

# Effects of Financial Support Programs for SMEs on Manufacturing Sector Productivity: Analysis of the Growth Curves of Individual Establishments

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# I

## Introduction

The South Korean economy has been experiencing a continued decrease in its economic growth rate since the late 2000s. This decrease has heightened policy interest in enhancing productivity, one of the decisive factors of economic growth. If we understand the aggregate productivity of a given economy as the weighted average of the added values of individual establishment productivity, we will need to find ways to enhance that productivity to raise the aggregate productivity of our economy.

Hsieh and Klenow (2014) compared the manufacturing sectors of the United States, India, and Mexico and concluded that much of the differences in aggregate productivity from nation to nation could be explained by the differences in the extent of growth individual establishments could achieve on the basis of their ages. Taking inspiration from that study, we attempt here to analyze the correlation between the decline in Korea's economic growth rate since the 2000s, on the one hand, and the trend in productivity growth rates of individual establishments in Korea.

Given the nature of our central topic, the range of industries and establishments we analyze is naturally limited. To determine the productivity trend of individual establishments, it is crucial to make use of micro-level data in the form of panels that allow estimation of the production functions and productivity of those establishments, such as the amount of added value, quantities of intermediary goods used, number of employees, and scale of capital stock. Statistics Korea's *Mining and Manufacturing Surveys* provide the information we need, and we therefore limit our analysis to the manufacturing

sector. In general, establishments are small when they enter the market and grow as they accumulate ages. As the central focus of our study is on the rates of productivity of individual establishments dependent upon these ages, we concentrate on small and medium-sized enterprises (SMEs) rather than large corporations that have already seen significant growth.

Accordingly, we decompose the panel-structured information provided by the *Mining and Manufacturing Surveys* into productivity, production factor inputs, efficiency of the distribution of production factors, and so forth to examine whether changes in productivity growth rates do actually explain changes in the rates at which the gross amount of added value increases in the entire manufacturing sector. Next, we decompose the growth rates of establishments into growth caused by the exit of establishments with relatively low productivity and the resulting growth in those that survive. To determine the effects of financial support programs for SMEs on the growth rates of manufacturing SMEs with varying ages, we link the data on the financial support programs for SMEs provided by the Small and Medium Business Corporation (SBC), the Korea Technology Finance Corporation (KOTEC), and the Korea Credit Guarantee Fund (KODIT) for SMEs with the data from the Mining and Manufacturing Surveys and examine the paths by which financial support programs for SMEs affected the growth rates of establishments, the correlation between their productivity and likelihood of exiting from the market, and the efficiency of resource distribution.

After empirical analysis, we apply the industrial equilibrium model of Atkeson and Burstein, which includes appropriate elements that can be applied to the Korean manufacturing sector (individual establishment decisions on investing in internal process innovation, on exporting their products, etc.) to analyze and quantify how the decline in the productivity rates of individual manufacturing establishments in Korea affect the sector's overall productivity and output.

In addition, we use a model economy, reflecting the distribution of Korean manufacturing establishments in the late 2000s, to determine how diverse policy support measures, such as subsidies for new establishments to enter the market, subsidies for fixed export costs, subsidies for fixed operating costs (decisive on exit), and the like affect the growth rates of individual establishments and

thereby influence the overall productivity and output of the entire sector.

This report is structured as follows. Chapter II provides a review of the existing literature. Chapter III introduces the *Mining and Manufacturing Surveys* at the basis of our empirical analysis, and describes the changing distributions of manufacturing establishments with different ages at different points in time. Chapter IV provides a decomposition of the rate of added-value growth in the manufacturing sector into the rates of increase in productivity, production factor inputs, and efficiency in distribution of production factors. It also provides a decomposition on the rates of growth of establishments with different ages into growth due to the exit of less productive establishments and the consequent growth of those that survive. Chapter V provides a fixed-effect panel regression analysis on whether the degrees of growth in establishments' added value and productivity changed over time. In this section, we also examine whether growth rates dependent on age made any significant difference in growth between export-dependent manufacturing and other segments. Chapter VI provides an analysis of how financial support programs for SMEs has affected the growth rates of SMEs with different ages. In particular, the correlation between the productivity of establishments in a given industry and the likelihood of their exit and the efficiency of labor and resource distribution are examined as the specific paths by which financial support programs for SMEs affect SME growth. Chapter VII combines the findings of the structural model and empirical analysis to explain how the overall decline in the growth rates of individual establishments in the 2000s influenced the aggregate productivity and output of the manufacturing sector.

## II

### Literature Review

#### 1 International Literature

Hsieh and Klenow (2009) presented a model of empirical analysis with which we can measure the degree to which the distorted distribution of production factors (labor, capital, etc.) will lower the aggregate productivity of an overall economy, under a given distribution and the quantity total factor productivity (QTFP) of individual establishments.<sup>1)</sup> In a market of monopolistic competition, with a constant elasticity of substitution, production factors like labor and capital should move from less productive establishments to more productive ones until the revenue total factor productivity (RTFP)<sup>2)</sup> of establishments becomes equal insofar as production factors are perfectly distributed on that market without distortion and notwithstanding differences in the QTFP of individual establishments. The output of such an economy would become maximized when the RTFP of all establishments under the given level of QTFP becomes identical. The authors' analysis based on the micro-data of manufacturing establishments in the United States, China, and India showed that inefficiency of resource distribution under the given distributions of productivity explained approximately 33 percent of the productivity difference between these three nations. This finding, however, strongly suggests the need to identify other factors that can

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1) Measures how many units of products can be produced given a single unit of production factors.

2) Measures how many units of revenue can be generated from a single unit of production factors.

explain the remaining 67 percent of productivity difference.

In exploring the other decisive factors of productivity distribution among individual establishments, Hsieh and Klenow (2014) seized upon the fact that the extent of growth to which individual establishments attain varied according to the length of their age. The authors used manufacturing micro-data on the United States, Mexico, and India to determine the patterns by which the employment scale and productivity of establishments<sup>3)</sup> grew in proportion to those ages. In the United States, firms with 40 years of age hired seven times more workers than firms with ages five years or less in length. In Mexico, on the other hand, the employment scale of establishments doubled by the time they reached the 25th year of their ages in a fashion similar to that of their American counterparts, but the employment scale did not grow beyond that point in time. In India, establishments with 40 years of history hired approximately 40 percent more workers than establishments with less than five years of history. To examine how the differences in the growth curves of individual firms affected the aggregate productivity of the entire manufacturing sector, the authors set up a general equilibrium model involving factors of corporate dynamics, and concluded that replacing the growth curves of American establishments with those of their Mexican and Indian counterparts would lower the overall productivity of the American manufacturing sector by 25 percent.

While the authors do not elucidate the specific factors contributing to the differences in the growth curves of American, Mexican, and Indian establishments, Hsieh and Klenow rely on the findings from their 2009 study to conclude that the RTFP of American establishments was 500 to 600 percent greater than that of Mexican and Indian establishments with the same QTFP. The authors' interpretation was that the tax structure, regulations applying to establishments with different scales of revenue or employment, and the frictional financial markets tended to disadvantage establishments in Mexico and India with relatively higher

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3) According to Statistics Korea's overview and glossaries on *Surveys of Establishments*, an "establishment" refers to any "unit of management that engages in industrial activities, including production, sales, and distribution of goods and services, under single ownership or control from a single source at a fixed location." An "enterprise," according to this explanation, is different from an "establishment" in that the former is defined "legally as being owned and controlled by capital from the same single source and may consist of more than one establishment."

QTFP. Facing such disadvantages, individual establishments do not expect to be able to earn much more by dramatically improving their productivity through R&D and the like. This would keep the increases in productivity and optimal output of Indian and Mexican establishments considerably lower than for American establishments. For quantitative testing of this hypothesis, the authors applied the industrial equilibrium model of Atkeson and Burstein (2010)—which views increases in establishment productivity as a function of optimization through increasing investment in R&D—to the quantity and RTFP of establishments in the United States and elsewhere. They found that increases in productivity due to accumulation of age explained 33 percent of the differences in productivity growth rates between American and Indian establishments.

Hsieh and Klenow (2014) has inspired a series of studies exploring specific factors that could explain differences in the growth curves of establishments in different countries. Of particular interest in recent literature are the structures of financial markets and the composition of human capital available in different countries.

Caggese (2016) and Cole et al. (2016) provide analyses on how frictional financial markets influence enterprise growth curves. Caggese (2016) used panel data on Italian manufacturers to determine how each industry's friction with the Italian financial market affected the growth curves of individual enterprise productivity. The author revealed that, the severer the friction between a given industry and the financial market, the clearly weaker the positive influence of accumulated age on increasing the productivity of the firms in that industry. Based on this finding, the author formulated a structural model that showed how friction with the financial market would serve as a barrier to new enterprise entry into the market and thereby disincentivize existing enterprises from investing in R&D, ultimately influencing the growth curves of existing enterprises. Cole et al. (2016) also demonstrated that, in countries where enterprises seeking to enter the market face significant friction with financial markets, new entrants would favor projects with stable prospects and low growth potential because of the difficulty they have in securing financial resources. This, in turn, can adversely affect the growth curves of individual enterprises overall.

Based on Gennaioili et al. (2013), which emphasized the educational attainment of entrepreneurs as key to enterprise productivity and Bloom et al.

(2013), which also pointed to the educational attainment of employees as an important indicator of enterprise performance, Roys and Seshadri (2014) formulated an occupation choice model in which the quantity and quality of human capital are in an imperfect substitution relationship and demonstrated the efficiency of the match of human capital between employers and employees could be a decisive factor in enterprise growth curves. Bhattacharya et al. (2013) presented an endogenous decision-making model, in which enterprise productivity varies depending on the choices employers make on whether to invest in human capital, and added the distortion of the distribution of productivity-affecting resources to that model to show how such distortion can disincentivize employers from investing in human capital and thereby significantly lower the aggregate productivity of the overall economy.

These studies, taking the methodology of empirical analysis offered by Hsieh and Klenow (2009, 2014), seek to find alternative ways to measure the efficiency of resource distribution in given economies. However, some researchers have begun to question whether the RTFP, measured as a cost share of added value, should be regarded as “an idiosyncratic measure of establishment-level distortion” as attempted by Hsieh and Klenow (2009, 2014) and other such studies.

Using the amounts of raw materials and energy consumption surveyed in their earlier study from 2003, Petrin and Levinsohn (2012) sought to control the variability in productivity due to unobserved factors. The authors also developed a method for estimating the elasticity of production functions to production factors as a way of estimating the QTFP of individual establishments. The authors suggest a methodology that draws on the elasticity of production functions and the QTFP of individual establishments to decompose the rate of growth in the entire manufacturing sector’s added value into rates of increase in production factor inputs, productivity of individual firms, and efficiency of product factor distribution. Whereas Hsieh and Klenow (2009) measured the extent of distortion of resource distribution among establishments of a given industry to estimate the gains from improving the efficiency of resource distribution, Petrin and Levinsohn (2012) estimated how establishments whose marginal productivity of production factors outweigh the marginal costs increased the use of those production factors to determine how the actual efficiency of

resource distribution contributed to improving the added value of the entire manufacturing sector. Although the authors did not decompose the contributions of those factors to increased added value of the entire manufacturing sector in this study, the method provided by Petrin and Levinsohn can be used to identify how the growth rates of establishments with different ages contributed to overall growth of the manufacturing sector. In this study, we use Levinsohn and Petrin's method to determine the contributions made by establishments with different ages to the growth of added value of the Korean manufacturing sector at different points in time.

Viewing the dispersion of RTFP, measured as the cost shares observed in the individual establishments making up specific industries, as resulting from the distortion of resource distribution at the level of establishments, Hsieh and Klenow (2009, 2014) interpreted the gap between individual establishments' RTFP and the industry-wide average as the degree of distortion of resource distribution faced by establishments. Foster et al. (2017) analyzed micro-data on American manufacturers and confirmed the high level of correlation between the QTFP and the RTFP of individual establishments as well as the positive correlation between the RTFP of establishments and the likelihood of their growth and survival. Based on this finding, the authors suggested that the dispersion of RTFP among establishments making up specific industries reflect the employment- and investment-related costs of adjustment rather than resulting from distortion in resource distribution at the establishment level. Based on an analysis of the data on a number of American manufacturing industries that admit the simultaneous observation of prices and product quantities at the level of establishments, Haltiwanger et al. (2017) also questioned the validity of interpreting that the dispersion of establishment RTFP measured in terms of cost shares should be taken to mean the distortion of establishment-level resource distribution.

## 2 Literature in Korea

Oh (2014) applied Hsieh and Klenow (2009)'s method to the Korean manufacturing sector to estimate the trend in resource distribution inefficiency.



She then compared her findings to those of Hosono and Takizawa, which applied the same approach to the Japanese manufacturing sector. Oh showed that, while there was no significant difference between the two countries with respect to resource distribution efficiency, the pace of decrease in efficiency had been more rapid in Korea since the 1990s. There has also been a trend in Korea, since 2000, toward declining rates of new establishments entering and old establishments leaving the market, and also decreasing margins by which production factors, such as capital and labor, are redistributed within specific industries. These, in other words, were evidence of the declining vitality of the Korean manufacturing sector.

Jang and Yang (2014) linked the data on financial support programs for SMEs support provided by the SBC, KODIT, and KOTEC in 2009 and the data provided by Statistics Korea's *Mining and Manufacturing Surveys* from 2007 to 2011 to analyze the effects of financial support programs for SMEs on the productivity of individual establishments. Using propensity score matching estimation and multiple linear regression, the authors found that, whichever method of estimation was used, financial support programs for SMEs provided in 2009 did increase the margins at which the productivity of individual establishments grew from between 2008 and 2011, while the size of this positive effect varied from institution to institution. From these findings, the authors propose that the Korean government explicitly switch from enhancing the outlook for enterprise survival to enhancing productivity by providing financial support programs for SMEs for SMEs.

### 3 Distinction of This Study

Whereas Oh (2014) assumes that the distribution of productivity across establishments in the manufacturing sector is given and therefore focuses attention solely on the efficiency of the distribution of production factors, this study addresses the question of what determines the distribution of establishment-level productivity first, and seeks to answer that question by analyzing changes in the growth curves of individual establishments.

Contrary to Jang and Yang (2014), which estimates the effects of financial support programs for SMEs on establishment-level productivity, this study concentrates on how financial support programs for SMEs for specific industries affects the productivity of not only individual establishments, but also the efficiency of industry-wide distribution of resources, and how that fiscal support enhances the productivity of various industries by inducing the exit of less productive establishments.

Another important respect in which this departs from other studies on factors contributing to the growth of establishments is that we, in this study, simulate the increases in productivity over time by applying the structured model on R&D investment provided by Atkeson and Burstein (2010), and thereby demonstrate the effect of change in the steepness of establishment growth curves at different points in time on the overall productivity of the manufacturing sector. Furthermore, unlike other studies, we also provide a quantitative analysis, based on our structured model, of which form of financial support programs for SMEs — whether subsidizing the operating costs that influence establishments' decision to exit the market or subsidizing the cost of exports by existing establishments — is more effective at enhancing productivity of the overall manufacturing sector.

# III

## Data & Method for Estimating Establishment-Level Productivity

### 1 Data

This study relies on the panel data on manufacturing provided by Statistics Korea's *Mining and Manufacturing Surveys*. Of the data available from Statistics Korea, spanning the years 1992 through 2014, that pertaining to the 1992-2006 period concerned establishments employing at least five paid workers, while that pertaining to 2007 and afterward concerned establishments employing at least 10 paid workers. These surveys provide detailed information on output, added value, scale of employment by type, input of raw materials / electricity / fuel / intermediary goods, stock and investment in capital goods by type, and the cost of labor (including total wages, retirement benefits and fringe benefits) at the establishment level. The survey conducted in 2010 was a manufacturing census and therefore collected data on all manufacturing establishments and not just those employing 10 or more paid workers. Even if we were to narrow down the scope of data we collect from this particular survey to establishments employing 10 or more workers, there would have been no means to ensure the consistency of age distribution between the sample of 2010 and the samples of previous years' surveys. The 2010 survey, in particular, also exhibited numerous missing data items on capital stock-related variables. We therefore excluded the sample of the 2010 survey from our analysis. In order to ensure the time-sequential consistency of samples we used, we also confined the scope

of sampling units provided by surveys from 1992 through 2006 to establishments employing at least 10 paid workers.

The most important preparation required by our empirical analysis was to provide consistency to our estimations of the length of establishment age. One way to do this was to count the number of years establishments had been in business starting in their year of establishment as indicated in the *Mining and Manufacturing Surveys*. However, over 50 percent of surveyed establishments changed their answers on when they were established as the surveys were repeated over the years. Therefore, instead of beginning the establishment ages from their claimed years of establishment, we started with the years in which each establishment began to employ 10 or more paid workers. As for establishments included in the 1992 survey—the first of the annual surveys—we screened and selected only those that provided consistent answers on their year of establishment in subsequent surveys and counted their ages from that year of establishment. As time is needed for establishments to grow to where they become able to employ 10 or more workers, our particular way of measuring their ages may run the risk of underestimation. We thus examined the changing distribution of firms by the length of age as measured in the two ways just described.

To measure individual establishment productivity, information is needed on their output as well as labor and capital inputs. For the output, we referred to the amount of added value. For capital stock, we referred to the average value of the premises, structures, machinery, and vehicles establishments owned at the beginning and end of each year. For labor input, we relied on the number of employees each year.

Analysis of distortion in resource distribution requires additional information on the costs of labor and capital. Cost of labor includes total wage, the cost of fringe benefits, and the amount used for retirement benefits. For establishments whose workers include owners and their (unpaid) family members, we calculated the average amount of wages at those establishments first by dividing their total wages by the number of paid workers they employed, and assumed that the average amount of wage had been paid to establishment owners and their family members as well. We also estimated the cost of capital by applying an annual depreciation rate of 3.5 percent—as done by Oh (2014) and Cho (2012)—to

premises and structures, and an annual depreciation rate of 17.9 percent to machinery, ships and vehicles, as well as real interest rates by year in Korea as listed by the World Bank.

It is necessary to realize the nominal variables provided by the *Mining and Manufacturing Surveys*, such as added value, intermediate inputs, capital stock, and labor costs, using appropriate deflators. For added value and intermediate inputs, we used the deflators found in the Organisation for Economic Cooperation and Development (OECD)'s Structural Analysis Database (STAN). Because there are no official statistics for the deflators of capital stock for Korean manufacturers, we resorted instead to the deflators for investment in different types of capital stock. The ratios of nominal values of different types of capital stock (non-residential buildings, transportation vehicles, and machinery) as indicated under national accounts and provided by the Bank of Korea to the real values of this stock were used as deflators. For the cost of labor, we turned to the consumer price index provided by the Bank of Korea.

As we estimated production functions for industrial subcategories (identified by three digits each) and compared the pace of growth of establishments with different ages in each given industry, it was important to apply a consistent industrial classification system (ICS) throughout the period of time under our analysis. The standard ICS in Korea, however, was changed three times during our analysis period, from 1992 to 2014. We thus used the industrial classification matching tables provided by Statistics Korea to match prior and subsequent classification systems to the Eighth ICS.

◁Table III-1▷ Changes in the Korean Standard ICS (1991-2014)

	Announced	Effective as of
6 <sup>th</sup> Update	September 9, 1991	January 1, 1992
7 <sup>th</sup> Update	February 18, 1998	February 18, 1998
8 <sup>th</sup> Update	January 7, 2000	March 1, 2000
9 <sup>th</sup> Update	December 28, 2007	February 1, 2008

Source: Statistics Korea.

## 2 Method for the Estimation of Establishment-Level Productivity<sup>4)</sup>

As one of the main objectives of our empirical analysis is to estimate the growth of productivity of individual establishments with different ages, we had to explore how we could estimate establishment-level productivity that was not readily apparent from the given data. This led us to measure the elasticity of production factors involved in establishments' production functions. In general, the production factor inputs, such as labor and capital, increase in proportion to productivity under given conditions of production. The general ordinary least square (OLS) method is therefore unable to give us unbiased estimates on their elasticity. Think of the Cobb-Douglas production function that involves labor and capital as production factors.  $y_{it}$  represents the logarithm of added value;  $l_{it}$ , the logarithm of labor input;  $k_{it}$ , the logarithm of capital input; and  $\epsilon_{it}$ , the productivity shock of establishment  $i$  at time  $t$ .

$$y_{it} = \beta_o + \beta_l l_{it} + \beta_x k_{it} + \epsilon_{it}$$

The OLS regressions for the elasticities of labor and capital,  $\beta_l$  and  $\beta_x$ , would be as follows:

$$\hat{\beta}_l = \beta_l + \frac{\hat{\sigma}_{x,x} \hat{\sigma}_{l,\epsilon} - \hat{\sigma}_{l,x} \hat{\sigma}_{x,\epsilon}}{\hat{\sigma}_{l,l} \hat{\sigma}_{x,x} - \hat{\sigma}_{l,x}^2}$$

$$\hat{\beta}_x = \beta_x + \frac{\hat{\sigma}_{l,l} \hat{\sigma}_{x,\epsilon} - \hat{\sigma}_{l,x} \hat{\sigma}_{l,\epsilon}}{\hat{\sigma}_{l,l} \hat{\sigma}_{x,x} - \hat{\sigma}_{l,x}^2}$$

Therefore, if only labor input responded to the given productivity shock with no correlation to capital, the production function would lead to a biased over-estimate of the elasticity of labor. If there were a positive correlation between labor input and capital input, and the correlation between labor and productivity was stronger than the correlation between labor and capital, the production function would lead to not only a biased over-estimate of labor

4) This section is based on Levinsohn and Petrin (2003) and Foster et al. (2017).

elasticity, but also a biased under-estimate of capital elasticity. Olley and Pakes (1996) suggested overcoming this problem of endogeneity by including variables in monotonic relations with the movement of productivity shocks and related to production factor inputs into the production function.

Let us break down the productivity shock of the current term,  $\epsilon_t$ , into  $w_t$ , representing the portion that influences production factor inputs by the given establishment during the current term, and  $n_t$ , representing the portion that does not exert such influence.

$$y_t = \beta_o + \beta_l l_t + \beta_x k_t + w_t + n_t$$

Whereas the establishment can adjust the amount of labor input at every term as it wishes, it does not have as much freedom in adjusting the amount of capital input due to the larger cost of adjustment involved. The quantity of capital stock that the establishment has at the beginning of each term would therefore form a state variable involved in the optimization of production factor inputs. In such a case, the establishment's decision to invest in capital stock may be expressed as a function of  $w_t$ , the portion of a productivity shock that influences capital and other production factor inputs.

$$i_t = i_t(w_t, k_t)$$

If  $w_t$  has a continuing effect so that, if it were high this term, the  $w_{t+1}$  for the subsequent term would also be high, the investment function of the establishment would bear a monotonic correlation of increment to  $w_t$ . In such a case,  $w_t$  may be expressed as a function of capital stock and investment, both of which are observable variables.

$$w_t = w_t(i_t, k_t)$$

Using this correlation, we may rewrite our production function as follows:

$$y_t = \beta_o + \phi_t(i_t, k_t) + n_t;$$

$$\phi_t(i_t, k_t) = \beta_o + \beta_x k_t + w_t(i_t, k_t).$$

Olley and Pakes (1996) approximates the  $\phi(\cdot)$  function of investment and productivity as a quartic polynomial equation of investment and capital, and applies the OLS regression to the first equation of estimation presented above to estimate  $l_t$ , the elasticity of the production function to labor input. In order to identify the elasticity of production to capital, one needs the additional assumption that  $w_t$  follows the first stage Markov chain. Under this assumption, the amount of capital stock that the establishment had at the beginning of the current term (already determined by the investment decisions made in previous terms), would no longer have relation to  $\xi_t$ , a productivity shock that has not been foreseen.

$$\xi_t = w_t - E[w_t | w_{t-1}]$$

Because the capital stock and the error term,  $n_t^*$ , are no longer correlated to each other, we may now apply the regression equation above to estimate the elasticity of the production function to capital.

$$y_t^* = \beta_0 + \beta_x k_t + E[w_t | w_{t-1}] + n_t^*$$

$$y_t^* \equiv y_t - \beta_l l_t, \quad n_t^* \equiv n_t + \xi_t$$

Levinsohn and Petrin (2003) suggested using the inputs of intermediate goods, such as the costs of raw materials and energy, instead of investment as control variables for productivity shocks in production functions. In general, establishments tend to make zero investment in capital stock for extended periods of time due to fixed costs, and capital stock is thus unlikely to react strongly to productivity shocks. The costs of raw materials and energy, on the other hand, involve relatively smaller costs of adjustment and generally appear as positive values in panel data on establishments for most years. Estimations based on these intermediate goods thus have the added benefit of missing less data.

The methods suggested by Olley and Pakes (1996) and Levinsohn and Petrin (2003) tend to disregard the fact that the optimal levels of labor inputs decided by establishments are themselves dependent upon the given establishments' productivity levels. Akerberg, Cavas, and Frazer (2015) therefore point out that



the elasticity of the production function to labor would not be estimated accurately in the first step of the estimation process described so far.

Wooldridge (2009) proposes a single equation of generalized method of moments (GMM) estimation that could solve the problem identified by Akerberg et al. (2015).

One of the commonly used alternative methods for estimating the elasticity of production functions, i.e., measuring the proportion of factor costs to the amount of added value, fails to yield accurate estimates of elasticity if the given production function does not satisfy the principle of constant return to scale, if there are costs of adjustment in production factor inputs that prevent static optimization, or if the market is not in a state of perfect competition. The method of estimation in Levinsohn and Petrin (2003), with a modification of Wooldridge (2009)'s method, can yield consistent elasticities even when these conditions are not satisfied.

In this study, we modify the method of Levinsohn and Petrin (2003) with the GMM estimation technique suggested by Wooldridge (2009) to estimate the elasticity of the production function of each industrial subcategory to labor and capital. As 99.7 percent of observed establishment-year combinations provide information on the cost of raw materials, we use this cost to avoid the problem of endogeneity between the unobserved productivity and production factor input decisions of establishments. Equating the number of employees with labor input and the quantities of capital stock with capital input, we estimate the elasticity of establishments' added value to labor and input. We also account for differences in the productive technologies of different industrial subcategories by estimating the elasticity of each subcategory to labor and capital. As for the distribution of diminishing returns by industrial subcategory, the mean degree of return to scale is 0.8, and the median degree, 0.79, which are larger than the range of diminishing returns to scale, 0.83 to 0.91, identified in Lee (2005). Using the elasticity of each industrial subcategory's production function to labor and capital, we estimate the logarithm of the productivity of establishment  $i$  in industry  $s$  at time  $t$  as follows:

$$\ln x_{ist} = \ln(VA_{ist}) - (\hat{\epsilon}^{L_{ist}} \ln L_{ist} + \hat{\epsilon}^{K_{ist}} \ln K_{ist}).$$

## IV

### **Factor Decomposition Analysis: Manufacturing & the Growth of Added Value**

Petrin and Levinsohn (2012) provided a method, based on manufacturing micro-data, for decomposing the rates of increase in the manufacturing sector's added value into contributions from production factors, the growing productivity of individual establishments, and the efficiency of production factor distribution. We applied this method to our analysis of the Korean manufacturing sector to determine which factors and aspects should be regarded in understanding the trend of change in the Korean manufacturing sector's added value. By dividing the establishments subject to our analysis into two groups—those with less than five years of age and others with five years or more—we were able to quantify the contributions made by relatively newer establishments to each aspect of added-value growth across the entire sector.

Applying this method requires establishment-level data on added value, labor inputs, capital inputs, labor costs, capital costs, and productivity. As the sample from 2010 carries a significant amount of missing data concerning capital, we exclude it from our analysis. In addition, we also excluded the rate of increase observed in 2011 to maintain consistency in the time series through which the rates of increase were observed.

Levinsohn and Petrin's decomposition method can be described as follows:

$$\begin{aligned} \sum_i \bar{D}_{i,t} \Delta \ln VA_{i,t} = & \sum_i \bar{D}_{i,t} (\bar{s}_{i,l,t} \Delta \ln L_{i,t} + \bar{s}_{i,k,t} \Delta \ln K_{i,t}): \text{Rate of increase in} \\ & \text{labor and capital inputs} \\ & + \sum_i \bar{D}_{i,t} \Delta \ln x_{i,t}: \text{Rate of increase in productivity} \\ & + \sum_i \bar{D}_{i,t} (\epsilon_l^j - \bar{s}_{i,l,t}) \Delta \ln L_{i,t} + \epsilon_k^j - \bar{s}_{i,k,t}) \Delta \ln K_{i,t}: \text{Rate of} \\ & \text{increase in efficiency of production factor distribution} \end{aligned}$$

Where:

- $\epsilon_l^j$ : Elasticity of the production function of establishments belonging to industrial subcategory, “j,” to labor
- $\epsilon_k^j$ : Elasticity of the production function of establishments belonging to industrial subcategory, “j,” to capital
- $\ln x_{i,t} = \ln(VA_{i,t}) - (\epsilon_l^j \ln L_{i,t} + \epsilon_k^j \ln K_{i,t})$ : Productivity of establishment “i” in industrial subcategory “j”
- $\bar{D}_{i,t}$ : Mean share of establishment “i” in the amount of added value across the manufacturing sector at times “t-1” and “t.”
- $\bar{s}_{i,l,t}$ : Mean value of establishment “i”’s labor cost as a share of added value at times “t-1” and “t.”
- $\bar{s}_{i,k,t}$ : Mean value of establishment “i”’s user cost of capital as a share of added value at times “t-1” and “t.”
- $(\epsilon_l^j - \bar{s}_{i,l,t})$ : A measure of the disparity between the marginal productivity and the marginal cost of labor at establishment “i” at time “t.”
- $(\epsilon_k^j - \bar{s}_{i,k,t})$ : A measure of the disparity between the marginal productivity and the marginal cost of capital at establishment “i” at time “t.”

Petrin and Levinsohn (2012)’s method departs from the methods provided by Baily et al. (1992) and Hsieh and Klenow (2009). Whereas Hsieh and Klenow sought to estimate the benefits of increasing the efficiency of a virtual distribution of resources where the distortion of resource distribution among actual establishments converged upon the industry-wide average, Petrin and Levinsohn’s interest lay in estimating the contributions made by the actual efficiency of resource distribution to the increase in the manufacturing sector’s added value at a given time by analyzing whether establishments, whose marginal

productivity of production factors outweighs marginal costs, did actually increase the use of those factors. Baily et al. used the weighted productivity of individual establishments to estimate the efficiency of resource distribution across the industry. Petrin and Levinsohn, in contrast, uses the disparity between marginal productivity, on the one hand, and marginal cost, on the other, of production factors as weights. If we assume, as the theory holds, that individual establishments bring the marginal productivity of their production factor inputs on a par with the marginal cost on average irrespective of their productivity levels,<sup>5)</sup> Baily et al.'s method of estimating increases in the efficiency of production factor distribution would always yield positive estimates of increases in added value because their model assumes no distortion of production factor distribution, regardless of the differences in establishment-level productivity, and therefore assumes production factors would be redistributed even in the absence of the inefficiency of resource distribution.

[Figure IV-1] shows the decomposition of the rate of growth in the Korean manufacturing sector's added value into parts played by increases, respectively, in production factor inputs, productivity, and the efficiency of production factor distribution.

From 1993 to 2009, the real added value of the manufacturing sector achieved a cumulative growth rate of 91 percent, 81 percentage points of which came from the increased productivity of establishments. The cumulative rates of increase attributable to labor, capital, and the efficiency of resource distribution were -18 percent, 17 percent, and 11 percent, respectively. In other words, the Korean manufacturing sector's added value grew mostly thanks to the increased productivity of individual establishments.

After the establishments were divided into those less than five years in operation and those in operation longer, the former emerged as having contributed 59 percentage points to the cumulative rate of growth in the sector-wide added value, while the latter contributed 32 percentage points.

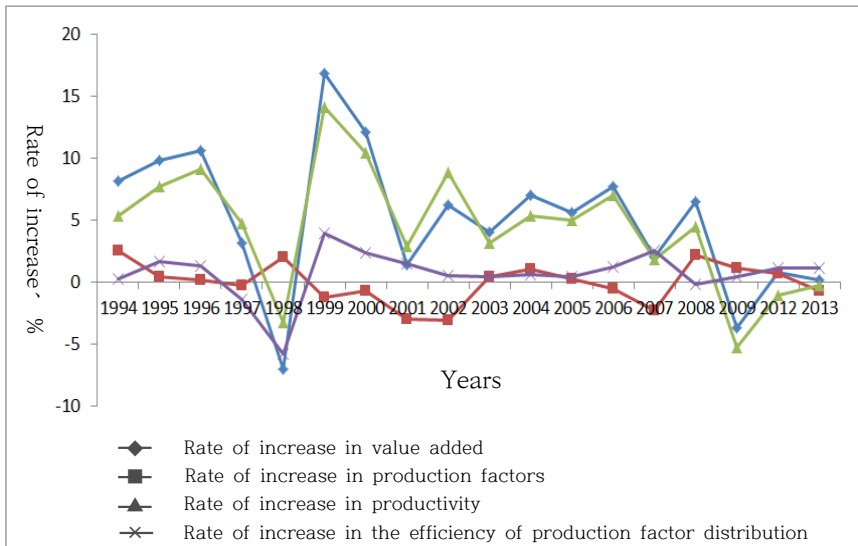
In sum, the increases in establishment productivity have been the most

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5) Where there exists the cost of adjusting labor and capital, the static first order condition for production factor inputs would not arise in every term, but would hold only on average in the intermediate to long run.

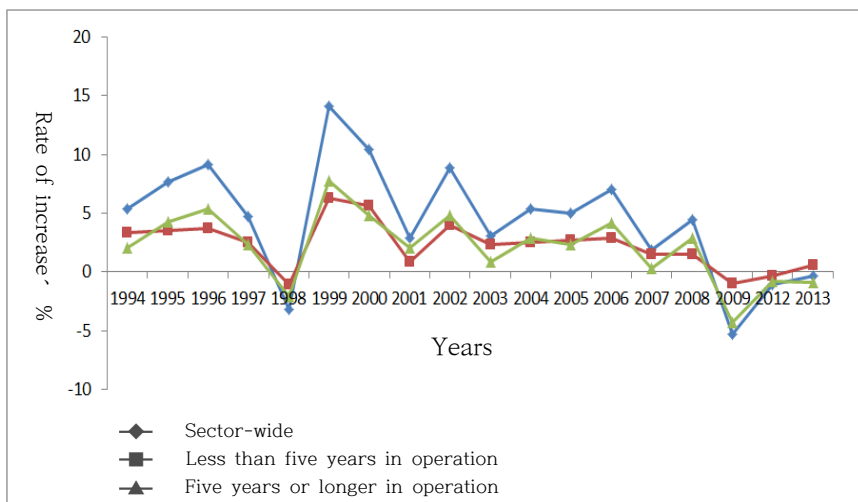
important factor of increase in the Korean manufacturing sector's added value, and relatively newer establishments with less than five years of age played just as important a role, if not more, than older ones in leading this increase. This suggests the need to understand how the effect of longer ages on establishment productivity impacts not only establishment behavior, but also the growth of the entire manufacturing sector.

**[Figure IV-1] Factor Decomposition of the Rates of Growth in Added Value by the Korean Manufacturing Sector**



Note: The sector-wide unit is percentage, while the unit for establishments is percentage point.  
Source: Based on Statistics Korea's *Mining and Manufacturing Surveys*.

**[Figure IV-2] Decomposition of the Rates of Growth in Added Value by the Korean Manufacturing Sector: Newer Vs. Older Establishments**



Note: The sector-wide unit is percentage, while the unit for establishments is percentage point.  
Source: Based on Statistics Korea's *Mining and Manufacturing Surveys*.

# V

## Estimating Pace of Growth by the Length of Establishment Age

### 1 Pace of Growth by the Length of Establishment Age at Different Times

Factors known to affect the growth of establishments include the entrepreneurial competency of the owners, technological structure of the market at the time of entry, available types of external financial resources, and so forth. These are idiosyncratic factors of establishments that were not directly observed in studies like the *Mining and Manufacturing Surveys*. In this section, we attempt to estimate the effects of establishment-level productivity, added value, employment scale, labor cost, and capital histories on the growth of establishments by controlling for these unobserved factors and estimating fixed effects using the panel structure of the *Mining and Manufacturing Surveys*.

