Long-Term Shifts in Korean Manufacturing and Plant-Level Productivity Dynamics

Yoonsoo Lee
Abstract

The Korean manufacturing sector has undergone active structural transformation in the past few decades. In particular, the composition of core manufacturing products has changed over time. In the 1970s, textiles, which are used to produce fabric, clothes, apparel, and shoes, were the main product. Over time, the value added shares have shifted toward electronics, ships, and cars. By analyzing plant-level microdata, this paper documents the patterns of entry, exit, job creation and destruction, and the growth of young plants during the industrial shift. This industrial shift involved active job reallocations, as well as the entry and exit of plants. The paper quantifies the extent to which such plant-level dynamics explain aggregate productivity growth. The findings show that within-plant productivity growth, which includes the effects of fast growth of young plants as well as robust growth of large continuing plants, played an important role in the productivity growth of the Korean manufacturing sector. The contribution of reallocations between continuing plants was relatively small. Moreover, productivity growth of an industry accompanied an increase of productivity dispersion, a measure commonly interpreted as the degree of misallocation.

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1. Introduction

Productivity growth is an important source of long-term economic growth. Cross-country differences in GDP per capita mainly reflect large differences in productivity. The sustained growth of total factor productivity (TFP) is also an important characteristic of the so-called miracle economies. For example, the sustainability of Korean economic growth, which has continued for over half a century, is quite remarkable. However, the standard one-sector neoclassical growth model does not clearly explain the sustained growth of per capita income and productivity (Buera and Shin, 2013).

This paper provides a new perspective on the explanation of Korean economic growth. It starts by examining the role of the long-term shifts of industries in the growth of the Korean manufacturing sector over the past four decades. The structural transformation from agriculture to manufacturing is a well-known phenomenon, one commonly observed in the development process. For example, there has been a secular decline in the share of farm goods in US output and employment. The Republic of Korea also went through a transformation from agriculture to manufacturing over several decades. However, the secular shift of industries within the manufacturing sector is less well known. Figure 1 plots the value-added growth of the 13 two-digit Korea Standard Industrial Classification (KSIC) industries from 1970 to 2017. While most of the

\footnotetext{1}{Cross-country differences in aggregate productivity may be explained by the widespread dispersion of firm performance or differences in allocative efficiency (Hsieh and Klenow, 2009; Bartelsman, Haltiwanger, and Scarpetta, 2013). Recent studies emphasize the role of reallocations (e.g., the entry, exit, and reallocation of resources across sectors and plants) in explaining productivity growth (Bartelsman, Haltiwanger, and Scarpetta, 2013).}

\footnotetext{2}{See, for example, Duarte and Restuccia (2010) for structural transformation and productivity growth.}
industries have expanded over time, not all have grown at a common rate. Noticeable, rapid expansion has occurred in a few industries, including transportation, electronics, and chemicals.

Export-oriented industrialization is a well-known policy that helps explain the successful economic growth of the Korean economy. One important but often overlooked element of this success story is the fact that the composition of core-export products has changed over time. For example, textiles, which are used to produce fabric, clothes, apparel, and shoes, were the main export in the 1970s. Over time, the main exports have shifted toward electronics, ships, and cars. Consequently, the value-added shares of traditional light industries, such as textiles, food, and beverages, have declined substantially, matched by an increase in the shares of electronics and transportation.

As an initial step to analyze the plant-level dynamics underling structural change, we document the patterns of entry, exit, job creation and destruction, and the growth of young plants during the industrial shift. Specifically, we focus on the difference between growing industries, which increased their value-added shares (e.g., electronic and electrical equipment and transportation equipment), and declining industries, which decreased their value-added shares over time (e.g., textiles and leather products). In addition to these three industries, we also examine chemical products, which have steadily grown over time and consistently accounted for about 10% of the value-added shares in manufacturing.

The structural transformation in Korean manufacturing involved the active entry, exit, and growth of surviving plants. We quantify the extent to which such plant-level dynamics explain productivity growth. The differences in aggregate TFP are well known to account for most of the income differences across countries. Recent empirical studies spanning a number of countries have
consistently shown that changes in market shares between firms are important drivers of aggregate productivity. In particular, start-ups and the growth of young firms are known to be crucial in job creation and productivity growth (Haltiwanger, Jarmin, and Miranda, 2013; Foster, Haltiwanger, and Krizan, 2001). However, the role of entry and exit in accounting for aggregate productivity growth varies across countries. For example, Foster, Haltiwanger, and Krizan (2001) find that plant entry and exit account for 25% of US productivity growth. On the other hand, Brandt, Van Biesebroeck, and Zhang (2012) find that entry and exit account for approximately 70% of Chinese productivity growth. Asturias et al. (2017) argue that entry and exit are especially important during periods of rapid aggregate growth. However, since the Great Recession, there has been a growing concern that the recent decline in entry rates (i.e., “start-up deficits”) may affect long-term economic growth.3

Our decomposition results based on Foster, Haltiwanger, and Krizan (2001) and Melitz and Polanec (2015) show that reallocations along with entry and exit helped increase the productivity of the Korean manufacturing sector. However, most of the productivity growth was driven by the efficiency gains among continuing plants. In spite of the very high rates of entry and exit, the contribution of these plants (i.e., net-entry effects) was relatively small. However, the contribution of entrants varied across industries. The fast growth of entrants played an especially

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3 Entry, exit, and plant-level dynamics between growing and declining industries may provide some empirical support for investment dynamics and slow but sustained productivity growth observed in miracle economies. The neoclassical model implies that investment rates jump at the beginning of the “reform” but decrease monotonically back to the long-run value. However, in countries with growth miracles, investment rates responded slowly, building to peak and then falling back over time. The evidence regarding the industrial shift implies that such growth processes, which involve entry and growth of entrepreneurs, may occur over long time horizons, shifting from one industry to another.
important role in the high-growth period of the electronic and electrical equipment industry. Along with the fast growth of young plants, the continuing plants’ productivity growth accounted for most of the productivity growth in Korea.

