Regional economic analysis of major areas in South Korea: using 2005–2010–2015 multi-regional input–output tables

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Abstract

South Korea's Seoul metropolitan area accounts for more than half of the country's GDP and population. This phenomenon is exacerbating annually. Regions outside the metropolitan area of Korea are not only decreasing in terms of economic size, but are also becoming more dependent on the metropolitan area in terms of economic structure. Earlier, the metropolitan area was based on the service industry, while other regions had a large manufacturing sector; however, the size of the latter also increased in the metropolitan area over time. To analyze dependence on the Seoul Metropolitan area, this study conducts regional production inducement effects, regional division of labor, and three regional structural decomposition analyses using Korea's 2005–2010–2015 multi-regional input–output table (MRIO) to further analyze dependence on the metropolitan area. Furthermore, this research integrates industry classification and realizes the price level of input–output tables to link 3 years of MRIO in three industries: wholesale and retail trade and product brokerage services, motor vehicles, semiconductors, and other electronic components. From the inter-regional production inducement effect, the relation between the metropolitan area and each region is calculated using the regional export and import effects of each region. Furthermore, the proportion of metropolitan areas in major industries and their changes are measured through regional division of labor, and through multi regional structural decomposition analysis, the growth factors of each region over 10 years are determined by own region, metropolitan area, and other regions.

Keywords: Multi-regional input–output table, National balanced development, Input–output analysis, Production inducement effect, Division of labor, Multi regional structural decomposition analysis

1 Introduction

The concentration of economic development in metropolitan areas or large cities is a global problem, and South Korea (Korea) is no exception in this regard. South Korea has recorded remarkable growth in terms of economic development, but it has also been beset by concerns about potential problems, such as an aging population and unbalanced development of the national economy. The country has one of the most severe cases of concentration in metropolitan areas. As of 2021, more than half of the country's

population lived in metropolitan areas, and more than half of the gross regional domestic product (GRDP) was also concentrated in these areas. According to Lee (2020), due to the deepening concentration of the metropolitan area, the population of regions except the Seoul Metropolitan area began to decline. The population of Jeollanam-do began to decrease in 2013, and from 2018, the population has naturally decreased in most regions except Seoul Metropolitan. In particular, the outflow of the young population to the metropolitan area is intensifying, and as of 2019, lots of young populations are moving to the metropolitan area except for the Sejong City, newly created in 2012.

In recent times, the Korean government has been making efforts to balance national development in diverse ways, such as relocating central government agencies to other regions, or fostering specialized industries in various regions for balanced national development. However, the proportion of the population and economy in metropolitan areas is increasing, and some regions have experienced a decrease in population and the GRDP for several years. With growing interest in these issues, the need for regional economic analysis in Korea has increased.

Korea has 17 major administrative districts. Considering the geographical location, economic scale, and density of these districts, the following five areas constitute their own respective economic zones: the Seoul metropolitan area, Chungcheong, Jeolla, Gyeongbuk, and Gyeongnam. Each area forms an economic zone based on its central city; nevertheless, it is difficult to claim that Gangwon-do and Jeju-do have formed a single economic zone, considering their economic sizes. Since each economic zone or region has established economic relations with the surrounding region or metropolitan area according to the role of a specialized industry or city, it is necessary to consider not only the economy of each region, but also the industry as a whole to examine the regional economy of Korea.

Since multi-regional input–output (MRIO) data record the entire economy of Korea in various ways, the Korean economy can be analyzed separately by region and industry using MRIO analysis. In addition, because input–output (IO) analysis using MRIO data can calculate and analyze the induced effects according to the characteristics of the industry, specialty industries can be studied across different locations in a number of ways. Hence, this study intends to analyze how the economic structure of each economic region of Korea and the concentration in metropolitan areas has changed, using the MRIO table. In addition, this study analyzes the factors that have had a significant influence on economic change in each region.

2 Literature review

Regional economic analysis, using Korea's IO table, mainly focuses on analyzing the effects of industry in the region by limiting the scope of analysis to specific industries or regions. For this reason, few studies have used MRIO to explore the whole of South Korea. Using Korea's 2003 MRIO table, Lee (2008) divided the country into metropolitan and non-metropolitan areas, and then assessed the consequences of the industrial relationships between them. He was concerned about the metropolitan area's economic concentration, because the backwash effect of the local economy's attraction to the metropolitan area was stronger than the spillover effect of the latter's development on the former.

Regarding regional economic research on Korea, which has not employed IO analysis thus far, Choi et al. (2007) compared South Korea with major Organization for Economic Co-operation and Development (OECD) countries and found that the regional imbalance in the former was more severe than that of the latter. In addition, changes in employment growth by industry in 16 regions of Korea from 1997 to 2005 were measured using time-series data, and it was concluded that the concentration in major cities increased over time. Kim (2018) examined the change in the economic power gap among Korea's regions with the most recent data available and found that it shrunk from 2003 to 2015. However, the author argued that the southern economic zone needed to be stabilized, because the Seoul and Chungcheong economic zones expanded in proportion to the southern economic zones.

Referring to regional economic analysis using the regional IO table, Ishiro (2012) produced the 2000 MRIO table of the Kanto region and estimated the industrial relationship among areas within this region by designating the target industry and region. In the present study, referring to the aforementioned methodology, we measure how close the industrial relationship is with the regions to which each area belongs and how close the industrial relationship is with the metropolitan area.

In addition, Ishiro (2014) extended the existing 2000 MRIO table to the Kanto region to create a 2005 version. Furthermore, the division of labor based on the total input in Kanto was calculated by industry and year, and the areas affecting the economy of the region and the changes in them were analyzed. In the present study, referring to the aforementioned methodology, we attempt to analyze the dependence of each region, and the changes therein, by dividing the region and industry in Korea for 3 years (2005, 2010, and 2015) and calculating the division of labor based on the total input by region or area.

This study aims to analyze not only the changes in regional economies, but also the factors that cause these changes. In a related study, Akita (1999) divided Japan's seven regions into a target region, the Kanto region, and the rest of Japan, and analyzed the growth factors of each region from 1965 to 1985. Growth factors for each region were divided into eight components: final demand, input–output structure, exports, and import share in the region, as regional factors; direct and indirect effects of the Kanto region; and the direct and indirect effects of other factors. Using this method, this study analyzes the factors that have been greatly affected by changes in each region of Korea, focusing on metropolitan areas.

3 Methods

This study uses Korea's MRIO table for a regionwise analysis. Furthermore, three MRIO tables for 2005, 2010, and 2015 were used to examine the changes in the Korean regional economy over a period of 10 years. Because of changes in industry classification changes for each base year, and use of nominal prices, adjustments are necessary when using multiple IO tables. Therefore, this study is meaningful in connecting the industrial classifications of the three IO tables and realizing prices.

This study employed three methods to study the concentration phenomenon in Korea's metropolitan areas and the local economy. First, it identified the main industries in each region of Korea and elucidated the interregional relationships, including those with the metropolitan area. The metropolitan area is where population and economic power are

concentrated and is expected to have a consumption- and service-oriented economy. In addition, other regions can be expected to develop mainly the manufacturing economy in response to the demand of the metropolitan area, leading to economic relations between them. In addition, there is a central city playing the role of a metropolitan area in Korea, not only in the larger metropolitan area, but also in each economic region. When these central cities show a high proportion of consumption-oriented and service industries, similar to the metropolitan area, it can be concluded that the economic zone is well-formed.

Second, this study determines the dependence on metropolitan areas and other regions by calculating the regional division of labor, based on the total input. