Establishment Dynamics and Productivity: Is the ICT Industry Improving?

Nyeong Seon Son

The Korean ICT industry has recently experienced low productivity growth. This study examines this decline of labor productivity growth using the perspective of establishment dynamics. The establishment dataset covering one or more employees shows that the ICT industry has higher entry and exit rates than the other sectors. However, active reallocation in the ICT industry has slowed and the contribution of entrants to productivity growth has rapidly declined, especially in its service sector. Results show that the slowdown of establishment dynamics is related to the decline in productivity growth in the ICT industry.

Keywords: Establishment Dynamics, ICT Industry, Productivity Growth, Entry and Exit

JEL Classification: D24, J24, O47

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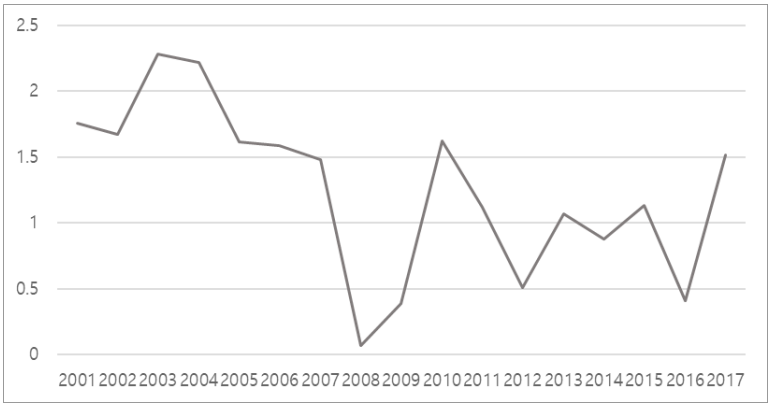
I. Introduction

Advanced countries have recently exhibited a pervasive decline in labor productivity. Among the Organization for Economic Cooperation and Development (OECD) members, the average labor productivity growth was 1.46% between 2001 and 2010, but decreased to 0.95% from 2011 to 2017.

Figure 1 shows the average labor productivity growth of OECD members, which has been tailing off since 2011 compared with its growth at the end of 2010.

Similarly, the Korean economy has experienced low productivity growth.

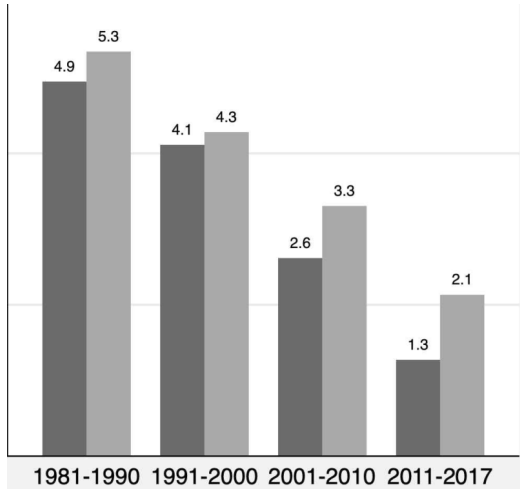
Figure 2 shows the average labor productivity growth in Korea, which has been declining since 2011. Although positive, its value remained at 1%–2%. OECD (2020) also reports that the slowdown of productivity growth in Korea is more significant than that in advanced countries.[1] Moreover, the Korean decline is more worrying because the productivity growth of the Information and Communications Technology (ICT)



Source: OECD (2020), Labour productivity and utilisation (indicator). doi: 10.1787/02c02f63-en (Accessed on 10 February 2020)

Figure 1
Average Labor Productivity growth in OECD countries (Unit: %)

[1] The annual growth in labor productivity in 2011–2017 period was only 51.6% of the rate recorded in the 2001–2010 period in Korea, which is well below the 64.6% average of OECD countries.

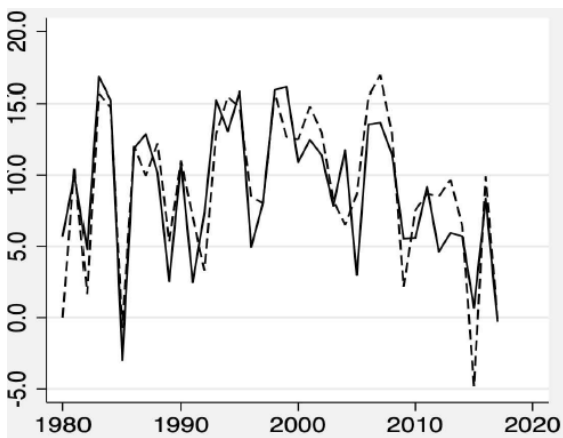


Source: Jung *et al.* (2018)

Notes: Left and right bars are based on the number of workers and labor hours, respectively.

Figure 2

Labor Productivity Growth in Korea (Unit: %)



Source: Jung *et al.* (2018)

Note: The solid line represents labor productivity growth calculated using labor employment and the dashed line shows labor productivity growth calculated using labor hours.

Figure 3

Labor Productivity Growth in Korean ICT industry (Unit: %)

industry has also decreased rapidly (Figure 3). ICT is the core industry in Korean economy; and thus, its slowdown is not a small matter. These facts put value on a study to understand why Korea's ICT industry has recently experienced low growth trends.

Among the many factors related to productivity growth, this study focuses on establishment dynamics, which covers the patterns of entry, exit, and growth of organizations. Establishment dynamics is deeply related to resource reallocation, startup, and exit rate. Several studies have examined the cause of the slowdown in productivity growth in advanced countries. Among the causes, the relationship between firm dynamics and productivity growth is an important factor.[2] Disney *et al.* (2003) showed that resource reallocation caused by such dynamics explains approximately 80% of productivity growth in the United Kingdom manufacturing sector. Hsieh and Klenow (2009) stated that resource misallocation can be a crucial factor to explain productivity differences between countries. Andrews and Cingano (2014) argued that the United States has high productivity growth because of efficient resource allocation. However, countries such as Greece and Korea have inefficient resource allocation, which is related to low productivity growth. The decline in establishment dynamics affects the slowdown of productivity growth in advanced countries (Decker *et al.* 2016, 2017, 2018; Alon *et al.* 2018).

These results imply that the deepening of dynamics slowdown is related to resource misallocation, thereby resulting to low productivity growth. In addition, the dynamics influence economic indicators such as employment and wages have been investigated (Calvino *et al.* 2015; Shambaugh *et al.* 2018; Bakhtiari, 2019).

In Korea, various studies also support the importance of establishment dynamics. Hahn (2003) investigated the relationship between total factor productivity (TFP) and dynamics in the Korean manufacturing sector. Creative destruction generated by dynamics accounted for productivity growth of 45%–65%. Kang *et al.* (2017) studied the dynamics of Korean service industry and determined that the deviation of entry and exit rates accounted for the gap of labor

[2] The patterns of entry and exit are called "firm dynamics" or "establishment dynamics" depending on the level of data used. However, their definitions are similar. This study uses establishment-level data; thus, "dynamics" or "establishment dynamics" is used.

productivity by approximately 16% and 2%, respectively. Cho *et al.* (2017) linked dynamics with job creation and destruction, and proved that a very small number of entrants play an important role for aggregate employment growth. These studies prove that establishment dynamics has meaningful implications in the Korean economy.

Therefore, examining the establishment dynamics in Korean ICT industry is a rational direction to understand the slowdown in productivity growth. This study investigates the detailed structure of establishment dynamics in the Korean ICT industry and its relationship with labor productivity growth. Establishment dynamics can provide an understanding of structural change and its impact on economic growth. In the context of the Korean ICT industry, I use establishment-level data on establishments with one or more employees from 2011 to 2017.

This study presents the following contributions to existing literature. First, the relationship between establishment dynamics and labor productivity is examined by using establishment-level data covering all establishments with one or more employees. Using data that can cover widespread establishments to study dynamics is crucial because small establishments cause most of the entry and exits.

Literature has also used various datasets that cover small establishments, such as the Mining and Manufacturing Survey, Census of Establishments, and Economic Census surveyed by Statistics Korea. However, previous studies cannot provide simultaneous measures of both dynamics and labor productivity. The Mining and Manufacturing Survey provides valuable information on plants such as the total number of workers, sales, and value added, and thus allows measurement of the productivity of establishments. However, the survey only covers establishments with 10 or more employees in the manufacturing sector.[3] The advantage of the Census of Establishments is its coverage, which includes one or more employees in all industries. Moreover, basic information on the total number of workers and five-digit industry codes for each establishment is provided. However, the census does not provide sales information, and thus investigating the labor productivity of establishments is impossible.[4] From the Economic

[3] Mining and Manufacturing Survey had surveyed manufacturing establishments with five or more employees until 2007. Since 2008, it has covered manufacturing establishments with 10 or more employees.

[4] The Census of Establishments has been providing sales information of each

Census, although establishments with one or more employees are covered and the labor productivity of establishments can be defined, the available data are only for 2010 and 2015.

The present study overcomes the above limitations by using matched data — the Statistical Business Register and the Census of Establishments — from Statistical Korea. The matched dataset covers employment and sales of all Korean establishments with one or more employees, and thus allows the examination of the relationship between establishment dynamics and labor productivity for both the manufacturing and service sectors.

Second, this study focuses on the relationship between establishment dynamics and labor productivity in the ICT industry. Previous studies concentrate on the manufacturing or service sectors, and scarce attention is paid on the ICT industry. Considering the importance of the ICT industry in the Korean economy, I believe it is meaningful to examine this sector in detail.

Third, with 2011–2017 as the sample period, this study investigates the recent trends of dynamics. Previous literature excludes the latest years, and therefore, establishment dynamics in Korea during this period remain vague. This study may contribute to the understanding of establishment dynamics in current years.

Specifically, I divide the data into two sample periods, 2011–2014 and 2014–2017. The understanding of the slowdown in productivity growth in the ICT industry varies depending on whether this phenomenon is improving or worsening over time. The latter implies that the low productivity growth is not temporary. Given these points, investigating the difference over time by using two sample periods can be more meaningful.

In addition, in the 2010s, the development of ICT technology triggered the rapid structural change of the economy[5] and the importance of this trend has been increasing since the mid-2010s.[6] Given this background,

establishment since 2016. However, the periods that include sales information are short and at interval levels.

[5] The Fourth Industrial Revolution and the digital economy are representative of this change.

[6] The rise of the Fourth Industrial Revolution after the World Economic Forum 2016 and Google DeepMind Challenge Match in March 2016 are typical examples of this new trend.

having two sample periods can allow a better study on how the Korean ICT industry prepares for a deepening change over time. For convenience of description, I define 2011–2014 as the former period and 2014–2017 as the latter period.

The main findings of this study can be summarized as follows. First, the ICT industry, especially its service sector, has higher entry and exit rates compared with manufacturing and services. Thus, reallocations are active in the ICT industry. Second, compared with the former period, the latter period has an apparent slowdown of establishment dynamics in the ICT industry. Third, continuers are the main contributors of the growth of labor productivity in the ICT industry. Establishments with large number of employees have more contributions to the growth of labor productivity. Fourth, the net entry effect has weakened in the ICT service sector mainly because of the low productivity of entrants.

The remainder of this paper is organized as follows. Section 2 explains the data and key variables. Section 3 shows the pattern of dynamics by industries. Section 4 explains the main findings on labor productivity and dynamics. Section 5 summarizes the main results.

II. Data and Variables

In this study, I use Census of Establishments (CE) and Statistical Business Register (SBR) conducted by Statistics Korea. CE comprises establishment-level data that encompass all firms in Korea with one or more employees in all sectors, and includes characteristics such as employment, region, and industry. SBR, as the comprehensive database for economic statistics in Korea, is constructed using administration and survey data. The data comprise establishment (firm)-level information on characteristics such as employment, sales, and industry.

CE has been used to analyze the entry and exit patterns by industry-level (Kang *et al.* 2017; Sung and Jeong 2019). The advantage of CE for studying dynamics is its coverage of all establishments with one or more employees in all industries. The share of small establishments in dynamics is significant, especially in the service sector (Chun *et al.* 2013); therefore, CE is suitable for this study.

However, given that CE provides information on establishments related to employment, relevant studies have mainly investigated the implications of dynamics on employment. To overcome this limitation, I combine SBR and CE through a unique identifier to obtain not only

employment but also sales information for each establishment.[7] The importance of obtaining both of the above data is the possibility of defining labor productivity of each establishment, and thus allowing the study of its relationship with dynamics. Considering that the slowdown of productivity growth has deepened in Korea since 2011, the results may help reveal the cause in view of establishment dynamics. The sample of dataset used is from 2011 to 2017.

To study dynamics, I define an establishment 'exit' if an establishment in CE in the first year is absent in the end year. Similarly, an establishment 'entry' is defined when an establishment is absent in CE in the first year but present in the end year. An establishment that is present in the CE between the first and end years is defined as a 'continuer'.

Labor productivity is the natural log of the ratio of real sales to labor hours of an establishment. Real sales are defined as nominal sales deflated by the three-digit level prices constructed by the Korea Information Society Development Institute.[8] In this study, the labor hours of each establishment is defined by multiplying the number of employees of an establishment by the two-digit industry total labor hours obtained from the Labor Force Survey at Establishments published by the Ministry of Employment and Labor.

The main analysis of this study is to examine dynamics and productivity in the ICT industry. To attain this goal, I define ICT industry classifications based on the Korean Standard Industry Classification (KSIC) code. The ICT service sector includes information and communication (58–63) while ICT manufacturing includes electronic components, computers, and visual sound and communication equipment (26).

III. Entry and Exit Pattern: Establishment Dynamics

This chapter discusses the patterns of establishment dynamics

[7] In this study, establishment entry and exit are defined on the basis of the information in CE, meaning only for firms with physical locations. Previous literature commonly used CE to examine establishment dynamics, and thus the present results can extend their implications.

[8] Jung *et al.* (2018) explained the definition of industry classification and the construction method of deflators.

Table 1
Entry and Exit Patterns

Panel A. Former Period

	ICT service	ICT manufacturing	Service	Manufacturing
Entrants	24,280	8,286	1,431,763	159,333
Exiters	13,644	4,694	1,170,708	103,071
Net entrants	10,636	3,592	261,055	56,262
Entry rate	69%	69%	45%	43%
Exit rate	39%	39%	37%	28%
Net entry rate	30%	30%	8%	15%
Reallocation rate	108%	108%	82%	71%
Excess reallocation rate	78%	78%	74%	56%

Panel B. Latter Period

	ICT service	ICT manufacturing	Service	Manufacturing
Entrants	21,133	6,026	1,332,895	133,821
Exiters	18,910	6,569	1,160,484	110,661
Net entrants	2,223	–543	172,411	23,160
Entry rate	51%	44%	40%	33%
Exit rate	45%	48%	34%	27%
Net entry rate	6%	–4%	6%	6%
Reallocation rate	96%	92%	74%	60%
Excess reallocation rate	90%	88%	68%	54%

Notes: Net entrants are calculated as the number of entrants minus the number of exiters. Net entry rate is calculated by entry rate minus exit rate. Reallocation rate is defined as the total of entry and exit rates. Excess reallocation rate is calculated by reallocation rate minus net entry rate. Former period is 2011–2014 and latter period is 2014–2017.

by industry. This approach can clarify the change in establishment dynamics in Korea according to the study period.

Table 1 shows the basic statistics of entry and exit by industry. The rows represent the number of entrants and exiters, between which the difference denotes the net entrants. The entry rate is calculated based

on the number of entrants over the average number of establishments in the industry between sample periods. Similarly, the exit rate is the proportion of the number of exiting establishments to the average number of establishments in the industry. Meanwhile, the net entry rate is the deviation between entry and exit rates. Reallocation rate is defined as the total of entry and exit rates. Finally, excess reallocation rate is the difference between reallocation rate and absolute value of net entry. These variables are useful because they efficiently summarize establishment-level dynamics (Davis *et al.* 1998; Chun *et al.* 2013).

Panel A in Table 1 shows the numbers of entrants and exiters in the ICT service industry in the former period, which are 24,280 and 13,644, respectively. Net entrants is 10,636. Meanwhile, the entry and exit rates are 69% and 39%, respectively. The reallocation rate is 108% and excess reallocation is 78%. In the case of the ICT manufacturing sector, the number of entrants and exiters are 8,286 and 4,694, respectively. Net entrants is 3,592. The net entry, reallocation, and excess reallocation rates are 69%, 39%, and 30%, respectively. Through comparison, I found that the number of entrants and exiters are higher in the ICT service sector than in the ICT manufacturing sector. This result may represent the stylized fact that the number of establishments in the ICT service sector is larger than those in the manufacturing sector. However, both sectors have similar entry, reallocation, and excess reallocation rates.

To clarify the characteristics of the ICT industry, I compare its statistics with those of other industries.[9] Compared with the ICT service sector, the service industry has more entrants (1,431,763) and exiters (1,170,708), but has a lower entry rate (45%). Its exit rate (37%) is also similar to that in the ICT service sector, but the net entry (8%) and reallocation (82%) rates are lower. These results imply that in terms of establishments the ICT service sector has more active reallocations than the service industry. This reallocation is related to the increase in establishments. Active reallocation may imply that the ICT service sector undergoes dynamic structural changes. If this is true, how structural change affects the outcome of the ICT service industry

[9] The service sector consists of all service industries, including the ICT service sector, based on the KSIC code (E, G, H, I, J, K, L, M, N, O, P, Q, R, S). Similarly, the manufacturing sector covers all manufacturing industries, including the ICT manufacturing sector, on the basis of KSIC code (C).

requires examination.

Similarly, compared with the ICT manufacturing sector, the manufacturing industry has higher entrants (159,333) and exiters (103,071), but lower entry (43%) and exit (28%) rates. In addition, the manufacturing sector represents lower reallocation (71%) and excess reallocation (56%) rates. These results also show that the ICT manufacturing sector has significant establishment dynamics compared with the manufacturing industry.

Panel B in Table 1 shows the entry and exit patterns in the latter period. Comparing the results of Panels A and B, the interesting point is that the overall establishment dynamics in the ICT industry declined in the latter period. In particular, comparing the decline of entry rate in the service (−5%p) and the manufacturing (−10%p) sectors, the slowdown of the entry rate in the ICT industry is clear. The entry rate in the ICT service and manufacturing sectors between the former and the latter periods declined by 18%p and 25%p, respectively. This decline is related to the downsizing of net entry and reallocation rates.

The above results can be summarized as follows. Both the ICT service and the manufacturing sectors have more active establishment dynamics than those in other industries, implying the existence of active reallocation in the ICT sector that may cause industrial structural change. However, the reallocation rate in the ICT declined after 2014, due to the slowdown of entry rate. The patterns of establishment dynamics prove the need of in-depth study for this industry. From the next table and onward, I focus on the analysis of the ICT industry.

Table 2 shows the means of employment and labor productivity in the ICT industry. In addition, the establishments are divided by continuers, entrants, and exiters to clarify their basic characteristics in detail. The main point is that most of the mean values in the ICT service sector in the former period are larger than those in the latter period. In terms of productivity, continuers and entrants have lower values in the latter period compared with the former period. Otherwise, the mean productivity of exiters is higher in the latter period than in the former period. The results of Tables 1 and 2 suggest the possibility that the ICT service sector experienced not only the slowdown of establishment dynamics but also low labor productivity growth after 2014. In the ICT manufacturing sector, although the entry rate also decreased in the same period, the productivity of all establishment types in the latter period is higher than that in the former period. These results suggest

Table 2
Descriptive Statistics[10]

		ICT service Former period	ICT service Latter period	ICT manufacturing Former period	ICT manufacturing Latter period
Continuers	Workers	20.98	18.73	54.90	46.64
	Productivity	4.34	4.31	4.94	5.05
	Observations	32,768	43,508	11,190	14,624
Entrants	Workers	7.75	7.42	15.35	11.45
	Productivity	3.82	3.71	4.70	4.83
	Observations	24,280	21,133	8,286	6,026
Exiters	Workers	10.11	7.28	26.01	13.41
	Productivity	3.73	3.82	4.47	4.72
	Observations	13,644	18,910	4,694	6,569

Notes: The table shows descriptive statistics by industry. Workers and productivity are mean values. Productivity indicates labor productivity, which is constructed as the natural log of the ratio of real sales to labor hours of an establishment. Former period is 2011–2014 and latter period is 2014–2017.

that the slowdown of establishment dynamics may be a more serious problem for the service sector in ICT than for its manufacturing sector.

IV. Empirical Results for Productivity Growth

A. Transition Matrix

This chapter presents the relationship between establishment dynamics and productivity growth by industries. First, a transition matrix is constructed to describe the growth path of productivity. The transition matrix is useful as a way of studying dynamism in many areas, and I apply this to the productivity distribution. This matrix provides information on the movement of establishments in the productivity quartile in the sample periods. For example, which proportion was in the top quartile of the ICT sector in $t + 1$

[10] Several establishments do not have information on sales, and the number of firms for which productivity can be defined are smaller than the observations of establishments in Table 2.

establishments are also in the second quartile in the ICT sector in t can be determined. In addition, the fractions of entrants and exiters in each quartile are also revealed (Baily *et al.*, 1992).

To create a transition matrix, I classify establishments into quartiles of the labor productivity distribution.[11] The results are weighted by labor hours.

TABLE 3
TRANSITION MATRIX

Panel A. ICT Service Sector: Former Period

	Q1(2014)	Q2(2014)	Q3(2014)	Q4(2014)	Exits	Row Total
Q1(2011)	18.3%	9.7%	6.7%	4.5%	60.7%	14.1%
	14.1%	*7.3%*	*5.1%*	*3.4%*		
Q2(2011)	6.7%	23.6%	19.3%	8.3%	42.0%	14.0%
	5.2%	*17.7%*	*14.7%*	*6.2%*		
Q3(2011)	2.8%	14.5%	24.6%	17.9%	40.2%	14.2%
	2.1%	*11.0%*	*18.9%*	*13.5%*		
Q4(2011)	1.6%	9.1%	16.2%	34.1%	39.0%	14.1%
	1.2%	*6.9%*	*12.3%*	*25.4%*		
Entrants	77.4%	57.2%	49.0%	51.5%		43.6%
Column Total	18.3%	18.7%	18.5%	18.8%	25.6%	

Panel B. ICT Service Sector: Latter Period

	Q1(2017)	Q2(2017)	Q3(2017)	Q4(2017)	Exits	Row Total
Q1(2014)	20.3%	10.0%	5.5%	4.0%	60.2%	16.1%
	19.2%	*9.1%*	*5.0%*	*3.6%*		
Q2(2014)	6.8%	17.5%	20.7%	10.8%	44.3%	16.4%
	6.5%	*16.3%*	*19.1%*	*9.9%*		
Q3(2014)	4.4%	11.2%	27.5%	19.5%	37.5%	16.2%
	4.1%	*10.3%*	*24.9%*	*17.6%*		
Q4(2014)	2.6%	9.4%	11.6%	36.3%	40.1%	16.4%

[11] Following Foster *et al.* (2001), I examine the percentiles of the labor productivity distribution across industries after controlling for four-digit industry fixed effects. After calculation of the transition of establishments in this distribution between sample periods, the results are aggregated for the ICT service and manufacturing sectors.

	Q1(2017)	Q2(2017)	Q3(2017)	Q4(2017)	Exits	Row Total
	2.5%	*8.7%*	*10.7%*	*33.3%*		
Entrants	67.7%	55.5%	40.3%	35.6%		34.9%
Column Total	17.0%	17.6%	17.8%	17.9%	29.6%	

Panel C. ICT Manufacturing Sector: Former Period

	Q1(2014)	Q2(2014)	Q3(2014)	Q4(2014)	Exits	Row Total
Q1(2011)	21.2%	10.7%	5.2%	3.5%	59.5%	13.8%
	15.7%	*7.9%*	*3.8%*	*2.6%*		
Q2(2011)	10.4%	24.8%	14.3%	5.5%	45.1%	13.9%
	7.7%	*18.5%*	*10.7%*	*4.1%*		
Q3(2011)	3.6%	15.6%	25.9%	15.1%	39.7%	13.9%
	2.7%	*11.6%*	*19.4%*	*11.3%*		
Q4(2011)	2.1%	4.6%	14.6%	40.7%	38.1%	14.0%
	1.6%	*3.5%*	*11.0%*	*30.3%*		
Entrants	72.3%	58.4%	55.1%	51.8%		44.4%
Column Total	18.7%	18.7%	18.6%	18.7%	25.3%	

Panel D. ICT Manufacturing Sector: Latter Period

	Q1(2017)	Q2(2017)	Q3(2017)	Q4(2017)	Exits	Row Total
Q1(2014)	22.3%	12.7%	5.2%	1.9%	57.8%	17.3%
	23.0%	*13.1%*	*5.4%*	*2.0%*		
Q2(2014)	12.4%	23.2%	14.4%	5.9%	44.2%	17.5%
	12.9%	*24.1%*	*15.0%*	*6.1%*		
Q3(2014)	5.3%	12.7%	24.4%	14.7%	43.0%	17.4%
	5.4%	*13.1%*	*25.2%*	*15.1%*		
Q4(2014)	2.7%	4.4%	13.5%	36.3%	43.2%	17.4%
	2.7%	*4.5%*	*14.0%*	*37.5%*		
Entrants	56.0%	45.2%	40.4%	39.3%		30.4%
Column Total	16.9%	16.8%	16.8%	16.9%	32.7%	

Notes: Quartile 1 is the lowest productivity within the four-digit industry. Quartile 4 means the highest productivity. The top number of each box means the proportion of establishments in quartile X in the first year that end in quartile Y in the end year (row percentage). The bottom number of each box (in italics) represents the proportion of establishments in quartile Y in end year that came from quartile X in first year (column percentage). Figures are weighted by labor hours. Former period is 2011–2014 and latter period is 2014–2017.

Table 3 shows the transition matrix in the ICT industry. Panels A and B represent the results of the ICT service industry. Similarly, Panels C and D indicate those in the ICT manufacturing industry.

Q1, Q2, Q3, and Q4 indicate the first to fourth quartiles, respectively. In the case of the ICT service sector in Panel A, the value (18.3%) in Q1(2011) and Q1(2014) indicates that, out of establishments in the first quartile in 2011, 18.3% were also in the first quartile in 2014. The next value (14.1%) in Q1(2011) and Q1(2014) indicates that of the establishments in the top quartile in 2014, 14.1% came from the top quartile in 2011. In addition, 77.4% of establishments in the first quartile in 2014 were entrants and 60.7% in the first quartile in 2011 were closed.

The results from Table 3 show the sustainability in relative productivity. The possibility that establishments maintain the same quartile or move to a lower distribution is significant. The proportion of entrants and exiters is higher in low quartiles, indicating that these firms are likely to have lower than average productivity. Thus, establishment dynamics in the two ICT sectors are concentrated in low productivity distributions. In particular, the fact that entrants are distributed in low productivity groups is one of the main reasons of low productivity growth.

Moreover, the meaningful point is that the shares of exiters and especially of entrants in the productivity distribution are reduced in the latter period compared with the former period, with a degree of decline distributed by 16%p and 2%p, respectively.[12] Most of the share of exiters also decreased, but this result is less significant.[13] Overall, the results prove the slowdown of dynamics after 2014.

B. Productivity Decomposition

In this chapter, I conduct empirical analysis to draw the contributions of continuers, entrants, and exiters for productivity in the ICT industry. Various studies examine the relationship between establishment

[12] The ranges of decline in the ICT service and manufacturing sectors are 2%p–16%p and 12%p–16%p, respectively.

[13] In several quartiles in the ICT sector (*e.g.*, Q2 and Q4 in the ICT service sector and Q3 and Q4 in the ICT manufacturing sector), the share of exiters increased in the latter period.

dynamics and productivity growth (Baily *et al.*, 1992; Olley and Pakes, 1996; Foster *et al.*, 2001; Melitz and Polanec, 2015), mainly considering decomposition methodology to calculate the firm contributions. In this study, I use the methodology provided by Foster *et al.* (2001)[14] and the same variables and equations to explain decomposition.

First, industry-level productivity is defined as follows:

$$P_{it} = \sum_{e \in i} s_{et} p_{et}, \tag{1}$$

where P_{it} is the index of industry productivity; s_{et} is the share of establishment e in industry i, calculated by labor hours; and p_{et} is an index of establishment-level labor productivity. Thus, the change of productivity dynamics can be examined by decomposing the time series changes in aggregate-level productivity into factors, revealing establishment dynamics. The decomposition method is given as:

$$\begin{aligned}\Delta P_i = &\sum_{e \in c} s_{et\text{-}1}(p_{et} - p_{et\text{-}1}) + \sum_{e \in c}(s_{et} - s_{et\text{-}1})(p_{et\text{-}1} - p_{it\text{-}1}) \\ &+ \sum_{e \in c}(s_{et} - s_{et\text{-}1})(p_{et} - p_{et\text{-}1}) + \sum_{e \in N} s_{et}(p_{et} - p_{it\text{-}1}) - \sum_{e \in X} s_{et\text{-}1}(p_{et\text{-}1} - p_{it\text{-}1}),\end{aligned} \tag{2}$$

where C represents continuers, N denotes entrants, and X means exiters. Foster *et al.* (2001) decomposed the change of aggregate-level productivity into five components. The first term denotes a within-effect based on establishment-level changes weighted by shares in the industry in $t - 1$. If continuer e experienced productivity growth between t and $t - 1$ ($p_{et} > p_{et\text{-}1}$), then the first term has a positive value, implying a positive contribution of establishment e to the productivity growth in the industry. The second term represents a between-effect that is related to the change of shares weighted by the difference of establishment productivity from that of industry in $t - 1$. The productivity level of continuer e($p_{et\text{-}1}$) and changing share ($s_{et} - s_{et\text{-}1}$) affect the contribution of the second term. The third term denotes the cross and focuses on the difference between both share and productivity in continuer e. The fourth term represents the contribution of entrants. If entrant e has higher productivity than the industry productivity index in $t - 1$, then the firm positively contributes to productivity growth in the industry.

[14] For robustness check, I use the alternative methodologies used by (1) Griliches and Regev (1995) and (2) Melitz and Polanec (2015) and obtain similar results. The results are provided in Table A1 of the appendix.

Table 4
Decomposition Result

	ICT service Former period	ICT service Latter Period	ICT manufacturing Former Period	ICT manufacturing Latter Period
	13.1	7.4	52.7	34.1
Within	96.4%	167.8%	68.4%	65.4%
Between	42.0%	64.0%	5.5%	10.3%
Cross	−62.1%	−105.7%	−4.9%	−2.7%
Net entry	23.7%	−26.2%	30.9%	27.0%
Entry	−40.6%	−152.0%	15.6%	0.7%
Exit	64.4%	125.9%	15.4%	26.3%

Notes: The aggregate productivity growth rate is calculated by the weighted average of industry productivity growth rates at the 4-digit level using labor hours as a weight variable. The figures represent the contribution of each factor. Former period is 2011–2014 and latter period is 2014–2017.

Lastly, the fifth term means the contribution of exiters. If exiters in the industry have lower productivity than the industry productivity index, then their contribution for productivity growth is positive. The sum of the fourth and the fifth terms is defined as the net entry effect.

Table 4 shows the aggregate labor productivity growth in ICT sectors and their decomposed factors. The aggregate productivity growth rate is calculated by the weighted average of the four-digit level industry productivity growth using labor hours. Within, between, and cross effects are related to the contribution of continuing establishments. The sum of entry and exit effects is the net entry effect.

Columns 1 and 2 show the results of the ICT service sector. Similarly, Columns 3 and 4 represent those of the ICT manufacturing sector. The growth rate of the ICT service sector was 13.1% in the former period, indicating that the annual growth rate in the ICT service sector was approximately 4.4% because the sample periods have three-year terms. The growth rate of the ICT service sector in the latter period is 7.4% (approximately 2.5% per year).

Meanwhile, the growth rate of the ICT manufacturing sector was 52.7% in the former period (approximately 17.6% per year) and 34.1% (approximately 11.4% per year) in the latter period. Clearly, the growth rates of both ICT service and manufacturing sectors declined over time,

confirming the slowdown of labor productivity growth in the ICT sector.

In both ICT sectors, the growth of continuers accounts for over half of productivity gains. For example, the contribution of continuers in the ICT service sector was 76.3% (96.4% + 42.0% − 62.1%) in the former period and 126.7% (167.8%+64.0%-105.7%) in the latter period. Similarly, those in the ICT manufacturing sector was 69% (68.4%+5.5%-4.9%) in the former period and 73% (65.4%+10.3%-2.7%) in the latter period. Within effect is the main factor of productivity growth in the ICT sector.

The striking point in the decomposition result is related to net entry effect. Despite positive contribution of the exit effect to productivity growth, the contribution of net entry in the ICT service sector decreased rapidly in the latter period. This result is related to the sharp decline of the entry effect. The negative contribution of entrants indicates their lower productivity than the average industry productivity. In other words, the level of productivity of entrants does not reach that of the average industry productivity. Given that the entry rate also declined significantly in the same period, the contribution of establishment dynamics, especially entrants, to industry productivity growth in the ICT service sector has clearly become weaker dramatically. Although the gap is not significant compared with the ICT service sector, the contribution of the entry effect also declined in the ICT manufacturing sector. These results imply that the decline of the power of entry is one of the important factors to the slowdown of productivity growth in ICT sector.

To investigate the decomposition results in detail, I divide each decomposition factor by employment size. This approach is based on the assumption that each component has heterogeneous effects on productivity growth according to firm size. Then, I distinguish establishments by three size groups: 1–9 (G1), 10–99 (G2), and more than 100 (G3) workers.

Table 5 reports the decomposition results divided by size groups. The results show that establishments with more workers considerably contribute to ICT industry productivity growth. In particular, establishments with over 100 workers in the ICT manufacturing sector have dominant proportions for growth, which implies that the firm size is more important for productivity growth in the manufacturing sector of ICT than in its service sector. This result may reflect the fact that several representative firms in Korea belong to the ICT manufacturing

TABLE 5
DECOMPOSITION RESULTS DIVIDED BY ESTABLISHMENT SIZE

	ICT service Former period	ICT service Latter Period	ICT manufacturing Former Period	ICT manufacturing Latter Period
Total – G1	−8.8%	1.2%	−0.2%	2.9%
Within - G1	7.9%	22.3%	1.3%	2.5%
Between - G1	12.4%	25.2%	0.4%	0.9%
Cross - G1	−15.5%	−36.9%	-0.9%	-2.3%
Net entry – G1	−13.6%	-9.4%	−1.0%	1.7%
Entry – G1	−61.0%	−108.4%	−7.0%	−11.3%
Exit – G1	47.4%	99.0%	6.0%	13.0%
Total – G2	79.3%	27.4%	11.4%	18.5%
Within – G2	64.6%	49.3%	6.5%	12.1%
Between – G2	13.4%	27.4%	2.7%	1.5%
Cross – G2	−18.4%	−37.6%	−2.0%	−1.8%
Net entry – G2	19.7%	−11.6%	4.2%	6.7%
Entry – G2	−17.9%	−60.2%	−5.9%	−7.6%
Exit – G2	37.6%	48.6%	10.0%	14.3%
Total – G3	29.5%	71.3%	88.8%	78.6%
Within – G3	23.9%	96.3%	60.7%	50.7%
Between – G3	16.2%	11.4%	2.4%	7.9%
Cross – G3	−28.2%	−31.2%	−2.1%	1.4%
Net entry – G3	17.6%	−5.2%	27.8%	18.6%
Entry – G3	38.3%	16.6%	28.5%	19.6%
Exit – G3	−20.6%	−21.8%	−0.7%	−1.0%

Notes: G1, G2, and G3 represent establishments with 1–9, 10–99, and more than 100 workers, respectively. The figures represent the contribution of each factor. Former period is 2011–2014 and latter period is 2014–2017.

sector. By comparison, the contribution of establishments in G1 is not meaningful.

Clearly, the entry effects in all groups in the ICT service sector declined in the latter period compared with the former period. The entry effect in each group decreased by 47.4%p (1–9 workers), 42.3%p (10–99 workers), and 21.7%p (more than 100 workers). These decreases have caused the coefficients in net entry effects in the latter period to be

negative in G2 and G3. The change of contribution of net entry effect is not significant in the ICT manufacturing sector, which also has a relatively stable composition of contribution.

C. Regression Results

To analyze the role of establishment dynamics in productivity growth in a regression context, I implement the following regression specification:

$$Y_{e,t} = a + \beta EN_{e,t} + \delta EX_{e,t} + \gamma year_t + \theta_k \sum_k ind_{e,k,t} + \varepsilon_{e,t}, \quad (3)$$

where the dependent variable is the labor productivity of establishment e in year t; $EN_{e,t}$ is a dummy variable with a value of 1 if establishment e is an entrant in year t; Similarly, $EX_{e,t}$ is a dummy variable with a value of 1 if establishment e is an exiter in year t; $year_t$ is a year dummy to control for average differences in productivity across sample periods; and $ind_{e,k,t}$ is a set of dummy variables for four-digit industries. The purpose of the regression is to examine the difference in productivity according to establishment type. The results show that the coefficients of the establishment types exhibit relative labor productivity. In the case of the former period, the omitted group is continuers in 2011. $\delta > 0$ means that the average productivity of exiters during the sample period is higher than the productivity value of continuers in 2011. Similarly, $\beta > 0$ implies that the productivity of entering establishments is higher than that of continuers in 2011. In addition, the difference in average level of productivity in each year should be included. If $\gamma > 0$, then the average productivity in 2014 is higher than that in 2011. Therefore, the productivity of entering establishments in 2014 relative to that of continuing establishments in 2011 is $\beta + \gamma$.

To explore the role of establishment size in productivity growth, I extend the above model by using the interaction term, as follows:

$$\begin{aligned} Y_{e,t} = {} & a + \beta_1 EN_{e,t} + \delta_1 EX_{e,t} + \beta_2 EN_{e,t} * g2_{e,t} + \beta_3 EN_{e,t} * g3_{e,t} \\ & + \delta_2 EX_{e,t} * g2_{e,t} + \delta_3 EX_{e,t} * g3_{e,t} + \tau_1 CN_{e,t} * g2_{e,t} + \tau_2 CN_{e,t} * g3_{e,t} \\ & + \tau_3 CN_{e,t} * g2_{e,t} * year_{e,t} + \tau_4 CN_{e,t} * g3_{e,t} * year_t + \gamma year_t \\ & + \theta_k \sum_k ind_{e,k,t} + \varepsilon_{e,t}, \end{aligned} \quad (4)$$

TABLE 6
REGRESSION RESULTS

Panel A. ICT service sector

	(1) ICT Service Former Period	(2) ICT Service Former Period	(3) ICT Service Latter Period	(4) ICT Service Latter Period
Entrants	−0.473***	−0.562***	−0.648***	−0.644***
	(0.071)	(0.105)	(0.083)	(0.110)
Exiters	−0.450***	−0.549***	−0.466***	−0.476***
	(0.120)	(0.190)	(0.090)	(0.065)
Entrants in G2		0.579***		0.587***
		(0.088)		(0.062)
Entrants in G3		1.296***		1.078***
		(0.151)		(0.108)
Exiters in G2		0.443***		0.607***
		(0.074)		(0.077)
Exiters in G3		1.051***		1.102***
		(0.284)		(0.153)
Continuers in G2		0.256		0.413***
		(0.168)		(0.087)
Continuers in G2 x next year		0.212		0.006
		(0.125)		(0.052)
Continuers in G3		0.742***		0.826***
		(0.260)		(0.161)
Continuers in G3 x next year		0.019		0.079**
		(0.112)		(0.037)
Next year	0.161*	0.073	0.141**	0.111*
	(0.080)	(0.112)	(0.052)	(0.060)
Adjusted R2	0.167	0.225	0.233	0.296
Sample size	69,256	69,256	82,012	82,012

Panel B. ICT manufacturing sector

	(1) ICT manufacturing Former Period	(2) ICT manufacturing Former Period	(3) ICT manufacturing Latter Period	(4) ICT manufacturing Latter Period
Entrants	−0.479**	−0.182***	−0.456***	−0.227***
	(0.213)	(0.026)	(0.143)	(0.036)
Exiters	−0.461	−0.252***	−0.517***	−0.141***
	(0.276)	(0.040)	(0.129)	(0.038)
Entrants in G2		0.331***		0.423***
		(0.047)		(0.086)
Entrants in G3		1.524***		1.576***
		(0.147)		(0.229)
Exiters in G2		0.268***		0.306***
		(0.057)		(0.058)
Exiters in G3		0.821**		1.109***
		(0.316)		(0.190)
Continuers in G2		0.436***		0.431***
		(0.037)		(0.050)
Continuers in G2 x next year		0.083**		0.071
		(0.027)		(0.045)
Continuers in G3		0.953***		1.370***
		(0.219)		(0.148)
Continuers in G3 x next year		0.487**		0.136
		(0.189)		(0.112)
Next year	0.538***	0.158***	0.314***	0.209***
	(0.169)	(0.025)	(0.077)	(0.023)
Adjusted R2	0.259	0.361	0.338	0.464
Sample size	23,999	23,999	27,056	27,056

Notes: All specifications include four-digit industry dummies. Standard errors are in parenthesis. G2 and G3 show the coefficients of establishments with 10–99 workers and with more than 100 workers, respectively. Former period is 2011–2014 and latter period is 2014–2017.

where $g2_{e,t}$ and $g3_{e,t}$ are dummy variables representing establishments with 10–99 workers and more than 100 workers in year t, respectively. $CN_{e,t}$ is a dummy variable for continuers.

Panel A in Table 6 shows the regression results for the ICT service sector, and Columns (1) and (2) reveal the results in the former period. Similarly, the coefficients of Columns (3) and (4) are from the latter period.

In Column (1), the estimated coefficients of entrants ($-0.473 + 0.161 = -0.312$) and exiters (-0.450) are all negative, implying that entrants and exiters have lower productivity than continuing establishments. Column (3) also shows similar patterns. In Columns (2) and (4), large establishments have higher productivity than other firms in all establishment types. This result implies that the size of establishments is an important factor related to productivity. While other coefficients are higher in the latter period compared with the former period, that of entrants declines in the latter period, thereby proving its weakening contribution to productivity growth.

Panel B shows the regression results for the ICT manufacturing sector. Entrants and exiters have lower productivity than continuers, clearly indicating the importance of establishment size in productivity. However, contrary to the ICT service sector, the coefficient of entrants does not decrease between the former and the latter periods. Overall, the contributions of each group in the ICT manufacturing sector shows stable trends. Thus, despite the apparent slowdown of establishment dynamics, this change does not have significant influence on the productivity growth in the manufacturing sector of ICT compared with its service sector.[15]

To compare entry and exit effects, I calculate the coefficient of entrants and exiters in each group.[16] Table 7 shows the results. Each coefficient indicates the relative productivity of entrants and exiters

[15] In addition, although productivity growth declined in the ICT manufacturing sector in the latter period, the productivity growth rate of ICT manufacturing sector remained high compared with the ICT service sector. Considering the importance of the ICT service sector in the era of the Fourth Industrial Revolution, the low productivity growth related to the slowdown of establishment dynamics in ICT service sector may be a more serious issue for the Korean economy.

[16] Cho *et al.* (2020) used a similar approach to compare the productivity of establishments by size.

