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Aggregate Productivity Growth and Firm Dynamics in Korean Manufacturing 2007-2017

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We study aggregate productivity growth of the Korean manufacturing industry for the 2007-2017 period. We find that the nature of such growth was quite different for two measures of productivity. For labor productivity, most of growth comes from productivity changes among surviving firms. On the other hand, for TFP, most of the productivity growth comes from that of new entrants in recent years. Our work illustrates the different nature of two productivity measures in terms of their growth paths. We also show interesting industry dynamics for both productivity measures, as exiting firms contributed positively to aggregate productivity growth with increasing trends, which suggests that the market had gradually eliminated firms of lower productivity. Using the dynamic Olley and Pakes (1996) decomposition, we also find that for both productivity measures, a substantial productivity growth after the 2008 global financial crisis was due to market share reallocations between firms, but this between-firm contribution has somewhat slowed or been decreasing since then. Our industry sector level study also shows that there has been fundamentally different heterogeneous productivity growth patterns and components across manufacturing sectors. Finally, we find that the wage level also plays a role in moderating or as an accelerating factor for different productivity growth paths among surviving, entering, and exiting firms. We find that higher wage groups had disproportionately higher entry and exit rates, and that the contributions of these industry dynamics to aggregate productivity growth were largest for the highest wage group while the productivity growth from the between firm component was substantially higher for lower wage groups. Therefore, we find that not only a timely change in input and output, but also in the wage, is a necessary ingredient for the pace and magnitude of reallocation to be effective in aggregate productivity growth.

Keywords: Aggregate Productivity Growth, Labor Productivity, Total Factor Productivity, Resource Reallocation, Entry and Exit, Wage

JEL Classification: C14, C18, D24

Ⅰ. Introduction

The aggregate productivity of an economy is a weighted average of productivity at the firm or plant level. Aggregate productivity can change over time through various channels. First, it can change due to shifts in the distribution of producer-level productivity. Second, it can also change due to dynamics in the distribution of firms, including changes in market shares across surviving firms, the appearance of new producers, and the exit of existing firms. This dynamic entry and exit of firms is a process of market selection or evolution, potentially influenced by productivity levels, and it allows resources to be reallocated within or across firms or industries (Baily, Hulten, and Campbell, 1992; Griliches and Regev, 1995; Olley and Pakes, 1996; Foster, Haltiwanger and Krizan, 2001; and Levinsohn and Petrin, 2012). This dynamic process of industry has been explained, at least in theory, by Schumpeter's creative destruction process (see, e.g., Aghion and Howitt, 1992) for which new technologies and innovations, successfully introduced by new or growing firms, constantly drive out other lagging incumbent firms. Also the industry learning models, such as Jovanovic (1982) and Ericson and Pakes (1995), show how firms experiment when faced with uncertainty about the demand for new products or about how the effectiveness of alternative technologies for quality improvements or advantages in costs can create heterogeneity in firms and hence industry dynamics.

In the literature there have been substantial amounts of research conducted on aggregate productivity growth and on decomposing its factors. These studies intend to provide a better accounting of the contributions that entry and exit have on aggregate productivity changes. The decomposition also breaks down the separate contributions among surviving firms of within-firm productivity shifts and between-firm market share reallocations, e.g., by employment size. These studies also have reported some interesting patterns in aggregate productivity changes and factors that have driven such changes. First, there has been an persistent reallocation of outputs and inputs among individual producers. Second, the speed and magnitude of this reallocation varies over time and across sectors. Third, depending on different methods of aggregate productivity decomposition and also depending on country and industry sector, some studies find that much of this reallocation come from within-firm changes rather than from between-firm reallocations, while other studies find the opposite results.

This process of survival or entry and exit and resulting changes in aggregate productivity can be also moderated or accelerated due to changes in the cost of labor or capital, as well. In this paper we also investigate the magnitude, and characteristics of this dynamic process among Korean manufacturing firms using micro-level data, and analyze the contributions of survivors, entrants, and exiters to aggregate productivity growth. In particular, we try to shed lights on how different wage levels has affected this dynamic process, and also examine how the effects may differ across firms with different levels of productivity and wages.

The effects of changes in wages on worker and firm behavior have been well-studied, both theoretically and empirically economics, e.g., Card and Krueger (1994), Dube, Lester, and Reich (2010), Neumark and Wascher (2008), Rebitzer and Taylor (1995), Salop and Salop (1976) and Stiglitz (1976), among many others. One of the important findings is that the wage level can influence the firm-level (labor) productivity through several channels, which may or may not impact employment, besides direct changes in the cost of labor. Therefore, it is important to see how wages and firm productivity influence industry dynamics simultaneously. For this purpose, we investigate firm-level productivity changes using a structural approach to estimate production functions. Given the estimates, we decompose the contributions of survivors, entrants, and exiters to aggregate productivity growth.[1] We then examine how this decomposition of the contribution, and the pattern of aggregate productivity growth, can differ across firms in different wage groups and across manufacturing sectors.

1) The fundamental empirical issue in estimating production functions is that inputs and outputs are concurrently decided by the firms (Marschak and Andrews, 1944; Olley and Pakes, 1996, OP) based on factors that include the unobserved productivity and heterogeneous input costs. We estimate the firm-level productivity model of Levinsohn and Petrin (2003, LP) that allows for firm's exit, using a proxy variable approach to control for the unobserved productivity.

Although many of the fundamental questions above regarding industry dynamics and productivity should be answered empirically to some extent, formal econometric analysis using micro-level data has been somewhat scarce for the Korean industry.

For the decomposition method we utilize the dynamic Olley-Pakes decomposition method with entry and exit as proposed by Melitz and Polanec (2015). They argue that Olley and Pakes (1996)'s approach has attractive properties in their decomposition because the approach is more in line with the measured components of aggregate productivity changes within a framework that allows for heterogeneous firms, and they also argue that other commonly used decomposition methods proposed in previous studies, e.g., Baily, Hulten, and Campbell (1992), Griliches and Regev (1995), and Foster, Haltiwanger and Krizan (2001), all used some fixed reference points for growth accounting, and that the resulting breakdown of aggregate productivity changes introduces some biases in the measurement of the contributions of firm's entry and exit.

For our empirical analysis, using a firm-level panel data set, we study aggregate productivity growth in the Korean manufacturing industry, and find that there had been about 21% growth in total factor productivity, compared to 23% growth in labor productivity, from 2007 to 2017. However, we also find that the nature of such growth was quite different for the two measures of productivity. For labor productivity, most of the productivity growth comes from productivity changes among surviving firms, rather than from entering or exiting firms. On the other hand, for total factor productivity, most of the productivity growth comes from contributions from entering firms, and in recent years the contribution of surviving firms was even negative due to decreasing between-firm components. We also find that for both productivity measures, exiting firms contributed positively to aggregate productivity growth with upward trends and that the contribution of net entry, the combined contributions of entering and exiting firms, were all positive and increasing during the period. This suggests that firms with lower productivity could not survive the test of market, while new firms entered the market with higher productivity, illustrating Schumpeter's creative destruction process. Also, this phenomenon was more noticeable for TFP, since most of productivity growth comes from the contribution of entering firms over recent years.

The observed discrepancy of the growth paths between labor productivity and TFP can happen, for example, if the capital accumulation is faster or slower for continuing firms or entrants than the growth of the labor force beyond an optimal mix of inputs. For example, if labor productivity growth is the result of heavy capital spending by firms, then the resulting TFP growth can be low or negative. In the literature, the different nature of the two productivity measures is well understood, at least in theory. For example, Syverson (2011) notes that labor productivity, being a single-factor productivity measure, can be sensitive to the use of other inputs and relative input prices. Bernard and Jones (1996) also note that a change in labor productivity is not neutral since it influences technology changes and other factor accumulations. On the other hand, TFP measures a firm ability that is not accounted for by observed input factors. Bernard and Jones (1996) conclude, unlike labor productivity, TFP is independent of capital accumulation or changes in observed inputs and factor prices, and should be viewed as a different productivity measure. Our empirical work illustrates such differences in terms of the growth patterns of the two productivity measures.

Using the dynamic Olley and Pakes (1996) decomposition, we also find that for both productivity measures, the substantial productivity growth seen after the 2008 global financial crisis was due to market share reallocations between firms, but that this between-firm contribution has somewhat slowed or been decreasing ever since. Our industry sector level study also illustrates that there had been substantially heterogeneous productivity growth patterns and components across different industry sectors. Finally, we find that the wage level is also an important factor for different productivity growth paths among surviving, entering, and exiting firms. We find that higher wage groups disproportionately displayed higher entry and exit rates, and that contributions from those entering and exiting firms to the aggregate productivity growth were positive and largest for the highest wage group, compared to mostly negative contributions for other wage groups. This suggests that the creative destruction process was most effective for the highest wage group. On the other hand, the productivity growth of surviving firms was substantially higher for lower wage groups due to the between-firm component.

Our paper is organized as follows. In Section Ⅱ, we review the methods of production function estimation and aggregate productivity decomposition. In Section Ⅲ, we explain our data and give some industry background. In Section Ⅳ, we present our main findings and discuss the results. In Section Ⅴ, we conclude with some policy implications of our study.

Ⅱ. Review of Model and Estimation

Our empirical analysis focuses on looking at productivity decomposition that explicates the contributions of continuing firms by within- and between-firm effects, entering firms and exiting firms to aggregate productivity changes, using the firm-level production function. We then examine how this decomposition of the contribution, as well as the pattern of aggregate productivity growth, can differ across firms in different wage groups and across manufacturing sectors. First, we introduce the production function estimation method and firm-level productivity. Next, we introduce the method of decomposing the aggregate productivity change in a dynamic setting.

1. Production Function and Productivity Estimation

We briefly discuss Levinsohn and Petrin (2003) procedure to estimate production functions. The gross output production function corresponding to a firm i at time t is defined by

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + w_{it} + \eta_{it} \qquad (1)$$

where y_{it} is the output of the firm, l_{it} is the labor input, k_{it} is the capital input, m_{it} is the intermediate inputs, such as material, electricity, and fuel cost, w_{it}

is an unobserved state variable that impacts the firm's decisions on inputs and production level simultaneously, and η_{it} denotes a pure i.i.d. shock in the production process. These variables are all measured in logs, and in particular w_{it} denotes the log of total factor productivity(TFP).

Because labor and capital, or investment decisions rely on w_{it}, the regressors l_{it} and k_{it} are potentially endogenous, and the OLS estimates of the production function coefficients are inconsistent. As it is illustrated in LP, the OLS tends to overestimate the labor coefficient and underestimate the capital coefficient. To deal with this endogeneity issue, OP and LP put forward a proposal to use a proxy variable to invert the unobserved productivity w_{it}. As the proxy variable, OP employs the investment while LP recommends the intermediate input instead, because smaller firms often do not report any investment. OP and LP both make an implicit assumption about the timing of labor input in their proxy variable approach.[2)]

We use the LP approach to estimate the production function and the productivity.[3)] Following LP, we assume that the intermediate input demand is given by

$$m_{it} = h_t(k_{it}, w_{it})$$

and that demand is strictly increasing in the productivity. Then the inverse $w_{it} = f_t(k_{it}, m_{it})$ exists, and it becomes the proxy for the unobserved productivity. Plugging the proxy variable into production function (1), we obtain

2) To overcome the endogeneity problem, previous studies also used a firm fixed effects model. The fixed effects approach is valid under the assumption that the productivity of a firm does not change over time. Grilliches and Mairesse (1998) point out that an important contribution of the proxy variable approach is that the approach solves the underestimation problem of the fixed effects estimation because, in most cases, the short-term panel data does not yield a statistically meaningful variation in the input of a firm.

3) Recent developments in estimating production function using a proxy variable include Wooldridge (2009), Ackerberg, Caves, and Frazer (2015), Gandhi, Navarro, and Rivers (2017), and Kim, Luo, and Su (2019a,b). In particular, Kim, Petrin, and Song (2016) study the measurement error problem in capital input, and Kim, Luo, and Su (2019b) propose estimation methods robust to flexible timing of labor input.

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + \beta_m m_{it} + f_t(k_{it}, m_{it}) + \eta_{it}$$

From this equation, using the partial linear regression by Robinson (1988), we first estimate the labor coefficient β_l and the coefficients on other freely variable inputs, and obtain the function,

$$\tilde{\Phi}_{it} = \beta_k k_{it} + \beta_m m_{it} + w_{it}$$

from which we can write $w_{it} = \tilde{\Phi}_{it} - \beta_k k_{it} - \beta_m m_{it}$.[4)]

Next, to estimate the capital coefficient and the (proxy) intermediate input coefficient, we assume w_{it} follows the AR_(1) process

$$w_{it} = \rho w_{i,t-1} + \xi_{it}$$

and assume the innovation term, ξ_{it}, is conditionally mean independent of any firm information available at time $t-1$. Given the timing assumptions of input demand in the LP setting, this implies the current capital k_{it} and its lagged variables, and the lagged l_{it} and m_{it}, are not correlated with ξ_{it}. From these identifying conditions, we can construct the moment conditions and estimate the production function parameters using the Generalized Method of Moments estimation (GMM). To implement this GMM procedure, we can first concentrate out ρ by regressing $w_{it} = \tilde{\Phi}_{it} - \beta_k k_{it} - \beta_m m_{it}$ (or $w_{it} + \eta_{it} = y_{it} - \beta_l l_{it} - \beta_k k_{it} - \beta_m m_{it}$) on its lag $w_{i,t-1} = \tilde{\Phi}_{i,t-1} - \beta_k k_{i,t-1} - \beta_m m_{i,t-1}$ and obtain the residual as $\hat{\xi}_{it}(\beta_k, \beta_m)$. We can then construct the moment condition for estimation as

$$0 = E[\hat{\xi}_{it}(\beta_k, \beta_m) | k_{it}, k_{i,t-1}, m_{i,t-1}, l_{i,t-1}].$$

4) Here the constant term is subsumed into w_{it} because the constant is not separably identified in the LP procedure.