To examine changing rates of growth of establishments with different ages in recent years, we divided the sample period, 2001 to 2014, into two segments (2001 to 2007 vs. 2008 to 2014, with 2010 excluded) to see how the onset of the global financial crisis in the late 2000s affected the rates of establishment growth. The reason we divided the sample period into two parts with the year 2008 in the middle is because the information on varying amounts of financial support programs for SMEs for SMEs that we were able to access concerned the years 2008 through 2012. The year 2008 thus appeared to be an appropriate point from which we could focus on the differences created by financial support

programs for SMEs in the growth of manufacturing establishments in Korea.

The basic regression model involved regressing the interest variables, i.e., productivity, added value, employment level, labor costs, and capital costs, to ages, squares of ages, establishments and the fixed effects of years.

$$\ln x_{i,t} = \beta_1 age_{i,t} + \beta_2 age_{i,t}^2 + \theta_i + \mu_t + \epsilon_{i,t}$$

To examine whether the lengths of ages affected the growth of establishments differently at different points in time, we applied the regression model to different periods to compare the coefficients of ages and their squares. We also included the interaction terms of ages, squares of ages, and dummy variables for interest timelines into our regression model to test the statistical significance of differences in growth rates over time. The main reason for using these two methods to test the findings of our analysis is as follows. We examined the changes in the coefficient of fixed effects as applying to time-dependent dummy variables with the expectation that, unlike in the general linear regression analysis, basing estimates on dummy variables, on the one hand, and applying interaction terms between dummy variables and interest variables, on the other, would lead to different coefficients. The latter implies the assumption that the differences of idiosyncratic effects would be the same on all establishments in both periods, 2001 to 2007 and 2008 to 2014. Separating estimates according to period, however, would be free of such a condition. As a result, the ages of establishments would exert quite different effects on interest variables.

In light of the fact that the distribution of ages varied significantly between the two periods and that the rates of growth tended to be higher for relatively newer establishments, we measured the growth rates of only establishments that had been zero to 15 years in operation in each given period.

<Table V-1> lists the estimates on productivity increases in proportion to age. <Table V-2> compares those estimates to increases in added value.

<Table V-1> shows that, irrespective of the period, the length of age has a statistically significant positive value at a one-percent level, while the square of ages has a statistically significant negative value at a one-percent level. In other words, as establishments grow older, their productivity increases, but the



rate of that increase slows over time. If we consider the linear effect of age only, increasing age by one year led to a 5.6-percent increase in productivity during 2001 through 2007, but the rate dropped to 2.7 percent in 2008 and afterward. The pace of increase in establishment productivity associated with age thus slowed in 2008 and afterward. When the interaction term between the dummy variable of 2008 and ages is added to the regression model, the rate of productivity increase was reduced by 3.1 percentage points or so, with the disparity between the two periods retaining statistical significance at a one-percent level.

〈Table V-1〉 Effects of Age on Productivity, 2001-2014

	(1)	(2)	(3)	(4)
Age	0.0391** -0.0013	0.0559** -0.0018	0.0268** -0.0039	0.0544** -0.0016
Age <sup>2</sup>	-0.0024** -0.0001	-0.0034** -0.0001	-0.0017** -0.0001	-0.0034** -0.0001
1[year ≥ 2008] × age				-0.0307** -0.0017
1[year ≥ 2008] × age <sup>2</sup>				0.0022** -0.0001
N	611587	344808	266779	611587
Adj. R <sup>2</sup>	0.061	0.076	0.01	0.062
Sample period	2001–2014 (2010 excl.)	2001–2007	2008–2014 (2010 excl.)	2001–2014

Notes: (1) \*p < 0.05, \*\*p < 0.01. Figures in parentheses indicate standard deviations.

(2) Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

In the simple linear model, the effect of ages on increases in added value amounted to 9.6 percent prior to 2008, but dropped five percentage points to 4.6 percent in 2008 and afterward.

〈Table V-2〉 Effects of Age on Added Value, 2001-2014

	(1)	(2)	(3)	(4)
Age	0.0716** -0.0017	0.0955** -0.0023	0.0456** -0.0045	0.0936** -0.002
Age <sup>2</sup>	-0.0041** -0.0001	-0.0056** -0.0001	-0.0031** -0.0001	-0.0056** -0.0001
1[year ≥ 2008] x age				-0.0463** -0.002
1[year ≥ 2008] x age <sup>2</sup>				0.0033** -0.0001
N	611587	344808	266779	611587
Adj. R <sup>2</sup>	0.11	0.106	0.036	0.111
Sample period	2001-2014 (2010 excl.)	2001-2007	2008-2014 (2010 excl.)	2001-2014

Notes: (1) \*p < 0.05, \*\*p < 0.01. Figures in parentheses indicate standard deviations.  
(2) Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

## VI

### Effects of Financial Support Programs for SMEs on Manufacturing Productivity<sup>6)</sup>

We merged the data on financial support programs for SMEs support provided by KODIT, KOTEC, and the SBC for manufacturing establishments across various industrial subcategories from 2008 to 2012 with data from the *Mining and Manufacturing Surveys* and examined how financial support programs for SMEs influenced the growth of establishments with different ages in each industrial subcategory. In addition, we analyzed the effect of financial support programs for SMEs on the elasticity of productivity to distortions in the production factor distribution and also on the correlation between exit by less productive establishments and productivity of the manufacturing sector, with a view to identifying the paths by which financial support programs for SMEs may distort establishments' investment in enhancing productivity.

We divided the establishments of each industrial subcategory into five quintiles according to the gross sum of the financial support programs for SMEs received by that subcategory or the gross sum of the financial support programs for SMEs provided by each financing institution from 2008 to 2012. We then measured the difference in the rates of growth shown by these establishments in 2001 through 2007, on the one hand, and 2008 through 2014 (2010 excluded), on the other, in relation to the lengths of their ages. We then examined whether the sum of financial support programs for SMEs provided by the three financing

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6) Special thanks to Dr. Woohyeon Jang, junior research fellow at the KIPF, who shared the details of financial support programs for SMEs for industrial subcategories.

institutions affected the paces of decrease in establishment growth rates in and around 2008 differently.<sup>7)</sup>

Based on the conclusion of earlier studies that financial support programs for SMEs was primarily focused on improving SME survival rates, we also sought to analyze whether financial support programs for SMEs weakened the correlation between productivity and market exit. If financial support programs for SMEs had been concentrated in less productive (and therefore more likely-to-exit) establishments, the likelihood of establishments to exit the market would have grown weaker as the productivity of establishments grew under a logit regression model designed to explain the likelihood of exit with the observable idiosyncrasies of establishments under control. On the basis of this assumption, we set out to determine whether the coefficients of productivity in our logit regression model that was designed to explain the likelihood of exit by quintile changed at different rates in and around 2008.<sup>8)</sup>

Furthermore, to examine whether financial support programs for SMEs weakened the choice effect of exit and strengthened the distortion of production factor distribution, we also analyzed whether the elasticity of productivity to production factor inputs changed in each quintile, and if so, at what pace, in and around 2008.

## Trend in Financial Support Programs for SMEs

In an effort to alleviate the financial burden on cash-strapped SMEs around the onset of the global financial crisis in 2008, the Korean government radically increased the amount of financial support programs for SMEs available for SMEs in 2009, including policy loans from the SBC and credit from KODIT and KOTEC.

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7) See the Appendix for the findings of our analysis of the effect of financial support programs for SMEs provided by each financing institution on each quintile.

8) The coefficients in such a logit regression model represent log odds ratios.

〈Table VI-1〉 Trend in Financial Support Programs from Major Sources

Unit: KRW trillion

Source	SBC		KODIT		KOTEC	
Year	Total	Loans	Total	New	Total	New
2006	3.3	3.2	29.6	9.1	10.6	2.8
2007	3.3	3.1	29.6	8.5	11.1	3.7
2008	3.3	3.1	30.3	9.3	12.7	4.4
2009	6.2	5.9	45.6	17.7	17.6	8.2
2010	3.5	3.3	44.7	10.2	16.9	4.8
2011	3.5	3.4	43.5	9.3	16.9	4.1
2012	3.8	3.6	42.5	9.9	18.1	5.2

Sources: Annual business reports of 2010 and 2012 from each institution.

Note that the Korean government not only increased the sheer amounts of financial support programs for SMEs available, but also loosened the related eligibility criteria. In 2009, the SBC, for example, loosened the eligibility criteria of the Workspace Security Loans, Unregistered Factory Support, and Loan-Limiting Debt Ratios. KODIT, too, raised the ceiling on the amounts of loans to be guaranteed, loosened the revenue restrictions on loan amounts, raised the guarantee rates, reduced the rigor of criteria requiring guarantee investigations, loosened criteria applying to enterprises with poor credit ratings, and extended the grace periods on all loans and guarantees that were originally supposed to mature by the end of 2009. Such increases in financial support programs for SMEs for establishments that would not have survived on their own without such support may have increased the likelihood of less productive establishments to survive in the market by weakening their incentive to invest more vigorously in enhancing productivity.

## 2 Effects of Financial Support Programs for SMEs on the Growth of Manufacturing Establishments

As our main interest lay in whether financial support programs for SMEs for SMEs increased the productivity and growth of manufacturing establishments in the intermediate to long run, we regrouped establishments into subcategories according to the total amount of financial support programs for SMEs they received in 2008 through 2012 and examined whether the productivity of establishments that received financial support programs for SMEs grew at a more dramatic pace than that of establishments that did not receive financial support programs for SMEs in 2001 through 2007. The findings of another analysis on whether the varying amounts of financial support programs for SMEs provided by different institutions—the SBC, KODIT, and KOTEC—made any difference to the rates of growth are provided in the Appendix. We sought to measure the impact of financial support programs for SMEs on the added value, productivity, number of employees, unit labor costs, and capital of establishments, which had been divided into five quintiles according to the amounts of financial support programs for SMEs they received from 2008 to 2012.

We first examined the margins of decrease in the growth rates of establishments in the top and bottom quintiles according to age. The establishments in the bottom quintile saw their amount of added value drop by 3.8 percentage points, while those in the top quintile saw theirs drop by 5.2 percentage points. Productivity, too, decreased by 2.1 percentage points in the bottom quintile as opposed to a 3.3-percentage-point drop in the top quintile. The bottom quintile's number of employees decreased by 1.6 percentage points while the top quintile's decreased by 1.7 percentage points. Finally, the bottom quintile's capital shrank by 5.3 percentage points as opposed to the 4.9-percentage-point decrease in the top quintile's.

The relatively larger drop in the added value of establishments belonging to the top quintile in terms of the amounts of financial support programs for SMEs received compared to the bottom quintile can be explained as an outcome of the significant drop in the productivity increase rates rather than reduction in the production factor inputs (labor and capital). This suggests that financial

support programs for SMEs, provided from 2008 to 2012, could well have disincentivized establishments from investing in increasing their productivity.

**〈Table VI-2〉 Changing Rates of Increase in the Added Value of Establishments After Policy Introduction in 2008 (2001-2014)**

	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Age	0.0936** (0.0020)	0.0875** (0.0079)	0.0872** (0.0131)	0.0988** (0.0057)	0.0848** (0.0040)	0.0960** (0.0028)
Age <sup>2</sup>	-0.0056** (0.0001)	-0.0053** (0.0004)	-0.0055** (0.0007)	-0.0057** (0.0003)	-0.0049** (0.0002)	-0.0058** (0.0001)
1[year ≥ 2008] x age	-0.0463** (0.0020)	-0.0377** (0.0078)	-0.0402** (0.0137)	-0.0456** (0.0058)	-0.0386** (0.0039)	-0.0515** (0.0026)
1[year ≥ 2008] x age <sup>2</sup>	0.0033** (0.0001)	0.0027** (0.0005)	0.0027** (0.0009)	0.0033** (0.0004)	0.0028** (0.0003)	0.0036** (0.0002)
N	611587	36282	17340	78357	140228	339380
Adj. <i>R</i> <sup>2</sup>	0.111	0.080	0.093	0.062	0.070	0.139

Notes: 1. \**p* < 0.05, \*\**p* < 0.01. Figures in parentheses indicate standard deviations.

2. Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

**〈Table VI-3〉 Changing Rates of Increase in Establishment Productivity According to Amount of Policy Finance Received In & After 2008 (2001-2014)**

	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Age	0.0544** (0.0016)	0.0510** (0.0065)	0.0633** (0.0097)	0.0579** (0.0045)	0.0498** (0.0032)	0.0557** (0.0022)
Age <sup>2</sup>	-0.0034** (0.0001)	-0.0032** (0.0003)	-0.0040** (0.0006)	-0.0036** (0.0002)	-0.0031** (0.0002)	-0.0035** (0.0001)
1[year ≥ 2008] x age	-0.0307** (0.0017)	-0.0214** (0.0069)	-0.0395** (0.0117)	-0.0292** (0.0049)	-0.0259** (0.0035)	-0.0329** (0.0023)
1[year ≥ 2008] x age <sup>2</sup>	0.0022** (0.0001)	0.0017** (0.0004)	0.0029** (0.0007)	0.0022** (0.0003)	0.0019** (0.0002)	0.0023** (0.0001)
N	611587	36282	17340	78357	140228	339380
Adj. <i>R</i> <sup>2</sup>	0.062	0.048	0.055	0.044	0.049	0.072

Notes: 1. \**p* < 0.05, \*\**p* < 0.01. Figures in parentheses indicate standard deviations.

2. Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

### 3 Effects of Financial Support Programs for SMEs on the Correlation Between Establishment Exit & Productivity

We shall now see whether the log odds ratios on the likelihood of exit due to under-productivity, as featured in our logit model on the likelihood of manufacturing establishment exit from the market, changed in and after 2008 as a result of the financial support programs for SMEs received by establishments. The goal is to determine whether financial support programs for SMEs for SMEs has indeed weakened the effect of paths leading to the choice of exit.

<Table VI-4> lists the findings of our logit regression analysis on industries categorized according to the sums of financial support programs for SMEs they received. In all quintiles of industries, we can see that the likelihood of exit decreases as productivity rises. Our focus should be on how the interaction term between dummies and productivity changed in response to the different amounts of financial support programs for SMEs provided in and after 2008. The table shows that, while different levels of productivity failed to exert a statistically significant effect on the likelihood of exit around 2008 in the first three quintiles, the effect of rising productivity on increasing the likelihood of exit grew significantly weaker in the fourth and fifth quintiles that received relatively larger amounts of financial support programs for SMEs in 2008 and afterward. As financial support programs for SMEs was provided mainly to increase the survival rate of establishments, industries that received large amounts thereof tended to see more establishments survive in the market regardless of a drop in or stagnation of their productivity.

If financial support programs for SMEs enables less productive establishments to survive, the productivity gap between establishments remaining in the market and those that exit would decrease, lowering the average level of productivity among establishments. Moreover, such financial support programs for SMEs could discourage or disincentivize establishments, through diverse indirect channels, from investing more rigorously in enhancing productivity. Financial support programs for SMEs, in other words, may be a major reason for the relatively greater margin of decrease in the productivity of companies that have benefitted more from financial support programs for SMEs than others.



**〈Table VI-4〉 Correlations between Productivity & the Likelihood of Exit After the Introduction of Financial Support Programs for SMEs in 2008 (2001-2014)**

	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Productivity	-0.3303** (0.0072)	-0.3579** (0.0249)	-0.2168** (0.0356)	-0.2724** (0.0194)	-0.3313** (0.0136)	-0.3833** (0.0107)
1[year ≥ 2008] x productivity	0.0519** (0.0112)	-0.0137 (0.0501)	-0.0029 (0.0595)	0.0160 (0.0314)	0.0588** (0.0209)	0.0961** (0.0162)
Labor	-0.6133** (0.0110)	-0.4458** (0.0354)	-0.6658** (0.0705)	-0.6431** (0.0280)	-0.6758** (0.0232)	-0.6168** (0.0156)
Capital	-0.2154** (0.0033)	-0.1496** (0.0105)	-0.2309** (0.0201)	-0.1751** (0.0088)	-0.2080** (0.0064)	-0.2220** (0.0050)
Age	-0.0263** (0.0009)	-0.0155** (0.0028)	-0.0251** (0.0041)	-0.0223** (0.0023)	-0.0297** (0.0019)	-0.0302** (0.0014)
1[year ≥ 2008] x labor	0.1809** (0.0169)	-0.1423 (0.0824)	0.1656 (0.1108)	0.1873** (0.0474)	0.1651** (0.0379)	0.2240** (0.0222)
1[year ≥ 2008] x capital	0.0576** (0.0047)	0.0111 (0.0205)	0.0553 (0.0291)	0.0364** (0.0132)	0.0717** (0.0094)	0.0530** (0.0068)
1[year ≥ 2008] x age	-0.0370** (0.0017)	0.0439** (0.0065)	-0.0196* (0.0077)	-0.0274** (0.0042)	-0.0334** (0.0034)	-0.0385** (0.0024)
N	682756	41216	21322	88427	156035	375756

Notes: 1. \*p < 0.05, \*\*p < 0.01. Figures in parentheses indicate standard deviations.

2. Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

#### 4 Effects of Financial Support Programs for SMEs on the Correlation Between Distortion of Production Factor Distribution & Productivity

Hsieh and Klenow (2014) showed that, for Mexican and Indian manufacturing establishments, increases in technological productivity tended to accompany more severe distortions in production factor inputs than was the case in the United States. The authors concluded that this was because Indian and

Mexican establishments faced less expected returns on investment in productivity, and therefore increased their productivity and optimal production scales less than their American counterparts. In this study, we, too, empirically analyzed whether there were any correlations between the productivity of Korean establishments, on the one hand, and the distortion of production factor inputs, such as labor and capital, on the other. In doing so, however, we had to determine how to measure the sizes of distortions as faced by individual establishments. The method offered by Hsieh and Klenow (2009, 2014) assumes the dispersion of RTFP throughout a given industry, measured in terms of the share of the production factor costs observed at the level of establishments, as reflecting the distortion of resource distribution experienced by establishments, and therefore equates the disparity between individual establishments' RTFP and the industry average RTFP with the distortion of resource distribution. Foster et al. (2017), based on their analysis of micro-data on American manufacturers, revealed a significant correlation between the QTFP and the RTFP of individual establishments as well as a strong positive correlation between establishments' RTFP and their likelihood of survival and growth. Drawing upon this finding, Foster et al. suggest that the dispersion of RTFP within a given industry should be interpreted not as an outcome of resource distribution at the establishment level, but as reflecting the presence of the costs of adjustment concerning employment and investment.

Acknowledging these criticisms, we, in this study, sought to measure the sizes of distortions in production factor distribution at the establishment level not by employing Hsieh and Klenow's method, but using the method from Petrin and Levinsohn (2012) instead. Using elasticity of the establishment-level production functions to labor and capital as a measure of the marginal productivity of those factors, and substituting the cost share of production factors in added value for their marginal cost, we use the difference between marginal productivity and marginal costs at the establishment level as the size of distortion in production factor distribution faced by establishments. If no such distortions existed in a given industry, individual establishments, in theory, would inject the quantities of production factors that bring the average marginal productivity and the average marginal costs into alignment irrespective of their productivity levels. In this theoretical situation, therefore, no correlation would exist between

establishments' productivity levels and the distortion of resource distribution. However, where there are regulatory measures disadvantaging relatively more productive establishments or where there are subsidies advantaging relatively less productive ones, establishments with high levels of productivity would face greater distortion of resource distribution. If the distortion of production factor inputs were to increase in proportion to establishment productivity, establishments would lose the incentive to invest in R&D and productivity. As a result, the pace of increase in establishment productivity would decrease as establishments grow older.

We may estimate the elasticity of each industrial subcategory's productivity to the distortion of production factor inputs. Let us first calculate the difference, at the establishment level, between the marginal productivity of labor and capital (i.e., the elasticity of the added value of each industry's production function to labor and capital) and the marginal costs thereof (i.e., the share of the costs of labor and capital in added value). Let us then apply the pooled OLS and fixed-effect model, as shown below, to the differences to measure the elasticity of establishments to the industry-wide average level of productivity.

$$\ln\left(\frac{\epsilon_j^{L_j}}{s_{i,j,t}^{L_j}}\right) = \beta_j^{L_j} \left( \frac{\ln x_{i,j,t}}{E_j[\ln x_t]} \right) + \mu_t + \epsilon_{i,t} : \text{Pooled OLS}$$

$$\ln\left(\frac{\epsilon_j^L}{s_{i,j,t}^L}\right) = \beta_j^L \left( \frac{\ln x_{i,j,t}}{E_j[\ln x_t]} \right) + \delta_i + \mu_t + n_{i1} : \text{Fixed-effect}$$

Where:

- $s_{i,j,t}^L$ : Labor cost share in the added value of establishment "i" in industry "j" at time "t"
- $E_j[\ln x_t]$ : Mean logarithm of the productivity of establishments in industry "j" at "t"
- $\beta_j^{L_j}$ : Elasticity of the distortion of labor distribution in industry "j" to productivity

The productivity of individual establishments may rise without changing their respective productivity ranks within the given industry. Therefore, the more suitable method for measuring the efficiency of resource distribution is to use the pooled OLS, which reveals the difference of productivity between establishments on cross sections.

The elasticity of productivity to distortion in labor inputs decreased by 0.06 percentage point in the first quintile, but increased by 0.01 percentage point in the fifth quintile in and around 2008. In other words, more productive establishments in industries that received relatively larger sums of financial support programs for SMEs faced greater distortion in labor inputs. The elasticity of productivity to distortion in capital inputs decreased by 0.13 percentage point in the first quintile, but did not change significantly in the fifth quintile in and around 2008. Because the direction of change was inconsistent across quintiles, it is difficult to determine how financial support programs for SMEs affected the correlation between elasticity of productivity and distortion in capital inputs.

〈Table VI-5〉 **Effect of Financial Support Programs for SMEs in 2008 & Afterward:  
Correlation Between Labor Distortion & Productivity (2001-2014):  
Pooled OLS**

	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Relative productivity	0.5325** (0.0023)	0.5809** (0.0085)	0.5433** (0.0123)	0.5265** (0.0059)	0.5416** (0.0041)	0.5228** (0.0033)
1[year ≥ 2008] x productivity	-0.0047 (0.0027)	-0.0661** (0.0116)	-0.0063 (0.0136)	0.0005 (0.0074)	-0.0256** (0.0053)	0.0108** (0.0038)
N	697779	41908	22013	90043	158825	384990
Adj. $R^2$	0.473	0.468	0.511	0.492	0.488	0.463

Notes: 1. \*p < 0.05, \*\*p < 0.01. Figures in parentheses indicate standard deviations.

2. Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

**〈Table VI-6〉 Effect of Financial Support Programs for SMEs in 2008 & Afterward:  
Correlation Between Labor Capital & Productivity (2001-2014):  
Pooled OLS**

	Overall	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Relative productivity	0.6475** (0.0054)	0.7665** (0.0200)	0.5451** (0.0296)	0.6480** (0.0135)	0.6977** (0.0105)	0.6178** (0.0073)
1[year ≥ 2008] x productivity	-0.0176** (0.0059)	-0.1264** (0.0264)	0.0526* (0.0266)	0.0214 (0.0161)	-0.0638** (0.0120)	0.0025 (0.0081)
N	699137	41961	22068	90182	159142	385784
Adj. $R^2$	0.123	0.141	0.139	0.138	0.142	0.109

Notes: 1. \*p < 0.05, \*\*p < 0.01. Figures in parentheses indicate standard deviations.

2. Fixed effects of years are included.

Source: Based on the *Mining and Manufacturing Surveys*.

# VII

## Effects of Establishment-Level Productivity on the Manufacturing Sector: A Structured Model Analysis

Atkeson and Burstein (2010)'s industrial equilibrium model, in which the rates of increase in establishment productivity are determined endogenously through optimization and innovation of the production process, assumes that establishment decisions on whether to export are also determined endogenously by the maximization of profits. This model thus provides an apt tool with which we may analyze increases in the productivity of Korean manufacturing establishments, which are largely dependent on exports. In this chapter, we apply Atkeson and Burstein (2010)'s model to the findings of our earlier empirical analyses to determine the extent the decreasing rate of increase in the productivity of manufacturing establishments affected productivity and output of the entire manufacturing sector in Korea.

### 1 Description of the Model Economy<sup>9)</sup>

Let us imagine an economy consisting of two countries.<sup>10)</sup> The households of each country supply hours of labor in the units of  $L$ . The end goods produced in each country are not traded, but are used only by domestic households or

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9) This section is based on Atkeson and Burstein (2010).