Although the magnitude varies depending on the choice of decomposition method, the relatively small role of reallocations raises a question regarding the allocative efficiency of Korea’s manufacturing sector. We examine the relationship between productivity growth and productivity dispersion, which is a measure commonly interpreted as a degree of misallocation (Hsieh and Klenow, 2009). A growing number of studies have examined productivity dispersion by focusing on the misallocation and the allocative efficiency (e.g., see Chuah, Loayza, and Nguyen (2018) for Malaysia and studies using the microdata of other countries). Recent research maintains that productivity dispersion may reflect resource misallocation and room for efficiency gains through reforms. By examining the changes of productivity dispersion over time, we find that productivity dispersion did not necessarily decrease when industry-level productivity increased.4 This puzzling finding draws attention to the importance of traditional factors that improve productivity, such as innovation, technology, and research and development.

In Section 2, we document the patterns of industrial shift in the Korean manufacturing sector. In Section 3, we examine the role of entry, exit, and reallocations in industry productivity growth. In Section 4, we address the relationship between productivity dispersion and productivity

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4 Brown, Dinlersoz, and Earle (2016) shows that reforms reducing reallocation frictions may raise dispersion in a model. They find that productivity dispersion in fact increased when the U.S. telecommunications industry was deregulated between the late 1970s and early 1980s. They also find that productivity dispersion rose along with reforms in Soviet Russia, Soviet Ukraine, and Hungary.
growth, along with caveats and remaining issues. Lastly, a conclusion is presented in Section 5.

2. Structural Shifts in Korean Manufacturing Industries

2.1 Shifts in Industries within Manufacturing: Changes in “flagship” industries

One interesting pattern observed during the expansion of Korea’s manufacturing sector is that there was a dramatic shift between industries within the manufacturing sector. Export-oriented industrialization and growth is an important characteristic of the Korean economy. While the Korean manufacturing sector has concentrated on a few key products, the composition of core-export products has changed over time. For example, fabric clothes, apparel, and shoes were the major export products in the 1970s, but the share of these products in total exports has steadily declined. Ships, cars, and semiconductors have been the most important three exports since the early 1990s.5

We used the data from national accounts that were constructed by Bank of Korea for two-digit industries (i.e., in terms of GDP and GNI according to Economic Activities) to examine the extent to which the value-added shares changed between 1970 and 2017. Figure 2 shows the changes in value-added shares for selected manufacturing industries that experienced substantial changes during the sample period (see Appendix Table A1 for all 13 two-digit KSIC industries).6 We focus on the following four industries. We consider textiles and leather products as a declining industry. Transportation equipment and electronic and electrical equipment represent two growing industries. The chemical products sector, which has maintained a steady value-added share, shows

5 See Figure A1 in the Appendix for changes in export shares of major products.

6 I acknowledge Frederic Warzinski for pointing out the dynamics in the value-added share changes in the selected industries.
a growth pattern which is similar to that of the manufacturing as a whole.

Textiles and leather products, along with food and beverages (not shown in the figure), accounted for about the half of total value added in the entire manufacturing sector in the early 1970s. Over time, the value-added share of these two industries steadily declined. The value-added share of textiles and leather products dropped from 28.0% in 1970 to a mere 4.2% in 2010. Although it is not shown in the figure, the value-added share of food and beverages, the second largest manufacturing industry in the 1970s, dropped from 19.6% to 4.8% during the same time period. These two industries’ dominant roles in the 1970s were gradually overtaken by growing industries, such as electronic and electrical equipment (the solid green line in the remainder of the figures) and transportation equipment (the long-dashed orange line), whose shares increased from 5.7% and 8.5% in 1970 to 26.3% and 16.0% in 2010, respectively. The growth of electronic and electrical equipment reflects the rapid expansion of semiconductors, which began in the early 1990s, and the surge of communication and broadcasting apparatus (e.g., cellular phones) in the mid- and late 1990s.

Figure 3 shows that the growth rates of these flagship industries remained very high throughout the sample period, suggesting that these industries were important for the growth of the Korean economy. The average growth rates of electronics and transportation between 1970 and 2000 were 25.5% and 22.0%, respectively. On the other hand, the declining share of textiles does not necessarily mean that this sector has experienced low growth rates. For the earlier period of the observation period, when the Korean Economy expanded at a remarkable speed, most industries maintained relatively high growth rates. Although the relative share of textiles has declined, the textile sector also recorded very high growth rates (around 10% per year) until 2000,
when overall growth rates for most industries began declining.

2.2 Entry, Exit, and Job Growth in Fast-Growing Industries

The figures presented in the previous section showed that the Korean manufacturing industries have undergone a striking structural transformation over the past 40 years. This shift in flagship industries was accompanied by the reallocation of resources between industries. We believe that entry and exit (i.e., the opening of a new plant and closings of plants in declining industries) played a crucial role, gradually shifting resources from one industry to another. Given that some of these industries did not exist in the past, differences in growth rates across existing plants alone do not fully explain the transformation process. Therefore, it is important to examine the behavior of new firms and plants, which deliver new products and technologies to the economy and alter value creation in various industries.

Figure 4 plots the entry and exit rates of the four industries we focus on. Electronics and transportation have relatively high entry and exit rates. About 30% of plants in the late 1980s and early 1990s were new. Entry rates for textiles were also high in the late 1980s, when the industry maintained a relatively high growth rate. However, as the growth rate went down in the early 1990s,

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7 The Mining and Manufacturing Survey collected information for plants with more than five employees until 2006. From 2007 and on, the survey criterion changes to 10 employees and more. We construct a sample with 10 and more employees to keep consistency. Thus, plants that reduce size below 10 would be considered as an exit. In a similar way, if an existing plant with fewer than 10 employees increases the number of workers and enters the survey sample, it will be considered as an entry. Figures for entry and exit rates from the earlier survey sample (that includes plants with five and more employees) are available upon request.