Using the estimated production function parameters, we can then impute the productivity by

$$w_{it} = \tilde{\Phi}_{it} - \beta_k k_{it} - \beta_m m_{it}.$$

An important advantage of this approach compared to the method using OLS, which would define the residual from regression as the productivity, is that it eliminates the idiosyncratic error from the production function, yielding the true productivity. For the value-added production function, we instead estimate

$$y_{it} = \beta_0 + \beta_l l_{it} + \beta_k k_{it} + w_{it} + \eta_{it}$$

where y_{it} now denotes the value-added of the firm in log. The estimation follows similar steps to the gross output production function, as above. In our empirical section we estimate the production function using the panel data constructed from the Mining-Manufacturing Survey and the Economic Survey of Statistics Korea for the 2007-2017 period.

2. Dynamic Olley-Pakes Decomposition

Following Melitz and Polanec (2015) we first define aggregate productivity at time t as a share weighted average of firm productivity φ_{it} and its share S_{it} in the market

$$\Phi_t = \sum_i S_{it} \varphi_{it}$$

where the productivity φ_{it} can denote labor productivity, typically defined by the ratio of value-added and employment size, or total factor productivity.[5)]

5) In this framework the aggregate productivity is not given by simply summing individual firm's productivity, but is calculated as the weighted sum of the firm level productivity by its employment share, or valued-added share. Therefore, the aggregate productivity measure we use effectively reflects firm size factors, even without controlling for or potentially removing many small firms.

Here the essential variable to examine is the change in aggregate productivity over time from $t=1$ to 2, as $\triangle\Phi=\Phi_2-\Phi_1$. Here period 1 becomes a benchmark year, and the growth in any particular period 2 is measured as the change relative to period 1.

Let E, X, and S denote the sets of entering, exiting, and surviving firms, respectively. Let $S_{Gt}=\Sigma_{i\in G}S_{it}$ be the aggregate market share of a group $G\in\{E,X,S\}$ of firms. In this definition, for each year in period 1, the surviving firms are those firms that survived until that year, while the exiting firms are those firms that exited from the market before the end of that year. Because the exiting firms are accumulated over time, since the base year, by construction, the shares of exiting firms are increasing and the shares of surviving firms are decreasing over time. Similarly, for each year in period 2, the surviving firms are those firms that survived until that year, while the entering firms are those firms who entered the market before the end of that year and since the base year. Because the entering firms are accumulated over time, since the base year, by construction, the shares of entering firms are increasing and the shares of surviving firms are decreasing over time.

Define $\Phi_{Gt}=\Sigma_{i\in G}(S_{it}/S_{Gt})\varphi_{it}$ as that group's aggregate (average) productivity. Given these groups of firms we can write the aggregate productivity as

$$\Phi_1=S_{S1}\Phi_{S1}+S_{X1}\Phi_{X1}=\Phi_{S1}+S_{X1}(\Phi_{X1}-\Phi_{S1}),$$
$$\Phi_2=S_{S2}\Phi_{S2}+S_{E2}\Phi_{E2}=\Phi_{S2}+S_{E2}(\Phi_{E2}-\Phi_{S2}),$$

since $S_{S1}+S_{X1}=1$ and $S_{S2}+S_{E2}=1$ in each period. The main idea of Melitz and Polanec (2015, MP) is to utilize the decomposition proposed by Olley and Pakes (1996) grounded on a decomposition of the aggregate productivity level Φ_t in each period as

$$\Phi_t=\overline{\varphi}_t+\Sigma_i(S_{it}-\overline{S}_t)(\varphi_{it}-\overline{\varphi}_t)=\overline{\varphi}_t+cov(S_{it},\varphi_{it})$$

where $\overline{\varphi}_t = \frac{1}{n_t}\Sigma_{i=1}^{n_t}\varphi_{it}$ the neutrally weighted mean (sample average) level productivity among n_t firms and $\overline{S}_t = 1/n_t$ denotes the average market share. In this OP decomposition, the aggregate productivity is decomposed into one induced by the (unweighted) average productivity $\overline{\varphi}_t$ and the covariance between market share and productivity of firms $cov(S_{it}, \varphi_{it})$, which measures the joint cross-sectional distribution of market share and productivity. This provides an informative way of decomposing productivity changes into a component, measuring shifts in the mean level of productivity for all surviving firms, and into another component that measures market share reallocations across firms. The market share reallocation means shifts in labor forces among firms for labor productivity, and it means shifts in value-added, which can happen due to shifts in various resources among firms, for total factor productivity.

Given this OP decomposition, MP propose the decomposition, focusing on the within-firm and the between-firm decomposition for surviving firms, as

$$\begin{aligned} \triangle\Phi &= (\Phi_{S2} - \Phi_{S1}) + S_{E2}(\Phi_{E2} - \Phi_{S2}) + S_{X1}(\Phi_{S1} - \Phi_{X1}) \\ &= \triangle\overline{\varphi}_S + \triangle cov_S + S_{E2}(\Phi_{E2} - \Phi_{S2}) + S_{X1}(\Phi_{S1} - \Phi_{X1}) \end{aligned} \tag{2}$$

Here the first two terms in the second line of equation (2) further decompose the aggregate productivity change due to surviving firms into one generated by a change in the distribution of firm productivity (within-firm change), and the other induced by market share reallocation (between firm change). Therefore, this decomposition disassembles the contribution for surviving firms into the within- and the between-firm subcomponents. The third and the fourth term denote the aggregate productivity changes due to entering firms and exiting firms, respectively.[6] In this decomposition a positive contribution by

6) The contribution of entry or exit can be further decomposed similar to the surviving firms. For entering firms, for example, we have $S_{E2}(\Phi_{E2} - \Phi_{S2}) = S_{E2}(\overline{\varphi}_{E2} - \overline{\varphi}_{S2}) + S_{E2}(cov_{E2} - cov_{S2})$ where the first component reflects dissimilarities in the productivity distribution between entering and surviving firms, and the second component reflects differences in the covariance between market shares and productivity for entrants and surviving firms.

entering firms means that on average entering firms have higher productivity than the continuing firms since period 1. On the other hand, a positive contribution of exiting firms indicates that on average exiting firms have lower productivity than all the existing firms since period 1, which means that exiting may contribute to aggregate productivity growth by eliminating firms with lower productivity.

For actual empirical analysis, we perform the decomposition for each year since the base year. In each year's growth accounting based on (2), the contribution of surviving firms for each year to aggregate productivity growth measures the contribution of those continuing firms since the base year relative to their aggregate productivity level in the base year. The contribution of entering firms for each year measures the contribution of all new entrants since the base year relative to the continuing firms in terms of that year's aggregate productivity. The contribution of exiting firms for each year measures the contribution of all exiters since the base year relative to that of the continuing firms in terms of their aggregate productivity levels in the base year.

Melitz and Polanec (2015) argue that their decomposition more precisely mirrors the contributions of those three groups, such that each group's contribution in the growth accounting is related to a specific counterfactual scenario such as the contribution of continuing firms is purely the aggregate productivity that would have been kept under observation in the absence of entry and exit. This can be compared to Griliches and Regev (1995) and to Foster, Haltiwanger and Krizan (2001), who use some fixed reference productivity levels.[7] Also, the contribution of entrants in the MP decomposition, $S_{E2}(\Phi_{E2}-\Phi_{S2})$, is the shift in aggregate productivity caused by counting up entrants. Similarly, the contribution of exiting firms in the MP decomposition, $S_{X1}(\Phi_{S1}-\Phi_{X1})$, is the change in aggregate productivity generated by removing

7) Because both decompositions of GR and FHK trail continuing firms over time, they necessitate application of the identical reference productivity levels uniformly over all groups, including entrants and exiters, as well. Compared to MP, any choice of fixed reference productivity level will generally yield a bias in measuring the contribution of one group or the other. For the reference productivity level GR used the time average $(\Phi_1+\Phi_2)/2$ while FHK used the base period aggregate productivity Φ_1 .

exiting firms. In the MP decomposition, all three components used different reference groups, which are more natural in the counterfactual sense.

In our analysis we further decompose the groups of firms based on their wage level. We divide firms into the first, second, third and fourth quartile in their wage rate distribution among all firms for each year. Each wage group is denoted by W_1, W_2, W_3 and W_4, respectively. Then we can decompose the contribution to aggregate productivity by surviving, entering and exiting firms, and also by the wage group as

$$\triangle\Phi = \sum_{q=1,2,3,4} \{(\Phi_{SWq2} - \Phi_{SWq1}) + S_{EWq2}(\Phi_{EWq2} - \Phi_{SWq2}) + S_{XWq1}(\Phi_{SWq1} - \Phi_{XWq1})\}$$

where we define $S_{GWqt} = \Sigma_{i \in G \ in \ Wq} S_{it}$ be the aggregate market share of a group $G \in \{E, X, S\}$ of firms in the wage group W_q for $q = \{1,2,3,4\}$ and define $\Phi_{GWqt} = \Sigma_{i \in G \ in \ Wq}(S_{it}/S_{GWqt})\varphi_{it}$ as that group's aggregate productivity for each period.

Ⅲ. Data and Industry Background

We use the Mining-Manufacturing Survey and the Economic Survey data from Statistics Korea to estimate production function and productivity. To create wage groups, we first derive the wage distribution using firm-level average wage rates, calculated from the wage information reported at the firm level from the industry survey, and divide firms into four groups depending on their level in the distribution. Our focus will be on surveys from the 2007 to 2017 statistical years, which include the 2008 period of financial turmoil. To measure more accurately firm entry and exit, we augment the Mining-Manufacturing Survey with the Census on Establishments from Statistics Korea. The annual Mining-Manufacturing Survey itself includes all data necessary to estimate the production function, but the survey is conducted for establishments employing more than nine employees only, so even if a firm disappears from the survey, based on the Mining-Manufacturing Survey we cannot tell whether the firm

Table 1: Descriptive Statistics for Korean Economy and Industries(2007-2017)

		Food, Beverages (10)(11)		Textiles (13)		Electronics (26)		Motor Vehicles (30)	
Year	GDP	Plants	Gross Output	Plants	Gross Output	Plants	Gross Output	Plants	Gross Output
2007	1,147,311	4,257	55,731	3,372	20,215	4,126	164,745	3,271	114,293
2008	1,179,771	4,061	62,205	3,113	19,953	3,820	186,533	3,037	123,079
2009	1,188,118	4,169	61,623	3,050	18,013	3,652	212,551	3,019	115,495
2010	1,265,308	4,255	63,924	3,168	19,651	3,937	254,479	3,467	146,027
2011	1,311,893	4,360	66,193	3,193	20,763	4,027	243,184	3,685	167,560
2012	1,341,967	4,423	68,271	3,176	19,653	4,096	238,119	3,869	170,006
2013	1,380,833	4,616	66,237	3,158	19,255	4,111	237,545	4,219	168,815
2014	1,426,972	4,983	66,457	3,224	19,255	4,228	222,204	4,579	181,728
2015	1,466,788	5,124	66,546	3,216	18,467	4,026	204,304	4,660	178,106
2016	1,509,755	5,274	65,981	3,134	17,746	3,804	187,897	4,622	167,568
2017	1,555,995	5,481	69,010	3,033	18,005	3,621	275,428	4,605	174,677

Note: GDP figures are from Bank of Korea. Both the number of factories and gross output by sector are from Statistics Korea. The number of plants is in units. GDP and gross output by sector are in billions of 2010 Korean won.

exits from the market or simply reduces its number of employees.[8] The Census on Establishments surveys all businesses annually, so we can obtain more accurate information about firm entry or exit. On the other hand, the census only contains brief information about the number of employees, and is not suitable for estimating the production function.

Using firm-level data combined with the National Accounts, e.g., an investment deflator by type of asset and an output deflator for each industry sector, provided by the Bank of Korea, we construct output, labor and capital stock for the productivity analysis. Table 1 provides some basic statistics on the macroeconomic background and selected industries for the 2007-2017 period. The selected sectors include examples of labor-intensive and capital-intensive industries, as well as expanding and contracting sectors during the period. Real GDP slowed briefly during the 2008 global financial crisis, but has grown steadily by 3-4% since the recovery of the financial crisis. Meanwhile, the number of establishments in each industry sector shows considerable

8) One related potential concern when using the Mining-Manufacturing Survey to measure aggregate productivity is that information about small firms with nine or fewer employees is missing. However, we argue that the aggregate share of small companies with fewer than 10 employees in the whole industry is quite small, so the effect of these missing observations is not expected to be significant.

dynamics.[9]. Looking at several sectors of the manufacturing industry, for example, we observe the number of businesses in the food and beverage sectors to have increased by 29% and gross output increased by 24% from 2007 to 2017. On the other hand, in the textile sector, a representative declining sector in Korea, both the number of businesses and the gross output gradually decreased during the period. We also look at Korea's two flagship industries. In the electronics sector, the number of businesses decreased by 12%, but the output increased by 67%, suggesting that the market concentration controlled by large firms increased over the time span. For the motor vehicles sector, the number of establishments and gross output grew by 40% and 53%, respectively, during the period.