10) Variables pertaining to the external country are marked by asterisks.

as factors of production for research goods. Intermediate goods, dispersed continually, are used to produce end goods. The intermediate goods production market is a structure of monopolistic competition. The countries trade intermediate goods, but such trade involves fixed costs. The productivity of establishments producing intermediate goods is determined endogenously by the decision by those establishments to invest in process innovation. The number of establishments producing intermediate goods at the level of the economy is determined by the exit of existing establishments and the decision of new ones to enter the production market through product innovation. Establishment investment in process innovation, the cost of product innovation by new entrants, the fixed operating costs of existing establishments, and the fixed costs of exports are all paid for in research goods. The research goods of each country are produced using the labor and end goods available on the given country's competitive market and may not be traded for the goods of the other.

The state variables concerning the heterogenous distributions of intermediate goods producers are productivity ( $z$ ) and the amount of fixed cost ( $n_y$ ) involved in exports. Let  $\delta$  refer to the vector ( $z, n_y$ ) of establishments' state variables. The production function of intermediate goods producers with labor as the sole production factor and with productivity at  $z$  would be as follows:

$$y = eXD(z)^{1/(\rho-1)}\xi$$

For the producer to continue to do business on the market, it must pay  $n_f$ -amount of fixed cost in research goods every term. The producer may sell its products to a domestic manufacturer of end goods or to a foreign manufacturer of end goods. If the producer wants to export its products, it must pay  $n_f$ -amount of fixed cost in research goods. The percentage of products exported by producers is determined by parameter  $L$ . In order to sell  $\hat{a}$  units of products abroad, the producer must export the  $D\hat{a}$ -amount or quantity of products. Where  $L$  is greater than 1, exporting establishments are exporting 50 percent or less of their products abroad.  $L$ , in such a situation, may be taken as the variable cost of exports. Where  $L$  is smaller than 1, exporting establishments are exporting more than 50 percent of their products abroad. In such a situation,  $L$  may be taken as the foreign demand for imported products. The size of parameter  $L$

is determined by the percentage of exports in the manufacturing sector's output and also by the exporting establishments' share of total employment in the given manufacturing sector.

Let  $x_t(\delta)(x_t(\delta) = 1$  denotes export) serve as the indicator variable indicating an establishment's decision, with state variable  $\delta$ , on whether to export at time  $t$ . As a producer of domestic intermediate goods, the producer,  $\delta$ , must satisfy the following condition:

$$a_t(\delta) + x_t(\delta)Da^*(\delta) = y_t(\delta)$$

With  $b_t(\delta)$  representing the goods exported by a foreign manufacturer of intermediate goods, the foreign manufacturer,  $\delta$ , must satisfy the following condition:

$$x_t(\delta)Db_t(\delta) + b_t(\delta) = y_t(\delta)$$

If the distribution of state variables among domestic establishments can be expressed as  $M_t(z, n_x)$ , and that of foreign establishments as  $M_t^*(z, n_x)$ , the end goods,  $Y_t$ , that are produced domestically using domestic and re-imported domestic goods and with a production function of a constant scale can be expressed as follows:

$$Y_t = \left[ \sum_{n_x} \int a_t(z, n_x)^{1-1/\rho} M_t(z, n_x) dz + \sum_{n_x} \int x_t^*(z, n_x) b_t(z, n_x)^{1-1/\rho} M_t^*(z, n_x) dz \right]^{\rho/(1-\rho)}$$

The price of domestic end goods and the demand curves for domestic and imported intermediate goods necessary to produce those domestic end goods can be written as follows:

$$P_t = \left[ \sum_{n_x} \int p_{at}(z, n_x)^{1-\rho} M_t(z, n_x) dz + \sum_{n_x} \int x_t^*(z, n_x) p_{bt}(z, n_x)^{1-\rho} M_t^*(z, n_x) dz \right]^{1/(1-\rho)}$$

$$\text{and } \frac{a_t(\delta)}{Y_t} = \left[ \frac{p_{at}(\delta)}{P_t} \right]^{-\rho} \quad \text{and} \quad \frac{b_t(\delta)}{Y_t} = \left[ \frac{p_{bt}(\delta)}{P_t} \right]^{-i}$$



The research goods in one country are produced with the Cobb-Douglas production function,  $L^\lambda Y^{(1-\lambda)}$ , of a constant scale, and using labor and domestic end goods as production factors. Once we regularize the price of end goods as 1 on the basis of the cost minimization condition implied by the given production function and the research goods as a numeraire, the wage and the price of end goods in the given economy would be determined as follows:

$$\frac{\lambda}{1-\lambda} \frac{Y_{rt}}{L_{rt}} = \frac{W_t}{P_t}, \quad \frac{\lambda}{1-\lambda} \frac{Y^{*}_{rt}}{L^{*}_{rt}} = \frac{W^{*}_t}{P^{*}_t} \quad \text{and}$$

$$1 = \lambda^{-\lambda} (1-\lambda)^{-(1-\lambda)} (W_t)^\lambda (P_t)^{1-\lambda},$$

$$W^{*}_{rt} = \lambda^{-\lambda} (1-\lambda)^{-(1-\lambda)} (W^{*}_t)^\lambda (P^{*}_t)^{1-\lambda}$$

Intermediate goods producers have to decide how to maximize their returns—a static question—and invest in process innovation—a dynamic question—under the given price and market structure. The maximization of returns requires that the labor input, quantities of exports, and the price of the product this term be determined. This optimization problem can be written as follows:

$$\Pi_t(\delta) = \max_{y, l, p_x, p_x, a, a, x \in [0, 1]} p_a a + x p^{*}_a a^{*} - W_t l - x n_x$$

Due to the exogenous exit shock given at the beginning of each term, intermediate goods producers are forced to exit the market at  $\delta$  probability.<sup>11)</sup> Establishments that survive this exogenous shock compare the operating costs they will need to spend while doing business and the expected returns on continuing their business so that they can decide to continue their business where the latter outweigh the former, and also whether to export their products, in light of the additional fixed costs, or keep their eyes on the domestic market only. They will also need to estimate the probability of increasing their productivity in the future by investing in process innovation this term. The

11) In the absence of exogenous exit shocks, establishments of certain sizes and larger would have zero probability of exit. Such a phenomenon, however, does not occur in the real world. Let us therefore suppose that, in our model economy, too, establishments of certain sizes and larger may exit the market due to exogenous shocks.

process of decision-making on investment in process innovation would be as follows. An establishment with productivity  $z$  in the current term could expect its productivity to rise by  $z + \Delta_2$  with  $q$  probability, and to drop by  $z - \Delta_2$  with  $(1 - q)$  probability the next term by investing  $\exp(z)c(a)$  amount of research goods in the current term.<sup>12)</sup> Let us suppose that the cost of process innovation increases in proportion to the current level of productivity so that the Gibrat theorem that the rates of establishment growth remain independent of the current sizes of establishments would be true. The question of dynamic optimization decision-making, including establishments' endogenous decision to exit the market, can be written as the following value function:

$$V_t(z, n_x) = \max[0, V^{oi}_t(z, n_x)]$$

$$V^{oi}_t(z, n_x) = \max_{a \in [0, 1]} \Pi_t(z, n_x) - \exp(z)c(q) - n_f + (1 - \delta) \frac{1}{R_t} \sum_{n_x} [q V_{t+1}(z + \Delta_x, n_x') + (1 - q) V_{t+1}(z - \Delta_x, n_x')] \Gamma(n_x' | n_g)$$

In our model economy, new establishments enter the market until their expected returns and entry costs are matched. In order to enter the market, new entrants must pay  $n_\epsilon$ -amounts of fixed costs in research goods. The size of the return that intermediate goods producers may expect to generate per unit of productivity on equilibrium would be the same as the point at which new entrants' expected returns and fixed costs of entry are matched.

$$n_\epsilon = \frac{1}{R_t} \sum_{n_x} \int V_{t+1}(z, n_x) G(z, n_x) dz, \quad \text{Conditions for new establishments to enter the market}$$

Households, which form another component of our model economy, obtain the utility of end goods by consuming them and also finally own the returns generated by intermediate goods producers. Households may also spend the

12)  $c(a)$  is given as the convex increasing function of  $a$ . The function is written as  $c(a) = h \exp(ba)$  in specific numerical simulations of the model.

labor income they earn by purchasing products for consumption. Using their ownership of establishments and available labor income, households have to optimize/maximize the value of utility from consumption of end goods.

$$\max_{C_t}^{INF_t=0} \beta^t \log(C_t) \\ P_o C_o - W_o L + \sum_{t=1}^{\infty} \left( \prod_{j=1}^t \frac{1}{R_j} \right) (P_t C_t - W_t L) \leq \bar{W}$$

The conditions for clearing the market of final goods, the labor market, and the market of research goods, and the change in distribution of intermediate goods producers' state variables are written as follows:

$C_t + Y_{rt} = Y_t$ , final goods market clearing condition;

$\sum_{n_x} \int l_t(z, n_x) M_t(z, n_x) dz + L_{rt} = L$ , labor market clearing condition;

$$M_{et} n_e + \sum_{n_x} \int [n_f + x_t(x, n_x) n_x + \exp(z) c(q_t(z, n_x))] M_t(z, n_x) dz = L^{\lambda_{rt}} Y^{1-\lambda_{rt}},$$

research goods market clearing condition;

$$M_{t+1}(z', n_x') = M_{et} G(z', n_x') + (1-\delta) \sum_{n_x} q_t(z - \Delta_x, n_x) M_t(x - \Delta_x, n_x) \Gamma(n_x' | n_x) \\ + (1-\delta) \sum_{n_x} [1 - q_t(x + \Delta_x, n_x)] M_t(z + \Delta_x, n_x) \Gamma(n_x' | n_x)$$

For our model economy, we assume a symmetrical and steady-state equilibrium, where the conditions of the two countries are symmetrical and the distributions of establishments, price equilibrium, and the sum of variables remain constant. Under such a symmetrical and steady-state equilibrium, individual establishments would optimize their exports according to the following process of decision-making.

Intermediate goods producers with  $z$  productivity would solve their problem of static optimization by expecting their returns to amount to  $\Pi_d \exp(z)$  if they do not export and to amount to  $\Pi_d D^{1-\rho} \exp(z)$  if they do export.

$$\Pi_d = \frac{(W/P)^{1-\rho} P Y}{\rho^\rho (\rho-1)^{1-\rho}}$$

The size of returns per unit of productivity would be determined by the price of end goods, the aggregate output of the given economy, and the real wage level under the equilibrium described above. Intermediate goods producers would endogenously decide whether to export in light of the size of the additional returns they could expect to generate through exports each term and the relative size of the fixed cost involved in exports.

$$x(z, n_x) = 1 \text{ if and only if } \Pi_d D^{1-\rho} \exp(z) \geq n_x$$

Once establishment decisions on investment in R&D, exports, and exiting the market are combined, the aggregate productivity of establishments operating on the domestic market only and those exporting abroad can be obtained as follows:

$$Z_d = \sum_{n_x} \int [1 - x(z, n_x)] \exp(z) \tilde{M}(z, n_x) dz, \text{ Aggregate productivity of non-exporting establishments}$$

$$Z_x = \sum_{n_x} \int x(z, n_x) \exp(z) \tilde{M}(z, n_x) dz, \text{ Aggregate productivity of exporting establishments}$$

With  $M_\epsilon$  standing for the number of new establishments and  $L_\gamma$  for the amount of labor necessary to produce research goods, the aggregate productivity, the output of end goods, and the real wage of our model economy would be obtained as follows:

$$Z = M_\epsilon [Z_d + (1 + D^{1-\rho}) Z_x]^{1/(\rho-1)}, \text{ Aggregate productivity;}$$

$$Y = M_\epsilon [Z_d + (1 + D^{1-\rho}) Z_x]^{1/(\rho-1)} (L - L_\gamma), \text{ Output of final goods;}$$

$$\frac{W}{P} = \frac{\rho-1}{\rho} M_\epsilon [Z_d + (1 + D^{1-\rho}) Z_x]^{1/(\rho-1)}, \text{ real wages;}$$

## 2 Setting Parameters

To simulate a model economy, the model economy should be sufficiently steady, with appropriate parameters capable of approximating the conditions of manufacturing establishments. Of the parameters we had to set, ones that were exogenously decided (therefore not needing simulating) or otherwise directly estimable on the basis of the given data included the time discount rates of households ( $\beta$ ), the elasticity of intermediate goods to substitution ( $\rho$ ), and the share of labor in the production function of research goods ( $\lambda$ ). The time discount rate,  $\beta$ , was set at 0.962 to match the 3.9 percent in average real interest rate in Korea from 2001 to 2007. The substitution elasticity of intermediate goods,  $\rho$ , was set at five in line with Atkeson and Burstein (2010), while the share of labor in the production function of research goods was set at 50 percent.

