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A Study on the Revitalization Pattern of Industry in Decline : Focusing on Korean Shoe Industry

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Abstract

Purpose **-** This study aims to study the activation pattern of declining industries by applying the Gompertz growth model using available resources based on the theory of industrial life cycle, classifying declining industries among Korean manufacturing industries, and identifying resource input characteristics.

Research design and methodology - This study was conducted by combining the Gompertz growth model that predicts the limit of output based on available resources under the industrial life cycle theory. Using Gompertz model, this study analyzed the life cycle of 39 Korean manufacturing industries from the perspective of domestic production, number of employees, and fixed assets

Results **-** According to a life cycle analysis of 39 manufacturing industries in Korea, the computer, textile, and shoe industries were classified as declining industries. Among them, research on resource input characteristics on the shoe industry showed that domestic production and the number of employees decreased, while the proportion of domestic R&D personnel and the number of research departments gradually increased.

Conclusion **-** Among the declining industries in Korea, the shoe industry is considered to revitalize the industry, that is, to extend the life of the declining industry by offshoring its production site and improving constitution with a "R&D center for global" support.

Keywords: Declining Industry, Industrial Life Cycle, Gompertz Model

JEL Classification Code: C53, D15, L67

1. Introduction

The Korean manufacturing industry accounts for 32.58% of Korea's GDP (World Bank, 2020) and has increased 13.6% annually in overseas investment (2010-2018), but only 5.1% annually in domestic production facilities investment. The resulting job loss is estimated to be about 420,000 (Korea Economic Research Institute, 2019). Around 2010, Korean domestic manufacturing companies entered R&D centers in developed countries for the purpose of acquiring technology and overseas expansion into developing countries with relatively low labor costs for the purpose of reducing product costs. Since then, overseas expansion has been invested in places where customers and markets are located, and expansion has been expanding to developing countries and developed countries for the purpose of resolving trade barriers and avoiding regulations (Korea Development Bank, 2019). To improve this, Korean government was promoting reshoring to propose support policy measures such as corporate tax reduction for expansion of domestic workplaces, long-term lease of state-owned property, rent reduction, and establishment of facility investment programs (Ministry of Trade, Industry and Energy, 2019). However, a total of 52 companies have reshoring in Korea over the past five years, and 975 new jobs have been created for reshoring companies (National Federation of Industries, 2019).

Since the 1980s, the shoe industry has been on the decline for decades, considered a declining industry, but has recovered since 2010. However, as the market situation has changed rapidly since 2015, the shoe industry has suffered. The Korean shoe industry was forced to give up a low-priced market due to its rapidly growing Chinese products. However, the Korean shoe industry was trying to overcome these difficulties through the integration of technology, aggregated know-how, and related infrastructure that had accumulated over the years.

Since 2015, domestic brands have suffered from the global brand offensive, but Korean shoe ODM companies have grown rapidly with the expansion of the global brand market. Hwaseung Enterprises has now become the world's second-largest supplier of Adidas, making a total of 6.1 million pairs of shoes per month after establishing a factory in Vietnam in 2002. Parkland has maintained its growth since entering the shoe OEM market in 2005 by supplying to Adidas and New Balance. Parkland's Indonesian plant continues to expand to become the world's fifth largest in 2020. Changshin Inc is a major ODM company in Nike, and sales have quadrupled over the past decade. These achievements are the result of the Korean shoe industry's steady investment in R&D and product innovation, not just a business model that delivers to global brand companies through OEM production.

Korea's shoe industry is classified as a representative manufacturing industry in the declining period, but the performance of the second leap as above is becoming visible, so it is necessary to treat it as research subject to identify the mechanism of activation of the declining industry.

In this study, by estimating the potential output of the Korean manufacturing industry based on the Gompertz model, the life of the manufacturing industry is calculated in a quantitative manner and the production saturation by industry is measured to classify the Korean declining industry. In addition, we intend to devise a plan to revitalize the declining industry through intensive research on the human and material resource input patterns of the Korean shoe industry.

Prior research on industrial life cycle theory has been conducted, and each life stage is defined through its own separator, and the situation that the industry will face at each life stage is logically interpreted. However, it is mainly valuable as an analytical frame of characteristics over the past life stages, but it is limited to use as a practical working frame that can set improvement goals for industry life, manage progress, and predict future life patterns. This study aims to mathematically calculate the results and quantitative interpretation of the consideration of the life cycle, resource input pattern, and life extension plan of the Korean manufacturing industry using the Gompertz model. Through this, it is intended to increase the value of practical use in terms of setting specific (quantitative) goals and managing progress to improve the sustainability of the industry.

2. Literature Review

2.1 Theory of Industrial Life Cycle

Levitt (1965) introduced the industrial life cycle theory for the first time as an extended concept in explaining the concept of product life cycle to the development of products, companies, and industries. Just as the product life cycle classified the product life by stages, interpreted and predicted the characteristics of each stage, the industrial life cycle classified into a step-by-step process, and the characteristics of each stage and the development of the industry can be predicted in advance. Michael Porter also presented an idea for the industrial life cycle, and Michael Porter argued that it is the most important part for corporate managers to grasp the industrial cycle (Porter, 1980).

The industrial life cycle is usually divided into four stages (introduction period, growth period, maturity period, and decline period), but sometimes it is divided into five stages (introduction period, growth period, maturity period, revival period, and decline period) by researchers.

2.2 Global Expansion of R&D

The global division of labor system was carried out in the entire process of product planning, design, production, and service, and was divided into a global production network and a global innovation network. This global division of labor system has been changed to a division of labor system in which core component materials are developed and produced in the home country, exported to low-wage countries, and assembled and produced. (Bae et al, 2020)

The stage of technological development in developing countries takes place through imitation and technology learning from developed countries. After that, developing countries develop into a stage where they can scale up their own capabilities and digest them to create more improved technological innovation. At this time, the experience of globalization in developing countries can be used as an essential strategy (Lee et al., 1988).