Table 7
Regression Results by Each Group

			(1) ICT service Former Period	(2) ICT service Latter Period	(3) ICT manufacturing Former Period	(4) ICT manufacturing Latter Period
G1	Entrants	Entrants + Next year	−0.489**	−0.533***	−0.024	−0.019
			(0.204)	(0.061)	(0.038)	(0.028)
	Exiters	Exiters	−0.549***	−0.476***	−0.252***	−0.141***
			(0.190)	(0.065)	(0.040)	(0.038)
G2	Entrants	Entrants + Entrants in G2	−0.165**	−0.359***	−0.129***	−0.027
		+Next year – Continuers in G2	(0.078)	(0.052)	(0.040)	(0.077)
	Exiters	Exiters + Exiters in G2 -	−0.361***	−0.282***	−0.421***	−0.266***
		Continuers in G2	(0.070)	(0.077)	(0.057)	(0.071)
G3	Entrants	Entrants + Entrants in G3	0.065	−0.281*	0.547*	0.187
		+Next year – Continuers in G3	(0.140)	(0.141)	(0.280)	(0.202)
	Exiters	Exiters + Exiters in G3	−0.240	−0.200	−0.384	−0.402**
		-Continuers in G3	(0.298)	(0.200)	(0.389)	(0.197)

Notes: Each coefficient means the relative productivity of entrants and exiters compared with continuers in the same group. The coefficients are calculated through linear combination based on the estimation results in Table 6. Standard errors are in parentheses. G2 and G3 show the coefficients of establishments with 10–99 workers and with more than 100 workers, respectively. Former period is 2011–2014 and latter period is 2014–2017.

compared with that of continuers in first year within same group. In the former period of ICT service sector, both entrants and exiters have lower productivity than continuers in G1 and G2. The productivity of continuers does not significantly differ from other establishments in

G3, and that of entrants is higher than of exiters. However, in the latter period, the coefficient of entrants is lower than that of exiters in all groups. Compared with the ICT manufacturing sector, the weakening of contribution of entrants to productivity growth in the ICT service sector is more apparent.

V. Conclusion

This study examines the patterns of establishment dynamics using detailed establishment-level microdata. In addition, insights into the role of establishment dynamics in productivity growth are provided using a decomposition method and regression focusing on the ICT sector. Between 2011 and 2014, the ICT service and manufacturing sectors, especially the ICT service sector, have active reallocations caused by entry and exit. However, after 2014, establishment dynamics in Korea shows a decreasing trend, which is especially rapid in the ICT service sector. This decline is mainly generated by the slowdown of the entry rate. Furthermore, the slowdown of establishment dynamics is related to the productivity growth. Net entry effect in productivity growth has been decreasing after 2014, caused mainly by the decline in the contribution of entrants. These results suggest that the slowdown of active reallocation has deepened, thereby affecting productivity growth.

The ICT sectors cover core industries related to the innovation in the era of the Fourth Industrial Revolution, and thus its slowdown in productivity growth is highly likely to lead to weakening the competitiveness of the Korean economy. The results of this study imply that supporting new establishments with potential for innovation may help improve the productivity growth. Removal of regulations that increase barriers to entry and increasing financial support to start-ups is an option.[17]

This study contributes to the understanding of establishment dynamics and productivity growth in the Korean economy by using establishment-level data that cover establishments with one or more employees and available sales information. Moreover, the results of this study can improve the understanding of the structural change in

[17] Financial support is likely to have a significant impact on the innovation caused by start-ups that do not have enough funds in the early stage. Kim (2007) shows that financial development is related to the technological innovation.

the ICT sectors. However, this study does not fully examine the reason why establishment dynamics in the ICT sectors have declined. Further analysis can help reveal the main factors related to the decline of active reallocation.

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Appendix A: Alternative decomposition methodologies

This chapter briefly explains two decomposition methodologies that I use to verify the robustness of main results. First, the method used by Griliches and Regev (1995) is given by:

$$\Delta P_i = \sum_{e\in c}\bar{s}_e(p_{et} - p_{et\text{-}1}) + \sum_{e\in c}(s_{et} - s_{et\text{-}1})(\bar{p}_e - \bar{p}_i) + \sum_{e\in N}s_{et}(p_{et} - \bar{p}_i) - \sum_{e\in X}s_{et\text{-}1}(p_{et\text{-}1} - \bar{p}_i), \quad (5)$$

where $\bar{s}_e$ is the average of establishment share over the base and end years; and $\bar{p}_e$ and $\bar{p}_i$ are the average of productivity defined by establishment-level and industry-level, respectively.

Second, the following decomposition method is suggested by Melitz and Polanec (2015):

$$\Delta P_i = \Delta\bar{P}_c + \Delta cov_c + \sum_{e\in N}s_{et}(p_{et} - P_{Ct}) - \sum_{e\in X}s_{et\text{-}1}(p_{et\text{-}1} - P_{Ct\text{-}1}), \quad (6)$$

P_{Ct}, $P_{Ct\text{-}1}$ are the unweighted productivity of continuing firms in t and $t-1$, respectively. First term means the unweighted average change in the productivity of continuing firms. The second term represents the covariance change between share and productivity for continuing firms. The sum of two terms is the contribution of continuers. The third and fourth terms are entry and exit effects.

Table A1.
Decomposition Results

Panel A. Griliches and Regev (1995)

	ICT Service Former period	ICT Service Latter period	ICT Manufacturing Former period	ICT Manufacturing Latter period
Within	64.9%	113.6%	66.1%	63.9%
Between	10.1%	11.0%	2.7%	7.6%
Net entry	25.0%	−24.5%	31.2%	28.5%
Entry	−59.0%	−160.0%	0.1%	−10.0%
Exit	84.0%	135.4%	31.1%	38.5%

Panel B. Melitz and Polanec (2015)

	ICT Service Former period	ICT Service Latter period	ICT Manufacturing Former period	ICT Manufacturing Latter period
Continuer	135.7%	168.4%	94.1%	92.0%
Net entry	−35.7%	−68.4%	5.9%	8.0%
Entry	−137.0%	−263.0%	−19.5%	−26.4%
Exit	101.4%	194.7%	25.3%	34.3%

Notes: For robustness checks, I use two alternative decomposition methodologies suggested by Griliches and Regev (1995) and Melitz and Polanec (2015). The aggregate productivity growth rate is calculated by the weighted average of industry productivity growth rates at the 4-digit level using labor hours as a weight variable. The figures represent the contribution of each factor. The former period is 2011–2014 and latter period is 2014–2017.

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