 (0.023)	0.021 (0.023)	0.018 (0.022)
Machinery and equipment	-0.062 (0.015)	-0.016 (0.015)	-0.007 (0.015)	0.010 (0.015)	0.023 (0.015)	0.037 (0.015)	0.032 (0.015)	0.021 (0.014)
Communications equipment	-0.105 (0.041)	-0.083 (0.037)	-0.065 (0.040)	-0.085 (0.031)	-0.024 (0.036)	-0.037 (0.029)	-0.045 (0.029)	-0.060 (0.029)
Medical and precision instruments	-0.034 (0.042)	-0.043 (0.043)	-0.021 (0.042)	0.038 (0.048)	-0.012 (0.040)	0.013 (0.050)	0.010 (0.039)	0.011 (0.038)
Transport equipment	-0.016 (0.027)	-0.053 (0.029)	-0.014 (0.032)	-0.009 (0.028)	0.004 (0.032)	-0.004 (0.029)	0.004 (0.030)	-0.011 (0.029)
Others	-0.033 (0.031)	-0.006 (0.031)	-0.003 (0.031)	0.045 (0.023)	0.060 (0.025)	0.045 (0.024)	0.009 (0.031)	-0.014 (0.028)

Note: Numbers in parentheses are standard errors.

<Table 12> Pre-Exit Productivity Performance of Deaths relative to Survivors

	1990	1991	1992	1993	1994	1995	1996	1997	1998
Deaths 1990	-0.044								
Deaths 1991	-0.042	0.015							
Deaths 1992	-0.033	0.022	0.027						
Deaths 1993	-0.021	0.027	0.041	0.072					
Deaths 1994	-0.027	0.032	0.048	0.079	0.107				
Deaths 1995	-0.014	0.038	0.049	0.078	0.112	0.154			
Deaths 1996	-0.021	0.034	0.046	0.072	0.117	0.164	0.156		
Deaths 1997	-0.022	0.033	0.048	0.066	0.110	0.166	0.163	0.177	
Survivors until 1998	0.015	0.068	0.087	0.113	0.153	0.206	0.209	0.242	0.258

<Table 13> Pre-Exit Productivity Performance of Deaths relative to Survivors by Industry

	Year							
	1990	1991	1992	1993	1994	1995	1996	1997
Food and beverages	-0.153 (0.039)	-0.161 (0.038)	-0.118 (0.031)	-0.105 (0.037)	-0.120 (0.032)	-0.124 (0.041)	-0.118 (0.039)	-0.209 (0.035)
Textile and apparel	0.007 (0.021)	-0.015 (0.018)	-0.014 (0.018)	-0.029 (0.017)	-0.017 (0.017)	0.001 (0.017)	0.002 (0.017)	-0.053 (0.018)
Wood and pulp	-0.015 (0.016)	-0.014 (0.016)	-0.033 (0.016)	-0.079 (0.016)	-0.053 (0.016)	-0.040 (0.015)	-0.033 (0.016)	-0.066 (0.015)
Chemical products	-0.099 (0.024)	-0.080 (0.025)	-0.090 (0.026)	-0.099 (0.025)	-0.087 (0.025)	-0.070 (0.025)	-0.077 (0.025)	-0.099 (0.024)
Non-metallic mineral products	-0.067 (0.025)	-0.039 (0.020)	-0.080 (0.020)	-0.066 (0.020)	-0.055 (0.020)	-0.054 (0.020)	-0.075 (0.020)	-0.086 (0.019)
Basic metals	-0.082 (0.036)	-0.145 (0.037)	-0.107 (0.037)	-0.110 (0.037)	-0.077 (0.037)	-0.061 (0.037)	-0.065 (0.037)	-0.073 (0.036)
Fabricated metal products	-0.065 (0.020)	-0.066 (0.020)	-0.049 (0.020)	-0.030 (0.021)	-0.022 (0.021)	-0.023 (0.021)	-0.022 (0.020)	-0.029 (0.019)
Machinery and equipment	-0.031 (0.014)	0.006 (0.15)	-0.017 (0.015)	-0.001 (0.015)	-0.023 (0.015)	-0.034 (0.015)	-0.035 (0.015)	-0.025 (0.014)
Communications equipment	-0.048 (0.041)	-0.070 (0.042)	-0.032 (0.041)	-0.052 (0.044)	-0.059 (0.031)	-0.092 (0.041)	-0.085 (0.030)	-0.094 (0.030)
Medical and precision instruments	-0.049 (0.068)	-0.064 (0.048)	-0.082 (0.058)	-0.041 (0.053)	-0.056 (0.055)	-0.073 (0.046)	-0.055 (0.053)	-0.045 (0.045)
Transport equipment	-0.075 (0.026)	-0.102 (0.028)	-0.110 (0.028)	-0.112 (0.029)	-0.076 (0.028)	-0.068 (0.028)	-0.055 (0.028)	-0.088 (0.028)
Others	-0.019 (0.027)	-0.041 (0.027)	-0.073 (0.028)	-0.048 (0.029)	-0.030 (0.019)	-0.023 (0.019)	-0.030 (0.020)	-0.069 (0.027)

Note: Numbers in parentheses are standard errors.

<Table 14> 1993 Productivity Differential between Deaths and Survivors

	Continuing plants that survived (α)	Births that died (β_1)	Births that survived (β_2)	Switch-ins that died (γ_1)	Switch-ins that survived (γ_2)
All	0.038	-0.039	-0.033	0.017	0.040
Food and beverages	0.080	-0.115	-0.039	0.091	0.026
Textile and apparel	0.025	-0.058	-0.044	0.020	0.041
Wood and pulp	0.037	-0.001	0.004	0.048	0.071
Chemical products	0.060	-0.070	-0.030	-0.028	0.022
Non-metallic mineral products	0.088	-0.053	-0.061	-0.025	0.133
Basic metals	0.053	-0.071	-0.055	0.031	-0.006
Fabricated metal products	0.027	-0.033	-0.032	0.020	0.035
Machinery and equipment	0.005	-0.055	-0.048	-0.007	0.004
Communications equipment	0.057	-0.074	-0.081	-0.024	0.066
Medical and precision instruments	0.048	0.000	0.031	0.034	0.074
Transport equipment	0.037	-0.042	-0.043	0.008	0.040
Others	-0.007	-0.035	-0.038	0.005	-0.020
Test results of productivity difference					
	($\alpha > 0$)	($\beta_1 = \beta_2$)	($\gamma_1 = \gamma_2$)		
All	13.1	1.8	14.5		
Food and beverages	4.9	6.7	1.8		
Textile and apparel	3.0	0.8	1.1		
Wood and pulp	4.5	0.2	1.7		
Chemical products	7.2	9.6	10.0		
Non-metallic mineral products	8.7	0.1	14.3		
Basic metals	3.2	0.4	1.4		
Fabricated metal products	3.2	0.0	0.9		
Machinery and equipment	0.8	0.8	1.2		
Communications equipment	3.3	0.1	6.6		
Medical and precision instruments	2.7	1.6	1.2		
Transport equipment	3.3	0.0	1.5		
Others	-0.5	0.0	0.6		

Note: The first column in the lower panel shows t-statistics and the second and the third columns show F-statistics.

**<Table 15> 1994 Productivity Differential between Deaths and Survivors among
1991 Births**

	1991 Births that died before 1998	1991 Births that survived until 1998
All	0.126 (0.004)	0.027 (0.006)
Food and beverages	0.070 (0.033)	0.016 (0.042)
Textile and apparel	0.160 (0.012)	-0.022 (0.018)
Wood and pulp	0.199 (0.010)	0.036 (0.016)
Chemical products	0.174 (0.013)	0.037 (0.018)
Non-metallic mineral products	0.080 (0.015)	0.084 (0.021)
Basic metals	0.212 (0.025)	0.048 (0.035)
Fabricated metal products	0.112 (0.011)	0.034 (0.017)
Machinery and equipment	0.133 (0.008)	-0.001 (0.012)
Communications equipment	0.005 (0.015)	0.033 (0.024)
Medical and precision instruments	0.105 (0.028)	0.027 (0.040)
Transport equipment	0.103 (0.014)	0.042 (0.020)
Others	0.057 (0.011)	0.037 (0.019)

Note: Numbers in parentheses are standard errors.