Developing countries were proceeding with globalization to move production sites abroad for cost competitiveness. There is no growth without innovation in the process of developing an industry. Technological innovation plays an important role in achieving steady competitiveness in economic development, and a representative activity of technological innovation is research and development. Therefore, globalization of R&D activities is important in the process of growth of an industry (Lee et al., 2005).

Globalization is the interaction of economic systems between countries through international trade or overseas investment and capital flows. Globalization is the sharing of knowledge and culture through communication between each other by separating time and space from the sharing of economic knowledge (Giddens, 2003). Globalization is also the process of eliminating the concept of geographical distance in building and maintaining economic, political, social, and cultural relations across borders (Lubbers, 1996).

Technological innovation is the planning, securing, and utilizing new products and process technologies to strengthen the competitiveness of companies and increase productivity (Kim et al., 2014). Globalization of technological innovation refers to a strategy that acquires, manages, utilizes, and spreads new technologies across borders, not limited to any specific country. Technological innovation activities can be responded to by corporate R&D activities, and globalization of R&D activities has an important meaning in implementing globalization strategies for companies and industries (Lee et al., 1988).

Globalization of R&D activities can also be seen as a basic function of companies and industries. Previous studies have shown that the motives for globalization of R&D activities are largely divided into two reasons. First, the motivation for globalization of R&D activities is the case of localization of products to meet the needs of customers in overseas markets. Second, the motivation for globalization of R&D activities is when new technology trends are identified and new technologies are acquired (Lee et al., 2007).

Globalization of R&D activities has different technical and market characteristics and can show significant differences by industry (Kim et al., 2006). While the automobile and electronics industries often globalize to meet the needs of local customers who are end consumers, the biotechnology industry often globalized to secure advanced technologies or collaborate with advanced companies.

The driving force behind the globalization of R&D activities of major developed companies is, first, to meet demand through product differentiation in the global market, which is gradually becoming a single market. Second, this is because opportunities for international technological cooperation are increasing due to technological leveling. Third, this is because the geographical distribution of R&D activities is necessary in terms of risk management. Fourth, this is because the speed of product entry is gradually decreasing. Fifth, this is because the demands of each government for technology transfer are growing (Grand et al., 1993).

Ghoshal and Bartlett (1988) classified research institutes into the following four types in their study on overseas R&D bases. The first is the Center for Global, which develops new products and processes for the global market in its home country. The second is local for local, which targets the local market at each overseas R&D center. Third is locally for global which the overseas R&D center targets the global market. And fourthly, it was classified as Globally linked, which connects several R&D centers in multiple markets through a network.

2.3 Gompertz Model

The Gompertz curve was proposed by Benjamin Gompertz (1779-1865), a British mathematician and actuary. Benjamin devised an S-shaped time series growth model to explain human growth and death. Benjamin devised the Gompertz model in 1825 to elaborate on his law of human mortality. Benjamin named the Gompertz model after him. The Gompertz model is an S-shaped function that describes the slowest growth at the start and end of a particular period and is a type of time series mathematical model.

As Gompertz explained that population growth is also determined by limited resources and environment, it can be assumed that industrial growth has a lifespan such as people, animals, plants, and markets. The behavior of industrial growth variables over life is normal. The Gompertz model can derive a differential equation as shown in Equation (1).

$$\frac{dP}{dt} = r\,P\ln\left(\frac{K}{P}\right) \quad (1)$$

P = Population
t = Time elapsed
K = Environmental receptive capacity
r = Positive constant

The solution is

$$P(t) = Ke^{ce^{-rt}} = Ke^{\ln(\frac{P_0}{K})e^{-rt}} \quad (2)$$

$$P(t) = Ke^{\ln(\frac{P_0}{K})e^{-rt}} = Ka^{b^t} \quad (3)$$

where, $e^{\ln\left(\frac{P_0}{K}\right)} = a, \ e^{-rt} = b^t$

According to previous studies, the Gompertz model was used in various ways, such as predicting product sales, predicting growth and death of people, animals, and plants, predicting tourism demand, predicting market potential, and predicting movie demand. Therefore, it was inferred that population growth and output growth would be similar, and manufactured output was used as data for growth prediction, and the cumulative number of people P(t) in the Gomperts model was changed to cumulative manufactured output Y(t). It is converted to $Y_t = K \cdot a^{b^t}$, when putting logs, it is converted to log, $\log Y = \log K + (\log a) \cdot b^t$

Y_t: Cumulative production up to t period
b : Degree of diffusion 0<<b<1
a : Initial market acceptance rate 0<a<<1
t : Year
K : Total potential production

3. Methodology and Results

Previous studies described that the growth rate of sales, employee growth, and fixed assets decreased as characteristics of the declining industry (Bae et al, 2014).

In this study, the industrial life cycle was calculated using the Gompertz model based on the time series data of 39 Korean manufacturing industries provided by the Industrial Statistics Analysis System (https://istans.or.kr/mainMenu.do) from 1991 to 2018. The industrial stage was classified based on the saturation of domestic production, the number of employees, and the saturation of fixed assets. All three industries located in the declining industrial stage were classified into computer, textile, and shoe industries. Among the selected three declining industries, we would like to analyze in-depth the characteristics of resource input and industrial revitalization measures of the declining industries, focusing on the shoe industry.

3.1 Classification of Industrial Life in Korean Manufacturing Industry

This research calculated cumulative potential production K[2], industry diffusion b[3], and initial market acceptance a[4],based on time series

[1] The cumulative potential production K is the production amount created by domestic and foreign companies through domestic production activities, and

data of domestic production, number of employees, and fixed assets in Korean 39 industries through the Gompertz model (Table 1).

