Korea and the World Economy, Vol. 21, No. 1 (April 2020) 75-101

Impacts of Changes on Productivity Growth in Korea's Export-leading Industries*

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This study investigates the impacts of changes on productivity growth in 10 export-leading industries from 1995 to 2014 in Korea. The extent of the impact thereof reflects the industrial features, the level of technological innovation, the maturity of the industry, the growth trajectory within the growth policy framework, market exogenous shocks, and market selection forces. The target industries led the growth and structural upgrades and reached record high productivity growth during the economic upturns. Large establishments persevered in the target industries, thereby verifying their resilience and contributing to the productivity growth in the aftermath of the market exogenous shocks.

JEL Classification: D21, D24, C23, L6, O47

Keywords: impacts of changes, productivity growth, unrelenting large establishments

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* Received December 16, 2019. Revised March 18, 2020. Accepted March 26, 2020. I would like to express my deepest gratitude for the thoughtful support of Professor Jeffrey B. Nugent at the University of Southern California (USC). His keen insight into the Korean case of economic growth made the completion and publication of this work possible. I am also grateful for the invaluable comments from Dr. Hang Koo Lee at the Korea Institute for Industrial Economics and Trade on the fieldwork of Korea's core growth-leading industries, as well as the professional help I have received from Min Ji Kim and Christine Kim. I am also thankful for the substantial micro panel data set provided by Statistics Korea and the Korea Statistics Promotion Institute. Lastly, I am especially grateful to the anonymous referees for their considerate comments; without those, I would not have been able to meaningfully scrutinize and enhance the contents of my paper.

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1. INTRODUCTION

Korea's economy has passed through the acknowledged developmental phases driven by growth-leading industries in the framework of "selection and concentration" industrial policy. The developmental phases were the light industry in the 1960s, heavy machinery and chemical industries (HCI) in the 1970s, electric home appliances, shipbuilding, and automobiles in the 1980s, information and communication technology (IT) in the 1990s, and finally, the artificial intelligence and biotechnology today.

Large establishments (LE), subcontracting small and medium-sized establishments (SME) within the structures of their specific industries, have led Korea's export-driven economic growth to save transaction costs and promote efficiency in the global competitive arena. Consequently, core growth-leading industries retain unparalleled vertical integration of subcontracting hierarchies especially in the automobile, electronics, shipbuilding, and machinery industries, and shared growth between LE and SME has been continuously encouraged by the government.

Finally, Nugent (1996) found that shares of LE in the employment and value-added of the industries soared sharply from 1963 to 1976, and then fell until 1988, and Nugent (2002) found that the much higher shares of SME in total employment and value-added of the industries contributed to exports, foreign investment, and productivity growth after 1975.

In the Korean literature, Park *et al.* (2010) used panel data for 7,889 Korean manufacturing firms between 1994 and 2003 to confirm that firm size and age had significant negative effects on firm growth but significant positive impacts on firm survival, while R&D and export activities together facilitated firm growth and survival.

On the other hand, the entry and exit of establishments, like most micro-dynamics of production units, impact the productivity growth of their own individual industries, as well as that of the entire Korean manufacturing sector. Especially, more progressive dynamics arose under the macroeconomic turbulence triggered by the 1997 Asian financial crisis and

the 2008 global financial crisis.

In a leading study on Korean manufacturing, Hahn (2000) used a plant-level panel dataset from 1990 to 1998 and found that the combined effect of entry and exit and the market share reallocation effect could explain aggregate productivity growth in manufacturing.

Likewise, using establishment-level data for the U.S. manufacturing sector, Foster *et al.* (1998) found that the reallocation of outputs and inputs from less productive to more productive establishments was a significant factor in aggregate productivity growth.

In a more recent study, Pai (2016a), used an establishment-level dataset of Korea's 37 growth-leading industries from 1995 to 2012 and verified that the Korean government's "selection and concentration" policy attained technical progress and productivity growth in the target industries. Furthermore, Pai (2019) showed that the Korean government's recent institutional push ensured that the productivity growth of firms that were not vertically integrated with capital share in Korea's core growth-leading industries, reached their highest levels in 2010. Consequently, Pai (2016b) specified policy guidelines for firms that were vertically integrated with capital share to share growth with their counterparts and also found that the direction of causality ran from higher productivity to a larger export share in the global market for Korea's core growth-leading industries.

Although some studies have considered firm age, no previous studies have attempted to measure the extent of the impact of changes in business durations as an incumbent effect on the productivity growth of industries across establishments of different sizes. The business durations of SME and LE are defined here as persistent participation in the production process in one industry.

Thus, it is an open question whether longer business durations of SME and LE, i.e., the stability of incumbent SME and LE, and the impact from changes in entry and exit of SME and LE, enhance productivity growth in their industries. Furthermore, these effects may vary by industry and time.

Therefore, this study attempts to measure the respective impacts of

changes in the entry, exit, and business durations of SME and LE on productivity growth from 1995 to 2014, especially focus on two exogenous market shocks, the 1997 Asian financial crisis and the 2008 global financial crisis.

The remainder of this paper is organized as follows. Section 2 explains the estimation model and data used in this analysis, section 3 discusses the empirical results. Finally, section 4 presents conclusions and policy implications.

The Appendix elaborates on the 10 growth-leading industries considered in this study based on the Korean Standard Industrial Classification (KSIC) codes.

2. MODEL AND DATA

A translog time-varying stochastic frontier production function (SFPF) model is applied to an unbalanced establishment-level panel dataset for 29 subsectors of Korea's 10 growth-leading industries.

$$\begin{aligned}\ln VA_{it}=&\alpha_0+\alpha_L\ln L_{it}+\alpha_K\ln K_{it}+\alpha_T t+\alpha_{LL}(\ln L_{it})^2+\alpha_{KK}(\ln K_{it})^2\\&+\alpha_{TT}t^2+\alpha_{LK}\ln L_{it}K_{it}+\alpha_{TL}t\ln L_{it}+\alpha_{TK}t\ln K_{it}\\&+\varphi_{SME}BD_{SME_{it}}+\varphi_{LE}BD_{LE_{it}}+(v_{it}-u_{it}),\end{aligned}\tag{1}$$

$$\begin{aligned}\ln VA_{it}=&\alpha_0+\alpha_L\ln L_{it}+\alpha_K\ln K_{it}+\alpha_T t+\alpha_{LL}(\ln L_{it})^2+\alpha_{KK}(\ln K_{it})^2\\&+\alpha_{TT}t^2+\alpha_{LK}\ln L_{it}K_{it}+\alpha_{TL}t\ln L_{it}+\alpha_{TK}t\ln K_{it}\\&+\phi_{EntrySME}Entry_{SME_{it}}+\phi_{EntryLE}Entry_{LE_{it}}+(v_{it}-u_{it}),\end{aligned}\tag{2}$$