8 The trend is the fitted line from the regression of the variable against the fourth-order polynomial function. We prefer using this methodology to the HP (Hodrick-Prescott) filtering for samples with a shorter time period.
exit rates also increased, making the net entry rate for textiles close to or below zero.

Higher entry rates in growing industries suggest that a larger number of new plants were created in these industries. However, not all of these plants were successful. Exit rates were also high in growing industries. High correlations between entry and exit rates are well documented in previous studies (see Dunne, Roberts, and Samuelson (1989) for the industry level and Lee (2009) for the evidence across US states). Dunne, Roberts, and Samuelson find that entry and exit rates are correlated across four-digit SIC industries. Lee (2009) finds that both entry and exit rates are higher in growing states in the South and West, while they are relatively low in declining states in the Rust Belt and Midwest. Similar to these findings, both entry and exit rates are higher in fast-growing industries, such as electronics and transportation. While the exit rates are also high, they remained much lower than the entry rates, so the number of plants increased over time.

The secular shift in manufacturing involved reallocations of jobs between growing and declining industries as well. In order to examine the shifting of jobs between industries, Figure 5 plots job creation and destruction shares for each of the four industries. Although its value-added shares steadily declined during the sample period, the textiles industry, accounting for a large share of employment in the 1980s, played an important role in job creation. However, the number of jobs lost in textiles was disproportionately large, accounting for about 40% of jobs lost in manufacturing in the late 1980s and early 1990s. Jobs lost in textiles have been replaced by new jobs created in growing industries, with a relatively higher portion of jobs being created in electronics. The higher rates of entry and job creation in electronics suggest that a relatively larger

9 Job creation and destruction rates, not reported, are very similar to the patterns of entry and exit rates.
portion of inputs was allocated toward this industry. It is worth noting that job creation and job
destruction shares are also highly correlated. Similar to entry and exit rates, both job creation and
destruction rates were higher in growing industries. The reallocation process during the high-
growth period involved not only job creation, but also higher rates of job destruction. This finding
suggests that growing industries went through a very active reallocation process during the high-
growth period.

Figures 4 and 5 show that active entry, exit, and job flows (i.e., extensive margin) are
important characteristics of growing industries. Another important element to consider at the
intensive margin (i.e., growth of continuing plants) is the fast growth of startups. A study by
Haltiwanger et al. (2013) and following works emphasize the role of young plants in employment
growth. Figure 6 plots changes in value added, employment, and investment-output ratio over the
lifecycle. The age-growth profiles suggest that the growth of value added, employment, and
investment among very young plants plays an important role in the growth of an industry. The
difference in growth rates between young plants and others is substantial, but these values
converge very quickly. Regarding value added and the investment-output ratio, most of the young-
plant effect disappears after three years. The employment growth rates of young plants are much
higher than those of old plants but steadily decreased as a young plant’s age increased. With the
exception of transportation and chemical products, employment growth rates became negative
before the plants became five years old.

3. Entry, Exit, Reallocations and Productivity Growth

Structural change within the Korean manufacturing industries involves active entry, exit, and
growth of surviving plants. Successful transition from relatively low valued-added industries to
more advanced industries, such as electronics, involves entry and growth of new plants in the growing industry. We first examine the characteristics of entrants into the fast-growing industries, such as electronics and transportation, compared to their counterparts in other manufacturing industries (i.e., the manufacturing sector as a whole, textiles, and chemical products). Then we examine the contribution of entry and exit to productivity growth. Productivity growth is the most important factor in long-run growth. As briefly discussed, sustained but slow growth of productivity observed among the miracle economies is not explained by a typical standard growth model. Recent studies show that reallocations of resources across plants and sectors may help explain the productivity growth process.

3.1 Measurement of TFP

The plant-level data used in this study are taken from the Mining and Manufacturing Survey maintained by Statistics Korea. This data set comprises a representative sample of manufacturing plants with at least 10 employees, and the survey allows the assessment of the contribution of entering and exiting plants to the growth of productivity, as well as the impact of output reallocation across plants.

Plant-level productivities are estimated using the methodology by Wooldridge (2009). We used GMM estimation at the 3-digit industry level. Using the estimated elasticity of each factor, the TFP index for plant $j$ is computed as follows:

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\ln tfp_{jt} = \ln Y_{jt} - \alpha_l \ln L_{jt} - \alpha_m \ln M_{jt} - \alpha_k \ln K_{jt},
$$

where $Y_{jt}$ is real gross output, $L_{jt}$ is labor input (employment), $M_{jt}$ is real materials, and $K_{jt}$ is
real capital stock. Real gross output is measured as the total value of sales, adjusted for the changes in inventories and deflated by the two-digit industry-specific deflator from the Bank of Korea. Note that this measure of TFP is actually TFPR (Revenue TFP) in the literature, which is distinguished from TFPQ (Quantity TFP).

3.2 Characteristics of Entrants

Table 1 summarizes the characteristics of entrants by industry for the sample years. In order to control for the differences in industry size and productivity, we report the relative size and productivity of entrants compared to the same 3-digit SIC industry average of continuing plants. Overall, entrants are relatively smaller and have lower productivity (both labor productivity and TFP). However, we do not find substantial differences in the relative productivity of entrants between growing industries and declining industries. Although entry and exit rates are relatively high in electronic and electrical equipment and transportation equipment industries, the entrants in these industries are not particularly more productive or larger. In fact, higher exit rates in the last column imply that entrants in these industries are more likely to fail.