**<Table 16> Five-year Transition Matrix of Relative Productivity Rankings:
weighted by employment**

(Unit: %)

	Top 20	20-40	40-60	60-80	80-100	Switch- outs during 1990-95	Deaths during 1990-95
Top 20	28.53	13.42	5.98	1.96	1.06	26.45	22.61
20-40	16.74	16.59	10.23	5.23	1.68	23.20	26.33
40-60	12.09	16.65	7.66	6.16	3.91	20.26	33.26
60-80	4.49	5.95	5.91	6.57	4.74	30.04	42.31
80-100	3.06	4.09	12.68	5.40	6.02	25.27	43.48
Switch-ins during 1990-95	28.28	24.52	19.81	16.64	1074	0.00	0.00
Birth and Alive During 1990-95	25.63	22.09	18.90	16.91	16.47	0.00	0.00

**<Table 17> Five-year Transition Matrix of Relative Productivity Rankings:
number of plants**

(Unit: %)

	Top 20	20-40	40-60	60-80	80-100	Switch- outs during 1990-95	Deaths during 1990-95
Top 20	11.55	7.16	5.06	3.05	1.84	25.35	45.98
20-40	6.73	6.96	6.61	4.65	2.68	25.32	47.05
40-60	4.43	5.64	6.17	5.74	3.75	24.10	50.17
60-80	3.15	4.18	4.71	5.74	4.76	24.02	53.44
80-100	2.28	3.17	3.83	4.95	7.04	21.70	57.03
Switch-ins during 1990-95	20.25	21.56	20.51	20.47	17.20	0.00	0.00
Births and survivors during 1990-95	19.84	19.25	19.69	20.06	21.15	0.00	0.00

**<Table 18> Decomposition of Total Factor Productivity Growth in Korean
Manufacturing**

	Total	Within Effect	Entry and Exit	Share Effect
1990-1995	0.230	0.132	0.105	-0.007
	(1.00)	(0.57)	(0.46)	(-0.03)
1995-1998	0.047	-0.001	0.031	0.018
	(1.00)	(-0.02)	(0.65)	(0.38)

Note : Decomposition is based on the methodology by Baily, Hulten, and Campbell (1992).

Numbers in parentheses are the relative contributions.

**<Table 19> Comparison of Productivity Decompositions between Korea and the
U.S.**

Source	Data	Period	MFG Total (%)	Relative Contribution from		
				Within Effect	Entry and Exit	Share Effect
Upturn						
This Study	Korea	1990-95	23.0	0.57	0.46	-0.03
Baily, Hulten, and Cambell (1992)	U.S.	1982-87	15.6	0.87	-0.07	0.20
Foster, Haltiwanger, And Krizan (1998)	U.S.	1982-87	7.3	0.52	0.14	0.33
Downturn						
This Study	Korea	1995-98	4.7	-0.02	0.65	0.38
Baily, Hulten, and Cambell (1992)	U.S.	1977-82	2.4	-0.46	0.40	1.06
Foster, Haltiwanger, And Krizan (1998)	U.S.	1977-82	2.7	-0.09	0.25	0.84

Note: The figures from Foster, Haltiwanger, and Krizan (1998) are those based on methodology modified from Baily, Hulten, and Campbell (1992).

Appendix A. Data and Measurement of Plant Productivity

- **Data**

This study uses the unpublished plant-level data underlying the Annual Report on Mining and Manufacturing Survey (Survey henceforth) during the 1990-98 period. The Survey covers all plants with five or more employees in mining and manufacturing industries and contains information on outputs and inputs that are necessary to calculate plant-level total factor productivity. In this paper, we focused on the manufacturing sector. Plant codes are consistently followed over time so that it is possible to identify which plants first appeared in the data set and which plants disappeared. In addition, the industry code for each plant allows us to identify which plants moved to another industry.