$$\begin{aligned}\ln VA_{it}=&\alpha_0+\alpha_L\ln L_{it}+\alpha_K\ln K_{it}+\alpha_T t+\alpha_{LL}(\ln L_{it})^2+\alpha_{KK}(\ln K_{it})^2\\&+\alpha_{TT}t^2+\alpha_{LK}\ln L_{it}K_{it}+\alpha_{TL}t\ln L_{it}+\alpha_{TK}t\ln K_{it}\\&+\psi_{ExitSME}Exit_{SME_{it}}+\psi_{ExitLE}Exit_{LE_{it}}+(v_{it}-u_{it}),\end{aligned}\tag{3}$$

where VA_{it} is the real value-added of the i-th establishment in the t-th period, L_{it} and K_{it} are the production inputs of labor and capital, t is a time trend

used as a proxy for technical change, $BD_{SME_{it}}$ is the business durations of SME, and $BD_{LE_{it}}$ is the business durations of LE. $Entry_{SME_{it}}$ represents the impact of the entry of SME, $Entry_{LE_{it}}$ represents the impact of the entry of LE: $Entry_{SME_{it}}$=1, if an establishment is a new SME entrant, otherwise, $Entry_{SME_{it}}$=0; $Entry_{LE_{it}}$=1, if an establishment is a new LE entrant, otherwise, $Entry_{LE_{it}}$=0. $Exit_{SME_{it}}$ refers to the pre-exit impact of SME one year prior to their actual exit, and $Exit_{LE_{it}}$ refers to the pre-exit impact of LE one year prior to their actual exit: $Exit_{SME_{it}}$=1, if an establishment is an exiting SME, otherwise, $Exit_{SME_{it}}$=0; $Exit_{LE_{it}}$=1, if an establishment is an exiting LE, otherwise, $Exit_{LE_{it}}$=0.

The stochastic frontier contains a composed error term (v_{it}–u_{it}), where v_{it} is a statistical error, assumed to be independently and identically distributed as $N(0, \sigma_v^2)$. The establishment-specific technical inefficiency u_{it} indicates the actual production loss relative to the production frontiers.

$$u_{it}=\eta_{it}u_i=\exp\ (-\eta\ (t-T))u_i,\ u_{it}>0, \tag{4}$$

$$\gamma=\frac{\sigma_u^2}{\sigma^2},\ \ \sigma^2=\sigma_u^2+\sigma_v^2. \tag{5}$$

In equation (4), u_i is assumed to have a flexible, nonnegative truncated normal distribution, $N\left(0, \sigma_u^2\right)$, and η is a parameter reflecting the technological catch-up rate. Thus, a positive η indicates that technical efficiency (TE) improves over time. In equation (5), the parameter γ represents the variance of technical inefficiency relative to the variance of the composed error, (v_{it}–u_{it}). Thus, γ takes a value between zero and one.

Finally, all parameters in equations (1)-(5) are estimated using FRONTIER 4.1, which was built by Coelli (1996).

Next, Solow (1956) defined TFP growth ($\dot{TFP}$) as output growth not explained by input growth, and Kumbhakar (2000) decomposed TFP growth into four sources. In this study, output growth is value-added growth, which is decomposed into six sources (the derivation of six sources of TFP growth is available from the author upon request).

An increase in the frontier output at a given input level is driven by

exogenous technical progress (*TP*) that shifts up the production frontier. The change in TE ($\dot{TE}$) refers to the speed required to achieve an output on the production frontier using the current technology. The scale component (*SC*) reflects the effects of input use on output growth, and the scale economy vanishes when *SC* goes to zero. Changes in allocative efficiency (*AE*) examine the efficiency of resource allocation; any deviation in input prices from the market values of their marginal products leads to a negative *AE*. From (1), the impacts of changes in business duration of SME (BD_S) and those of LE (BD_L) are derived in a given industry. The rate of TFP growth is expressed in percentage terms, and the components *TP*, $\dot{TE}$, *SC*, *AE*, BD_S, and BD_L are expressed in percentage points. Specific remedies and strategies for enhancing the competitiveness of the industry can be derived from these components.

Eventually,

$$\dot{TFP} = TP+\dot{TE}+SC+AE+BD_S+BD_L, \quad (6)$$

Likewise, (7) and (8) are derived from (2) and (3), respectively.

$$\dot{TFP} = TP+\dot{TE}+SC+AE+enS+enL, \quad (7)$$

$$\dot{TFP} = TP+\dot{TE}+SC+AE+exS+exL. \quad (8)$$

In (7), $\dot{TFP}$ is composed of *TP,* $\dot{TE}$, *SC*, *AE*, and the impacts of changes in the entries of new SME (*enS)* and those of new LE (*enL*), and in (8), $\dot{TFP}$ is composed of *TP,* $\dot{TE}$, *SC*, *AE*, and the pre-exit impacts of changes in exiting SME (*exS)* and those of exiting LE (*exL*) one year prior to the actual exits.

Finally, this estimation model was applied to a micro-level unbalanced panel of establishments with more than nine workers is taken from *The Report on Mining and Manufacturing Survey*: *Industry-National Area* of Korea for the years 1995 to 2014.

Korea's 10 growth-leading manufacturing industries are composed of 29 growth-leading subsectors and the establishments in these industries are categorized as SME or LE based on whether they have between 10 and 299 workers or 300 and above workers. This definition is taken from the

Framework Act on Small and Medium Enterprises. This establishment-level micro-data set of the 29 growth-leading subsectors is used to estimate the translog SFPFs for each subsector.

Specifically, this source provides measures of the real value added (VA), the real value of tangible fixed assets (i.e., land and individual assets, such as buildings, structures, machinery, equipment, cars, ships, and durable delivery equipment) (K) at constant 2010 producers' prices, and the number of workers (L) who actually participated in the production process for each establishment. In particular, the individual VA deflators for each of the 29 growth-leading subsectors are taken from the *Bank of Korea*.

Furthermore, the measure of the cost of labor (C_L) is composed of employee remuneration, such as wages, retirement compensation, and welfare costs, and the cost of capital (C_K) is the sum of capital rent, depreciation costs, and interest payments. Therefore, the total cost (C) is the sum of the labor (C_L) and capital costs (C_K), and the respective shares of labor and capital in the total cost are $S_L=C_L/C$, and $S_K=C_K/C$.

3. RESULTS

3.1. Overall Trend

First, table 1 presents that *enS* and *enL* in the specified time periods, ranked by their respective average values for 1995-2014.

First of all, *enS* fluctuated to a greater extent than *enL* did over time, except in the machinery and textile and clothing industries. On average, *enS* was only positive for the HCI of machinery (0.05%) and basic metal products (0.04%). Especially, *enS* was most negative for the automobile industry (−1.36%), implying that the entry of new SME therefore has a strikingly large negative impact on productivity growth in the automobile industry, resulting from the weaker viability of new SME entrants given the strongest vertical integration of their industrial structure. IT products had

Table 1 *enS* and *enL* in the Specified Time Periods, Ranked by Their Average Values for 1995-2014

	1997-1999	2000-2003	2004-2006	2007-2009	2012-2014	1995-2014
enS						
Machinery	–0.09	0.23	0.13	0.21	–0.28	0.05
Basic metal products	0.04	0.25	0.00	0.05	–0.24	0.04
Precision instruments	–0.83	0.31	0.00	0.57	–0.20	–0.01
Fine chemicals	0.27	–0.22	–0.21	0.10	–0.27	–0.08
IT parts and components	–1.19	0.73	–0.16	–0.08	–0.07	–0.10
Shipbuilding	–0.39	0.22	–1.50	0.26	0.20	–0.23
Textile and clothing	–0.17	–0.42	0.06	0.03	–0.57	–0.24
Petrochemicals	–1.83	0.36	–0.15	–0.85	–1.07	–0.68
IT products	–0.76	–1.78	–0.73	–0.18	–0.40	–0.89
Automobiles	0.06	–2.06	–3.63	–0.09	–0.42	–1.36
enL						
Textile and clothing	1.74	3.60	–0.53	0.00	2.42	1.69
Basic metal products	0.27	0.00	0.00	0.00	0.03	0.06
Precision instruments	–0.11	0.00	0.19	0.02	0.00	0.02
Fine chemicals	0.00	0.00	0.00	0.00	0.01	0.00
Shipbuilding	0.00	0.00	0.00	0.00	–0.01	0.00
Automobiles	0.22	–0.10	–0.69	0.24	–0.25	–0.12
Petrochemicals	–1.47	–0.59	0.00	0.00	–0.03	–0.46
IT products	–1.24	–0.95	–0.05	–0.04	–0.02	–0.52
IT parts and components	0.07	–0.39	–1.81	–1.00	–0.99	–0.85
Machinery	–0.71	0.09	–0.13	–2.86	–1.27	–0.97

the second most negative *enS* (–0.89%), as new SME entrants in this industry are less likely to achieve fast technological progress given the second strongest vertical integration of their industrial structure.

Next, *enL* fluctuated extensively in the textile and clothing, machinery, and IT parts and components industries, while it declined over the period and close to zero for the remaining industries. As a result, new LE entrants in the textile and clothing industry raised productivity growth to a significant extent (1.69%), while new LE entrants hindered productivity growth the most in the machinery industry (–0.97%) and the second most in the IT parts and components industry (–0.85%).

Second, table 2 presents *exS* and *exL* in the specified time periods, ranked by their respective average values for 1995-2014.

exS fluctuated to a greater extent than *exL* did throughout the period in the basic metal products, shipbuilding, petrochemical, fine chemical, automobile, and IT parts and components industries. In particular, *exL* was mostly larger than *exS* when exits occurred, but LE exited far less frequently than SME did.

From 1995 to 2014, *exS* was entirely negative across industries, indicating that the increase in exiting SME had negative impact on the productivity growth of their industries. This result demonstrates the "shadow of death" of marginal plants. *exS* was the most negative for the automobile industry (–0.77%), followed by the IT parts and components industry (–0.28%), implying that the increase in exiting SME slowed productivity the most in these two industries, both of which had strong vertical integration in their industrial structures. However, *exS* was small and negative for the remaining industries, indicating that the increase in exiting SME slightly slowed productivity in these industries.

Whereas *exS* was negative for all 10 industries, *exL* was most positive in the IT parts and components industry (0.29%), and followed by the HCI of petrochemicals, machinery, and basic metal products. Therefore, the increase in exiting LE contributed the most to productivity growth in the IT parts and components industry, while it contributed the least to the mature HCI.

However, *exL* was negative in the other half of the industries, and the most negative for IT products (–1.37%). Thus, an increase in exiting LE slowed productivity growth one year prior to the actual exits to a greater extent in industries with strong vertical integration in their industrial structures.

Consequently, tables 2 and 3 shows that *enS* and *exS* were the most negative for the automobile industry (–1.36% and –0.77%), indicating that SME were significantly less viable in the automobile industry, which retained the strongest vertical integration in its industrial structure.

Table 2 *exS* and *exL* in the Specified Time Periods, Ranked by Their Average Values for 1995-2014

	1996-1998	1999-2002	2003-2005	2006-2008	2011-2013	1995-2014
exS						
Machinery	0.01	–0.02	0.01	0.03	–0.06	–0.01
Basic metal products	0.02	0.02	–0.03	–0.01	–0.08	–0.01
Precision instruments	0.00	–0.06	0.06	0.03	–0.09	–0.02
IT products	–0.03	–0.07	0.09	–0.03	–0.12	–0.04
Shipbuilding	–0.10	–0.17	0.02	–0.15	0.12	–0.07
Petrochemicals	–0.13	0.11	–0.28	–0.14	–0.10	–0.10
Textile and clothing	–0.24	–0.02	0.01	–0.05	–0.30	–0.12
Fine chemicals	–0.14	–0.09	–0.27	–0.21	–0.20	–0.19
IT parts and components	–0.15	–0.26	–0.30	–0.68	0.09	–0.28
Automobiles	–0.06	–1.04	–1.93	0.01	–0.49	–0.77
exL						
IT parts and components	0.10	0.44	0.25	0.36	0.17	0.29
Petrochemicals	0.05	–0.34	0.00	0.00	0.96	0.11
Machinery	0.52	0.14	–0.26	0.12	–0.15	0.08
Basic metal products	–0.04	0.00	0.01	0.00	0.16	0.03
Fine chemicals	0.00	0.00	0.00	0.00	0.06	0.01
Shipbuilding	–0.01	–0.07	0.00	0.00	–0.45	–0.11
Precision instruments	–0.25	0.04	0.00	–0.76	–0.68	–0.33
Automobiles	–0.67	–0.74	0.06	–0.02	–0.29	–0.38
Textile and clothing	0.29	–0.07	–3.06	0.11	0.01	–0.55
IT products	0.18	–2.29	–4.06	0.03	0.06	–1.37

Notably, the *enS* and *exS* rankings were quite similar among the 10 growth-leading industries, implying that the impact of SME entries and SME exits on productivity growth had similar rankings across these industries. The rank order was roughly machinery, basic metal products, precision

Table 3 BD_S and BD_L in the Specified Time Periods, Ranked by Their Average Values for 1995-2014

	1996	1997-1999	2000-2003	2004-2006	2007-2009	2011	2012-2014	1995-2014
BD_S								
Fine chemicals	5.2	3.2	1.8	1.6	1.7	–1.1	1.6	2.0
Petrochemicals	3.1	1.4	1.3	1.4	0.3	0.7	1.4	1.3
Automobiles	1.5	1.1	0.9	2.8	0.3	0.7	1.6	1.2
Basic metal products	2.7	1.3	1.2	0.7	0.9	–1.4	0.7	0.9
Shipbuilding	2.3	1.2	0.6	0.4	0.1	–1.1	0.5	0.6
Machinery	1.6	0.8	0.5	0.4	0.6	–0.8	0.4	0.5
IT parts and components	1.0	0.3	0.3	0.2	0.3	–0.7	0.3	0.2
Precision instruments	1.0	0.3	0.2	0.1	0.6	–0.4	0.2	0.2
Textile and clothing	0.9	0.5	0.3	0.1	0.3	–0.8	0.1	0.2
IT products	0.3	0.1	0.1	0.1	0.1	–0.1	0.0	0.1
BD_L								
Fine chemicals	8.9	6.7	5.5	5.3	1.6	3.4	2.1	4.5
Basic metal products	7.3	5.2	4.3	2.7	3.4	3.6	2.4	3.8
Petrochemicals	7.1	4.3	3.6	3.4	3.9	0.1	0.6	3.2
IT products	2.7	1.5	0.8	1.5	2.1	–1.1	2.6	1.5
Machinery	2.6	1.6	1.5	1.4	0.9	1.1	0.7	1.3
IT parts and components	0.5	0.3	0.1	0.5	–0.1	0.3	–0.1	0.2
Shipbuilding	0.3	0.2	0.1	0.1	0.0	0.2	0.0	0.1
Automobiles	–0.6	–0.1	–0.3	–0.4	0.2	–1.2	–0.6	–0.4
Textile and Clothing	–3.7	–2.4	–1.0	–2.5	–1.5	2.8	–0.9	–1.5
Precision instruments	–7.0	–4.8	–3.1	0.0	0.1	–3.5	–1.3	–2.3

instruments, shipbuilding, fine chemicals, petrochemicals, textile and clothing, IT manufacturing, and automobiles.

Consequently, the results reflect that the stability and viability of SME are related to industry-specific structural and technological features, not to mention the exogenous market shocks and market selection forces.

Therefore, this result calls for the effectiveness of the shared growth between LE and SME or among SME within the bounds of the respective industry's own distinctive features to reduce resource waste in the form of productivity loss.

3.2. Intertemporal Impacts by Industry

3.2.1. 1997 financial crisis and its aftermath

Table 4 shows that although *TP* was stable, $T\dot{F}P$ alarmingly declined across industries in 1997-1999 compared to 1996, except for a slight decrease in the precision instruments industry and a sharp increase in the textile and clothing industry (5.6%). During 1997-1999, around the time of the 1997 financial crisis, both of the relenting SME and LE concurrently reduced productivity growth across industries.

Table 4 $\dot{TFP}$, *TP*, *enS*, *exS*, BD_S, *enL*, *exL*, and BD_L by Industry Ranked by $\dot{TFP}$ over the Specified Time Periods

*		$\dot{TFP}$	*TP*	*enS*	*exS*	BD_S	*enL*	*exL*	BD_L
	1996								
	Fine chemicals	21.6	9.2	n.a.	n.a.	5.2	n.a.	n.a.	8.9
2	IT products	19.2	17.2	n.a.	n.a.	0.3	n.a.	n.a.	2.7
1	IT parts and components	16.0	12.7	n.a.	n.a.	1.0	n.a.	n.a.	0.5
7	Automobiles	12.9	11.1	n.a.	n.a.	1.5	n.a.	n.a.	–0.6
5	Basic metal products	12.5	4.1	n.a.	n.a.	2.7	n.a.	n.a.	7.3
4	Petrochemicals	10.6	8.9	n.a.	n.a.	3.1	n.a.	n.a.	7.1
3	Shipbuilding	8.3	4.5	n.a.	n.a.	2.3	n.a.	n.a.	0.3
6	Machinery	7.4	5.2	n.a.	n.a.	1.6	n.a.	n.a.	2.6
8	Precision instruments	1.9	8.4	n.a.	n.a.	1.0	n.a.	n.a.	–7.0
10	Textiles and clothing	–0.3	12.1	n.a.	n.a.	0.9	n.a.	n.a.	–3.7
	1997-1999				1996-1998			1996-1998	
2	IT products	13.3	16.7	–0.76	–0.03	0.1	–1.24	0.18	1.5
9	Fine chemicals	12.5	8.7	0.27	–0.14	3.2	0.00	0.00	6.7
1	IT parts and components	10.5	12.2	–1.19	–0.15	0.3	0.07	0.10	0.3
8	Basic metal products	6.8	3.6	0.04	0.02	1.3	0.27	–0.04	5.2
3	Automobiles	6.0	10.8	0.06	–0.06	1.1	0.22	–0.67	–0.1
10	Petrochemicals	5.8	8.4	–1.83	–0.13	1.4	–1.47	0.05	4.3
7	Textiles and clothing	5.6	11.3	–0.17	–0.24	0.5	1.74	0.29	–2.4
5	Machinery	5.0	5.0	–0.09	0.01	0.8	–0.71	0.52	1.6
4	Shipbuilding	3.2	4.1	–0.39	–0.10	1.2	0.00	–0.01	0.2
6	Precision instruments	1.7	8.4	–0.83	0.00	0.3	–0.11	–0.25	–4.8
	2000-2003				1999-2002			1999-2002	
1	IT products	15.6	15.7	–1.78	–0.07	0.1	–0.95	–2.29	0.8
2	Fine chemicals	12.3	7.6	–0.22	–0.09	1.8	0.00	0.00	5.5
9	Petrochemicals	10.8	7.5	0.36	0.11	1.3	–0.59	–0.34	3.6
5	Automobiles	10.6	10.4	–2.06	–1.04	0.9	–0.10	–0.74	–0.3
7	IT parts and components	9.5	11.6	0.73	–0.26	0.3	–0.39	0.44	0.1

4	Textiles and clothing	8.0	9.7	−0.42	−0.02	0.3	3.60	−0.07	−1.0
8	Basic metal products	7.6	2.6	0.25	0.02	1.2	0.00	0.00	4.3
3	Shipbuilding	7.1	3.6	0.22	−0.17	0.6	0.00	−0.07	0.1
6	Machinery	5.8	4.6	0.23	−0.02	0.5	0.09	0.14	1.5
10	Precision instruments	3.7	8.3	0.31	−0.06	0.2	0.00	0.04	−3.1
	2004-2006				2003-2005			2003-2005	
2	IT products	16.1	14.8	−0.73	0.09	0.1	−0.05	−4.06	1.5
9	IT parts and components	12.4	10.8	−0.16	−0.30	0.2	−1.81	0.25	0.5
4	Fine chemicals	10.6	6.5	-0.21	-0.27	1.6	0.00	0.00	5.3
5	Automobiles	9.4	10.1	−3.63	−1.93	2.8	−0.69	0.06	−0.4
1	Petrochemicals	9.1	6.7	−0.15	−0.28	1.4	0.00	0.00	3.4
8	Precision instruments	6.6	6.9	0.00	0.06	0.1	0.19	0.00	0.0
7	Machinery	5.1	4.2	0.13	0.01	0.4	−0.13	−0.26	1.4
6	Shipbuilding	4.6	3.2	−1.50	0.02	0.4	0.00	0.00	0.1
3	Textiles and clothing	3.9	8.2	0.06	0.01	0.1	−0.53	−3.06	−2.5
10	Basic metal products	3.3	1.7	0.00	−0.03	0.7	0.00	0.01	2.7
	2007-2009				2006-2008			2006-2008	
2	IT products	12.9	13.9	−0.18	−0.03	0.1	−0.04	0.03	2.1
1	IT parts and components	9.0	10.2	−0.08	−0.68	0.3	−1.00	0.36	−0.1
9	Automobiles	8.0	9.0	−0.09	0.01	0.3	0.24	−0.02	0.2
4	Precision instruments	7.5	7.2	0.57	0.03	0.6	0.02	−0.76	0.1
10	Petrochemicals	7.5	6.0	−0.85	−0.14	0.3	0.00	0.00	3.9
5	Fine chemicals	5.0	5.6	0.10	−0.21	1.7	0.00	0.00	1.6
8	Textiles and clothing	2.8	6.9	0.03	−0.05	0.3	0.00	0.11	−1.5
3	Machinery	2.6	3.7	0.21	0.03	0.6	−2.86	0.12	0.9
6	Basic metal products	2.0	0.9	0.05	−0.01	0.9	0.00	0.00	3.4
7	Shipbuilding	1.6	2.7	0.26	−0.15	0.1	0.00	0.00	0.0
	2011								
2	IT parts and components	8.3	9.9	n.a.	n.a.	−0.7	n.a.	n.a.	0.3
1	Automobiles	7.0	9.3	n.a.	n.a.	0.7	n.a.	n.a.	−1.2
10	IT products	5.3	13.4	n.a.	n.a.	−0.1	n.a.	n.a.	−1.1
4	Textiles and clothing	4.1	6.0	n.a.	n.a.	−0.8	n.a.	n.a.	2.8
5	Fine chemicals	2.3	5.0	n.a.	n.a.	−1.1	n.a.	n.a.	3.4
9	Precision instruments	2.1	8.1	n.a.	n.a.	−0.4	n.a.	n.a.	−3.5
7	Machinery	1.5	3.5	n.a.	n.a.	−0.8	n.a.	n.a.	1.1
6	Shipbuilding	−1.9	2.5	n.a.	n.a.	−1.1	n.a.	n.a.	0.2
3	Basic metal products	−2.1	0.3	n.a.	n.a.	−1.4	n.a.	n.a.	3.6
8	Petrochemicals	−8.2	5.4	n.a.	n.a.	0.7	n.a.	n.a.	0.1
	2012-2014				2011-2013			2011-2013	
5	IT products	13.3	12.9	−0.40	−0.12	0.0	−0.02	0.06	2.6
4	Automobiles	10.3	8.9	−0.42	−0.49	1.6	−0.25	−0.29	−0.6
1	IT parts and components	9.7	9.5	−0.07	0.09	0.3	−0.99	0.17	−0.1
2	Fine chemicals	6.7	4.3	−0.27	−0.20	1.6	0.01	0.06	2.1
10	Precision instruments	5.4	8.0	−0.20	−0.09	0.2	0.00	−0.68	−1.3
3	Petrochemicals	4.8	4.9	−1.07	−0.10	1.4	−0.03	0.96	0.6
8	Shipbuilding	4.7	2.2	0.20	0.12	0.5	−0.01	−0.45	0.0
6	Textiles and clothing	3.8	5.1	−0.57	−0.30	0.1	2.42	0.01	−0.9
9	Basic metal products	2.9	−0.2	−0.24	−0.08	0.7	0.03	0.16	2.4
7	Machinery	2.7	3.2	−0.28	−0.06	0.4	−1.27	−0.15	0.7

	1995-2014								
2	IT products	14.1	14.9	−0.89	−0.04	0.1	−0.52	−1.37	1.5
1	IT parts and components	10.5	10.9	−0.10	−0.28	0.3	−0.85	0.29	0.2
9	Fine chemicals	9.9	6.7	−0.08	−0.19	2.0	0.00	0.01	4.5
5	Automobiles	8.6	10.0	−1.36	−0.77	1.2	−0.12	−0.38	−0.4
4	Petrochemicals	7.1	6.8	−0.68	−0.10	1.3	−0.46	0.11	3.2
7	Basic metal products	4.8	1.8	0.04	−0.01	1.0	0.06	0.03	3.8
10	Precision instruments	4.7	8.2	−0.01	−0.02	0.2	0.02	−0.33	−2.3
8	Textiles and clothing	4.7	8.4	−0.24	−0.12	0.2	1.69	−0.55	−1.5
3	Machinery	4.3	4.2	0.05	−0.01	0.5	−0.97	0.08	1.3
6	Shipbuilding	4.3	3.2	−0.23	−0.07	0.6	0.00	−0.11	0.1

Notes: 1) *TFP*and *TP* are estimated with BD_S and BD_L.
2) Column * shows the rank of export volume in 2015.

3.2.2. Economic recovery in 2000-2003 and 2004-2006

enS, the increase in new SME entrants, had significant negative impact on productivity growth for the IT products (−1.78%) and the automobile (−2.06%) industries during the 2000-2003 economic recovery and on the automobile (−3.63%) and shipbuilding (−1.50%) industries during the following 2004-2007 economic upturn, where a strong vertical integration existed in their industrial structure.

enL declined across industries, an increase in new LE entrants, significantly promoted productivity growth for the textiles and clothing industry (3.60%), whereas an increase in new LE entrants reduced productivity growth for the IT products industry (−0.95%) during 2000-2003 and for IT parts and components (−1.81%) during 2004-2007. However, no new LE entrants were observed in the industries of basic metal products, fine chemicals, and shipbuilding.

On the other hand, an increase in exiting SME for the automobile industry had negative pre-exit impact on productivity growth during 1999-2002 (−1.04%) and during 2003-2005 (−1.93%).

Likewise, an increase in exiting LE for the IT products industry had significant negative pre-exit impact on productivity growth in 1999-2002 (−2.29%) and 2003-2005 (−4.06%), and the textiles and clothing industry during 2003-2005 (−3.06%) showed substantial “shadow of death” in marginal business. However, there were no exiting LE for the petrochemicals, fine chemicals, shipbuilding, and precision instruments

industries during 2004-2006.

Therefore, the dynamics of entry, exit, and incumbent businesses of SME during the economic upturn of 2000-2003 and 2004-2006 produced a positive BD_S value, indicating that the persevering SME contributed to productivity growth of the industries of fine chemicals (1.8%), petrochemicals (1.3%), and basic metal products (1.2%) during 2000-2003, as well as the automobiles (2.8%), fine chemicals (1.8%), and petrochemicals (1.3%) industries during 2004-2006.

Likewise, the dynamics of entry, exit, and incumbent businesses of LE during the economic upturn of 2000-2003 and 2004-2006 produced a positive BD_L value, which had larger magnitude than BD_S, indicating that the persistent LE promoted the productivity growth of fine chemicals (5.5%), basic metal products (4.3%), and petrochemicals (3.6%) in 2000-2003, and fine chemicals (5.3%), petrochemicals (3.4%), and basic metal products (2.7%) during 2004-2006.

Eventually, the mature industries of chemicals and basic metal products verified their resilience and the LE persevered substantially contributed to the productivity growth in the aftermath of the 1997 financial crisis.

3.2.3. 2008 global financial crisis and its aftermath

In the period of 2007-2009 and the 2008 global financial crisis, $T\dot{F}P$ and *TP* concurrently fell, except in the case of the precision instruments industry; and *enS* and *enL* declined, but an increase in new LE entrants significantly dragged down $T\dot{F}P$ for the machinery (−2.86%) and IT parts and components (−1.00%) industries. However, no LE entry was recorded in the industries of petrochemicals, fine chemicals, textiles and clothing, basic metal products, and shipbuilding.

On the other hand, *exS* and *exL* waned, and the increase in exiting SME mostly lowered productivity growth, while there were no exiting LE for the petrochemicals, basic metal products, fine chemicals, and shipbuilding industries.

As a consequence of the dynamics of entry, exit, and continuing SME and

LE during 2007-2009 around the time of the global financial crisis, BD_S and BD_L waned, but the persevering SME substantially contributed to productivity growth for fine chemicals (1.7%), and the persistent LE sustained a significant productivity growth for IT products (2.1%), petrochemicals (3.9%), fine chemicals (1.6%), and basic metal products (3.4%).

Finally, the LE persevered in the target industries of chemicals, basic metal products, and IT products considerably contributed to the productivity growth during 2007-2009 around the time of the 2008 global financial crisis.

Turning to the 2011 economic downturn, $T\dot{F}P$ fell across industries except for the textiles and clothing industry (4.1%), and *TP* also fell except for the automobiles (9.3%) and precision instruments (8.1%) industries.

In particular, BD_S concurrently fell to a negative value across industries resulting from the relenting SME except for the unrelenting SME for petrochemicals and automobile industries.

In contrast, BD_L widely varied across industries, and the unrelenting LE considerably promoted productivity growth for the fine chemicals (3.4%), basic metal products (3.6%), and machinery (1.1%) industries, but slowed productivity growth for IT products (−1.1%), automobile (−1.2%), and precision instruments (−3.5%). However, for the first time, relenting LE promoted productivity growth for the textiles and clothing industry (2.8%). As a result, SME received concurrent but smaller impact from the market exogenous shocks than LE did, while the persistent LE in the target mature HCI and textiles and clothing industry, substantially contributed to the productivity growth during the 2011 economic downturn.

Therefore, the active dynamics of SME and LE in the current growth-leading industries verified the substantial impact of market exogenous shocks and their aftermath across the industries. Especially, the extent of the impact of the entry, exit, and business durations of SME on productivity growth across industries reflected the weaker viability of SME in the aftermath of market exogenous shocks, as they are tied to specific features of their industrial structures, the extent of technological innovation, and the

growth trajectory in the framework of the "selection and concentration" policy, not to mention market selection forces.

Clearly, during the 1998 depression triggered by the 1997 financial crisis, both of the relenting SME and LE concurrently reduced productivity growth across industries, however, in the aftermath of the 2008 global financial crisis, the relenting SME concurrently reduced productivity growth across industries during the 2011 economic recovery, while the relenting LE slowed productivity growth over the longer period from 2008 to 2011.

3.2.4. 2012-2014 economic recovery

Lastly, during the 2012-2014 economic upturn, although *TP* declined, $T\dot{F}P$ concurrently rose except for the textiles and clothing industry. *enS* became negative across industries, while *enL* continued to decline, especially, an increase in new SME entrants significantly slowed productivity growth for petrochemicals (−1.07%).

Furthermore, during 2011-2013, *exS* was negative across industries, when marginal establishments experienced the "shadow of death," whereas *exL* varied across industries. In particular, the impact of the entry, exit, and business durations of SME on productivity growth were concurrent and similar, whereas those of LE on productivity growth varied by industry and were larger than those of SME. It is noteworthy that BD_S was positive for all industries, indicating that the persevering SME contributed to productivity growth during the 2012-2014 economic recovery.

However, BD_L was positive for only half the industries: the persistent LE promoted productivity growth for fine chemicals (2.1%), basic metal products (2.4%), and IT products (2.6%).

Again, the unrelenting LE in the mature industries of fine chemicals, basic metal products, and IT products considerably contributed to the productivity growth during the economic recovery of 2012-2014.

3.3. Industrial Structure Upgrades and Unrelenting LE

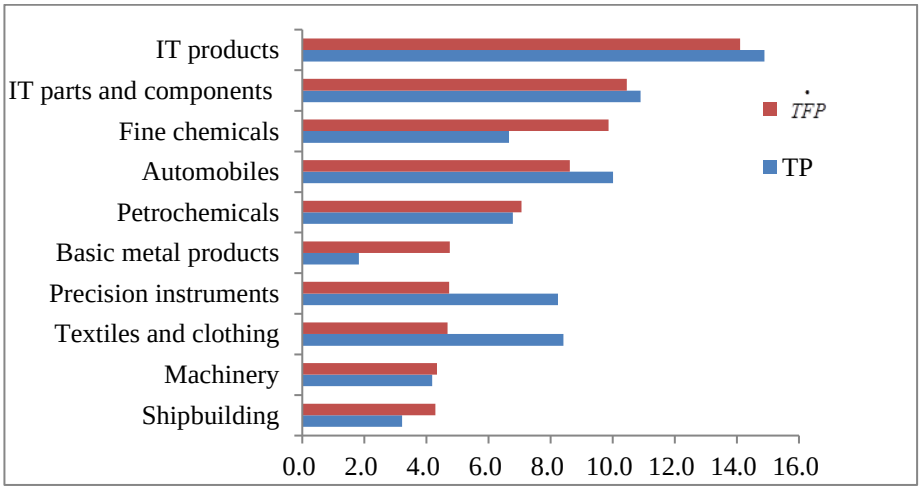
Table 5 and figure 1 present *TP* is driving force of $T\dot{F}P$, and $T\dot{F}P$ and *TP* of the IT manufacturing industry surpassed those of the HCI, as well as the automobile and shipbuilding industries. Especially, new frontier

Table 5 $\dot{TFP}$, *TP*, $\dot{TE}$, *SC*, *AE*, BD_S, BD_L, and *TE* by Industry, Ranked by $\dot{TFP}$ for the Period 1995-2014

*		$\dot{TFP}$	*TP*	$\dot{TE}$	*SC*	*AE*	BD_S	BD_L	*TE*
2	IT products	14.1	14.9	–2.2	0.0	–0.2	0.1	1.5	35.7
1	IT parts and components	10.5	10.9	0.1	0.1	–1.1	0.3	0.2	62.8
9	Fine chemicals	9.9	6.7	–1.7	–0.4	–1.1	2.0	4.5	39.7
5	Automobiles	8.6	10.0	–1.8	0.0	–0.5	1.2	–0.4	39.2
4	Petrochemicals	7.1	6.8	–2.6	0.6	–2.2	1.3	3.2	36.5
7	Basic metal products	4.8	1.8	–1.2	0.1	–0.8	1.0	3.8	42.2
10	Precision instruments	4.7	8.2	–0.8	–0.1	–0.5	0.2	–2.3	39.8
8	Textiles and clothing	4.7	8.4	–1.4	0.0	–1.0	0.2	–1.5	45.1
3	Machinery	4.3	4.2	–1.1	0.0	–0.6	0.5	1.3	43.7
6	Shipbuilding	4.3	3.2	0.2	0.3	–0.1	0.6	0.1	70.1

Note: Column* indicates the rank of export volume in 2015.

Figure 1 $\dot{TFP}$ and *TP* by Industry, Ranked by $\dot{TFP}$ for the Period 1995-2014



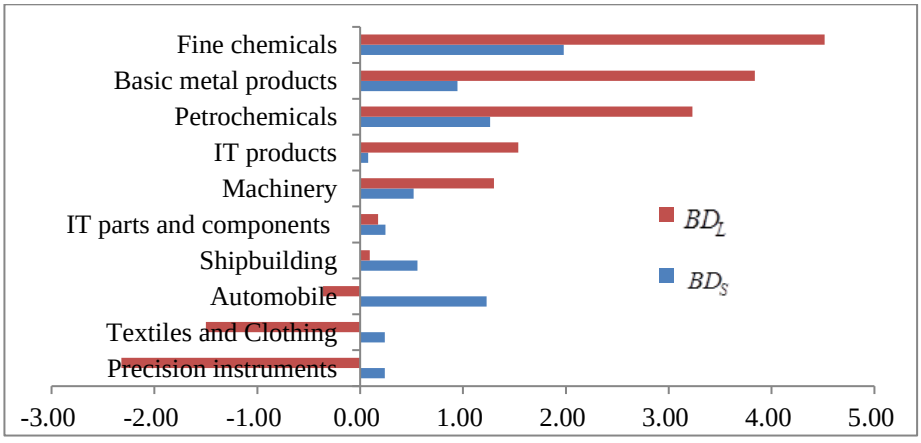
technologies are urgently needed to raise the relatively flagging *TP* to promote productivity growth of the mature HCI and shipbuilding industry.

TE was the highest for shipbuilding (70.1%), followed by IT parts and components (62.8%), and improved across time periods, however, it hovered about 40% in a declining trend in other industries. SC largely tapered off, and AE was negative across industries, indicating that market distortions prevailed across industries, especially in the aftermath of exogenous market shocks.

Table 5 and figure 2 show that the HCI targeted by "selection and concentration" policy earlier had significantly larger BD_L than BD_S, indicating that the unrelenting LEs significantly raised productivity growth: basic metal products (3.8%), petrochemicals (3.2%), and machinery (1.3%). The greatest increase came from fine chemicals (4.5%) and also for IT products (1.5%).

Therefore, the persistent LE promoted productivity growth to a greater extent than their counterparts in the HCI, the fine chemicals and the IT products industries, while the opposite was held for the automobile industry.

Figure 2 BD_S and BD_L by Industry, Ranked by BD_L for the Period 1995-2014



3.4. Industry Maturity and LE

Finally, the analysis again considers the estimates of BD_S and BD_L and their role in TFP growth during up and down periods by industry from 1995 to 2014. Not surprisingly, the years with the highest and lowest TFP growth differ across industries.

Table 6 shows BD_S and BD_L at the times of the highest and the lowest $T\dot{F}P$ values for export-leading industries to identify the contributions of BD_S and BD_L. Except in the precision instruments industry, record high $T\dot{F}P$ occurred during economic upturns, whereas record low $T\dot{F}P$ occurred during economic downturns.

In the framework of the "selection and concentration" industrial policy, the older target industries reached record high $T\dot{F}P$ values earlier: machinery (7.4%), basic metal products (12.5%), fine chemicals (21.6%) hit record highs in 1996, as did petrochemicals (14.0%) in 2000; automobiles (14.9%),

Table 6 BD_S and BD_L Values at the Times of the Highest and Lowest $T\dot{F}P$ Values for the Export-leading Industries

*		$T\dot{F}P$ record high	Year	BD_S	BD_L	$T\dot{F}P$ record low	Year	BD_S	BD_L
1	IT parts and components	16.0	1999	0.1	0.2	5.6	2001	0.3	0.1
2	IT products	20.5	2007	0.1	7.1	5.3	2011	–0.1	–1.1
3	Machinery	7.4	1996	1.6	2.6	1.4	2008	0.8	0.2
4	Petrochemicals	14.0	2000	1.8	3.4	–8.2	2011	0.7	0.1
5	Automobiles	14.9	2001	–0.4	–0.4	0.7	1998	0.8	–0.3
6	Shipbuilding	9.4	2001	0.4	0.2	–1.9	2011	–1.1	0.2
7	Basic metal products	12.5	1996	2.7	7.3	–2.1	2011	–1.4	3.6
8	Textiles and clothing	11.6	2001	0.2	–1.8	–2.2	2013	0.1	–2.6
9	Fine chemicals	21.6	1996	5.2	8.9	1.7	2009	1.3	–1.3
10	Precision instruments	10.6	2009	1.1	0.3	–0.8	1997	0.6	–5.3

Note: Column * shows the rank of export volume in 2015.

shipbuilding (9.4%), textiles and clothing (11.6%) in 2001, IT parts and components (16.0%) in 1999, IT products (20.5%) in 2007, and precision instruments (10.6%) in 2009.

The results reflect the maturity of industry, and thus, the older target industries reached the maturity phase earlier than did the later target industries.

The LE persevered contributed to the record high $T\dot{F}P$ values to a greater extent than did the SME persevered for the HCI of machinery (1.6%, 2.6%), petrochemicals (1.8%, 3.4%), and basic metal products (2.7%, 7.3%), not to mention for fine chemicals (5.2%, 8.9%) and IT products (0.1%, 7.1%).

Strikingly, the persistent LE served to considerably slow the evolution toward the record high values for textiles and clothing (–1.8%), whereas the persistent SME sped this evolution for precision instruments (1.1%).

On the contrary, the record low $T\dot{F}P$ values for the HCI of machinery (1.4%), petrochemicals (–8.2%), and basic metal products (–2.1%) occurred in 2008, 2011 and 2011, respectively. Furthermore, record lows appeared for fine chemicals (1.7%) in 2009, for textiles and clothing (–2.2%) in 2013, for automobiles (0.7%) in 1998, for shipbuilding (–1.9%) in 2011, for IT parts and components (5.6%) in 2001, for IT products (5.3%) in 2011, and for precision instruments (–0.8%) in 1997.

Concurrently, record low $T\dot{F}P$ prevailed during market exogenous shocks; six industries experienced their record low $T\dot{F}P$ during the economic downturns in the aftershocks of the 2008 financial crisis, whereas the precision instruments and automobiles posted their record lows during the 1997 financial crisis and the following 1998 depression, respectively.

The unrelenting LE served to slow down to record lows for IT products (–1.1%), textiles and clothing (–2.6%) and precision instruments (–5.3%), whereas the relenting LE served to slow down to record low for fine chemicals (–1.3%).

Meanwhile, the relenting SME served to slow down to record lows for shipbuilding (–1.1%) and basic metal products (–1.4%).

Therefore, the persistent LE mainly contributed to the record high

productivity growth across industries, whereas the persistent LE substantially served to slow down to the record low productivity growth in three industries and relenting SME did in two industries.

4. CONCLUSION

This study presents that market exogenous shocks had concurrent but smaller impact on SME than on LE, with different impact on LE according to the maturity of industries.

In fact, currently growth-leading industries have establishments with more active dynamics and show a larger and clearer impact of market exogenous shocks and economic upturns.

Furthermore, the extent of the impact of the dynamics of SME and LE on productivity growth by industry reflected the weaker viability of SME following market exogenous shocks, as these establishments are tied to specific features of their industrial structures, the extent of technological innovation, and the growth trajectory within the framework of the "selection and concentration" policy, let alone market selection forces.

Therefore, the shared growth between LE and subcontracting SME, or among SME equipped with technology should be redesigned to overcome the market exogenous shocks and reach a sustainable long-run economic growth of Korea.

Furthermore, within an institutional framework, *Fair Trade Commission* should effectively promote fair trade and competition to reduce resource waste in the form of productivity loss and build up guidelines tailored to industry's own distinctive features.

Notably, during the 1998 depression triggered by the 1997 financial crisis, the relenting SME and LE both concurrently reduced productivity growth across industries. However, in the aftermath of the 2008 global financial crisis, the relenting SME concurrently reduced productivity growth across the industries during the 2011 economic recovery, whereas the relenting LE

slowed productivity growth over the longer period from 2008 to 2011.

The empirical results present that the persevering LE promoted productivity growth surprisingly more frequently than their counterparts did in both the HCI and the IT products industry. Furthermore, for the older, growth-leading HCI, unrelenting LE increased productivity growth to a greater extent than they did among the newer, growth-leading IT products industry.

In addition, half of the export-leading industries posted record high TFP growth during the resurrection of manufacturing after the 1998 depression triggered by the 1997 financial crisis. The other four industries posted record-high TFP growth during the earlier economic upturns. This finding indicates the maturities of these industries, that is, the older target industries reached the maturity phase earlier than the newer target industries did.

In contrast, record low TFP growth prevailed during market exogenous shocks; seven industries posted record low TFP growth during the economic downturns following the 2008 financial crisis, whereas the automobile and IT parts and components industries posted record low TFP growth during the 1998 depression in the aftermath of the 1997 financial crisis.

In particular, the unrelenting SME and LE both contributed to record high TFP growth across industries, however, the unrelenting LE served to slow down TFP growth to record low.

Eventually, the empirical results provide guidance for reducing resource waste and reallocating resources more efficiently between SME and LE in the framework of a strategic industrial policy aiming at sustainable long-run economic growth of Korea.

APPENDIX

Table A1 10 Export-leading Manufacturing Industries with 29 Subsectors under the KSIC (Korean Standard Industrial Classification) System

Export-leading industries	
IT parts and components	
Semiconductors	Manufacture of semiconductors (KSIC 261)
Flat display boards	Manufacture of flat display boards (KSIC 2621)
Other electronic components	Manufacture of printed circuit boards and loaded electronic components onto PCB (KSIC 2622); manufacture of other electronic components, except for semiconductors and electronic integrated circuits (KSIC 2629)
Batteries	Manufacture of primary cells, batteries, and accumulators (KSIC 282)
IT products	
Telecommunications equipment	Manufacture of telecommunications and broadcasting equipment (KSIC 264)
Electric home appliances	Manufacture of domestic appliances (KSIC 2851)
Electronic video and audio equipment	Manufacture of electronic video and audio equipment (KSIC 265)
Computers	Manufacture of computers and peripheral equipment (KSIC 263)
Machinery	
Special-purpose machinery	Manufacture of special-purpose machinery (KSIC 292)
General-purpose machinery	Manufacture of general-purpose machinery (KSIC 291)
Electrical equipment	Manufacture of electric motors, generators, transforming, distributing and controlling apparatus of electricity (KSIC 281); Manufacture of insulated wires and cables, including insulated code sets (KSIC 283); Manufacture of other electrical equipment (KSIC 289);
Fabricated metal products	Manufacture of fabricated metal products, except for machinery and furniture (KSIC 25)
Petrochemicals	
Basic chemicals	Manufacture of basic chemicals (KSIC 201)
Synthetic rubbers and Plastic products in primary forms	Manufacture of synthetic rubber and plastic products in primary forms (KSIC 203)
Coke, briquettes, and refined petroleum products	Manufacture of coke, hard-coal and lignite fuel briquettes, and refined petroleum products (KSIC 19)
Automobile	
Assembled vehicles	Manufacture of motor vehicles and engines for motor vehicles (KSIC 301)
Automobile parts and components	Manufacture of bodies for motor vehicles and manufacture of trailers and semitrailers (KSIC 302); Manufacture of parts and accessories for motor vehicles and engines (KSIC 303)
Shipbuilding	Building of ships and boats (KSIC 311)
Basic metal products	
Basic iron and steel	Manufacture of basic iron and steel (KSIC 241)
Non-ferrous metals	Manufacture of basic precious and non-ferrous metals (KSIC 242)
Metal casting	Cast of metals (KSIC 243)
Textiles & Clothing	
Fibers	Manufacture of textiles, except for apparel (KSIC 13)
Man-made fibers	Manufacture of man-made fibers (KSIC 205)

Apparel	Manufacture of clothing apparel, clothing accessories, and fur articles (KSIC 14)
Fine chemicals	
Fertilizer and nitrogen compounds	Manufacture of fertilizer and nitrogen compounds (KSIC 202)
Other chemical products	Manufacture of other chemical products (KSIC 204)
Pharmaceuticals	Manufacture of pharmaceuticals, medical chemicals, and botanical products (KSIC 21)
Precision instruments	
Precision instruments	Manufacture of measuring, testing, navigation, control, and other precision instruments (KSIC 2721); manufacture of spectacles (KSIC 2731); manufacture of optical instruments and photographic equipment (KSIC 2732); manufacture of watches, clocks, and parts (KSIC 274)
Medical devices	Manufacture of radiation apparatus and electro-diagnostic apparatus (KSIC 2711); manufacture of other medical and surgical equipment and orthopedic appliances (KSIC 2719)

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