There is no meaningful difference in the observed characteristics at the time of entry. However, entrants in growing industries grew faster than those in other industries. When we calculate 3-year and 5-year cumulative growth rates for entrants, we find that entrants in electronics and transportation had relatively higher growth rates in employment and TFP. In the next sections, we explain the mechanism by which entry increases productivity and then quantify

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10 The instruments were one- and two-year lags of log employment and log real materials. This procedure implicitly assumes that all plants in the industry operate with the same production technology, a common assumption in such studies.
the contribution of entrants to productivity growth.

3.3 Reallocations and Productivity Growth

The reallocation patterns discussed in the previous section suggest several margins through which manufacturing productivity increases. The first channel is *between-industry* reallocation. 11 A similar argument to that regarding the effect of the structural transformation from agriculture to manufacturing on aggregate productivity may be applied here. The growth rate of aggregate productivity may increase as resources are reallocated to industries with higher productivity levels. 12 As resources are reallocated to more productive industries and used more efficiently, aggregate productivity may increase. Moreover, if growing industries have higher productivity growth rates, the growth rate of aggregate productivity will be increased even more.

The second channel is *within-industry* reallocations, which are the focus of most studies using establishment- or firm-level micro-data. The logic is similar to that of between-industry reallocations, but this growing literature focuses on reallocations that occur at the firm or establishment level (i.e., *between establishments* within an industry). Empirical literature has been

11 Previous studies using industry-level data implicitly assume that there exists a representative firm for each industry (See Lee (2005) for the detailed argument). For example, Basu and Fernald (1997) examined the cyclical properties of the reallocations between industries. They document that inputs tend to be reallocated toward industries with higher returns to scale and higher productivity levels during a boom in the cycle.

12 It is not clear to compare the levels of TFP between industries, due to the differences in the deflator and production technology (i.e., elasticities of inputs for each industry). We find that growth rates of TFP were higher for growing industries (e.g., transportation and electronics) than for declining industries (e.g., textile and leather).
vastly devoted to examining the importance of resource reallocation for aggregate productivity growth. Economic growth models emphasizing the role of creative destruction may explain the link between firm-level dynamics and aggregate productivity growth. A new firm enters the economy with new technology and competes with existing firms with old, conventional technology. As newer, more-productive plants become successful, less-productive ones are driven out, and resources are reallocated from incumbents to new entrants. As a result, the economy’s overall efficiency level rises, and aggregate productivity increases. Following the most common approach to decomposing aggregate productivity growth (e.g., Baily et al. (1992) and Foster et al. (2001)), we can quantify the role of plant-level reallocations in aggregate productivity growth.

3.4 Decomposition Methods and Results

Using plant-level data, we examine the extent to which changes in the share of outputs across plants affect the aggregate productivity growth. There is a growing literature on the decomposition methods of aggregate productivity. While we primarily focus on the method by Foster, Haltiwanger, and Krizan (hereafter FHK), we also use the Dynamic Olley Pakes method developed by Melitz and Polanec (2015).

First, following Baily et al. (2001) and Foster, Haltiwanger, and Kriza (2001), we have decomposed the time series changes in aggregate productivity into components that reflect within-plant productivity growth and other effects that reflect the reallocation of shares across plants including the effect of entry and exit: ¹³

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¹³ See Foster et al. (2001) for the reviews of previous studies using different decomposition methodologies and measurement issues.
where $\ln tfp_j$ is the TFP for plant $j$ at time $t$, $\ln TFP_t$ is the aggregate TFP index at time $t$ for each industry, $s_j$ is the share of output at plant $j$ at time $t$, and a bar over a variable indicates the average of the variable over the base and end years ($t-1$ and $t$). The first term in the equation, often interpreted as a “within” effect, reflects changes in productivity from continuing plants, given output shares fixed. The second term, often interpreted as a “between” effect, reflects changes in output shares from continuing plants for fixed levels of productivity. The last two terms represent the contribution of entering and exiting plants, respectively. These two terms together constitute the net entry effect. The net entry effect, along with the between effect, captures the effect of reallocations between plants on the industry-level productivity growth. The results of these decompositions for the manufacturing sector are reported in Figure 7. In order to minimize yearly fluctuations due to the business cycle and focus on long-term changes, we report the average values for five-year intervals. The Korean manufacturing sector have maintained solid productivity growth until the growth rate turned negative in the 2011-2016 sample period. The results reported in the figure suggest that most of the TFP growth in the manufacturing sector is accounted for by the within effect, i.e., productivity growth in continuing plants, given that their shares

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14 While understanding the slowdown in productivity growth after 2011 is potentially important, it goes beyond the scope of this paper, which focuses on the structural change during the high-growth period.
remained unchanged.\(^{15}\) The between effect is very small, accounting for only about 5% of total productivity growth. The net entry effect accounts for about 10% of total productivity growth for each five-year period.\(^{16}\) It is not straightforward to compare these results to those of other studies, for the magnitude of the net entry effect varies across countries and industries. Compared to the US manufacturing industry, within-plant productivity growth plays a more important role in productivity growth, and the reallocation effect (e.g., the between and net entry effects) seems to be relatively small. For example, Foster, Haltiwanger, and Krizan (2001) examined the manufacturing industry’s productivity growth between 1977 and 1987. They found that the within effect accounted for 65% of productivity growth, the between effect accounted for 10%, and the net-entry effect accounted for 25%.

Figures 8A and 8B present the decomposition results for the four selected industries. The productivity growth rate was relatively lower for textile and leather, a slowly growing and then declining industry. While net entry contributed to industry productivity growth to some degree during the late 1980s and the early 1990s, most of the productivity growth was driven by the within effect, i.e., productivity growth among continuing plants.

The value-added growth rate of the chemical products industry was very similar to that of the entire manufacturing sector over the sample period. However, the productivity growth path for

\(^{15}\) Note that the term “within” here is the weighted average of plant-level productivity growth among continuing plants. In the case of the Dynamic Olley Pakes method, the term is unweighted average.

\(^{16}\) Some of these entries and exits are incumbents switching industry classification. Their share is relatively small, except for during the 2001–2006 period. We count them together with net entry: a switch-in plant is considered as an entry, and a switch-out plant considered as an exit in the productivity decomposition results.
the chemical products industry was very different from that of the entire manufacturing sector. There was a substantial drop during the 1991—1995 period because of a massive expansion of production capacity in the 1980s, which was not met with an increase in demand. The net entry effect was also small, mostly due to the relatively lower entry and exit rates for the industry.

Productivity growth was much higher in the electronic and electrical equipment industry for most of the period examined. While the within effect was the most important factor in this industry’s productivity growth, the net-entry effect also made a sizable contribution. Moreover, the between effect played an important role in the 1991—1995 and 2001—2006 periods, accounting for about 20 percent of productivity growth. The productivity growth rate was also high in transportation. Similar to the other industries, the within effect explained most of the productivity growth, with a relatively small role on the part of net entry and between-plant reallocations.

3.5 Alternative Decomposition: Dynamic Olley–Pakes Method and Results

Melitz and Polanec (2015) extend the Olley and Pakes (1996) productivity decomposition methods to include the contributions of entering and exiting firms to aggregate productivity growth. Using Slovenian manufacturing data, Melitz and Polanec (2015) showed that other decomposition methods, such as FHK, may overstate the contribution of entry and exit due to differences in the reference (or benchmark) productivity. Although we do not find substantial net-entry effects from the FHK decomposition method, we apply the Dynamic Olley Pakes decomposition method (DOPD) as an alternative method. Using a similar notation to the FHK in equation (2), the

\[ \text{Productivity growth} = \text{Within effect} + \text{Net entry effect} + \text{Between effect} \]

17 The production capacity of petroleum and chemical products doubled in the 1980s, from 505,000 tons in the late 1970s to 1.16 million tons (in terms of ethylene production) in 1989.
decomposition equation is given by:

\[ \Delta \ln TFP_t = \Delta \ln TFP_{jt,conti} + \Delta cov_{jt,conti}(s_j, \ln tfp_j) \]

\[ + S_{jt,Entry} (\ln TFP_{jt,Entry} - \bar{\ln TFP}_{jt,conti}) - S_{jt-1,Exit} (\ln TFP_{jt-1,Exit} - \bar{\ln TFP}_{jt-1,conti}), \]

where \( \ln TFP_t \) is the aggregate TFP index at time \( t \), \( \Delta \ln TFP_{jt,conti} \) is the change in unweighted average productivity of continuing plants, \( \ln tfp_j \) is the TFP for plant \( j \), and \( \Delta cov_{jt,conti}(s_j, \ln tfp_j) \) is the change in the covariance term, which is often interpreted as the change in allocative efficiency among continuing plants (e.g., Decker, Haltiwanger, Jarmin and Miranda (2017)). The third and the fourth terms represent the aggregate contribution of entry and exit (i.e., net-entry effect, together).

Figure 9 presents the results of the decomposition result for the manufacturing sector. We find an even smaller contribution of net entry, which is consistent with the argument of Melitz and Polanec (2015). While the FHK method sets the average of productivity between \( t \) and \( t-1 \) as the reference productivity level, DOPD sets the average productivity at time \( t \) as the reference point, which would usually be higher in a growing economy. For this reason, the FHK decomposition may overstate the contribution of entry when the average productivity of an economy grows fast. We find that net-entry effects are negligible for most of the high growth periods. We find a small, positive effect only for the 2011–2016 period when the within effect is negative.

It is worth noting that within effects become smaller when DOPD is used, leading to a larger contribution of reallocations (i.e., covariance term) than that in the FHK method. The difference is driven by the fact that the within term in FHK is the weighted average among continuing plants and thus may draw on allocative-efficiency components that are included in the
changes in the covariance term of DOPD. When there is a positive correlation between the market share and the productivity level (i.e., plants with higher productivity growth are larger), within effects in FHK can be larger than in DOPD. The industry-level results of the DOPD method are reported in the Appendix.

3.6 Growth of Entrants and Their Contribution to Productivity Growth

The finding of a relatively small contribution of net entry does not mean that startups are not important sources of productivity growth. It is worth noting that the productivity growth of a plant occurs at a very early stage of the life-cycle. In a recent study, Alon, Berger, Dent, and Pugsley (2018) find that new entrants, conditional on survival, register a productivity growth of about 20% during the first five years of operation, but that the productivity-age profile becomes close to zero for the remainder of the age distribution. Similar to the findings of Alon et al. (2018), we also find a downward sloping and convex relationship between plant age and productivity in the industries we examined. In Figure 10, the productivity growth rate is shown to be very high for plants with ages of one or two years, but it dramatically drops and remains flat for the remainder of the age distribution.

Conditional on survival, entrants show very fast growth productivity. When we calculate productivity growth for surviving entrants, the average productivity growth rates for the first 3- or 5-year period were even higher for entrants in fast-growing industries. Because both FHK and DOPD focus on the initial effect of entry, their net-entry effects may understate the contribution of entrants: the contribution of surviving entrants would be reflected in the within components of the decomposition, along with those of older continuing plants.

In order to account separately for the early growth of effects of entrants, Figure 11 further
decomposes the within components of FHK into the contributions of three different age groups: 1–3 years, 4–7 years, and over 8 years. Overall, the contribution of entrants for the first 3 years accounts for about 30% of within effects, which is quite substantial considering their value-added of about 20%. Figure 12 presents the results for the four selected industries. The contribution of entrants’ productivity growth varies across industries. For example, their contribution is relatively small in chemical products, but the fast growth of entrants played an important role in the high growth period of the electronic and electrical equipment industry.