Since the Survey covers only those plants with five or more employees, there may be observations that intermittently appear in the data set within our sample period. Even though the National Statistical Office conducts a census on all plants every five years, it was not possible to incorporate the information on plants with less than five employees into our analysis because they apply an entirely different coding system to those plants. Since most of our results do not change qualitatively on the inclusion or the exclusion of those borderline observations, which account for about 15 percent of the total number of plants, we decided not to discard those observations. The inescapable cost of such a decision is that inaccurate exit and entry statuses might be assigned to those observations around intermittent period, even though we tried to correct for this problem as much as possible.

- **Measurement of Plant Level Productivity**

We estimate plant productivity using the chained-multilateral index number approach as developed in Good (1985) and Good, Nadiri, and Sickles (1996) and employed in Aw, Chen, and Roberts (1997). It uses a separate reference point for each cross-section of observations and then chain-links the reference points together over time as in the Tornqvist-Theil index. The reference point for a given time period is

constructed as a hypothetical plant with input shares that equal the arithmetic mean input shares and input levels that equal the geometric mean of the inputs over all cross-section observations. Thus, the output, inputs, and productivity level of each plant in each year are measured relative to the hypothetical plant at the base time period. This approach allows us to make transitive comparisons of productivity levels among observations in a panel data set.¹⁵

Specifically, the productivity index for plant i at time t in our study is measured in the following way.

$$\ln TFP_{it} = (\ln Y_{it} - \overline{\ln Y_t}) + \sum_{\tau=2}^t (\overline{\ln Y_\tau} - \overline{\ln Y_{\tau-1}}) \\ - \left\{ \sum_{n=1}^N \frac{1}{2} (S_{nt} + \overline{S_{nt}}) (\ln X_{nt} - \overline{\ln X_{nt}}) + \sum_{\tau=2}^t \sum_{n=1}^N \frac{1}{2} (\overline{S_{n\tau}} + \overline{S_{n\tau-1}}) (\overline{\ln X_{n\tau}} - \overline{\ln X_{n\tau-1}}) \right\},$$

where Y , X , S , and TFP denote output, input, input share, and TFP level, respectively, and symbols with an upper bar are corresponding measures for hypothetical firms. The subscripts τ and n are indices for time and inputs, respectively. In our study, the year 1990 is the base time period.

As a measure of output, we used the gross output of each plant in the Survey deflated by the producer price index at a disaggregated level. As a measure of capital stock, we used the average of the beginning and end of the year book value capital stock in the Survey deflated by the capital goods deflator. As a measure of labor input, we

¹⁵ Good, Nadiri, and Sickles (1996) summarize the usefulness of chaining multilateral productivity indices succinctly. While the chaining approach of the Tornqvist-Theil index, the discrete Divisia, is useful in time series applications, where input shares might change over time, it has severe limitations in cross-section or panel data where there is no obvious way of sequencing the observations. To the contrary, the hypothetical firm approach allows us to make transitive comparisons among cross-section data, while it has an undesirable property of sample dependency. The desirable properties of both the chaining approach and the hypothetical firm approach can be incorporated into a single index by a chained-multilateral index number approach.

used the number of workers, which includes paid employees (production and non-production workers), working proprietors and unpaid family workers. Here, we allowed for the quality differential between production workers and all the other type of workers. The labor quality index of the latter was calculated as the ratio of non-production workers' and production workers' average wage of each plant, averaged again over the entire plants in a year. As a measure of intermediate input, we used the "direct production cost" in the Survey. However, the intermediate input to output ratio calculated this way was much lower than corresponding figures in the Input-Output Table due probably to the fact that the direction cost in the Survey does not include much of the purchased services, such as insurance, transportation, communication, and advertising costs. Thus, we adjusted the amount of the intermediate inputs of all plants by the same proportion such that the manufacturing aggregate intermediate input to output ratio becomes equal to the corresponding figure from the Input-Output Table. The estimated intermediate input was again deflated by the intermediate input price index.