Tables 2 through 4 show the summary statistics on industry dynamics, some key inputs and outputs, and productivity measures for the first(2007), middle(2012) and final(2017) years of our sample. During this period, the average size of employment by active firms increased from 41.60 to 44.04, and then recently decreased to 42.62, but it was quite stable compared to real aggregate physical capital, which increased from 246,328 to 355,718 (44.41% increase). We later argue that this disparity in the growth of labor and capital inputs somewhat contributed to the different paths seen in labor and total factor productivity growth. We also note that during this time span, real aggregate output, real aggregate value added, average labor productivity and average TFP all increased by 35.10%, 42.18%, 5.40% and 3.80%, respectively, except some downturn in real aggregate output from 2012 to 2017. We also note for both productivity measures that average productivity was highest for continuing firms, and was then followed by that for entrant firms, and that exiting firms showed the lowest average productivity.

From the summary statistics by the wage groups (Table 3), we note some interesting observations that for both productivity measures, the lowest wage

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9) According to Olley and Pakes (1996), the use of an artificially created balance panel is undesirable for the production function analysis since it causes bias due to selection, and the use of an unbalanced panel helps to mitigate the selection bias caused by the entry and exit of firms. For this reason, we also use unbalanced panel data for our analysis.

Table 2: Descriptive Statistics for Korean Manufacturing Industry(2007-2017)

Number of	Year		
	2007	2012	2017
All Firms	53,847	54,823	60,632
Surviving Firms	50,796	45,955	44,872
Entering Firms	–	8,868	15,760
Exiting Firms	3,051	11,268	14,560
Variables			
Average Employment (# of people)	41.60	44.04	42.62
Aggregate Employment (1,000s)	2,240	2,415	2,584
Real Aggregate Value Added (KRW billion)	348,834	448,996	495,975
Real Aggregate Output (KRW billion)	1,029,131	1,392,860	1,390,364
Real Aggregate Physical Capital (KRW billion)	246,328	296,678	355,718
Average Labor Productivity			
All Firms	4.111	4.198	4.333
Surviving Firms	4.121	4.224	4.347
Entering Firms	–	4.070	4.292
Exiting Firms	3.941	4.051	4.085
Average TFP			
All Firms	4.390	4.451	4.557
Surviving Firms	4.399	4.477	4.574
Entering Firms	–	4.329	4.508
Exiting Firms	4.253	4.336	4.356

Note: The total value added, gross output and aggregate capital are in billions of 2010 Korean won. The nominal value added and gross output are deflated by the output deflator for each industry. The nominal physical capital stock is deflated by the investment deflator for each type of capital. Both labor productivity and total factor productivity are in logs. For each year, the surviving firms are those firms that survived until that year. The exiting firms are those firms that exited from the market by the end of that year, accumulated since the base year 2007, and the entering firms are those firms that entered the market by the end of that year, accumulated since the base year. For the year 2017, the exiting firms are those firms that exited by the end of 2016, accumulated since the base year.

group, when measured by the distribution of the 2007 base year, showed the highest growth in average productivity. For labor productivity, the growth of the lowest wage group was 16.97%, while other groups showed growth rates of 7.21% (second quartile), 4.44% (third quartile) and 2.94% (fourth quartile), respectively. Similarly, for TFP, the growth in the lowest wage group was 12.85%, while other groups showed growth rates of 5.58% (second quartile), 3.40% (third quartile) and 2.66% (fourth quartile), respectively. This suggests the upward shift in wage rates, e.g., by minimum wage hikes, were more effective for the lower wage group in terms of productivity growth over this time span.

Table 3: Descriptive Statistics for Korean Manufacturing (2007-2017) by Wage Rates

Number of Firms (in units)		Year			
		2007	2012	2017	
Entering Firms	Total	–	8,868	15,751	
(by wages each year)	Wage 1st qtile	–	2,937	4,495	
	Wage 2nd qtile	–	2,122	3,958	
	Wage 3rd qtile	–	1,958	3,831	
	Wage 4th qtile	–	1,851	3,467	
Exiting Firms	Total	3,051	11,268	14,560	
(by wages each year)	Wage 1st qtile	941	3,089	3,796	
	Wage 2nd qtile	778	2,871	3,675	
	Wage 3rd qtile	696	2,783	3,604	
	Wage 4th qtile	636	2,525	3,485	
Exiting Firms	Total	3,051	11,268	14,560	
(by 2007 wages)	Wage 1st qtile	941	3,109	3,815	
	Wage 2nd qtile	778	2,957	3,803	
	Wage 3rd qtile	696	2,678	3,520	
	Wage 4th qtile	636	2,524	3,422	
Productivity		Year			Growth(%)
		2007	2012	2017	2007 to 2017
Average Labor Productivity	Wage 1st qtile	3.489	3.547	3.730	6.91
(by wages each year)	Wage 2nd qtile	3.995	4.086	4.227	5.81
	Wage 3rd qtile	4.277	4.362	4.479	4.72
	Wage 4th qtile	4.686	4.799	4.899	4.55
Average Labor Productivity	Wage 1st qtile	3.489	3.871	4.081	16.97
(by 2007 wages)	Wage 2nd qtile	3.995	4.147	4.283	7.21
	Wage 3rd qtile	4.277	4.341	4.467	4.44
	Wage 4th qtile	4.686	4.719	4.824	2.94
Average TFP	Wage 1st qtile	3.844	3.905	4.055	5.49
(by wages each year)	Wage 2nd qtile	4.267	4.338	4.452	4.34
	Wage 3rd qtile	4.533	4.582	4.663	2.87
	Wage 4th qtile	4.923	4.983	5.060	2.78
Average TFP	Wage 1st qtile	3.844	4.160	4.338	12.85
(by 2007 wages)	Wage 2nd qtile	4.267	4.394	4.505	5.58
	Wage 3rd qtile	4.533	4.580	4.687	3.40
	Wage 4th qtile	4.923	4.958	5.054	2.66

Finally, Table 4 shows the annual entry and exit rates of firms in terms of number of firms, share of employment, and share of added value. The entry and exit rates are comparable in all three measures. However, the rates in terms of employment shares and value-added shares are generally smaller than those in terms of firm counts, which illustrates that both entry and exit are more frequent for smaller firms.

Table 4: Industry Dynamics of Korean Manufacturing: Entry/Exit Rates

Year	Number of Firms		Employment Share		Value-added Share	
	Entry	Exit	Entry	Exit	Entry	Exit
2007	5.5398	5.6661	3.3421	3.1328	1.7596	1.5631
2008	5.3560	6.5761	3.4432	4.7005	1.9792	3.3433
2009	4.2954	5.9558	3.5465	3.7350	3.7847	1.9435
2010	5.6867	3.9105	3.6384	3.1054	2.2482	3.0289
2011	4.9243	4.5911	2.9027	3.9903	3.5241	6.6709
2012	4.0731	6.3550	2.6002	3.9257	3.0919	2.2048
2013	8.0862	5.7249	4.6367	3.9622	2.7104	2.8547
2014	8.5388	5.1600	5.2034	3.0253	3.3156	1.7066
2015	3.5993	4.3731	2.2590	3.0496	1.2706	1.9626
2016	4.2011	3.7214	2.7371	2.8810	1.8745	2.2239
2017	3.9583	–	2.3154	–	1.8798	–

Note: The annual entry and exit rates in percentages are calculated in terms of number of firms, employment size, and value-added share from all firms in the sample.

1. Production Function and Productivity

For the production function estimation, we construct panel data for the period 2007-2017 by using the Economic Survey and the Mining-Manufacturing Survey. After estimating the production function by industry sector, we calculate the productivity of each firm from the estimated production function by year and sector.

For the output variable, we change the nominal value-added of each firm into real terms, with 2010 being the base year, by using the output deflator for each industry. In addition, we use the sum of the full-time and part-time workers as the labor input. For the capital input, after calculating the average of year-start and year-end stock of buildings, structures, machinery and transport equipment, we also convert all that to real capital stock by using the investment deflator for each type of asset. For the intermediate input, we use the input-output table to estimate the input structure of a firm. From the input-output table, we calculate the input coefficients by industry sector, and by using the price index for each input product, we generate the intermediate input deflator by industry sector. Then, we use the intermediate input deflator to obtain a real intermediate input figure. Lastly, we use the material as the proxy variable for the unobserved productivity. From the Mining-Manufacturing Survey in 2017, we find that almost 100% of firms report material expenses, while 97% of the electricity costs and 73% of the fuel costs are reported.

Ⅳ. Results

We first examine the aggregate productivity change for all manufacturing firms by surviving, entering and exiting firms, and also separately look at the within- and between- firm components for surviving firms. Our measures of aggregate productivity are labor productivity with employment share weights, and total factor productivity with nominal value-added weights. In Table 5a we decompose the aggregate productivity changes by within- and between-firm components for surviving firms, entrants and exiting firms. We then study the contributions of firms to aggregate productivity growth and to firm dynamics at the wage level. Our industry sectoral analysis that illustrates interesting similarities and differences across manufacturing sectors follows at the end.

1. All Manufacturing Firms

In Table 5a, we show the accounting for productivity growth and its components for all manufacturing firms. There had been about 21% growth in total factor productivity compared to 23% growth in labor productivity in the Korean manufacturing industry over this time period. This is equivalent to a yearly average growth rate of 2.3% and 2.1% for aggregate labor productivity and TFP, respectively (Table 5b).[10] However, we also find that the nature of such growth was quite different for the two measures of productivity. For labor productivity, most of the productivity growth comes from productivity changes among surviving firms (84.7% of annual average growth) rather than from entering (-4.8%) or exiting firms (20.1%) as shown in Table 5b. On the other hand, for total factor productivity, most of productivity growth comes from entering firms (81.3% of annual average growth), particularly, in recent years, and any contribution from surviving firms (-9.6%) was even

10) This is in line with findings in other existing works. For example, Jeong (2019) finds that Korea's sustained growth for the last three decades was mainly due to a growth regime switch from an input-driven one to a productivity-driven one, and that the overall average growth rate of aggregate TFP for the 1970-2016 period was 1.6%.

negative in the 2016-2017 period due to the between-firm component (-26.9%).

This observed discrepancy in the growth paths of labor productivity and TFP can happen if the capital accumulation by continuing firms might have been faster than the growth of the labor force beyond an optimal mix of inputs, as illustrated in the summary statistics. For example, if labor productivity growth is the result of heavy capital spending by firms, then the resulting TFP growth can be low or negative.

From Table 5a one interesting finding is that for both productivity measures, the growth slowed during the global financial crisis and quickly recovered afterward due to significant contributions from the between-firm component. However, we also note that total factor productivity had been significantly diminishing since 2014 with an uptick in 2017. Since 2015, overall, there were significant drops in aggregate total factor productivity among surviving firms, but the total growth rebounded somewhat in 2017 due to the contribution from entering firms. Finally, we also find healthy industry dynamics as exiting firms contributed positively to aggregate productivity growth with increasing trends throughout the period.

The within- and between-firm changes among surviving firms show that the within-firm contribution to aggregate productivity growth diminished dramatically right after the 2008 financial crisis and has been recovering since then, while the between-firm contribution substantially increased during the financial crisis and is gradually diminishing. This finding suggests that after the global financial crisis there was a substantial resource reallocation across firms, and that such a reallocation helped to somewhat maintain the aggregate productivity growth.

We also find that the relative changes of within-firm and between-firm effects have been more drastic for TFP. The within-firm contribution was 8.76% in 2008 for TFP, which shrank to minus 4.15% in 2009 during the aftermath of the financial crisis, but the contribution recovered to 3.63% by 2017. On the other hand, the between-firm contribution was 7.97% in 2008, which rose to 28.24% in 2011, and it has gradually shrunk since then, hitting minus 5.67% in 2017. This finding suggests that after the financial crisis, the between-firm

Table 5a: Aggregate Productivity Growth and Decomposition, 2008-2017

Aggregate Productivity Change Relative to 2007						
Labor Productivity (log percent) - Employment Share Weight						
Year	Surviving Firms			Entering Firms	Exiting Firms	All
	Within	Between	All			
2008	9.32	1.14	10.46	−1.87	1.91	10.50
2009	−3.85	6.33	2.48	−1.44	2.48	3.52
2010	2.08	6.99	9.08	−2.39	3.87	10.56
2011	−3.24	16.68	13.44	−2.20	3.86	15.10
2012	−1.87	15.1	13.24	−1.50	2.87	14.61
2013	−2.77	13.01	10.24	−3.25	3.52	10.51
2014	0.25	13.24	13.49	−3.48	3.62	13.63
2015	4.07	13.46	17.53	−2.48	4.29	19.34
2016	−1.72	13.94	12.23	−1.64	4.89	15.48
2017	7.01	12.41	19.43	−1.09	4.59	22.93
TFP (log percent) − Value Added Share Weight						
Year	Surviving Firms			Entering Firms	Exiting Firms	All
	Within	Between	All			
2008	8.76	7.97	16.73	−1.57	1.66	16.82
2009	−4.15	18.04	13.89	1.54	3.03	18.46
2010	3.48	20.23	23.71	1.08	4.59	29.38
2011	−4.05	28.24	24.19	6.60	2.94	33.73
2012	−2.94	27.71	24.77	6.35	0.60	31.72
2013	−4.02	26.88	22.86	4.44	2.05	29.35
2014	−1.78	19.70	17.92	2.75	3.03	23.70
2015	1.81	0.52	2.33	3.94	3.98	10.25
2016	−2.91	−1.81	−4.72	10.04	5.11	10.43
2017	3.63	−5.67	−2.04	16.88	5.93	20.77

Note: The decomposition of aggregate productivity growth for each year is relative to the base year 2007. For each year the surviving firms are those firms continuing until that year, the exiters are those firms that exited by the end of that year, accumulated since the base year, and the entrants are those firms entering the market by the end of that year, accumulated since the base year. The contribution of surviving firms for each year measures the contribution of those continuing firms since the base year, relative to their aggregate productivity level in the base year. The contribution of entering firms for each year measures the contributions of all new entrants since the base year, relative to the continuing firms in terms of that year's aggregate productivity. The contribution of exiting firms for each year measures the contribution of all exiters since the base year, relative to the continuing firms in terms of their aggregate productivity level in the base year.