Subsequently, in this study, the explanatory power(R^2) of the Gompertz model was 95% or more using the Root Mean Square Error (RMSE) method, and the predictive model was confirmed.

Table 1: Potential Production(K), Industry Diffusion(b), Market Maturity, & Explanatory Power(R^2) by Industry (Lee et al., 2021)

No	Industry	K (Cumulative potential production) (Mil.₩)	b (Industry diffusion)	a (Initial market acceptance)	Production Saturation, %	R^2
1	An electric cell	13,867,415,714	0.9709	0.00002	0.8%	0.996
2	Fine instrument	1,292,368,593	0.9481	0.00107	22.1%	0.995
3	Semiconductor	4,692,023,841	0.9411	0.00046	25.4%	0.996
4	Medicine	580,837,448	0.9323	0.00305	46.0%	0.998
5	Communication equipment	1,594,121,787	0.9059	0.00075	66.9%	0.986
6	Home appliances	863,305,028	0.9121	0.01183	75.7%	0.984
7	Computer	229,239,718	0.8283	0.00178	97.8%	0.988
8	Special Purpose Machine	2,400,257,577	0.9404	0.00186	33.2%	0.994
9	Fine chemistry	1,460,095,002	0.9366	0.00235	39.0%	0.996
10	Car	6,253,480,673	0.9303	0.00179	44.8%	0.994
11	General purpose machine	1,864,484,920	0.9278	0.00184	46.6%	0.994
12	Electrical equipment	1,316,936,360	0.9249	0.00275	52.7%	0.997
13	Petrochemical	2,950,504,211	0.9236	0.00154	53.7%	0.987
14	Transport Equipment	80,387,534	0.9467	0.00904	35.9%	0.977
15	Railway	77,632,649	0.9102	0.00136	62.6%	0.991
16	Electronic components	586,872,981	0.9132	0.00335	67.0%	0.988
17	Oil refining	10,783,722,302	0.9477	0.00060	17.7%	0.995
18	Assembly metal	5,627,436,350	0.9496	0.00117	19.7%	0.998
19	Nonferrous metal	1,631,078,725	0.9368	0.00141	35.2%	0.997
20	Plastics	1,807,755,245	0.9328	0.00191	42.7%	0.995
21	The steel	3,648,352,237	0.9304	0.00244	45.2%	0.987
22	Rubber	471,436,146	0.9295	0.00292	48.2%	0.983
23	Glass	331,853,840	0.9232	0.00275	53.9%	0.991
24	Brewing	173,550,719	0.9252	0.00285	54.6%	0.998

has an important meaning in terms of gross domestic product and job creation

[3] The Industry Diffusion b is defined as the degree of further growth in the future. If the production amount shows an increasing trend as of the present time, a constant value close to 1 is obtained. The degree of diffusion increases compared to the current time when an industry re-growth.

[4] The Initial market acceptance a means the initial market acceptance degree of industrial production.

25	Shipbuilding	1,509,067,561	0.9124	0.00164	65.8%	0.984
26	Ceramic	74,823,845	0.9179	0.01018	69.4%	0.993
27	Cement	478,422,806	0.9143	0.00813	72.3%	0.986
28	Furniture	438,602,533	0.9342	0.00305	44.1%	0.984
29	The food	2,619,431,127	0.9279	0.00430	53.3%	0.991
30	The printing	136,847,777	0.9165	0.00439	64.4%	0.995
31	Paper	632,168,050	0.9178	0.00512	64.8%	0.989
32	Timber	157,808,076	0.9205	0.00832	65.9%	0.985
33	Clothing	527,224,592	0.9140	0.00839	70.8%	0.989
34	Tobacco	115,061,200	0.8936	0.01663	88.4%	0.990
35	Textile	710,786,759	0.8903	0.01264	89.8%	0.984
36	Leather shoe	144,818,440	0.8917	0.03032	92.3%	0.973
37	Flight	287,722,007	0.9433	0.00074	22.9%	0.988
38	Nonmetallic mineral	99,335,166	0.9245	0.00744	60.9%	0.995
39	Others	138,083,047	0.9152	0.01306	77.4%	0.978

In this study, the production saturation was defined and calculated as follows by comparing the cumulative potential production amount with the production amount up to t period. Employee & fixed asset saturation can be also calculated by the same logic from data of employee & fixed asset.

$$\text{Production Saturation} = \frac{\text{cumulative production amount up to t period}}{\text{cumulative potential production amount}} \times 100 \quad (4)$$

The Korean declining industry was classified as domestic production saturation (%), employee saturation (%), and fixed asset saturation (%) based on the proportion of the Rogers diffusion model distribution (decline stage: 84% or more). Table 2 shows three kinds of saturation (%) in the computer industry (97.8%, 98.9%, 98.6%), the textile industry (89.8%, 91.8% and 97.2%), and the shoe industry (92.3%, 93.1%, and 99.0%). As a result, the computer, the textile, and the shoe industry are located in the declining stage in terms of all three kinds of saturation (%), be classified into declining industry. Figure 1 shows time series profile of production, employee, fixed asset in computer industry.