Other parameters were set so that moments pertaining to the distribution of establishments in the steady state of the model economy would be identical to the calculated moments of the actual distribution of manufacturing establishments in Korea prior to 2008. Parameters endogenously determined by the identification of moments included the cost of entry for newly entering establishments ( $n_e$ ), the fixed operating cost of existing establishments ( $n_t$ ), the fixed cost of exports ( $n_x$ ), the variable cost of exports ( $D$ ), parameters  $h$  and  $b$  that respectively determine the level and curve of the process innovation cost function ( $c(a) = h \exp(ba)$ ), the exogenous likelihood of exit ( $\delta$ ),<sup>13)</sup> and the margin of change in the productivity of establishments resulting from the success or failure of process innovation (*TRIANGLEz*). We set these parameters so that the distribution of the number of employees, the variability of the rates of increase in employment, the rates of increase in productivity associated with ages, the share of exporting establishment products in sector-wide output, and the share of exporting establishments in sector-wide establishment observed in the steady state would be identical to those observed in the Korean manufacturing sector prior to 2008.

13) In the absence of exogenous exit shocks, establishments of certain sizes and larger would have zero probability of exit. Such a phenomenon, however, does not occur in the real world.

The moments we estimated in the given data from the Mining and Manufacturing Surveys are as follows. The variability in the number of employees was 0.2, which was the standard deviation of the rate of increase in the number of employees working for establishments with 300 or more workers each in 2001 through 2007. The right tail coefficient, which represents the share of relatively larger establishments in a given industry's employment, was -0.42, observed among establishments hiring 300 to 1,000 workers each. When  $n$  stands for the number of employees at an establishment, and  $F(n)$  for the distribution of cumulative probabilities of employment scales within the manufacturing sector, the right tail coefficients may be measured using coefficients by regressing  $\log(1 - F(n))$  to  $\log(n)$ . The smaller the negative right tail coefficient, the larger the share of large establishments in a given industry's employment. The faster the rate of growth associated with ages of individual establishments, the larger the share of large establishments in the given industry, causing the absolute value of right tail coefficients to decrease. By combining the ages and the coefficients of productivity associated with squares of ages of establishments during 2001 through 2007, we arrived at 22 percent as the rate of cumulative increase in the productivity of establishments during the first 10 years in operation. The share of exporting establishments in employment across the manufacturing sector was shown to be 56.8 percent, equivalent to the share of establishments, for whom exports made up more than zero percent of their revenue, in employment across the manufacturing sector as shown by the sample from the *Mining and Manufacturing Survey* of 2007. As the *Mining and Manufacturing Surveys* indicate the shares of exports in establishment-revenue only, we had to refer to the average values of imports and exports in the final demand of the manufacturing sector in 2000, 2003, and 2005, as indicated in *Indicators of Trends in Major Industries* (2009) from the Korea Institute for Industrial Economics and Trade (KIET) to estimate the share of exports in the output of the entire manufacturing sector, which was 49.5 percent. As our model economy assumes a symmetrical balance between the two countries, we relied upon the average value of exports and imports.

While it is the interaction of all the endogenously determined parameters  $(n_e, n_\rho, n_x, D, h, b, \delta, \Delta_x)$  that determine the distribution of establishments in our model economy, we may still intuitively explain the role of each parameter in

relation to the characteristics of distribution it affects. Once an establishment grows to a certain size, the absolute fixed operating costs become insignificant in comparison to the value of the establishment. Variability in the number of employees hired by establishments of a certain size in our model economy is therefore mostly a function of productivity due to the success or failure of process innovation attempted by establishments. Therefore, the size of  $\Delta z$  is strongly correlated to the standard deviation of the rates of increase in the number of persons employed by establishments with 300 or more workers each. Parameter  $h$ , which determines the level of the process innovation cost function ( $c(a) = h \text{exd}(ba)$ ), reflects to what extent establishments grow on average after they enter the market, and therefore influences the right tail coefficient of the distribution of number of employees as well as the rate of cumulative increase in productivity in the first 10 years of establishment operation. Parameter  $b$ , which determines the curve of the cost function, reflects how quickly establishments increase investment in process innovation in response to the additional returns they expect to gain, and therefore exerts a significant effect on the rate of cumulative increase in productivity in the first 10 years of establishment operation. Parameter  $D$ , which represents the preference of exporting establishments for trade, determines the respective shares of domestic supply and exports in the output of exporting establishments. Where  $D$  is smaller than 1, exporting establishments supply more of their output domestically than for export. Where  $D$  is greater than 1, the opposite is true. The share of exports in output of the manufacturing sector and the relative share of exporting establishments in sector-wide employment are also determined by establishment preference for trade. Parameter  $n_x$ , which represents the amount of fixed costs involved in exports, determines the share of exporting establishments in a given industry and therefore directly affects the share of exporting establishments in industry-wide employment. As establishments likely increase the strengthening of their productivity in anticipation of additional returns they can earn by exporting their products, the parameter also affects the rate of cumulative increase in the establishments' first 10 years of operation. The cost of entry,  $n_e$ , and the fixed operating costs of existing establishments,  $n_t$ , affect the number of small establishments in a given industry, and thereby influence the share of exporting establishments in industry-wide output and employment as well as

the right tail coefficient of the distribution of number of employees by establishment size.

〈Table VII-1〉 Parameters of the Model Economy

Parameter	Description	Value
$\beta$	Time discount rate	0.962
$\rho$	Substitution elasticity of intermediate goods	5
$\lambda$	Share of labor in research goods	50%
$n_{\epsilon}$	Cost of entry	0.11
$n_t$	Fixed operating costs	0.05
$n_x$	Fixed cost of exports	2.2
$D$	Export preference of exporting establishments	0.68
$b$	Curve of process innovation cost curve	55
$\delta$	Likelihood of exogenous exit	5%
$\Delta_2$	Variability of establishment productivity	0.2

〈Table VII-2〉 Moments in the Model Economy & the Data

Moment	Model economy	Real-world manufacturing data
S.D. of rate of increase in employment	0.2	0.2
Right tail coefficient of employment distribution	-0.42	-0.42
Rate of cumulative increase in first 10 years of operation	22%	22%
Exporting establishment share of employment	56.8%	56.8%
Export share of output	47.0%	49.5%

Sources: Based on the model economy, *Mining and Manufacturing Surveys*, and *Indicators of Trends in Major Industries*.



### 3 Effects of Decrease in Establishment Productivity Associated with Ages on Aggregate Productivity of the Entire Manufacturing Sector

We estimated, using the fixed-effect panel model described in Chapter V, the rates of increase in the productivity of establishments with different ages. From 2001 to 2007, the rate of cumulative increase in the productivity of establishments in their first 10 years of operation was 22 percent. From 2008 to 2014, however, this rate dropped drastically to 10 percent. In this section, we shall analyze the quantitative effect of lowering the rate of cumulative increases in establishment productivity, associated with different ages, from 22 percent to 10 percent on the productivity and output of the manufacturing sector in our model economy.

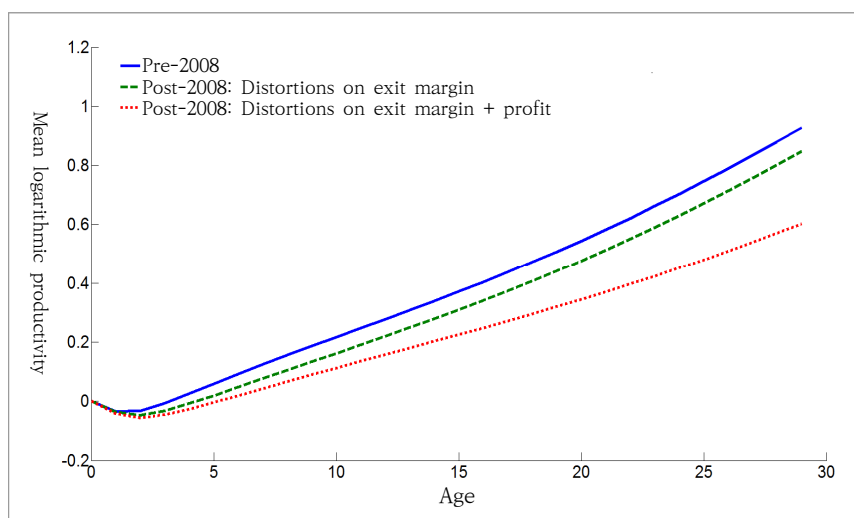
To perform this analysis, we must determine how the difference in the rate of cumulative increases in manufacturing productivity should be simulated in our model economy. Recall the following implications of our empirical analyses described in Chapters IV through VI. First, the decrease in the rate of increase in the productivity of establishments reflects not only the declining productivity of establishments remaining in the market, but also the reduced productivity gap between establishments that exited and those that remained. Second, the effects of financial support programs for SMEs on aggravating the distortion of resource distribution as faced by more productive establishments and on weakening the correlation between productivity decline and market exit may have slowed down the rate of productivity increases in establishments over time.

Based on these implications of our empirical analyses, we could lower the rate of cumulative increases in establishment productivity in our model economy in the following manner. First, lower the fixed operating costs of relatively less productive establishments (in the median level of productivity or below) and increase the fixed operating costs of the more productive ones so as to weaken the negative correlation between productivity and market exit and thereby reduce the productivity gap between establishments exiting and those remaining. Second, generate losses to some of the returns that more productive establishments generate per unit of productivity so as to disincentivize those establishments from investing in process innovation. This will lower the overall productivity

of establishments remaining in the market over time.

According to the decomposition of the growth rates of establishments performed in Chapter IV, approximately 40 percent of the decrease in the productivity of establishments with different ages circa 2000 can be attributed to the decreasing productivity gap between surviving and exiting establishments. Add to this the effect of financial support programs for SMEs on weakening the negative correlation between productivity and the likelihood of exit. We may then set our model economy so that (1) distortion of the exit decision-making due to distortion of the fixed operating costs and (2) distortion of the return function facing establishments in the top quintile of productivity would explain equal parts of the 12-percentage-point decrease in the rate of cumulative increases in the productivity of establishments in the first 10 years of operation in and after 2008. The sizes of the distortion in the fixed operating costs and the distortion in the return function were determined so that, with each distortion introduced, the rate of cumulative increase in the productivity of establishments in their first 10 years of operation would decrease by 5.5 percentage points.

**[Figure VII-1] Change in Mean Productivity of Establishments with Different Ages: Distortions of Exit Conditions & Returns Introduced**



[Figure VII-1] illustrates the changing mean productivity of establishments with different ages in our model economy when distortion of the exit decision was introduced alone, and also when distortions of both the exit decision and returns were introduced. Whereas the rate of cumulative increase in the productivity of establishments in their first 10 years of operation was 21.7 percent in the pre-2008 condition, this rate dropped to 16.2 percent when the exit conditions were altered by lowering the fixed operating costs of establishments at the mean- or sub-mean-level of productivity by 10 percent and increasing the fixed operating costs of more productive establishments by 10 percent. The rate dropped further to 11.3 percent when the return function for establishments in the top quintile of productivity was cut by 22 percent.

To separate the effects of distorting exit conditions and distorting the return function, we first estimated the effect that distorting the fixed operating costs of establishments would have over productivity and output of the entire manufacturing sector. Then we measured how adding the distortion of the return function to this state would further influence the manufacturing sector.