While the contribution of young startups is important, it is also worth noting the solid growth of older plants. In most industries, continuing plants over 8-years old accounted for more than half of the productivity growth among continuing plants.\(^\text{18}\) The key difference in the age-productivity profile between Korea and the United States is that in the Korean manufacturing sector, particularly during the high-growth period, continuing plants over age three also recorded positive and even relatively high growth rates. For example, continuing plants in electronic and electrical equipment and transportation equipment maintained relatively high productivity growth levels after the Asian Financial crisis (during the 1999—2006 period). Along with the fast growth of young plants, continuing plants’ productivity growth, rather than reallocations, explained most of the productivity growth in Korea.

4. Caveats and Remaining Issues

\(^\text{18}\) Note that a new plant is not necessarily a start-up by a new firm. The survey does not have firm information for the plant, and a new plant may belong to an older, existing firm. We discuss this issue in the next section.
4.1. Plants vs. Firms

This paper focuses on the entry and exit of plants and their contribution to structural change and productivity dynamics. Due to the limitation of the data, we are not able to examine the role of firms in such dynamics. However, we believe that investigating the characteristics of firms and their role in plant-level dynamics is crucial in understanding the structural transformation and the growth experience of Korea. For example, in a recent study, Cao, Hyatt, Mukoyama, and Sager (2019) found that increasing the number of establishments is an important feature of firm growth in the United States. In Korea, it is a well-known fact that large firms and business groups, often called conglomerates, have played a key role in the country’s growth.

As an alternative way to assess the role of firm size in productivity growth, we decompose the within effects further into the contributions of three different size groups: small (10 to 49 employees), medium (50 to 299 employees), and large (more than 300 employees). Overall, we find that plants with more than 300 employees account for more than half of within-plant productivity growth. The contribution of larger plants is more important in growing industries, such as electronics and transportation equipment. In electronics, more than half of the within effects were contributed to large plants over 8-years old, which is about the same magnitude as their market share. Considering that older, larger plants have a tendency to grow at a slower rate than younger, smaller ones, this finding highlights the importance of large firms in productivity growth in Korea’s leading industries.

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Note that the sample consists of plants with at least 10 employees. In most cases, a large plant with more than 300 employees is likely to belong to a large firm if it does not stand as a large firm by itself. The decomposition results are reported in the appendix.
While it would be challenging, understanding the relationship between productivity growth and innovation activity would help enlighten the structural transformation of the Korean manufacturing industry. In Korea, R&D spending is highly concentrated in large and mature firms, which have driven the solid productivity growth of the industry. In the earlier development stage of the 1960s and 1970s, the Korean government provided a road map and played a critical role in forging industries. Not all policies were successful, as in the case of the overinvestment in heavy and chemical industries. During this period, both the government and firms recognized the importance of technology and development. While the government used policy measures to protect the domestic market, it also provided incentives for the firms to develop, produce, and export electronic products and in the global market. As the Korean manufacturing sector shifted toward more technology intensive sectors, such as information technology (IT), the role of firms in developing new technology became increasingly important.

4.2. Allocative Efficiency: A Channel of TFP Growth?

In this section, we document the productivity dispersion in Korean manufacturing during the sample period and examine whether there is a difference in the misallocation measures between growing and declining industries. A seminar work by Hsieh and Klenow (2009) and following works provide an analysis of potential productivity increases by reducing productivity dispersion in developing countries (e.g., China and India). Such productivity dispersion may be caused by distortions (or wedges) due to policy or financial friction. In general, variations in TFPR (Revenue
TFP) within a sector are used as a measure of misallocation. In a special case where TFPQ (Quantity TFP) and TFPR are jointly normally distributed, the aggregate TFP can be written in a simple closed-form expression:

\[ \ln TFP_s = \frac{1}{\sigma - 1} \ln \left( \sum_{j=1}^{M_s} TFPQ_{sj} \sigma^{-1} \right) - \frac{\sigma}{2} \var (\ln TFPR_{sj}) . \]

In this equation, the variance of revenue productivity (TFP in this paper) across plants summarizes the negative effect of distortions on aggregate productivity. If other things are unchanged (for example, no change in TFPQ), more dispersion in TFPR across establishments in an industry means more dispersion in marginal products, which leads to lower TFP for the industry. As such misallocation is reduced, the aggregate productivity may increase.

Table 2 presents the standard deviation of log TFPR for manufacturing and the four selected industries. For the manufacturing sector as a whole, there are no substantial changes in the dispersion of TFPR. The dispersion somewhat decreased in the early 1990s but increased after. This is consistent with the finding of Kim, Oh, and Shin (2017), who examined misallocation in Korean manufacturing from 1982 to 2007. They found an improvement in allocative efficiency in

\[ TFP_{si} = P_{si} A_{si} = \frac{\sigma}{1-\sigma} \left( \frac{R}{A_s} \right)^{\alpha_s} \left( \frac{w}{1-\alpha_s} \right)^{1-\alpha_s} \frac{(1+\tau_{Ksi})^{\alpha_s}}{1-\tau_{Ysi}} . \]

The allocation efficiency depends not only on productivity levels, but also on the output and capital distortions (\( \tau_{Ysi} \) and \( \tau_{Ksi} \), respectively).

Note that a recent study by Bils, Klenow, and Ruane (2018) suggests that differences in revenue productivity dispersion may also reflect measurement errors and not necessarily differences in true marginal products.
the 1980s, which reversed after 1992. Our analysis shows that the dispersion continued to increase until very recently. The increase in dispersion is commonly observed in the four selected industries. For textiles whose productivity growth is relatively low, the standard deviation of log TFPR increased from 0.653 in the late 1980s to 0.884 in the mid-2010s. The dispersion in electronics, which reversed its decreasing trend in the early 1990s, continued to climb in the late 1990s and 2000s.