Table 2: Production Saturation, Employees Saturation, and Fixed Asset Saturation by Industry (Lee et al., 2021)

No	Industry	Sales Saturation%	Fixed Assets Saturation%	Employee Saturation%
1	An electric cell	0.80%	3.30%	47.00%
2	Fine instrument	22.10%	23.20%	67.40%
3	Semiconductor	25.40%	47.90%	78.70%
4	Medicine and medicine	46.00%	20.20%	91.10%
5	Communication equipment	66.90%	55.10%	68.60%
6	Home appliances	75.70%	79.40%	94.20%
7	Computer	97.80%	98.90%	98.60%
8	Special Purpose Machine	33.20%	41.00%	80.50%

9	Fine chemistry	39.00%	54.10%	83.60%
10	Car	44.80%	56.80%	79.40%
11	General purpose machine	46.60%	37.40%	80.90%
12	Electrical equipment	52.70%	52.60%	91.50%
13	Petrochemical	53.70%	68.90%	87.30%
14	Transport Equipment	35.90%	41.40%	91.10%
15	Railway	62.60%	84.20%	93.80%
16	Electronic components	67.00%	80.20%	85.40%
17	Oil refining	17.70%	50.80%	93.70%
18	Assembly metal	19.70%	17.10%	71.10%
19	Nonferrous metal	35.20%	53.60%	86.00%
20	Plastics	42.70%	41.60%	71.90%
21	The steel	45.20%	43.00%	82.40%
22	Rubber	48.20%	56.40%	82.20%
23	Glass	53.90%	38.60%	85.90%
24	brewing	54.60%	30.90%	79.00%
25	Shipbuilding	65.80%	45.90%	68.90%
26	Ceramic	69.40%	89.30%	96.30%
27	Cement	72.30%	87.70%	91.20%
28	Furniture	44.10%	54.00%	93.00%
29	The food	53.30%	66.80%	89.40%
30	The printing	64.40%	58.50%	87.60%
31	Paper	64.80%	78.70%	92.30%
32	Timber	65.90%	61.30%	93.00%
33	Clothing	70.80%	72.60%	97.10%
34	Tobacco	88.40%	71.40%	94.40%
35	Textile	89.80%	91.80%	97.20%
36	Shoe	92.30%	93.10%	99.00%
37	Flight	22.90%	67.40%	61.30%
38	Nonmetallic mineral	60.90%	59.50%	91.50%
39	Others	77.40%	85.60%	94.20%

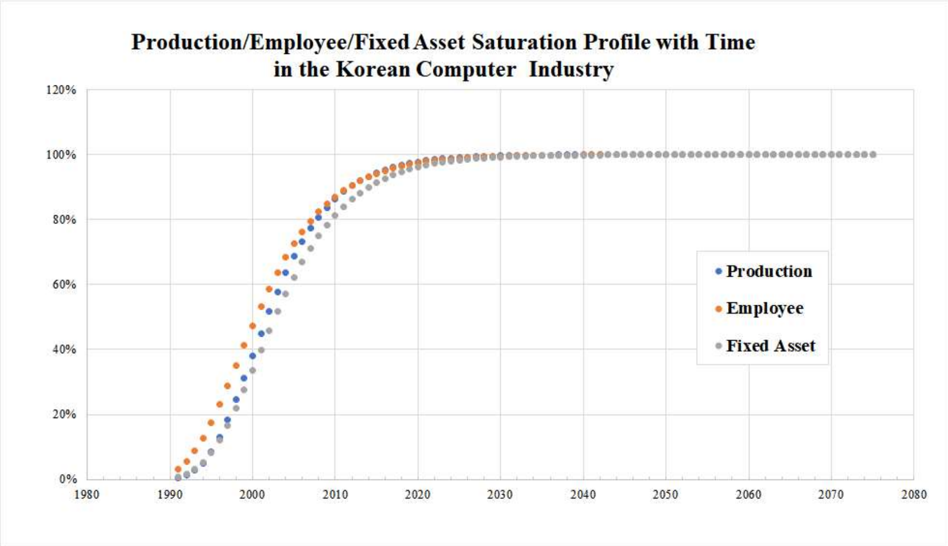

Figure 1: Production/Employee/Fixed Asset Saturation Profile with Time in the Korean Computer Industry

3.2 Characteristics of Resource Input in Declining Industries

3.2.1 Correlation Analysis between Number of Employees and R&D Expenses in Declining Industries

Table 3 is a correlation analysis between the number of employees in the computer, textile, and shoe industries in the declining Korean industry and R&D expenses. As a result of the analysis, the correlation coefficient values of -0.7006, -0.7418 and -0.7707 were derived with significance levels of less than 1% in the computer, textile, and shoe industries, respectively. This shows that the number of employees in the Korean declining industry has decreased, but R&D expenses are increasing.

Table 3: Correlation between the Number of Employees and R&D Expenses in Declining Industries

Computer		Textile		Shoe	
Pearson Correlation coefficient	Significance level	Pearson Correlation coefficient	Significance level	Pearson Correlation coefficient	Significance level
-0.7006	0.0036**	-0.7418	0.0015**	-0.7707	0.0008**

Note : ** indicates a significance level of 1% or less

It can be seen that R&D expenses used in Korea in the declining industry increased as overseas expansion increased. In other words, the Korean declining industry began to expand overseas as the price competitiveness of domestic production disappeared, and the number of all employees working in Korea decreased. However, it is interpreted that research and development activities have been strengthened in Korea in order to continuously maintain production competitiveness of production sites operated overseas. In particular, in the case of the shoe industry, the correlation between the number of employees and the R&D expenses is the strongest, and it is considered to be the most suitable in-depth research industry with the activation pattern of the declining industry.

3.2.2 Correlation Analysis between Number of Employees and R&D Employees in Declining Industries

In order to understand whether the resource input characteristics of the Korean declining industry are distinguished from those of the growing industry, the human resource input of the declining industry and the growing industry was compared and analyzed as shown in Table 4.

Table 4 analyzes the correlation between the number of employees and the number of R&D employees in the declining and growing industries. It was shown that the correlation coefficient between the number of employees in the growing industry and the number of R&D employees was 0.8 or more at a significance level of less than 1%. This is interpreted that as the industry developed, the number of employees increased and the number of R&D employees increased. However, the results of the correlation analysis between the number of employees in the computer, textile, and shoe industries, which are industrial groups in decline, and the number of R&D employees were derived as the opposite result. As shown in Table 4, the declining industry was analyzed as a strong negative (-) correlation with a correlation coefficient of -0.7896, -0.7043, and -0.8023, respectively, at a significance level of less than 1%. This is interpreted that the total number of employees in the Korean declining industry decreased, but the number of R&D employees was rather increasing.