Table 5b: Aggregate Productivity Growth and Decomposition, 2008-2017 (Annual Average)

(log %, %p)

	Aggregate Productivity Change Relative to 2007				
	Surviving Firms		Entering Firms	Exiting Firms	All Firms
	Within(A)	Between(B)	(C)	(D)	(A+B+C+D)
Labor Productivity	0.70 (30.6)	1.24 (54.1)	−0.11 (−4.8)	0.46 (20.1)	2.29 (100)
TFP	0.36 (17.3)	−0.56 (−26.9)	1.69 (81.3)	0.59 (28.4)	2.08 (100)

Note: The figures in parenthesis represent the contribution rate of each firm group to aggregate productivity growth.

resource reallocation was effective in maintaining productivity growth. The overall TFP growth of surviving firms was 16.73% in 2008, and that rose to 24.77% in 2012 after the crisis, but it went down to minus 2.04% in 2017.

For labor productivity, the decomposition shows similar patterns, but the annual changes were less volatile except right before and after the crisis. For labor productivity, the within-firm contribution was 9.32% in 2008, which shrank to minus 3.85% in 2009, but the contribution has recovered to 7.01% by 2017. On the other hand, the between-firm contribution was only 1.14% in 2008, but it rose to 6.33% in 2009, peaked at 16.68% in 2011, and then it gradually decreased to 12.41% by 2017. Over the 10-year interval from 2007-2017, we find these market share reallocations toward more productive firms together with the within-firm growth added 19.43%p to aggregate labor productivity.

We illustrate how these aggregate productivity growth decompositions are obtained for labor productivity from Table 6.[11] The first two blocks of Table 6 show the aggregate labor productivity of surviving and exiting firms in period 1, which is calculated by aggregating the productivity level of the base year 2007 with the employment shares of the base year. For each year in period 1, the surviving firms are those firms that survived until that year, while the exiting firms are those firms that left the market by the end of that year. Therefore, the decomposition in period 1 between surviving and exiting firms for each year is looking at the aggregate productivity level of those firms as it existed in the base year 2007.

The second two blocks of Table 6 show the aggregate labor productivity of surviving and entering firms in period 2, which is calculated by aggregating the productivity level of those firms that existed since the base year (surviving firms) and those firms that entered the market each year since the base year (entering firms). For each year in period 2, the surviving firms are those firms that survived until that year, while the entering firms are those firms entering the market by the end of that year since the base year. Therefore the

11) We do not report the alternative decompositions based on Griliches and Regev (1995) or Foster, Haltiwanger, Krizan (2001). One may calculate those decompositions based on the statistics shown in Table 6.

Table 6: Aggregate Labor Productivity and Employment Shares

Year	Surviving Firms		Exiting Firms		Surviving Firms		Entering Firms	
	Φ_{S1}	S_{S1}	Φ_{X1}	S_{X1}	Φ_{S2}	S_{S2}	Φ_{E2}	S_{E2}
2007/08	4.5249	0.9687	3.9141	0.0313	4.6294	0.9656	4.0868	0.0344
2008/09	4.5306	0.9308	4.1723	0.0692	4.5553	0.9348	4.3343	0.0652
2009/10	4.5445	0.9043	4.1400	0.0957	4.6352	0.9083	4.3748	0.0917
2010/11	4.5444	0.8801	4.2222	0.1199	4.6788	0.8876	4.4831	0.1124
2011/12	4.5345	0.8577	4.3326	0.1423	4.6668	0.8703	4.5512	0.1297
2012/13	4.5409	0.8349	4.3280	0.1651	4.6433	0.8391	4.4415	0.1609
2013/14	4.5420	0.8125	4.3489	0.1875	4.6769	0.8075	4.4960	0.1925
2014/15	4.5487	0.7982	4.3360	0.2018	4.7240	0.7957	4.6028	0.2043
2015/16	4.5547	0.7811	4.3311	0.2189	4.6770	0.7839	4.6011	0.2161
2016/17	4.5517	0.7661	4.3555	0.2339	4.7459	0.7723	4.6982	0.2277

Note: The aggregate labor productivity and employment shares of surviving firms and exiting firms in period 1 and those of surviving firms and entering firms in period 2 are calculated following Melitz and Polanec (2015).

decomposition in period 2 between surviving and entering firms for each year is looking at the aggregate productivity level of those firms that survived and entered the market since the base year. The aggregate employment shares in both period 1 and 2 are calculated by dividing groups of firms similar to the aggregate productivity by groups.

For labor productivity, those productivity growth decompositions are calculated from the group employment shares S_{S1}, S_{X1}, S_{S2}, and S_{E2}, and the group aggregate productivity Φ_{S1}, Φ_{X1}, Φ_{S2}, and Φ_{E2} as reported in Table 6. For example, we can see that the reason why the contributions of entering firms to aggregate labor productivity are negative in all years, is that the aggregate productivity of entering firms, denoted by Φ_{E2}, was lower than that of surviving firms, denoted by Φ_{S2}, in all years. For exiting firms, the contributions of exiting firms are positive in all years because the aggregate productivity of exiting firms, denoted by Φ_{X1}, was lower than that of surviving firms, denoted by Φ_{S1}, in all years. Note that the positive contribution of exiters in the aggregate productivity growth means that they contribute to the growth by leaving the market with relatively lower productivity on average. The steadily lower aggregate productivity of exiting firms suggests that those firms that will exit in the future have experienced adverse productivity shocks several years earlier, similar to the "shadow of death" effect indicated by Griliches and Regev (1995).

We also see that the firms that existed in 2007 were gradually exiting the market as the aggregate employment share for exiting firms increased to 0.234 by 2017, from 0.031 in 2007. Similarly, the aggregate employment share of surviving firms was gradually decreasing from 0.966 in 2008 to 0.772 by 2017 as new firms were entering the market. These findings suggest substantial dynamics with considerable turnover in the manufacturing industry. For all years, our decomposition reports negative contributions from entry firms to aggregate labor productivity changes, because entrants have an aggregate productivity Φ_{E2} lower than that of surviving firms Φ_{S2}, and its negative contribution is stable over the period, but somewhat diminishing in recent years.

We summarize our main findings as follows. 1. The nature of aggregate productivity growth is quite different for the two measures of productivity. For labor productivity, most of the growth comes from productivity changes among surviving firms, mainly due to the between-firm contribution, suggesting that market resource reallocations across firms had been effective to maintain productivity growth. For TFP, as well, the between-firm component contributed significantly to the productivity growth after the global financial crisis. However, in recent years, most of the growth is coming from entering firms. 2. For both productivity measures, the average productivity of exiting firms is significantly and steadily lower than that of surviving firms. 3. Concerning labor productivity, entering firms are somewhat more productive than exiting firms, but are less productive than surviving firms, and the gap is stable over time. On the other hand, for TFP, entering firms show higher aggregate productivity than surviving firms, yielding substantial contributions from surviving firms to aggregate productivity growth, and the gap has been increasing over recent years.[12)]

12) Note that the contribution of entering firms is given by $S_{E2}(\Phi_{E2}-\Phi_{S2})$ in the decomposition. Therefore, a positive contribution from entering firms to aggregate TFP indicates that the aggregate productivity of entrants is higher than that of continuing firms. The contribution of entering firms can grow either by increasing aggregate shares S_{E2} or by increasing the gap in $\Phi_{E2}-\Phi_{S2}$, or by both.

2. All Manufacturing Firms by Wage Group

Next we examine the productivity growth decomposition by wage rate level as shown in Table 7 and 8. Table 7 illustrates aggregate productivity growth by wage rate levels from 2008 to 2017. In particular, we find higher wage groups disproportionately had higher entry and exit rates in shares, while the productivity growth of surviving firms was substantially higher for lower wage groups, mainly due to the between-firm component, both in labor and total factor productivity. For labor productivity, the aggregate productivity growth of the lowest wage group among surviving firms was 30.83% compared to 20.92%-23.69% for other wage groups by 2017, and similarly for TFP the aggregate productivity growth of the lowest wage group among surviving firms was 32.16% compared to 4.73%-18.35% for other wage groups by 2017 (the highest wage group had the lowest productivity growth at 4.73%). On the other hand, the combined contributions of entering and exiting firms to aggregate productivity growth were positive and much higher for the highest wage group, compared to the mostly negative contributions by other groups, and the gaps seem to be increasing over time during the period we study. In terms of labor productivity, the combined contributions of entering and exiting firms for the highest wage group was 3.48% by 2017, compared to minus 0.19%, 0.17% and minus 0.43% for other groups. Also, in terms of TFP the combined contributions of entering and exiting firms for the highest wage group was 18.80% by 2017, compared to minus 0.15%, minus 0.04% and minus 1.49% for other groups. These findings suggest that the creative destruction process was most effective in the highest wage group.[13)]

13) This creative destruction process can be a part of "reallocation effect" for which higher revenue productivity firms may become more successful in the market by attracting more workers with higher productivity, as Gutiérrez and Phillipon (2019) suggest. However, we note that the productivity growth due to this reallocation effect in the Korean manufacturing sector has been sluggish in recent years, and thus we cannot guarantee that the aforementioned reallocation efficiency has been in effect. For example, as we see from Table 7 in our paper, for labor productivity, the highest wage group of the surviving firms continued to keep higher productivity than those of the entering and exiting firms over recent years. On the contrary, for TFP, the highest wage group of the surviving firms showed lower or similar productivity than those of the entering and exiting firms over the past few years. Lee (2017) attributes this difference between labor productivity and TFP to the inefficiency of capital allocation in explaining the relationship between productivity and wage dispersion in Korean manufacturing companies.

Table 7: Aggregate Productivity Growth by Wage Rates Level 2008 to 2017

	Aggregate Productivity Change Relative to 2007																			
	Surviving Firms												Entering Firms				Exiting Firms			
	Within				Between				All											
	Wage Category				Wage Category				Wage Category				Wage Category				Wage Category			
	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4
Year	Labor Productivity (in log percent)-Employment Share Weights																			
2008	10.31	8.98	7.58	8.54	0.51	1.43	-2.22	3.88	10.82	10.41	5.36	12.41	-0.42	-0.09	-0.01	-0.31	0.13	0.10	0.18	0.60
2009	-2.19	-3.20	-2.73	1.16	8.57	1.86	-3.07	5.77	6.37	-1.34	-5.80	6.93	-0.40	0.08	-0.06	0.30	0.19	0.13	0.24	0.59
2010	6.52	4.08	4.17	5.51	5.14	-1.43	-5.54	12.08	11.66	2.65	-1.36	17.59	-0.64	-0.06	0.00	0.20	0.36	0.21	0.31	1.06
2011	-4.88	1.43	2.87	4.49	14.97	7.03	-2.01	17.00	10.10	8.46	0.86	21.49	-0.46	-0.13	0.12	0.48	0.34	0.21	0.28	0.91
2012	-3.90	3.33	5.00	5.80	11.98	5.18	2.55	15.07	8.08	8.51	7.55	20.87	-0.46	0.14	-0.12	1.40	0.36	0.21	-0.42	0.41
2013	-5.40	2.55	5.05	3.95	13.14	1.31	-0.95	14.91	7.73	3.86	4.11	18.86	-0.62	-0.07	-0.19	0.95	0.28	0.18	-0.37	0.52
2014	-0.43	6.24	7.55	6.60	14.47	15.13	4.17	9.08	14.04	21.36	11.72	15.68	-0.78	-0.40	-0.15	1.21	0.29	0.22	-0.33	0.49
2015	5.87	10.89	11.23	11.15	18.78	8.66	4.96	12.18	24.66	19.55	16.19	23.33	-0.55	-0.13	-0.11	1.41	0.29	0.24	-0.32	0.84
2016	-1.20	5.18	6.62	6.34	20.18	10.23	6.29	11.22	18.98	15.40	12.90	17.56	-0.35	-0.12	-0.05	2.10	0.35	0.22	-0.29	1.22
2017	9.58	14.63	15.07	13.74	21.24	9.06	5.85	8.32	30.83	23.69	20.92	22.05	-0.53	0.01	0.06	2.44	0.34	0.16	-0.49	1.04
Year	Total Factor Productivity (in log percent)-Value-Added Share Weights																			
2008	10.56	9.11	6.24	7.46	-2.05	14.23	-13.20	11.60	8.51	23.34	-6.97	19.05	-0.02	-0.03	-0.03	-0.71	0.05	-0.09	0.04	0.63
2009	-1.87	-2.98	-3.76	0.06	-0.40	16.09	-19.02	17.63	-2.27	13.11	-22.78	17.69	0.02	0.13	0.08	2.27	0.06	-0.07	0.19	1.51
2010	9.52	5.96	4.65	5.32	12.54	15.58	-15.32	22.06	22.06	21.54	-10.67	27.38	0.16	-0.02	0.60	1.55	0.08	-0.07	0.34	2.23
2011	-3.76	1.29	1.01	1.54	9.50	9.79	-23.33	27.15	5.74	11.08	-22.33	28.69	0.14	-0.03	0.10	7.21	0.09	-0.05	0.37	0.63
2012	-1.96	2.62	3.02	1.94	15.41	8.82	3.15	27.37	13.45	11.43	6.17	29.31	-0.09	0.04	-0.10	6.55	0.11	-0.02	-3.56	0.31
2013	-4.17	2.92	2.39	-0.19	4.25	17.58	8.53	28.53	0.08	20.51	10.91	28.34	0.18	0.02	-0.20	5.28	0.09	-0.09	-3.49	0.90
2014	0.34	5.20	4.82	1.35	-3.07	11.83	6.98	15.02	8.24	17.03	11.80	16.37	0.18	-2.35	-0.01	5.62	0.10	-0.06	-3.40	1.61
2015	7.59	9.59	7.89	4.81	11.33	4.05	1.19	5.79	18.92	13.64	9.08	10.60	0.04	-0.05	-0.21	5.62	0.02	-0.04	-3.43	2.15
2016	1.91	4.49	4.09	1.42	14.12	8.18	0.67	3.18	16.02	12.68	4.76	4.60	0.23	-0.03	-0.12	10.76	0.02	-0.03	-3.38	2.86
2017	9.38	11.86	10.32	7.57	22.78	6.49	3.65	-2.84	32.16	18.35	13.97	4.73	-0.19	0.03	2.18	15.33	0.04	-0.07	-3.67	3.47

Note: The wage groups are from the wage distribution using firm-level average wage rates, calculated from the wage information reported at the firm level from the Mining-Manufacturing Survey. We divide firms into four groups depending on their spot in the distribution as the first (q1), the second (q2), the third (q3) and the fourth quartile (q4).

Table 8 shows the aggregate employment shares of surviving and exiting firms for each wage group in period 1, which is calculated by aggregating the employment shares in the base year 2007 for those firms that existed in the base year. For each year in period 1, like all manufacturing cases in Table 6, the surviving firms of each wage group are those firms that survived until that year, while the exiting firms are those firms that exited the market by the end of that year. Table 8 also shows the aggregate employment shares of surviving and entering firms in period 2, which is calculated by aggregating the employment shares of those firms in each wage group that existed since the base year (surviving firms) and those firms that entered the market each year since the base year (entering firms). From aggregate employment shares by wage group shown in Table 8, we find that the wage distribution is somewhat skewed in the sense that about 50% of the employment shares (adding shares of surviving firms and exiting firms in period 1, or adding shares of surviving firms and entering firms in period 2) are taken by the highest wage group only, which means the top 25% of firms in the wage distribution have about 50% of the total employment, while the shares for the lowest wage group are only about 12% of the total employment. These aggregate shares by wage group are quite stable over time, which suggests that there was no significant reallocation of labor force across different wage groups during the period. From the aggregate value-added shares by wage group shown in Table 12 in the appendix, we also find the wage distribution is more skewed compared to the aggregate employment shares since more than 74%-76% of the value-added shares are taken by the highest wage group, while the shares for the lowest wage group are only 3%-4%, which means that the top 25% of firms in the wage distribution produce more than 74%-76% of the total value-added, while the bottom 25% firms in the wage distribution produced only 3%-4% of the total value-added from 2007-2017.

Table 8: Employment Shares by Wage Rate Levels

Year	Surviving Firms S_{S1}				Exiting Firms S_{X1}				Surviving Firms S_{S2}				Entering Firms S_{E2}			
	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4
2007/08	0.1182	0.1543	0.2019	0.4943	0.0079	0.0075	0.0074	0.0087	0.1152	0.1550	0.2047	0.4907	0.0109	0.0059	0.0069	0.0107
2008/09	0.1111	0.1474	0.1949	0.4774	0.0149	0.0144	0.0144	0.0256	0.1137	0.1479	0.1968	0.4764	0.0154	0.0143	0.0114	0.0241
2009/10	0.1057	0.1415	0.1887	0.4684	0.0203	0.0202	0.0206	0.0345	0.1098	0.1467	0.1930	0.4588	0.0218	0.0179	0.0181	0.0339
2010/11	0.1022	0.1371	0.1834	0.4573	0.0238	0.0246	0.0259	0.0456	0.1039	0.1410	0.1840	0.4587	0.0246	0.0223	0.0218	0.0437
2011/12	0.0995	0.1336	0.1767	0.4480	0.0265	0.0282	0.0326	0.0549	0.1050	0.1400	0.1808	0.4444	0.0292	0.0249	0.0251	0.0505
2012/13	0.0960	0.1276	0.1703	0.4409	0.0300	0.0341	0.0390	0.0620	0.0942	0.1406	0.1790	0.4253	0.0357	0.0331	0.0319	0.0603
2013/14	0.0937	0.1238	0.1650	0.4299	0.0323	0.0380	0.0443	0.0730	0.0885	0.1372	0.1772	0.4044	0.0406	0.0391	0.0400	0.0728
2014/15	0.0916	0.1208	0.1613	0.4245	0.0344	0.0410	0.0480	0.0784	0.1015	0.1324	0.1655	0.3963	0.0404	0.0421	0.0441	0.0777
2015/16	0.0897	0.1172	0.1576	0.4166	0.0364	0.0446	0.0517	0.0863	0.0959	0.1331	0.1687	0.3860	0.0413	0.0450	0.0485	0.0812
2016/17	0.0879	0.1150	0.1530	0.4102	0.0381	0.0467	0.0563	0.0927	0.0940	0.1302	0.1627	0.3853	0.0424	0.0457	0.0518	0.0877

Note: The employment shares of surviving firms and exiting firms in period 1 and those of surviving firms and entering firms in period 2 are calculated following Melitz and Polanec (2015).

For the aggregate productivity growth of all firms, in Table 5a we observe that TFP growth has been significantly diminishing since 2014. From the separate accounting for each wage group in Table 7, we further find some important patterns to note as the diminishing productivity growth of TFP among surviving firms is mainly coming from the highest wage group, since the growth was 29.31% in 2012, 28.34% in 2013, and it became 4.73% in 2017 due to a significant drop in the between-firm contribution over recent years (It even dropped to minus 2.84% in 2007). Meanwhile, for other wage groups the productivity growth of surviving firms was still increasing or stable since 2014. This suggests that the market resource reallocation from low productivity firms to higher productivity ones did not work properly over recent years for the highest wage group.

We further find that the within-firm contribution is more dominant for higher wage groups, and the opposite is found for the between-firm contribution. In 2017 compared to 2007, the labor productivity (TFP) growth due to the within- and the between- contribution was 9.58% (9.38%) and 21.24% (22.78%), respectively, for the lowest wage group while it was 13.74% (7.57%) and 8.32% (minus 2.84%) for the highest wage group. The net entry contribution was mostly dominant for the highest wage group. In 2017, the labor productivity (TFP) growth due to the net entry was 3.48% (18.80%) for the highest wage group while it was negligible or even negative for other wage groups. For TFP, we also note the productivity growth contribution from entering firms was largest for the highest wage group, amounting to 10.76% in 2016 and 15.33% in 2017. For other wage groups, such contributions were starkly different, as the contributions were small or mostly negative across all years. For TFP, this productivity growth of entering firms in the highest wage group contributed to the overall aggregate TFP growth in recent years, contrasted with the pattern for the highest wage group of all surviving firms in Table 7. From these observations we note that a timely change, not only in input and output, but also in wages, is the necessary ingredient for the pace and magnitude of reallocation to be effective in aggregate productivity growth.

3. Productivity and Entry & Exit

Here we discuss how the productivity difference among firms is related to a firm's entry or exit decision. In Table 6, we find that the average productivity of exiting firms is significantly and steadily lower than that of continuing firms. Previous studies − Baily, Hulten and Campbell (1992), Dwyer (1995), Olley and Pakes (1996), and others − also show that the productivity level is one of the key factors that can predict firm exit. Firms having low productivity are more prone to leave the market, even after controlling for other firm characteristics, such as establishment size and age. Those studies also find that firm characteristics are correlated with productivity differences among firms, including size, age, input prices, such as wages, the adoption of advanced technologies, and whether or not a firm is exporting. See Baily, Hulten and Campbell (1992), Bernard and Jensen (1995), Olley and Pakes (1996), Doms, Dunne and Troske (1996), and others.

From our findings in the productivity growth decomposition by wage group, shown in Table 7, we argue that different wage levels also play a significant role in the heterogeneous patterns of entry, exit and productivity growth. In particular, our analysis shows that higher wage groups disproportionately experienced higher entry and exit rates in shares, and that the contributions of these entering and exiting firms were largest for the highest wage group, while the productivity growth of surviving firms was substantially higher for lower wage groups due to the between-firm resource reallocation effect. From our analysis in Table 5a, we also find that entering firms are somewhat more productive than exiting firms, and that the difference has been increasing over recent years. However, in the literature it has been more difficult to find what would drive such changes in productivity. For instance, Doms, Dunne and Troske (1996) discover that firms that have selected up-to-date technologies are more inclined to enjoy high productivity, but on the other hand the change in productivity is only weakly explained by the adoption of such advanced technologies.

Table 9: Aggregate Labor Productivity Growth by Wage Rate Levels

Year	Surviving Firms				Exiting Firms				Surviving Firms				Entering Firms			
	Φ_{S1}				Φ_{X1}				Φ_{S2}				Φ_{E2}			
	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4
2007/08	3.5093	3.9985	4.3394	5.0078	3.3438	3.8656	4.1009	4.3146	3.6175	4.1026	4.3930	5.1319	3.2340	3.9506	4.3768	4.8384
2008/09	3.5144	4.0007	4.3425	5.0075	3.3884	3.9074	4.1763	4.7786	3.5781	3.9873	4.2845	5.0768	3.3210	4.0425	4.2355	5.2011
2009/10	3.5277	4.0055	4.3458	5.0169	3.3500	3.9007	4.1966	4.7110	3.6442	4.0320	4.3321	5.1928	3.3527	3.9977	4.3340	5.2530
2010/11	3.5262	4.0053	4.3444	5.0139	3.3820	3.9206	4.2367	4.8153	3.6272	4.0899	4.3530	5.2288	3.4410	4.0319	4.4076	5.3376
2011/12	3.5276	4.0051	4.3112	5.0040	3.3919	3.9321	4.4387	4.9296	3.6083	4.0902	4.3867	5.2128	3.4511	4.1481	4.3378	5.4905
2012/13	3.5213	4.0036	4.3135	5.0062	3.4277	3.9504	4.4076	4.9224	3.5986	4.0422	4.3546	5.1949	3.4236	4.0214	4.2941	5.3518
2013/14	3.5218	4.0060	4.3151	5.0057	3.4330	3.9479	4.3905	4.9380	3.6622	4.2197	4.4323	5.1626	3.4706	4.1175	4.3938	5.3294
2014/15	3.5223	4.0074	4.3160	5.0126	3.4369	3.9480	4.3816	4.9053	3.7689	4.2029	4.4779	5.2459	3.6320	4.1714	4.4525	5.4269
2015/16	3.5267	4.0060	4.3171	5.0202	3.4306	3.9566	4.3734	4.8787	3.7165	4.1600	4.4462	5.1958	3.6313	4.1338	4.4362	5.4547
2016/17	3.5261	4.0023	4.3078	5.0165	3.4365	3.9680	4.3942	4.9048	3.8343	4.2392	4.5170	5.2370	3.7086	4.2423	4.5287	5.5153

Note: The labor productivity of surviving firms and exiting firms in period 1 and those of surviving firms and entering firms in period 2 are calculated following Melitz and Polanec (2015).

Our analysis of labor productivity by wage group, shown in Table 9, indicates that 1. overall, for all surviving, exiting and entering firms, the higher wage group showed higher aggregate productivity levels. 2. For both surviving firms and entering firms in period 2 for each year, the aggregate productivity grew from 2008-2017, except for during the financial crisis period. 3. In almost all wage groups, the aggregate productivity of exiting firms, denoted by Φ_{X1}, was lower than that of surviving firms, denoted by Φ_{S1}, during the period. However, we also find that in recent years for the third quartile wage group, the aggregate productivity of exiting firms was somewhat higher than that of continuing firms. 4. The aggregate productivity of entering firms, denoted by Φ_{E2}, was lower than that of surviving firms, denoted by Φ_{S2}, during the period. However, we also find somewhat different patterns across different wage groups. For example, entering firms in the lowest wage group showed lower aggregate productivity than continuing firms, while the opposite was true for entering firms in the highest wage group. From these findings, we conclude that the different wage levels have moderated or accelerated the process of industry dynamics through changes in firm productivity, entry and exit, and that such effects are somewhat heterogeneous across different wage groups.

4. Analysis by Industry Sector

Our industry sector level study shows that there were substantial heterogeneous productivity growth patterns, or components, across different industries. Our sectoral analysis focuses on productivity changes and industry dynamics within each sector, treating each sector as an economy, in order to better understand heterogeneities across sectors.[14] This analysis by industry sector level reveals similarities or differences across industry sectors in aggregate productivity growth. However, we note that an industry level analysis may not

14) In our sectoral analysis, we let the total shares of each sector be equal to one. For the purpose of growth accounting and aggregation of the whole industry, one may do a similar analysis to ours by allowing the total shares of each sector to vary over time, and then aggregating each sector's contribution to total aggregate productivity.

fully capture productivity changes through resource reallocations across industry sectors, e.g., some sectors as a whole may shrink or expand compared to other sectors.

Table 10 and 11 show the summary statistics on industry dynamics, inputs and outputs for the first, middle and last year of our sample by industry sector. During this period, some sectors were expanding and others were contracting, both in terms of number of establishments and employment size. Also, there were significant turnovers, illustrating substantial industry dynamics within sectors during the period. Nevertheless, total wages, wages per worker, total value-added, total output and total aggregate capital all substantially increased over the time span across almost all sectors, with only a few exceptions, e.g., textiles, wearing apparel and the furniture industry. Similarities and differences in transitions of these key variables have contributed to different patterns of aggregate productivity growth by sector, as we analyze below.

We show the aggregate productivity growth decompositions for a set of selected manufacturing sectors in order to illustrate similarities and differences in growth patterns across sectors in the appendix (see Tables 13-24). The selected sectors include both light and heavy industry, as well as expanding and contracting sectors. For each manufacturing sector, we decompose aggregate productivity growth into four components: the within- and the between-firm contribution for surviving firms, the contribution of entrants, and that of exiters.

Concerning labor productivity, in almost all manufacturing sectors we find that the aggregate productivity of entering firms was lower than that of surviving firms, while the aggregate productivity of surviving firms was higher than that of exiting firms. Therefore, in almost all manufacturing sectors, the decomposition results of aggregate labor productivity show that entering firms negatively contribute to aggregate productivity growth, while exiting firms positively contribute by exiting the market. However, we do find some exceptions. In particular, the contribution of entering firms to aggregate TFP growth was somewhat different across industry sectors. In the textiles and chemicals industries, the contribution of exiting firms was negative for TFP,

Table 10: Descriptive Statistics for Korean Manufacturing by Sector

Industry	Year	Number of All	Number of Entry	Number of Exit	Average Employ-ment	Total Employ-ment	Wage/ Worker	Total Wage	Total VA	Gross Output	Aggregate Capital
(10) Food	2007	3,633	–	191	38	138,938	17.04	2,923	16,593	45,288	9,493
	2012	3,852	763	790	40	152,916	21.46	3,896	18,075	57,859	11,570
	2017	4,777	1,545	1,016	37	178,429	27.58	5,640	19,418	57,095	15,960
(11) Beverage	2007	258	–	10	50	12,891	23.64	421	5,066	8,731	2,674
	2012	237	29	43	53	12,551	29.86	493	4,870	8,959	3,006
	2017	247	49	52	59	14,643	36.85	675	5,529	9,776	3,988
(12) Tobacco	2007	12	–	1	199	2,391	36.65	103	1,691	3,020	740
	2012	8	1	2	246	1,968	56.26	115	1,903	3,249	610
	2017	6	1	3	292	1,752	62.67	127	1,811	3,005	474
(13) Textiles	2007	2,927	–	175	30	88,614	18.73	1,837	6,703	19,102	4,885
	2012	2,798	375	578	31	85,344	23.41	2,190	6,154	18,598	3,831
	2017	2,723	652	758	28	77,246	31.10	2,551	6,187	17,103	3,816
(14) Wearing Apparel	2007	2,102	–	198	29	60,465	15.56	1,090	5,935	12,440	895
	2012	1,701	300	545	28	47,361	17.74	1,005	4,442	10,222	726
	2017	1,664	433	644	26	43,158	22.16	1,160	4,628	10,259	830
(15) Leather	2007	659	–	46	29	18,912	18.67	381	1,371	3,677	426
	2012	647	130	157	27	17,236	19.57	390	1,660	4,791	331
	2017	625	194	206	26	16,461	24.82	457	1,636	4,304	401
(16) Wood	2007	798	–	63	22	17,805	20.24	395	1,704	4,935	911
	2012	705	117	201	22	15,829	25.71	437	1,308	4,042	1,083
	2017	798	221	251	23	18,430	33.52	649	1,863	5,410	1,506
(17) Pulp and Paper	2007	1,458	–	66	32	47,235	20.54	1,280	5,375	15,656	7,222
	2012	1,491	182	261	33	49,550	26.24	1,631	6,182	18,644	6,663
	2017	1,685	381	335	32	54,059	33.57	2,129	5,972	17,537	7,091
(18) Publishing and printing	2007	1,269	–	74	22	27,674	21.37	618	1,557	3,229	1,289
	2012	1,054	171	296	23	24,408	26.78	672	1,679	3,655	1,075
	2017	1,062	231	351	24	25,490	33.31	870	1,823	3,804	1,221
(19) Cokes and Coal	2007	118	–	4	82	9,720	30.31	709	13,665	81,892	9,032
	2012	128	11	19	88	11,261	39.35	872	17,366	123,912	14,430
	2017	138	20	23	81	11,205	48.22	951	16,186	83,352	18,145
(20) Chemicals	2007	2,184	–	75	43	94,092	25.96	3,346	23,537	86,950	20,693
	2012	2,305	301	356	47	108,636	32.40	4,754	37,401	140,733	29,062
	2017	2,686	626	499	46	122,388	40.47	6,515	46,966	150,725	36,874
(21) Medicine	2007	362	–	11	65	23,443	25.60	686	5,781	9,159	1,996
	2012	394	56	52	68	26,770	31.05	951	7,388	13,212	3,541
	2017	490	132	71	79	38,928	36.59	1,629	11,111	18,531	6,552

Note: Wages per worker are in one million Korean won. Total wages, total value added, gross output, and aggregate capital are in one billion Korean won. The nominal value added and gross output are deflated by the output deflator for each industry. The nominal physical capital stock is deflated by the investment deflator for each type of capital.

Table 11: Descriptive Statistics for Korean Manufacturing by Sector

Industry	Year	Number of All	Number of Entry	Number of Exit	Average Employ-ment	Total Employ-ment	Wage/ Person	Total Wage	Total VA	Gross Output	Aggregate Capital
(22) Rubber and plastic	2007	4,936	–	287	34	168,508	20.11	4,049	17,195	44,612	10,796
	2012	5,123	815	1,052	37	190,900	25.63	5,772	18,379	54,170	11,881
	2017	5,867	1,566	1,376	37	214,249	34.27	8,392	22,801	61,655	16,686
(23) Non–metal	2007	2,248	–	88	33	73,115	23.12	2,018	12,144	27,833	10,624
	2012	2,227	276	350	33	72,384	29.42	2,478	13,623	31,398	12,546
	2017	2,501	515	459	33	81,391	36.46	3,294	15,349	34,802	13,121
(24) Basic metal	2007	2,155	–	101	52	111,764	25.07	4,147	33,778	134,040	28,991
	2012	2,471	416	400	51	126,543	32.75	5,757	29,223	151,768	41,183
	2017	2,658	713	553	48	128,809	40.45	6,998	28,783	136,471	47,701
(25) Fabricated Metal	2007	7,548	–	442	27	206,509	20.73	4,959	23,227	65,152	10,290
	2012	7,736	1,269	1,626	28	216,682	27.35	6,635	24,540	63,016	13,012
	2017	8,637	2,134	2,049	28	242,217	35.29	9,398	24,652	63,296	16,833
(26) Electronics	2007	3,117	–	244	105	327,410	22.07	10,900	68,875	155,604	66,034
	2012	3,021	645	844	118	355,760	26.77	15,600	122,924	259,253	70,626
	2017	2,768	818	1,078	118	327,313	34.56	19,500	135,790	267,117	81,260
(27) Precision Instruments	2007	1,391	–	82	34	47,889	21.65	1,162	4,307	10,843	2,298
	2012	1,677	292	289	37	61,669	27.07	1,824	6,591	15,262	2,379
	2017	1,957	505	366	39	75,695	34.50	2,855	12,100	30,073	3,836
(28) Electrical Machinery	2007	3,254	–	187	39	125,877	21.17	3,255	11,516	37,390	5,996
	2012	3,391	579	711	42	144,050	26.99	5,031	17,833	59,965	9,825
	2017	3,789	989	896	45	168,921	33.89	7,230	20,296	63,110	13,378
(29) Machinery and Equipment	2007	7,762	–	367	31	242,069	23.55	6,537	25,769	68,318	11,912
	2012	8,067	1,130	1,481	35	280,255	30.55	9,797	35,164	100,457	16,345
	2017	8,994	2,152	1,961	34	310,216	38.03	13,000	50,601	137,666	20,067
(30) Motor Vehicles	2007	2,971	–	178	83	246,601	21.89	9,525	36,664	113,087	23,330
	2012	3,177	537	605	84	266,272	28.30	12,900	49,644	165,651	25,209
	2017	3,564	1,025	844	80	286,808	36.78	16,100	44,141	156,836	30,288
(31) Other transport Equipment	2007	525	–	24	174	91,602	23.51	4,671	22,315	66,972	13,909
	2012	624	160	121	150	93,450	31.80	5,348	18,365	70,841	15,882
	2017	673	190	155	129	86,657	37.02	5,309	14,192	48,940	13,819
(32) Furniture	2007	1,325	–	94	27	35,513	18.40	757	2,744	8,205	1,270
	2012	1,125	192	324	28	31,104	23.42	892	2,738	9,519	1,156
	2017	1,178	315	401	23	27,180	30.68	867	2,149	5,281	985
(33) Other products	2007	835	–	43	25	21,185	18.86	425	1,322	2,992	623
	2012	864	121	165	25	21,641	23.46	528	1,545	3,685	709
	2017	1,145	353	213	28	32,300	31.07	1,111	1,990	4,215	887

Note: Wages per worker are in one million Korean won. Total wages, total value-added, gross output, and aggregate capital are in one billion Korean won. The nominal value added and gross output are deflated by the output deflator for each industry. The nominal physical capital stock is deflated by the investment deflator for each type of capital.

but was positive for labor productivity. Also in the chemicals industry, the contribution of entering firms was positive for TFP, but was negative for labor productivity. Therefore, in the chemicals industry, although aggregate productivity had grown according to both productivity measures, the nature of such growth was quite different depending on the productivity measure used. These heterogeneous productivity growth patterns were quite noticeable in the industry sector level analysis compared to the overall manufacturing sector.

During the global financial turmoil period across almost all manufacturing sectors, aggregate productivity went down and then quickly recovered right after the crisis, but the growth patterns in later years were quite different across industry sectors. We find interesting similarities and differences across manufacturing sectors as some industry sectors show growth patterns similar to the overall manufacturing industry, while some industries show decreasing aggregate productivity during the period we study, e.g., food, basic metals, and the furniture industry, and others show accelerated or steady growth in aggregate productivity, e.g., publishing and printing, chemicals, electronics, electrical machinery, and the machinery and equipment industry. In particular for electronics, in both productivity measures aggregate productivity had grown substantially, and entering firms also significantly contributed to the growth in recent years. On the other hand, for motor vehicles, aggregate productivity had grown since 2007 in both productivity measures, but the productivity decreased over recent years. Interestingly, in the chemicals industry, aggregate productivity growth was mainly due to surviving firms for labor productivity, while for TFP entering firms had also made significant contributions.

For some industry sectors, the two productivity measures show similar growth patterns, e.g., basic metals, food, electrical machinery, machinery & equipment and the motor vehicles industry, although there are still some notable differences in the growth components, as discussed below. On the other hand, for some industry sectors, labor productivity and TFP show somewhat different growth patterns, e.g., textiles, non-metals, fabricated metals, electronics and the furniture industry. For example, in the food industry, the overall aggregate productivity decreased in both productivity measures, but for surviving firms, labor productivity had somewhat steady growth, reaching 8.73% by 2017 (within-firm (minus 13.44%) + between-firm (22.17%)), while TFP decreased to -23.70% in 2016 (within-firm (minus 23.47%) + between-firm (minus 0.23%)), and then to minus 13.79% in 2017 (within-firm (minus 18.70%) + between-firm (4.91%)). For fabricated metals, in terms of labor productivity, aggregate productivity continuously decreased, while aggregate TFP shrank only in recent years. For the furniture industry, aggregate labor productivity decreased only moderately (20.73% in 2008, to 5.95% in 2017), while aggregate TFP substantially declined (from 17.13% in 2008 to minus 4.97% in 2017). On the other hand, for the textiles and the non-metals industries, aggregate labor productivity continuously increased, but the opposite pattern was found in terms of TFP, as aggregate productivity continuously decreased since 2012 after the financial crisis. This disparity seems more salient for the non-metals industry.

These observed discrepancies in the growth paths between labor productivity and TFP can arise due to intense capital spending by firms beyond the growth of the labor force for an optimal mix of inputs. We also note that for the non-metal, electrical machinery, motor vehicles and furniture industries, the entering firms more or less negatively contributed to TFP growth, contrasting with our findings for the overall manufacturing industry.

Industry sectors also show different patterns in terms of the within-firm and the between-firm changes. For example, in the fabricated metals industry, across almost all years, the positive contribution of surviving firms came from the between-firm component while the within-firm growth components were all negative except the year 2008. This suggests that for this industry, effective resource reallocation had taken place and contributed to aggregate productivity. On the other hand, for the machinery and equipment industry, the within-firm component positively contributed to the productivity growth of TFP, while the between-firm component negatively contributed.

Here we will summarize some notable findings for each industry. For the food industry, the within-firm contributions and the net entry contributions were negative for both productivity measures, but it is notable that the between-firm contribution was steadily growing for labor productivity, while such a pattern does not appear for TFP. This between-firm contribution to the labor productivity growth was also notable for the textiles, non-metals, and fabricated metals industries. For the publishing & printing industry, in terms of both productivity measures, the growth was mainly due to surviving firms, and both within- and between-firm contributions were significant, while the net entry contribution was negligible and mostly negative. For the chemicals industry, the within-firm, the between-firm and the net entry significantly contributed to the productivity growth for both measures. However, it is notable that the contribution of entering firms was quite significant for TFP, while the contribution was negative for labor productivity. For basic metals, the between-firm component showed a significantly negative contribution to the productivity growth for both measures. For electrical machinery, the between-firm component and the exit contribution were dominant for the productivity growth for both measures. For the machinery & equipment and motor vehicles industries, the within-firm component was dominant for the productivity growth for both measures, and the net entry effect was also positive due to the exit contribution. For the furniture industry, the between-firm component was positive, while the within-firm component was mostly negative for both productivity measures. The net entry contribution was mostly negative due to the entry effect. In sum, our industry sector level study has shown substantial heterogeneities in the nature or components of productivity growth across different industry sectors. The differential patterns or components for growth or decline of productivity as identified in this study will be useful in forming industry-specific policies.

Ⅴ. Conclusion

Across the literature, there has been substantial research into aggregate productivity growth and decomposing its factors. These studies have reported some interesting patterns in aggregate productivity changes and factors that have driven such changes. First, there has been a persistent reallocation of outputs and inputs among individual producers. Second, the speed and magnitude of this reallocation varies over time and across sector. Third, depending on different methods of aggregate productivity decomposition and also depending on country and industry sector, some studies find that much of this reallocation comes from within-firm changes rather than from between-firm reallocation, while other studies find the opposite.

In this study we try to cast some light on three important questions concerning the Korean manufacturing industry. First, we examine how industry dynamics and changes in aggregate productivity have been influenced by changes in firm productivity and wages. In particular, the aggregate productivity decomposition intends to provide a better accounting of the contributions made by the entry and exit of firms to aggregate productivity changes, and also among surviving firms, the decomposition breaks down the separate contributions of within-firm productivity shifts and between-firm market share reallocations. Second, we examine how the effects may differ across different manufacturing sectors. Third, we examine how differences in wage levels have moderated or accelerated this process of industry dynamics through changes in firm productivity, entry and exit.

From our analysis of aggregate productivity in the Korean manufacturing industry in the 2007-2017 period, we find that there was about 21% growth in total factor productivity and 23% growth in terms of labor productivity. However, we also find the nature of such growth to be quite different for each of the two measures of productivity. For labor productivity, most of the productivity growth comes from productivity changes among surviving firms, mainly due to the between-firm component, rather than from net entry effects. On the other hand, for TFP, most of the growth comes from entering firms in recent years.

Our findings that aggregate labor productivity and TFP had different growth paths is interesting and relevant for industry policies, and some studies also document different natures of the two measures. Please see Bernard and Jones (1996), Chang and Hong (2006), Syverson (2011) and others. For example, Chang and Hong (2006) find that there is a tantalizing dissimilarity in the feedback of labor hours to TFP and labor productivity changes in the U.S.

manufacturing sector.[15)]

We also find interesting industry dynamics, as for both productivity measures, exiting firms contribute positively to aggregate productivity growth, as firms of lower productivity are gradually exiting from the market, and the contribution of net entry, the combined contributions of entering and exiting firms together, are all positive and increasing. Our findings suggest that firms with lower productivity could not survive the test of the market, and new firms entered the market that have higher productivity, in line with Schumpeter's creative destruction process (Aghion and Howitt, 1992), and this was particularly true for TFP.

We further find that, for both productivity measures, the substantial productivity growth after the 2008 global financial crisis was due to market share reallocations among firms, but that this between-firm effect has been decreasing in recent years. Our industry level study also shows that there were substantial heterogeneous productivity growth patterns and components across different industries.

Finally, we argue that wages also play an important role in accounting for the different productivity growth paths. We find that higher wage groups disproportionately experienced higher entry and exit effects, and the contributions of these entering and exiting firms to aggregate productivity growth were largest for the highest wage group, compared to mostly negative contributions for other wage groups, suggesting that the creative destruction process was most effective for the highest wage group. On the other hand, the productivity growth of surviving firms was substantially higher for lower wage groups, and − more importantly − the between-firm effect was dominant in such growth, which suggests that increasing wage rates, such as the minimum wage, were most effective for lower wage groups by encouraging resource reallocations among firms.

From our analysis of industry sectors, we find interesting similarities and

15) They showed that some industries exhibit only a temporary reduction in employment in connection with a permanent positive shock in TFP, whereas other industries exhibit the opposite. However, in line with other existing work, a labor productivity shock has a forceful negative impact on employment.

disparities across manufacturing sectors, as some industry sectors show growth patterns similar to the overall manufacturing industry while some industries show decreasing aggregate productivity during the period we study, and others show accelerated or steady growth in aggregate productivity. For some industry sectors, both productivity measures show similar growth patterns, while for other industry sectors, labor productivity and TFP show somewhat different growth patterns. For the contribution of continuing firms to aggregate productivity growth, some industry sectors also show different patterns in terms of the within-firm and the between-firm decomposition. These findings suggest that there are substantial heterogeneous productivity growth patterns and components across different industries. Some similarities and disparities we find for aggregate productivity growth patterns and firm dynamics are worth further investigation, since the results would have important policy implications on each industry sector. In particular, the observed disparities of labor and total factor productivity growth need to be further examined. Some differentiated industry policies seem necessary to help productivity enhancement of continuing and entering firms, depending on the industry sector. The differential pattern or components of growth or decline in productivity identified in this study will be useful when crafting such industry-specific policies.

We conclude with the following industry policy suggestions. First, the observed different natures of labor productivity and total factor productivity growth bring attention to differing industry policy approaches to these two productivity measures. Given our findings, it is suggested that, for some sectors, investments in human capital will be more effective in boosting labor quality and productivity, while in other sectors, supporting research & development would be more effective for further significant technological innovations that boost TFP. Second, the study finds that for some sectors, resource reallocations have been effective, either through reallocations between existing firms or through industry dynamics of entry and exit, but that for other sectors, such channels of productivity growth have been lagged or are not significant. The problem of sluggish adjustment or growth in those sectors may happen for three reasons. There are not enough new firms to replace all the troubled firms due to some market barriers, existing innovative firms are not hiring or investing enough due to some market uncertainty, and, finally, the diffusion of new technology or resource reallocation is not effective across firms. This calls for the necessity of further investigation into such lagged sectors and into the development of policies that target such sectors, to pin down the reason behind this, and to ease the process of firms' entry and exit from the market, and to further promote resource reallocations within or across sectors.

Table 12: Value-Added Shares by Wage Levels

Year	Surviving Firms				Exiting Firms				Surviving Firms				Entering Firms			
	S_{S1}				S_{X1}				S_{S2}				S_{E2}			
	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4	q1	q2	q3	q4
2007/08	0.0342	0.0637	0.1279	0.7585	0.0019	0.0032	0.0043	0.0063	0.0327	0.0658	0.1195	0.7622	0.0024	0.0022	0.0037	0.0114
2008/09	0.0323	0.0609	0.1240	0.7353	0.0038	0.0060	0.0082	0.0295	0.0328	0.0596	0.1081	0.7376	0.0041	0.0067	0.0067	0.0443
2009/10	0.0309	0.0585	0.1207	0.7263	0.0052	0.0084	0.0114	0.0385	0.0320	0.0581	0.1050	0.7202	0.0054	0.0069	0.0118	0.0606
2010/11	0.0299	0.0567	0.1173	0.7021	0.0062	0.0102	0.0149	0.0627	0.0283	0.0553	0.0954	0.7003	0.0066	0.0087	0.0126	0.0928
2011/12	0.0291	0.0553	0.1009	0.6831	0.0070	0.0116	0.0313	0.0817	0.0296	0.0565	0.0955	0.6689	0.0075	0.0107	0.0134	0.1179
2012/13	0.0280	0.0526	0.0976	0.6754	0.0081	0.0143	0.0345	0.0894	0.0264	0.0577	0.0988	0.6497	0.0095	0.0134	0.0167	0.1278
2013/14	0.0274	0.0511	0.0949	0.6601	0.0088	0.0158	0.0372	0.1047	0.0266	0.0892	0.1038	0.5851	0.0116	0.0169	0.0237	0.1430
2014/15	0.0266	0.0500	0.0929	0.6553	0.0095	0.0169	0.0393	0.1095	0.0341	0.0625	0.1020	0.5934	0.0130	0.0193	0.0271	0.1487
2015/16	0.0260	0.0485	0.0909	0.6471	0.0100	0.0184	0.0413	0.1177	0.0329	0.0626	0.1029	0.5672	0.0144	0.0207	0.0289	0.1704
2016/17	0.0256	0.0474	0.0872	0.6370	0.0105	0.0195	0.0450	0.1278	0.0327	0.0581	0.0956	0.5461	0.0133	0.0211	0.0363	0.1967

Note: The value-added shares of surviving firms and exiting firms in period 1 and those of surviving firms and entering firms in period 2 are calculated following Melitz and Polanec (2015).

Table 13: Aggregate Productivity Growth 2008-2017: (10) Food

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	10.19	−3.05	−2.77	0.47	4.83	10.52	−5.93	−1.44	−1.00	2.15
2009	−4.08	3.53	−4.40	1.13	−3.82	−4.10	14.28	−2.56	1.04	8.66
2010	−7.27	5.82	−7.91	3.19	8.37	9.74	−10.04	−0.69	3.08	2.10
2011	−7.39	8.17	−3.80	3.38	0.35	−8.43	10.50	−5.33	4.14	0.88
2012	−10.16	14.47	−5.66	3.73	2.38	−11.36	8.16	−5.97	4.40	−4.77
2013	−14.59	11.01	−10.19	4.46	−9.32	−16.41	0.30	−2.80	6.29	−12.61
2014	−16.77	14.78	−11.92	4.37	−9.54	−20.64	3.87	−7.65	7.33	−17.10
2015	−14.57	16.26	−11.52	4.67	−5.16	−17.69	−5.47	−11.03	7.69	−26.50
2016	−19.71	20.26	−12.91	4.69	−7.68	−23.47	−0.23	−12.98	7.95	−28.74
2017	−13.44	22.17	−11.37	−0.25	−2.89	−18.70	4.91	−12.33	0.47	−25.65

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 14: Aggregate Productivity Growth 2008-2017: (13) Textiles

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	−0.17	5.12	−1.70	1.14	4.38	0.23	7.65	0.93	0.65	9.46
2009	−11.27	2.32	−1.54	1.51	−8.98	−10.88	12.93	−0.04	1.06	3.05
2010	−7.31	3.20	−1.09	0.90	−4.29	−5.80	20.42	1.82	−6.72	9.72
2011	−14.14	8.48	1.01	1.56	−3.09	−14.67	13.54	11.27	−5.89	4.25
2012	−11.17	1.68	0.55	1.58	−7.35	−11.80	−1.73	17.86	−5.55	−1.21
2013	−7.70	−2.12	−1.07	2.24	−8.64	−8.93	13.03	3.35	−4.61	2.83
2014	−3.31	0.59	−1.59	2.19	−2.13	−5.12	−1.11	3.45	−4.47	−7.25
2015	−4.66	4.68	0.10	2.35	2.47	−6.77	1.68	0.05	−4.28	−9.32
2016	−7.51	8.33	0.21	1.95	2.98	−9.33	2.21	1.71	−5.08	−10.48
2017	1.20	7.04	0.44	1.83	10.51	−1.82	−0.77	2.83	−5.04	−4.81

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 15: Aggregate Productivity Growth 2008-2017: (18) Publishing & Printing

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	18.88	1.89	−0.80	0.24	20.20	19.11	3.16	−1.09	0.64	21.82
2009	13.01	5.00	−0.66	0.39	17.74	13.06	15.78	−0.53	0.43	28.74
2010	16.14	8.57	−1.34	−0.10	23.27	18.55	9.31	0.05	−0.67	27.24
2011	12.42	5.71	−2.02	0.10	16.22	12.42	5.36	0.32	0.00	18.10
2012	11.63	12.83	−2.45	−0.36	21.65	10.83	8.39	2.23	0.35	21.79
2013	15.07	9.04	−2.08	−0.22	21.81	14.31	6.93	−2.24	1.04	20.03
2014	12.42	12.46	−1.83	−0.58	22.47	11.99	8.08	−0.50	0.82	20.40
2015	15.79	15.53	−1.93	−0.54	28.85	15.22	7.74	−0.82	1.06	23.21
2016	7.21	17.71	−3.07	−0.39	21.46	7.13	13.48	−0.80	0.82	20.64
2017	12.22	19.24	−1.04	−0.47	29.95	11.12	8.36	−0.15	0.94	20.26

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 16: Aggregate Productivity Growth 2008-2017: (20) Chemicals

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	10.90	−2.43	−1.43	1.49	8.52	10.98	7.17	−0.87	0.98	18.26
2009	9.12	−0.66	−2.41	2.26	8.32	9.03	5.61	−2.00	3.25	15.88
2010	9.98	−1.34	−2.07	2.87	9.43	13.02	6.10	−3.57	3.21	18.75
2011	−8.46	15.68	0.35	1.03	8.60	−9.10	35.77	55.47	−11.59	70.55
2012	−2.74	21.66	−1.71	1.09	18.29	−3.12	27.88	47.10	−11.26	60.61
2013	−4.89	16.20	−1.24	1.26	11.33	−5.10	43.06	42.94	−10.41	70.48
2014	10.46	8.62	−0.48	1.03	19.63	10.11	30.62	32.73	−14.00	59.46
2015	25.74	8.06	−1.25	2.71	35.25	24.47	16.98	19.97	−13.18	48.24
2016	31.16	6.37	−1.56	3.24	39.20	31.13	27.60	23.91	−12.41	70.23
2017	22.14	14.90	−2.44	2.85	37.46	18.54	26.31	21.60	−10.83	55.62

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 17: Aggregate Productivity Growth 2008-2017: (23) Non-Metals

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	6.87	−3.94	−1.93	1.47	2.48	6.72	11.15	−1.87	1.03	17.03
2009	−7.28	7.58	−4.29	2.27	−1.73	−7.30	48.35	−3.54	2.95	40.46
2010	−5.26	8.31	−3.94	2.91	2.01	−4.13	78.43	−5.71	4.28	72.87
2011	−6.59	8.81	−2.85	3.54	2.92	−9.14	62.78	−6.41	5.08	51.70
2012	−7.91	9.93	−3.47	3.55	2.10	−10.51	33.29	−7.07	6.16	21.88
2013	−3.76	17.00	−4.07	2.56	11.73	−5.84	22.04	−7.78	6.48	14.90
2014	−7.49	21.74	−3.36	2.79	13.68	−10.33	8.29	−7.24	8.04	−1.24
2015	−3.73	21.31	−2.65	4.22	19.15	−6.43	−2.60	−8.24	8.78	−8.49
2016	−9.59	22.53	−1.40	4.15	15.69	−10.02	−4.17	−7.30	9.77	−11.72
2017	3.17	21.02	−2.50	4.46	19.82	−4.20	−11.03	−6.83	10.63	−11.42

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 18: Aggregate Productivity Growth 2008-2017: (24) Basic Metals

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	−2.83	0.82	−2.61	1.83	−2.80	−3.06	0.69	0.40	0.89	−1.07
2009	−10.62	−7.67	−3.83	3.19	−18.93	−11.41	−15.31	5.35	2.38	−18.99
2010	−17.67	−2.05	−5.97	3.72	−21.97	−17.17	15.47	1.08	3.08	2.46
2011	−21.33	−0.93	−6.59	4.22	−24.63	−23.38	−0.80	−2.98	3.58	−23.57
2012	−20.57	−6.37	−5.92	5.41	−27.46	−23.65	−14.48	−5.93	4.86	−39.20
2013	−19.40	−17.10	−6.13	6.45	−36.18	−22.64	−25.98	−1.95	6.76	−43.81
2014	−14.36	−20.57	−6.24	7.09	−34.09	−18.41	−31.33	−6.16	7.60	−48.31
2015	−8.93	−20.81	−4.72	7.67	−26.80	−14.43	−55.74	−4.81	8.34	−66.63
2016	−15.98	−11.31	−7.16	7.82	−26.64	−19.35	−49.14	−6.81	7.66	−67.64
2017	−14.21	−4.88	−7.38	7.75	−18.72	−20.25	−40.81	−5.50	8.47	−58.09

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 19: Aggregate Productivity Growth 2008-2017: (25) Fabricated Metals

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	0.19	3.02	−1.40	1.03	2.83	0.55	18.66	−2.39	0.43	17.25
2009	−20.04	2.48	−2.20	2.25	−17.52	−20.54	27.90	−1.32	1.02	7.06
2010	−19.23	−4.83	−2.41	3.00	−23.47	−16.74	26.05	−1.31	0.43	8.43
2011	−23.07	4.30	−3.45	3.84	−18.39	−22.01	59.98	−11.02	−0.13	26.81
2012	−20.53	3.68	−3.14	4.11	−15.88	−20.74	74.08	−14.51	0.16	39.00
2013	−23.65	2.31	−3.42	4.41	−20.36	−23.24	61.16	−13.58	0.76	25.11
2014	−21.77	3.33	−3.00	4.59	−16.84	−21.29	43.53	−14.55	0.64	8.32
2015	−21.19	3.71	−1.90	5.05	−14.33	−12.98	16.31	−10.54	1.12	−6.09
2016	−20.48	4.53	−2.48	4.94	−13.50	−18.14	16.43	−13.14	1.54	−13.31
2017	−13.96	3.49	−2.50	4.46	−8.51	−14.13	17.59	−13.84	−0.73	−11.11

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 20: Aggregate Productivity Growth 2008-2017: (26) Electronics

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	10.86	16.95	−1.22	2.19	28.78	9.30	13.06	−2.13	1.23	21.46
2009	0.93	29.90	3.98	−0.78	34.03	0.15	36.19	4.33	3.81	44.49
2010	10.56	45.33	3.63	0.44	59.96	11.90	23.15	5.09	5.82	45.97
2011	10.62	55.64	4.73	−3.18	67.81	7.04	43.61	3.75	4.75	59.15
2012	10.21	64.16	9.65	−11.63	72.39	7.51	42.75	3.44	−0.11	53.59
2013	7.36	69.15	6.87	−10.68	72.70	4.20	44.48	−0.80	1.47	49.34
2014	15.25	70.80	6.90	−15.12	77.83	8.72	23.47	4.52	13.50	50.20
2015	21.86	76.84	6.28	−13.98	91.01	15.79	5.32	11.90	15.27	48.27
2016	18.73	71.55	14.09	−12.55	91.82	13.27	5.39	24.02	19.07	61.75
2017	28.39	58.19	19.13	−12.92	92.80	22.57	−17.85	42.86	22.10	69.69

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 21: Aggregate Productivity Growth 2008-2017: (28) Electrical Machinery

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	16.25	2.41	−1.62	1.77	18.81	15.99	14.93	−1.39	1.94	31.47
2009	6.23	10.40	−1.90	2.39	17.12	6.11	25.09	−1.90	2.95	32.26
2010	16.79	8.79	−3.02	5.40	27.97	18.55	50.93	−0.37	2.58	71.70
2011	13.18	9.45	−4.86	7.22	24.99	12.15	23.78	8.96	3.58	48.47
2012	12.33	11.82	−4.59	7.76	27.32	11.84	33.34	−5.35	4.49	44.32
2013	0.73	8.99	−5.24	8.18	12.64	0.36	25.73	−3.73	4.75	27.11
2014	0.61	8.35	−4.15	8.56	13.37	−0.56	7.03	−4.04	4.47	6.90
2015	−1.37	11.44	−4.83	8.65	13.90	−3.05	17.51	−5.97	5.86	14.35
2016	−10.59	14.57	−5.91	8.90	6.98	−11.12	20.17	−3.80	6.53	11.79
2017	8.58	16.45	−5.42	8.66	28.27	6.31	28.04	−7.85	6.70	33.20

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 22: Aggregate Productivity Growth 2008-2017: (29) Machinery & Equipment

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	13.78	−1.64	−0.69	1.02	12.48	13.52	−3.26	−1.01	0.97	10.23
2009	3.23	0.53	−0.70	1.86	4.93	1.49	−2.31	−0.74	2.01	0.44
2010	11.71	−3.82	−0.82	2.23	9.30	12.18	9.60	−2.32	2.94	22.40
2011	14.98	3.14	−1.03	2.03	19.12	13.37	−8.12	−2.64	3.94	6.55
2012	19.06	1.67	−0.87	2.03	21.88	16.34	−6.87	−1.91	3.91	11.47
2013	21.46	−3.07	−2.03	2.39	18.75	18.67	−10.30	−1.03	5.36	12.70
2014	27.45	1.98	−3.27	2.40	28.56	23.15	−14.14	0.33	6.05	15.39
2015	30.88	2.10	−1.88	2.93	34.03	26.29	−29.23	0.93	6.81	4.80
2016	32.00	3.21	−1.61	2.81	36.42	27.81	−25.07	1.18	5.74	9.65
2017	44.74	3.38	−1.03	2.68	49.76	39.60	−20.90	2.56	6.41	27.67

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 23: Aggregate Productivity Growth 2008-2017: (30) Motor Vehicles

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	17.29	−13.20	−0.84	1.94	5.20	14.63	2.30	−1.16	1.17	16.93
2009	1.34	−11.30	−1.31	3.53	−7.77	−0.57	7.66	−2.21	2.85	7.73
2010	12.74	−5.14	−4.16	4.75	8.20	15.34	8.02	−3.64	4.12	23.84
2011	16.90	−0.23	−3.68	5.36	18.35	18.01	5.91	−4.32	5.10	24.70
2012	14.96	−0.28	−5.00	5.88	15.56	14.70	11.81	−4.90	6.00	27.63
2013	8.90	−0.82	−8.24	6.59	6.42	9.15	13.39	−6.09	7.37	23.82
2014	14.42	−2.01	−7.68	6.74	11.46	13.36	9.68	−9.79	9.02	22.27
2015	14.19	−4.81	−7.10	7.64	9.92	12.16	0.79	−11.16	9.99	11.79
2016	−2.28	−2.73	−5.56	8.33	−2.24	2.03	−10.59	−10.21	11.04	−7.73
2017	12.58	−12.51	−5.52	9.25	3.81	9.02	−20.08	−10.26	11.86	−9.46

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

Table 24: Aggregate Productivity Growth 2008-2017: (32) Furniture

Year	Aggregate Productivity Change Relative to 2007									
	Labor Productivity (in log percent)					TFP (in log percent)				
	Surviving Firms		Entering Firms	Exiting Firms	All	Surviving Firms		Entering Firms	Exiting Firms	All
	Within	Between				Within	Between			
2008	17.38	4.25	−1.68	0.78	20.73	17.33	−2.57	0.63	1.74	17.13
2009	−0.32	9.31	−1.59	1.92	9.32	−0.71	31.31	−3.14	3.48	30.93
2010	8.49	3.35	−1.63	2.53	12.75	10.40	18.82	−2.98	5.29	31.54
2011	3.78	18.14	−4.92	1.97	18.97	2.98	10.85	−2.13	5.84	17.54
2012	3.72	9.32	−4.37	2.37	11.05	2.81	16.82	−2.58	6.86	23.90
2013	−7.25	13.51	−7.28	2.57	1.55	−8.42	13.04	−7.38	7.80	5.05
2014	−6.94	18.59	−5.97	2.70	8.38	−7.73	4.76	−7.92	8.96	−1.93
2015	1.84	13.22	−4.98	2.77	12.85	1.63	3.33	−9.97	9.73	4.72
2016	−8.48	8.82	−4.00	1.65	−2.01	−9.99	16.03	−15.86	4.58	−5.24
2017	−2.35	9.60	−3.19	1.89	5.95	−2.51	4.11	−11.52	4.95	−4.97

Note: Labor productivity is aggregated with employment share weights and TFP with valued-added share weights. For surviving firms aggregate productivity growth is divided into within-firm and between-firm components.

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<Abstract in Korean>

우리나라 제조업의 총생산성 향상과 기업역동성

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본고는 기업 존속, 진입 및 퇴출의 동태적 과정이 우리나라 제조업의 총생산성 성장에 기여하는 정도를 분석하였다. 이를 위해 기업단위 자료를 활용하여 추정된 개별기업 생산성 지표를 제조업 전체로 합산하여 총요소생산성(TFP)과 노동생산성 변화를 동태적 관점에서 4개 요인으로 분해하였다. 4개 요인은 존속기업의 생산성 기여효과, 존속기업간 시장점유율 재배분효과, 진입기업 및 퇴출기업의 생산성 기여효과로 구성되었다. 분석결과, 첫째, 노동생산성의 경우 생산성 향상은 존속기업간 생산성 기여에 주로 기인한 반면 총요소생산성의 경우 생산성 향상은 진입기업의 생산성 기여에 주로 기인하였다. 둘째, 최근 들어 퇴출기업이 총생산성 향상에 기여하는 부분이 증가하고 있는데, 이는 존속기업의 생산성 향상이 상대적으로 둔화되면서 나타난 결과로 추정될 수 있다. 셋째, 2008년 글로벌 금융위기 이후 총요소생산성과 노동생산성이 크게 향상된 것은 존속기업간 시장점유율 재배분효과에 기인하지만 이러한 재배분효과는 최근 들어 다소 완화되거나 감소하였다. 또한 업종별로는 생산성 성장 형태와 이에 기여하는 요소들이 상이하였다. 다섯째, 임금수준은 생산성 성장을 완화시키거나 가속시키는 요인으로 작용하였다. 임금구간을 4분위로 나누었을 때 최고임금구간에서는 기업 진입 및 퇴출의 생산성 기여효과가 두드러진 반면 최저임금구간에서는 존속기업간 시장점유율 재배분효과가 가장 컸다. 본고의 결과는 지속적인 생산성 성장을 도모하기 위해서는 진입장벽 철폐, 시장불확실성 제거 및 자원재배분 원활화가 필수적으로 수반되어야 함과 동시에 인적자본투자 또는 R&D투자 확대 등과 같이 업종별로 상이한 산업정책이 필요함을 시사한다.

핵심 주제어: 총생산성, 노동생산성, 총요소생산성, 자원재배분, 시장 진입 및 퇴출, 임금

JEL Classification: C14, C18, D24

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