We assumed constant returns to scale so that the sum of factor elasticities equals one. Labor and intermediate input elasticities for each plant are measured as average cost shares within the same plant-size class in the five-digit industry in a given year. Thus, factor elasticities of plants are allowed to vary across industries and size classes and over time. Here, plants are grouped into three size classes according to the number of employees(5-50, 51-300, and over 300).

Appendix B. Supplementary Tables

**<Table B-1> Eight-year Transition Matrix of Relative Productivity Rankings:
weighted by employment**

(Unit: %)

	Top 20	20-40	40-60	60-80	80-100	Switch-outs During 1990-98	Deaths During 1990-98
Top 20	15.89	9.95	5.98	2.40	1.02	27.02	37.75
20-40	9.96	12.66	6.70	6.15	1.84	22.49	40.21
40-60	8.54	14.87	4.46	3.99	2.86	16.97	48.31
60-80	3.27	4.48	3.04	4.26	2.91	23.57	58.47
80-100	2.00	8.81	2.69	2.95	3.76	19.74	60.04
Switch-ins during 1990-98	33.57	23.00	20.33	13.85	9.24	0.00	0.00
Births and survivors during 1990-98	25.48	21.98	19.41	18.09	15.03	0.00	0.00

**<Table B-2> Eight-year Transition Matrix of Relative Productivity Rankings:
number of plants**

(Unit: %)

	Top 20	20-40	40-60	60-80	80-100	Switch- outs during 1990-98	Deaths during 1990-98
Top 20	6.41	4.65	3.59	2.27	1.57	17.78	63.73
20-40	4.10	4.43	3.84	3.15	2.21	18.23	64.04
40-60	2.96	3.47	3.36	3.32	2.47	15.90	68.53
60-80	1.95	2.54	2.76	3.18	2.90	15.42	71.24
80-100	1.30	1.78	2.19	2.90	3.78	13.49	74.56
Switch-ins during 1990-98	20.17	21.41	20.93	20.52	16.97	0.00	0.00
Births and survivors during 1990-98	20.20	19.46	19.78	20.01	20.54	0.00	0.00

<Table B-3> Decomposition of Productivity Growth by Industry

	Total	Within Effect	Entry and Exit	Share Effect
Food and beverages				
1990-1995	0.158	0.098	0.043	0.017
1995-1998	-0.054	-0.062	-0.008	0.016
Textile and apparel				
1990-1995	0.160	0.046	0.107	0.008
1995-1998	0.076	0.017	0.010	0.070
Wood and pulp				
1990-1995	0.026	-0.001	0.071	-0.049
1995-1998	-0.012	-0.026	-0.016	0.030
Chemical products				
1990-1995	0.153	0.090	0.087	-0.025
1995-1998	-0.114	-0.145	0.027	0.005
Non-metallic mineral products				
1990-1995	0.260	0.086	0.177	-0.004
1995-1998	0.025	-0.005	-0.025	0.056
Basic metals				
1990-1995	0.222	0.169	0.100	-0.047
1995-1998	0.003	-0.004	-0.023	0.030
Fabricated metal products				
1990-1995	0.245	0.082	0.204	-0.045
1995-1998	0.057	0.006	-0.003	0.055
Machinery and equipment				
1990-1995	0.228	0.090	0.161	-0.024
1995-1998	0.137	0.074	0.086	-0.023
Communications equipment				
1990-1995	0.520	0.328	0.119	0.073
1995-1998	0.178	0.051	0.095	0.032
Medical and precision instruments				
1990-1995	0.258	0.126	0.128	0.005
1995-1998	0.070	0.022	0.030	0.019
Transport equipment				
1990-1995	0.264	0.225	0.053	-0.014
1995-1998	0.183	0.135	0.051	-0.003
Others				
1990-1995	0.141	0.025	0.129	-0.014
1995-1998	0.152	0.038	0.009	0.113