Table 4: Correlation between the Number of Employees and the Number of R&D Employees (Declining and Growing Industry)

Declining industry			Growing industry		
Industry	**Pearson Correlation coefficient**	**Significance level**	**Industry**	**Pearson Correlation coefficient**	**Significance level**
Computer	-0.7896	0.0005**	Electric Cell	0.8110	0.0044**
Textile	-0.7043	0.0034**	Medicine	0.9308	0.0001**
Shoe	-0.8023	0.0003**	Car	0.9050	0.0003**
			Precision Instruments	0.9542	0.0000**
			Special Purpose Equipment	0.9381	0.0001**
			General purpose Equipment	0.8163	0.0040**
			Metal Assembly	0.8387	0.0024**
			Steel	0.9128	0.0002**

Note : ** indicates a significance level of 1% or less

In particular, despite the decrease in the number of employees, which is a characteristic of the declining industry, the number of employees of shoe industry showed a strong negative (-) correlation of -0.8023 with the number of R&D employees and -0.7707 with R&D expenses. Therefore, the shoe industry was selected Korean declining industries, and we would like to conduct a more in-depth analysis.

3.3 Change of R&D Resources for Industrial Survival in Declining stage

In developing countries, it is more appropriate to classify R&D centers based on the technical capabilities of the headquarters. The R&D center at the headquarters in developing countries will start with a lack of technical capabilities and advance overseas to achieve price competitiveness through the growth, maturity, and decline of the industry. Research results were obtained that the higher the technical capabilities of the parent company in the home country, the higher the technical capabilities of the local country, the higher the performance of overseas R&D (Cho et al., 2010). Declining industries adopt a business model in the form of relocating production sites mainly to low wage developing countries (Dickerson, 1999) and selling locally produced products to developed markets (Howard, 1997).

Ghoshal and Bartlett (1988) divided R&D types into Local for Local, Center for Global, locally for global and Global Linked and R&D types vary depending on the industrial life cycle. If Local for Local is used in the growth period, it proceeds in the form of “R&D Center for Global” in the decline period. The declining industry also needs research and development for continuous survival.

In the shoe industry, domestic R&D investment has increased, but rather, the proportion of imports in the shoe industry has increased, which is interpreted as expanding R&D input to support overseas production. R&D must be conducted with original technology and design to increase potential cumulative production volume and extend industrial life. In other words, among domestic declining industries, the input of R&D in the shoe industry was not an unnecessary input, but a factor that increased the industrial life (cumulative potential production K).

It is possible to establish a hypothesis that R&D input eventually extends the life of the industry, regardless of the declining industry, representative industry and emerging industry. As a derivative hypothesis, in the case of decline, the trade balance decreases, but this is not a bad thing, but still increases domestic R&D activities and supports Korean production subsidiaries existing abroad. In the end, it contributes to the survival of the declining industry.

3.3.1 Number of R&D Departments in the Declining Industry

Section 3.3.1 analyzed using statistics on the number of departments dedicated to R&D by industry obtained from 2010 to 2019 from the Korea Industrial Technology Association and Statistics on domestic production by industry from the Industry Statistics Analysis System.

Table 5: Correlation between the Number of R&D Departments and Domestic Production in Declining Industries

Industry	Pearson Correlation coefficient	Significance level
Computer	-0.7717	0.0089**
Textile	-0.7404	0.0143*
Shoe	-0.6335	0.0492*

Note: * and ** indicate significance levels of 5% and 1% respectively

Table 5 is a correlation analysis between the number of domestic R&D departments in the computer, textile, and shoe industries classified as declining industries and the amount of domestic manufactured production. As a result of the analysis, it was analyzed that computer, textile and shoe industry obtained a correlation coefficient of -0.7717, -0.7404, and -0.6335 respectively at a significance level of 1%, and obtained a negative (-) correlation. It can be seen that while domestic production decreased, the number of R&D departments was rather increasing.

According to Articles 14(2) and 16(1) of the Basic Research Promotion and Technology Development Support Act, a company must meet human and physical requirements in order to be recognized as a department dedicated to research and development. As a human requirement, the number of research employees and the qualification requirements for research employees must be met. The minimum number of R&D employees in the R&D department is one or more. The physical requirements must meet the research space and research equipment standards, and an independent space that is distinguished from other departments must be secured. In addition, the reported R&D department must conduct follow-up management on a regular basis. The academic meaning of the R&D department is believed to be that individual companies have attempts and efforts to achieve technological innovation through R&D activities.

Research and development activities are expected to increase the cumulative potential sales of companies (Choi, 2021) to help extend the life span. As a result of this study, it is believed that the Korean declining industry supported companies and industries that moved domestic production sites abroad by increasing the domestic R&D department. For this reason, it is judged to be the intention to extend the life of companies and industries.

3.3.2 Analysis of R&D Intellectual Property Trends in Declining Industries (Focused on Shoe Industry)

Korean shoe industry managers began moving their domestic production sites overseas in 1990 to gain price competitiveness (Kim et al., 2010). Domestic production facilities were changed to produce and export parts to support production facilities transferred overseas rather than producing finished products (Jung et al., 2018). Accordingly, shoe exports were exported to overseas exporting countries, and the export amount of parts exported to overseas offshored countries was analyzed as a variable. The performance of exports by country by item was extracted from export and import trade statistics provided by the Korea Customs Service from 2000 to 2019. The export amount of parts from major overseas countries was calculated based on HS CODE of footwear. HS CODE 6406102000, shown in Table 6, refers to parts for footwear and has been exported to China, Vietnam, and Indonesia, where domestic companies have invested overseas.

Table 6: HS Code for Shoes

Classification	HS Code	HS name
Level 1	6400	Chapter 64 FOOTWEAR

Level 2	6406	Parts of footwear (including uppers whether or not attached to soles other than outer soles); removable in-soles, heel cushions and similar articles; gaiters, leggings and similar articles, and parts
Level 3	640610	Footwear uppers and parts thereof, except stiffeners
	6406101000	Uppers
	6406102000	Parts

Source: KOTRA HS CODE (2021)

Table 7 is a code that classifies the design of the shoe industry, and based on this, the number of design right registrations is indicated as shown in Table 8. Since 2005, the design rights of Koreans have been steadily increasing.

Table 7: Design Classification Codes for the Shoe Industry

Commodity name	Design classification codes
Shoe	B511, B511A, B511AA, B511AB, B511AC, B511AD, B511B, B511BA, B511BB

Source: Korean Intellectual Property Office Design Map (2012)

Table 8: The Number of Registered Shoes Industry Design Rights by Year

Year	Foreign	Domestic	Year	Foreign	Domestic
2005		1	2013	9	43
2006		4	2014	54	73
2007	1	4	2015	116	107
2008	2	8	2016	137	180
2009	1	6	2017	145	303
2010	4	22	2018	135	329
2011	4	23	2019	199	260
2012	15	42	2020	145	304

Source: Kipris Design Right (2021)

The size of a country's domestic market can be obtained by subtracting the trade balance from the amount of domestic production (Jeong et al.,2008). The size of the domestic market in the Korean shoe industry was increasing the proportion of the trade balance more than the domestic production from 2005 to 2019. In 2005, domestic production of the Korean shoe industry accounted for 61.3% of the size of the domestic shoe market, but it accounted for 24.8% in 2019, and the proportion of imports from abroad was continuously increasing. It is interpreted that as the size of the domestic market of the Korean shoe industry increases, imports from abroad increase, and the trade balance continues to decrease. Therefore, it is important to analyze the trade balance of the shoe industry as a variable.

Table 9 analyzes the amount of parts exports, R&D expenses, design rights, and trade balance as variables as a correlation analysis between variables for offshoring of the shoe industry.

Table 9: Correlation Analysis between Variables for Offshoring of Shoe Industry

Variables	Export amount of Parts to Offshored country	R&D Expense	Design Right	Balance of Trade
Export amount of Parts to Offshored country	1			

R&D Expense	0.9380** (<0.0001)	1		
Design Right	0.7228** (0.0016)	0.8559** (0.0002)	1	
Balance of Trade	-0.7980** (0.0006)	-0.9343** (<0.0001)	-0.8777** (<0.0001)	1

Note: ** indicates a significance level of 1% or less Parentheses indicates significance levels

The export amount of parts exported to overseas offshored countries[5] had a strong positive (+) 0.9380 correlation with domestic R&D expense at a significance level of 1%. The export amount of parts exported to overseas offshored countries also had a positive (+) correlation with the design right, which is an intangible asset, with a correlation coefficient value of 0.7228. However, the export amount of parts to foreign countries had a negative (-) correlation value of -0.7980 with trade balance of the Korean shoe industry at significance level of 1%. This is interpreted as a business model in which the Korean shoe industry exports parts to overseas countries, assembles them at local production facilities, and then imports them back to Korea. In other words, it is believed that the more active R&D and design development, the more parts exports to overseas workplaces, and overseas workplaces produce finished products based on exports to revitalize the business model that is finally exported to global markets, including Korea.

Table 10: Regression Analysis between Export of Parts and Domestic R&D Expenses of Shoe Industry to Overseas

Variable	Estimated Value	Standard Error	t statistics	P-Value
Domestic R&D expenses	0.807	0.081	9.861	<0.001

Table 10 is a regression analysis between parts exports to overseas countries and domestic R&D expenses, and it was analyzed that the export of parts from the shoe industry to overseas countries increased by 0.8 every unit of domestic R&D expenses from 1% significance level. This is interpreted as contributing to the increase in the amount of parts exports to overseas countries where domestic companies entered. In other words, the research results of Table 9 and Table 10 showed that the Korean shoe industry is evolving in the form of a "R&D center for global", which develops new products and processes for the global market.

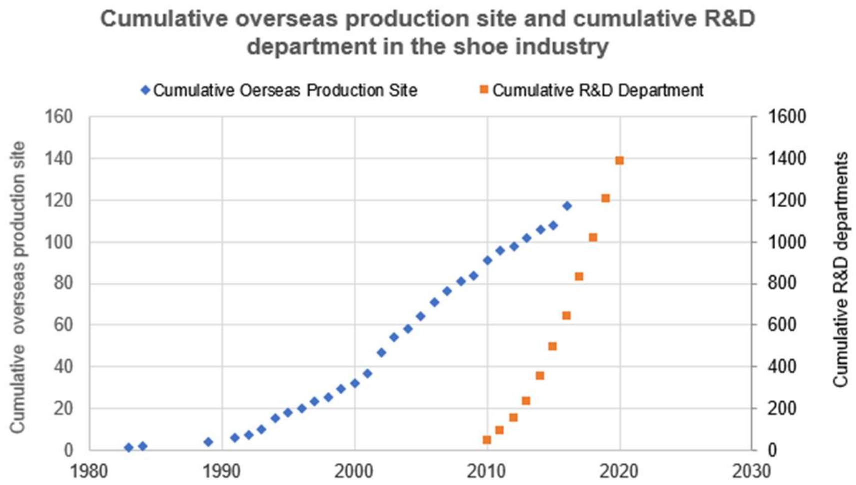

Figure 2: The Cumulative Number of Overseas Production Site and the Number of Departments in charge of Research and Development in the Shoe Industry

[5] Since 2000, companies in major Korean industries have been reorganized from finished product-oriented exports to parts exports, and have been transforming into parts-oriented manufacturing powerhouses like Japan. (Kim, 2017)

Figure 2 shows the cumulative number of overseas production sites[6] entered by the Korean shoe industry by year and the cumulative number of R&D departments registered in Korea. The saturation of the cumulative overseas production base was 73.6%, which was the maturity stage, while the cumulative R&D department was 45.9%, which was the growth stage. This is believed to have been devoted to stabilizing the production sites and satisfying the specifications of global OEM buyers in the early days when the Korean shoe industry moved its production sites overseas. Next, it is interpreted that it has entered the stage of stabilizing overseas production sites and strengthening quality competitiveness through the strengthening of R&D departments.

3.3.3 Analysis of Regional Centralization of R&D Departments in Declining Industry (Focusing on Shoe Industry)

This study is the result of analysis using data obtained from 2010 to 2020 from the Korea Industrial Technology Association. The location of the department in charge of R&D of the shoe industry classified as a Korean declining industry was concentrated in the metropolitan area.

In the past, the shoe industry accounted for 65.1% of the number of manufacturers, 76.3% of the production line, 82.8% of the number of employees, and 88.4% of sales, mainly in the Busan area (Jang, 2016). As the manufacturing and production infrastructure, which used to be built around Busan in the past, changed to R&D activities centered on the metropolitan area as shown in Figure 3, the location of the department in charge of R&D moved to the metropolitan area. Korea's declining industry has been operating manufacturing and production centering on existing regional bases, but since the relocation of domestic production facilities overseas, it has shown that the number of departments dedicated to R&D is concentrated in the metropolitan area. The concentration phenomenon of the department in charge of research and development in the metropolitan area means that the workplace and residence are close. It is considered to be an intention to make it easier to secure employees.

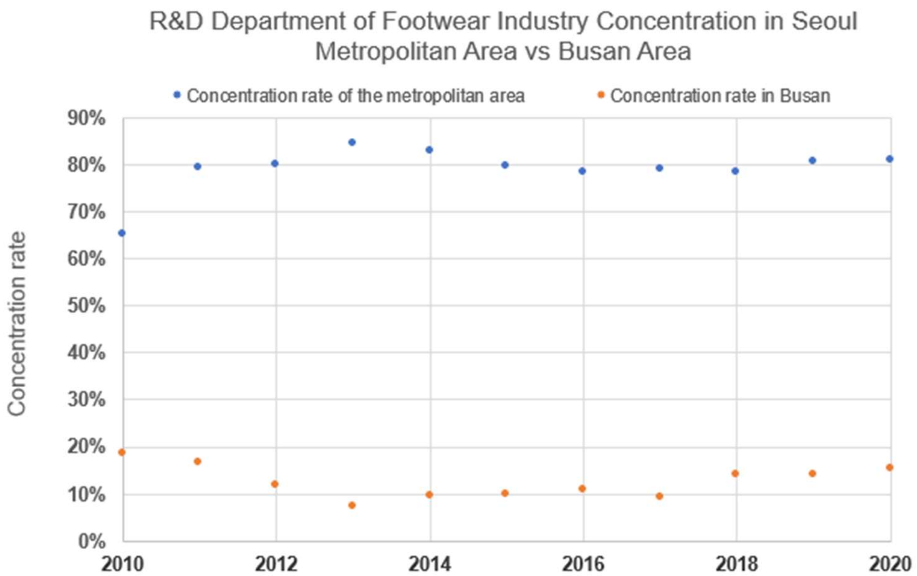

Figure 3: Geographic Concentration of the Number of R&D Departments in the Shoe Industry

In this study, as shown in Table 11, two group tests were conducted based on the department data dedicated to R&D of the shoe industry obtained from 2010 to 2020 by the Korea Industrial Technology Association and the number of people by region obtained by the National Statistical Office. The analysis results showed that 78.9% and 49.5% of the average research department's concentration rate in the metropolitan area and the average population concentration rate in the metropolitan area at the significance level of 1%. It can be seen that the production sites had already left the Busan area and moved abroad, but the research department dedicated to supporting the production sites overseas focused on the metropolitan area.

[6] The Korean shoe industry was greatly influenced by the supply chain of the global shoe industry and decided to enter overseas markets. (Lee, 2020).

Table 11: Analysis of Concentration of R&D Department in the Shoe Industry in the Seoul Metropolitan Area

Statistics	Concentration rate of research department in the Seoul metropolitan area	Population concentration rate in the metropolitan area
Average	0.789	0.495
Variance	0.0024	6.772E-06
Number of observations	11	11
Degree of Freedom	10	
t statistics	19.601	
P(T<=t) one-sided test	1.306E-09**	
t Rejection one- sided test	1.812	
P(T<=t) Two-sided test	2.612E-09**	
t Rejection Two-sided test	2.228	

Note: ** indicates a significance level of 1% or less

In conclusion, even though the production base of the Korean shoe industry has already left Busan and moved abroad, the department dedicated to research has moved to the metropolitan area. The increase in design rights at the same time as the increase in R&D departments is seen as evidence that R&D activities is focusing on core capabilities such as design rights. Meanwhile, past R&D activities were only focusing on production efficiency.

4. Conclusions and Implications

The Korean declining industry was classified by domestic production saturation (%), employee saturation (%), and fixed asset saturation (%) using the Gompertz growth model based on the proportion of the Rogers diffusion model distribution (decline: 84% or more). Above three kinds of saturation (%) in the computer industry (97.8%, 98.9%, 98.6%), the textile industry (89.8%, 91.8% and 97.2%), and the shoe industry (92.3%, 93.1%, and 99.0%) are all over 84%. Therefore, these industries are all classified into declining industry.