Based on casual observation, it is not easy to identify a systemic relationship between productivity dispersion and productivity growth. The higher dispersion in productivity may imply that more room may exist for efficient gains through reallocations. However, higher dispersion is not necessarily correlated with the overall TFP growth. In Table 3, the correlation between the 5-year average of TFP growth rates and the standard deviation of log TFPR (average values for the corresponding time period) across 13 two-digit industries is negative (-0.174) but not statistically different from zero.

We further examine whether the measured productivity dispersion is correlated with each component of productivity growth decomposition, in particular, the between-effect of the FHK and DOPD methods (i.e., change in the covariance term for the DOPD method). The first column reports the correlations with the FHK decomposition results and the third column for those with the DOPD results. The magnitude of the negative correlation is higher for the DOPD reallocation term, but it is not statistically significant. While more thorough investigation is needed, a casual observation implies that the levels of dispersion are not significantly correlated with the aggregate TFP growth.
We also examine whether there is a systemic relationship between the changes in dispersion and TFP growth rates across 13 two-digit industries (i.e., whether changes in the misallocation measure are related to the productivity growth). The second column reports the correlations between the change in the dispersion of TFPR and the FHK decomposition components, and the fourth column reports the correlations with those of the DOPD method. The positive correlation suggests that increases in productivity dispersion are correlated with productivity gains. The magnitude of correlation is higher for the change in the covariance term from the DOPD. This finding suggests that productivity growth of an industry is accompanied by an increase, not a decrease, in productivity dispersion.

Hsieh and Klenow (2009) and subsequent studies by others suggest that improvement in misallocation would lead to overall productivity growth. In general, a large dispersion in productivity implies that more room may exist for efficiency gains. However, the puzzling finding of the positive correlations between the change in dispersion and productivity growth raises a caution of interpreting the dispersion as the key measure of misallocation only. Productivity growth depends not only on efficiency gains through reallocation but also on other factors such as technological progress and innovation, whose effect on the productivity dispersion is not quite clear. For this reason, a decrease in dispersion may not always be observed with an overall productivity increase.

4.3 Implications on Growth Models

Despite its central role in economic growth research, the traditional one-sector growth model does a poor job in describing the long-run behavior of the U.S. economy and explaining the growth miracle in Asia. For the United States, Greenwood, Hercowitz, and Krusell (1997) develop a two-
sector model in which technological progress in the production of durable good is faster than in the rest of the economy. Whelan (2003) develops the two-sector approach to establish the long-run properties of the real NIPA aggregate data.

Our finding highlights the importance of examining growth in a detailed sectoral perspective. Most of the existing analyses focusing on the structural changes are based on two-sector (agriculture/non-agriculture) or a three-sector (agriculture/manufacturing/services) model with a few exceptions. For example, Ungor (2017) analyzes a nine-sector model for Korea, Taiwan, China, and Latin American countries and finds that productivity growth in manufacturing and wholesale is important in increasing aggregate productivity growth. Although our study empirically examines industries at an even more detailed level than that of Ungor (2017), it may not be practical to develop and analyze a growth model distinguishing very narrow industries. However, it is worthwhile to think about how to model the effect of reallocation (i.e., sectoral shift) in an existing two-sector model, because our empirical evidence suggests that industrial shift (e.g., from textiles to electronics) may provide a key to explain sustainable growth of income and productivity in Korea.

First, we have to think about how to deal with returns to investment when there is ongoing structural change. In particular, sectoral shift suggests that new investment is more likely to concentrate on the new, growing industries. A steep decrease in marginal returns to investment in a traditional one sector model may not be suitable to explain the returns to investment when there are multiple sectors and firms at different stages of the life cycle. Moreover, the marginal returns to investment may behave differently due to differential rates of R&D activity and other innovations.
Second, the model needs to explain the large gap in productivity growth in the leading industry and in the rest of the economy. Our results suggest different growth rates between growing industries and declining industries. Most existing growth models do not explicitly model the effect of reallocations between firms on the aggregate productivity growth. However, it is important to think about how to incorporate reallocations in the model and distinguish the behaviors of different sectors (e.g., investment sector) from that of other manufacturing industries (or the rest of economy).

Third, it will be useful to understand the effect of demand dynamics on firms’ and industries’ growth. Our results and those from others emphasize the role of young firms’ growth in economic growth. For example, startups are in general smaller than established businesses in the same market but this size gap closes only slowly as the producer ages. It is important to understand the role of demand dynamics in firms’ growth. Given the importance of outward-oriented policies in Korea, an export-oriented economy, understanding the role of demand dynamics in firm growth will provide a basic framework to analyze the role of international trade.

5. Conclusion

In this study, we examine the secular shift of industries within the manufacturing sector over the past four decades. The Korean economy went through very active reallocations, from textiles to electronics and transportation industries. This industrial shift accompanied active job reallocations, as well as the entry and exit of plants. Growing industries, such as electronics and transportation, have not only higher entry rates, but also higher exit rates.

It is well documented that reallocation from low to high productive firms is important in productivity growth. The reallocation of resources from less productive producers to more
productive ones is an important source of efficiency gains for an economy. Recently researchers have blamed declining dynamism and reallocations for the slow growth in the United States since the Great Recession. However, we find that the contribution of reallocations to productivity growth is relatively small. With the exception of special cases such as electronics, the reallocation effect was not the main driver of productivity growth in Korea. Moreover, we find that productivity dispersion increased when industry productivity increased. Our finding of the relatively larger role of within-plant productivity growth suggests that productivity gains among continuing plants, possibly thanks to the innovation activity of continuing firms and learning of young plants, have played an important role in the productivity growth of the Korean manufacturing sector.

The reallocation margin that worked in Korea was productivity growth among very young startups that entered a new industry. Startups’ and young firms’ growth also played an important role in productivity growth in fast-growing industries in Korea. However, recent studies document that, with the decline in the overall startup rate, the contribution of those young firms to aggregate productivity growth seems to have declined over time. More recently, declines in productivity growth are widely observed among older, continuing plants as well. Whether active entry and the successful growth of continuing firms can be maintained will be the key to sustain productivity and income growth for Korea.

Our findings suggest that productivity growth did not always accompany the decrease in productivity dispersion. While our results are not necessarily consistent with the predictions of the misallocation literature, they do not necessarily disregard the importance of policy reforms which will improve allocative efficiency. Ideally, improvement in reallocations would further boost
productivity growth in Korea. Moreover, the important role of the within-effect among continuing plants calls attention to the traditional views that emphasize innovation, technology, and policies promoting research and development (R&D). A recent study by Hsieh and Klenow (2018) also emphasizes that most innovation comes from existing firms rather than entrants or fast-growing young firms. While removing misallocation is important to improve allocative efficiency and enhance TFP growth, the most important contributor to growth can be innovation of incumbent firms, which leads to within-firm productivity growth.

Finally, the analysis of this paper is limited to the manufacturing sector. Moreover, our study abstracts from the role of international trade. However, manufacturing is the key industry in the industrialization process and TFP growth of the aggregate economy. Understanding the key mechanism involved in sustaining TFP growth in the Asian miracle economies will be of value for other developing countries.
References


Hsieh, Chang-Tai and Klenow, Peter J. “Reallocation Myth,” 2018, Stanford University WP.


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<tr>
<th>Entrants Characteristics by Industry</th>
<th>Relative Size</th>
<th>Relative LP</th>
<th>Relative TFP</th>
<th>Exit Rate</th>
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<td>0.89</td>
<td>0.961</td>
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<td>Textile and Leather</td>
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<td>0.899</td>
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<td>0.88</td>
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<td>0.85</td>
<td>0.938</td>
<td>0.364</td>
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<td>0.49</td>
<td>0.89</td>
<td>0.947</td>
<td>0.375</td>
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**Table 1: Characteristics of Entrants by Industry (all sample years)**

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<td>Manufacturing</td>
<td>0.696</td>
<td>0.664</td>
<td>0.714</td>
<td>0.759</td>
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**Table 2: Evolution of TFPR Dispersion**

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<td>Correlations between</td>
<td>SD(TFPR)</td>
<td>Change in SD(TFPR)</td>
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<td>TFP growth rate (Total)</td>
<td>-0.174</td>
<td>0.253**</td>
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<td>Between-effect</td>
<td>-0.052</td>
<td>0.168</td>
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<td>Reallocation (Between- &amp; Net-entry effect)</td>
<td>-0.102</td>
<td>0.243**</td>
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**Table 3: Correlations between Productivity Growth and Dispersion**

Note: Results for 13 two-digit KSIC industries.
Figure 1: Growth of Manufacturing

Figure 2: Change in the value added shares of selected industries

Note: Economic Statistics System (http://ecos.bok.or.kr/).
Figure 3: Growth Rates (Value Added) of Selected Industries

Note: Economic Statistics System (http://ecos.bok.or.kr/). The growth rates are based on the trend component of HP Filtering (lambda= 6.25).
Figure 4: Entry and Exit Rates

Note: Author’s calculation from Mining and Manufacturing Survey. Trend is the fitted line from the regression of the variable against the fourth-order polynomial function.
Figure 5: Job Creation and Job Destruction Shares
A. Value Added Growth Rate by Age

B. Employment Growth by Age

C. Investment-Output Ratio by Age

Figure 6: Age Growth Profile
Figure 7: TFP Decomposition, Manufacturing
Figure 8A: Productivity Decompositions of Selected Industries
Figure 8B: Productivity Decompositions of Selected Industries
Figure 9: TFP Decomposition, Manufacturing, DOPD

Note: Decomposition results from the Dynamic Olley Pakes method from Meilitz and Polanec (2015). Changes in the covariance terms are labeled as between effect.
Figure 10: Productivity Growth-Age Profile
Figure 11: Within-effect by Age Group
Figure 12: Within-effect by Age, Selected Industries

- Textile and Leather
- Chemical Products

Age 1-3 - Age 4-7 - Age 8+
Figure 12: Within-effect by Age, Selected Industries
Appendix:

Appendix Figures and Tables

Figure A1: Export Shares of Major Products

Not: Source KITA(http://stat.kita.net/). Author's calculation.
Figure A2: Productivity Decomposition (FHK), two-digit industries
Figure A3A: Productivity Decompositions of Selected Industries, DOPD
Figure A3B: Productivity Decompositions of Selected Industries, DOPD
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<td>Food, beverages and tobacco</td>
<td>19.6</td>
<td>10.7</td>
<td>7.2</td>
<td>6.1</td>
<td>4.2</td>
<td>3.7</td>
<td>-15.9</td>
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<td>Textile and leather</td>
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<td>23.2</td>
<td>13.4</td>
<td>7.9</td>
<td>4.8</td>
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<td>Wood and paper</td>
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<td>4.8</td>
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<td>2.8</td>
<td>2.3</td>
<td>-6.6</td>
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<td>Petroleum and coal</td>
<td>1.1</td>
<td>3.4</td>
<td>1.9</td>
<td>2.5</td>
<td>2.1</td>
<td>2.3</td>
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<td>Chemical products</td>
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<td>16.5</td>
<td>12.4</td>
<td>12.8</td>
<td>13.2</td>
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<td>Non-metallic mineral</td>
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<td>6.4</td>
<td>6.5</td>
<td>4.0</td>
<td>3.1</td>
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<td>Basic metal</td>
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<td>7.4</td>
<td>10.1</td>
<td>7.8</td>
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<td>Fabricated metal</td>
<td>1.0</td>
<td>2.9</td>
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<td>1.4</td>
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Table A1: Value Added Shares, 1970-2015