◁Table VII-3▷ Effects of Distortions in Exit Conditions & Returns on the Manufacturing Sector

Variable	Change due to distortion in exit conditions	Change due to distortions in exit conditions and returns
Rate of cum. increase in productivity in first 10 years of op.	-5.5% points	-10.4% points
Output of end goods	-0.26%	-2.89%
Aggregate productivity	-0.28%	-3.05%
Establishment-level productivity	0.88%	-10%
Number of new entrants	-1.17%	6.95%
Returns per unit of productivity	1.01%	10.8%
Real wage	-0.28%	-3.05%
Export share of output	-0.31% points	-18.95% points
Right tail coefficient	0.53% points	-7.76% points

<Table VII-3> summarizes the effects of introducing establishment-level distortions on the entire manufacturing sector. While introducing either distortion would lead to similar effects on the rate of cumulative increase in the productivity of establishments in the first 10 years of their operation, the distortion of returns exerted far more dramatic effects on reducing the aggregate productivity and output of the manufacturing sector. Whereas the aggregate productivity and output of the manufacturing sector dropped only slightly, by 0.28 percent and 0.26 percent, respectively, when exit conditions were distorted, they dropped by 3.05 percent and 2.89 percent, respectively, when the returns for establishments in the top quintile of productivity were arbitrarily lowered.<sup>14)</sup>

In order to understand the difference in the effects of the two distortions, we need to recall the definitions of the aggregate variables making up our model economy (Section 1).

$$n_{\epsilon} = \frac{1}{R_t} \sum_{n_x} \int V_{t+1}(z, n_x) G(z, n_x) dz, \text{ Conditions for new establishments to enter the market}$$

$$Z_d = \sum_{n_x} \int [1 - x(z, n_x)] \exp(z) \tilde{M}(z, n_x) dz, \text{ Aggregate productivity of non-exporting establishments}$$

$$Z_x = \sum_{n_x} \int x(z, n_x) \exp(z) \tilde{M}(z, n_x) dz, \text{ Aggregate productivity of exporting establishments}$$

$$UZ = [Z_d + (1 + D^{1-\rho}) Z_x]^{1/(\rho-1)}, \text{ Productivity per establishment}$$

$$Z = M_{\epsilon} [Z_d + (1 + D^{1-\rho}) Z_x]^{1/(\rho-1)}, \text{ Aggregate productivity}$$

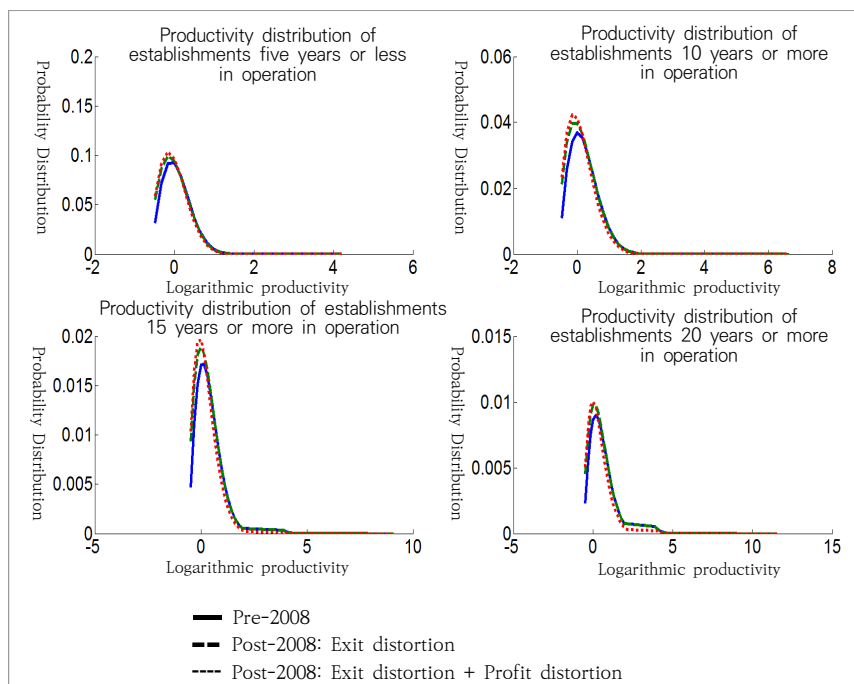
$$Y = M_{\epsilon} [Z_d + (1 + D^{1-\rho}) Z_x]^{1/(\rho-1)} (L - L_{\gamma}), \text{ Output of final goods}$$

14) The model economy we have set up is devoid of endogenous factors for growth, including natural increases in the productivity of establishments that newly enter the market due to exogenous shocks and the spillover of increases in the average productivity of existing establishments into the increases in productivity of new entrants. The distortions we introduce would therefore influence the aggregate variables only, such as output and productivity of the whole sector, with our model economy held in a steady state.

Under the given conditions of equilibrium,  $M_e$  represents the number of new establishments entering the market. It is in proportion to this number under the steady-state equilibrium that the number of all establishments operating in the manufacturing sector is determined. Productivity per establishment, defined as the mean productivity of the manufacturing sector when the number of new entrants to the sector is regularized as one, is determined by the combination of conditions affecting process innovation, exports and exit. As the rate of increase in the productivity of establishments with different ages rise, so does the productivity per establishment. The aggregate productivity of the manufacturing sector can be obtained by multiplying the productivity per establishment by the number of new entrants. <Table VII-3> shows that arbitrarily lowering the returns of establishments in the top quintile of productivity drastically lowers the productivity per establishment. As a result, when both the exit conditions and returns are distorted, the number of establishments toward the right tail of the graphs, with 10 years or more in ages, decreases significantly.

On the other hand, where the exit conditions were distorted only, the fixed operating costs of establishments at or below the median level of productivity dropped, increasing the likelihood of less productive establishments to survive. The proportion of these establishments on the market is not great to begin with, so their increased likelihood of survival barely exerts any effect on discouraging more productive companies from maximizing returns by investing in process innovation. Accordingly, with only exit conditions distorted, the distribution of the productivity of establishments with 10 years of age or longer toward the right tail of the graph remains similar to the pattern observed in the pre-2008 economy.

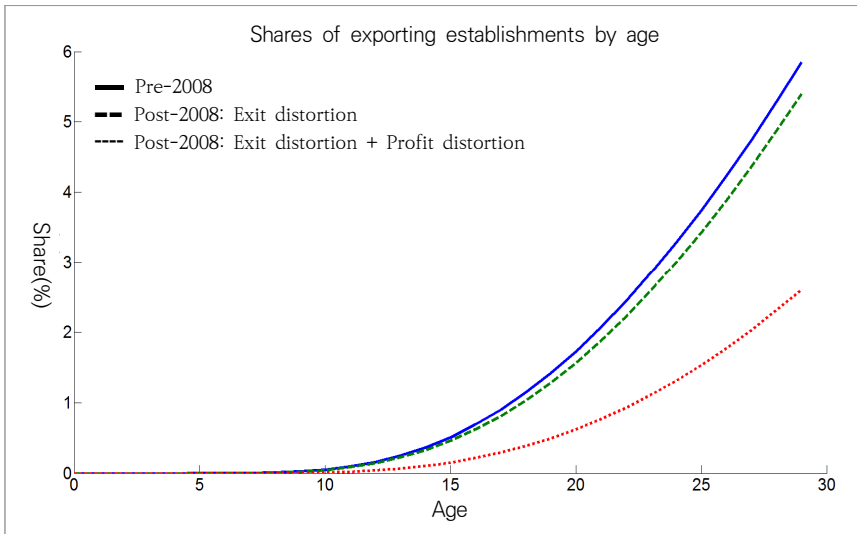
[Figure VII-2] Productivity distribution of establishments depending on age



As the rates of increase in productivity of surviving establishments drop, the proportion of establishments capable of paying the fixed costs of exports shrinks, leading to a reduced share of exports in sector-wide output. [Figure VII-3] illustrates the shares of exporting establishments with different ages observed in different situations of distortion. As the amount of fixed costs involved in export remains constant, the only cause for the differences in the shares of exporting establishments is found in the different distributions of establishment -level productivity. In particular, with returns distorted, the rates of increase in establishment productivity over time decrease, reducing the share of even establishments with 10 years or more of history that are capable of affording the fixed cost of exports. As a result, the shares of exporting establishments at all lengths of ages decrease. Exporting establishments increase

sector-wide output by  $D^{(1-\rho)}$  per unit of the output reserved for the domestic market and therefore contribute significantly more to aggregate productivity than establishments doing domestic business only. The decrease in rates of increase in productivity associated with ages therefore interacts with endogenous decision-making on exports and serves to accelerate the pace at which sector-wide productivity and output decrease.

**[Figure VII-3] Changing Shares of Exporting Establishments: Distortions of Exit Conditions & Returns Introduced**



As the increase in productivity of existing establishments associated with their ages begins to slow down, the amount of returns that relatively smaller new entrants may reap upon entering the market increases. As <Table VII-3> shows, the decrease in the productivity per establishment, due to the distortions introduced, is offset, at least partially, by the increase in the number of new entrants into the market.

# VIII

## Conclusion

In this study, we analyzed how the decline in the growth rate of the Korean manufacturing sector since the late 2000s has been correlated to the growth patterns of individual establishments with different ages.

Our decomposition of the rates of growth in the added values of the entire Korean manufacturing sector since 1990, using the method from Petrin and Levinsohn (2012), into production factor inputs, productivity increases in establishments, and increased efficiency in production factor distribution revealed that the rate of cumulative increases in added value, from 1993 to 2009 as indicated in the *Mining and Manufacturing Surveys*, amounted to 91 percent. Of this, 81 percentage points were attributable to the increased productivity of establishments. Of the 81 percentage points so attributable, 42 percentage points came from establishments in operation for five years or less, while the remaining 39 percentage points came from older establishments. In order to understand the pattern of increase in the added value of the Korean manufacturing sector, we should thus examine the rates of increase in the productivity of not just establishments of a certain age, but all establishments in general.

Our analysis, based on a linear panel model, controlling the fixed effects at the establishment level, also showed decreases in the added value and productivity of establishments as they grew older. Our comparison of the samples from 2001 through 2007 and 2008 through 2014 revealed that the rates of increase in added value and productivity associated with ages decreased by five percentage points and three percentage points, respectively, in and after 2008. Much of the decrease in added value in old establishments could thus be explained as



a result of the decrease in the rate of productivity increase in those establishments.

We sought to examine whether one of the causes for the decline in growth rates of establishments with different ages, in and after 2008, was the financial support programs for SMEs introduced to support the survival of relatively smaller and newer SMEs. We compared the rates of decrease in the growth rates of establishments in industries that were in the top quintile of financial support programs for SMEs received in 2008 through 2012 and the rates of establishments in industries that were in the bottom quintile during the same period of time. The added value of the bottom quintile dropped by 3.8 percentage points, while that of the top quintile decreased at an even more dramatic margin, by 5.2 percentage points. Productivity, too, decreased by 2.1 percentage points in the bottom quintile as opposed to 3.3 percentage points in the top quintile. In order to identify the specific paths by which financial support programs for SMEs lowered establishment growth rates, we performed a logit model analysis on the likelihood of establishments to exit the market. This revealed that financial support programs for SMEs significantly weakened the negative correlation between productivity and the likelihood of exit in the top quintile of industries. In addition, financial support programs for SMEs also tended to increase the distortion of labor inputs as experienced by more productive establishments in industries that received relatively more financial support programs for SMEs. These findings suggest that financial support programs for SMEs introduced to countervail the effect of the global financial crisis rather discouraged individual establishments from enhancing productivity on their own.

In an effort to measure the effect of declining productivity growth rates of establishments since 2008 on the aggregate productivity and output of the entire manufacturing sector in Korea, we applied the industrial equilibrium model, *à la* Atkeson and Burstein (2010), to Korea's case. Our analysis led to the conclusion that, had Korean manufacturers maintained the rate of productivity increase on a par with the level observed in the years 2001 through 2007, the aggregate productivity and final output of the Korean manufacturing sector would have been three percent and 2.9 percent higher, respectively.

The main policy implication of our analyses is that subsidizing less productive establishments or disadvantaging more productive establishments with greater regulation has the effect of lowering the returns those establishments expect

to generate by investing in process innovation and productivity increases, and therefore serves to slow down the rate of increase in productivity for the overall manufacturing sector. In Korea, manufacturers attain a certain size through active investment in productivity and ensure the continued growth of their business operations by entering the export market afterward. Policy measures that disincentivize establishments from increasing their productivity therefore influence their decisions on whether to start/continue exports as well, and may thereby aggravate the loss of productivity throughout the manufacturing sector.

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