In the Korean declining industry, the number of employees decreased, but the number of domestic R&D employees was increasing. In computer, textile, and shoe industry, correlation analysis between the number of domestic employees and the R&D employees was analyzed, and the correlation coefficient were calculated as -0.7717, -0.6745, and -0.7802, respectively at the significance level was 1% or less. It is interpreted that the industry in decline inevitably offshore its production sites, but R&D continued to invest domestic resources and at the same time reorganized and strengthened its function.

In particular, in the case of the shoe industry, the export amount of parts exported to overseas offshored countries by domestic companies had a strong positive (+) correlation with domestic R&D expenses at a significance level of 1%, also had a positive (+) correlation with the design right with a correlation coefficient value of 0.7228. Although the amount of domestic manufacturing production decreased, the number of domestic R&D departments, domestic R&D expenses, and design rights increased to support overseas manufacturing and production facilities. In addition, the saturation of the cumulative overseas production site was 73.6%, which was the maturity stage, while the saturation of the cumulative R&D department was 45.9%, which was the growth stage. It is interpreted that this has passed the maturity stage of overseas investment into low wage developing countries and entered the stage of strengthening the competitiveness of overseas production site through the strengthening of R&D departments.

Corporate managements of the Korean declining industry have continuously grown and developed R&D and design capabilities in Korea, which are the core competencies of the industry. This is interpreted as a pattern of industrial revitalization to support overseas production sites by changing the R&D type to “R&D Center for Global” and to extend the life of industries in the declining period (Figure 4). However, the concentration rate to metropolitan area of R&D department was close to 78.9% as of 2020, indicating that policy supplementation for balanced regional development is needed.

Through this study, an industrial life cycle study was conducted in the Korean manufacturing sector based on the quantitative methodology, and the Korean shoe industry was selected as an industry corresponding to the decline, and it was consistent with the universal perception of the decline industry. However, through the study of resource input patterns and trade balance data for the Korean shoe industry, it was confirmed that the industry was revitalized by transforming it into a new system such as Center for Global, not a continuous collapse of the shoe industry. In other words, this study can be meaningful in verifying and presenting the direction of activation of the declining industry in an empirical manner.

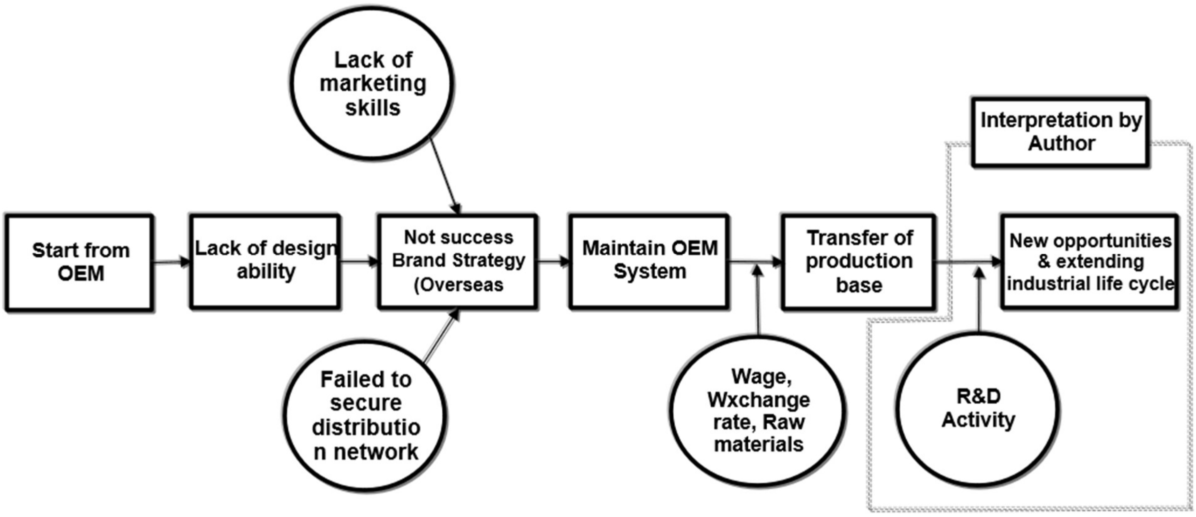

Figure 4: The Causes of Decline in Korea's Shoe Industry and the Analysis by Author

In order to revitalize the Korean shoe industry, strategies and active support at the shoe industry association, company, and national level are needed to secure the competitiveness of the shoe industry in the long term. If a specific action plan is proposed, First, it is necessary to nurture professional shoe specialists who can strengthen the design competitiveness and quality competitiveness of shoes. Second. It is necessary for Korea to maintain its competitive advantage in this field by further strengthening the R&D of parts and materials that are still competitive. Third, it is necessary to strengthen Korean shoe products and branding strategies. As Korean culture and contents have a high preference recently, it is possible to increase customer loyalty and demand through a branding strategy through strengthening communication with global customers. Fourth, there is a need for an online and mobile-based platform strategy that consumers can easily access. The trend of consumer purchasing patterns is online and mobile-based purchasing, which is a way to expand the shoe market to a global target.

The limitation of this study is that the subject of the study is a research result limited to the manufacturing industry group of a specific country. In addition, the Gompertz model was applied based on statistical data of the Korean manufacturing industry for 28 years. However, when a long-term cumulative input value of 28 years is applied, there is a limit to the model sensitivity that the rapid change by year of the industry is not sufficiently reflected.

Future research will be expanded to analyze industrial life and resource patterns in other countries' manufacturing industries or other industries. If the industry is an industrial environment showing initial explosive demand growth rather than an S growth pattern, the consistency of the Gompertz model may be deteriorated, so it is intended to supplement the Gompertz model or combine it with other mathematical growth prediction models.

This study addressed the expansion concept of the industrial life cycle theory from the normal life cycle to the second life extension but was limited to the Korean manufacturing industry. In the future, it is intended to expand to study the revitalization pattern of the manufacturing industry in the decline period in other foreign countries to ultimately study the revitalization global trend in the declining industry.

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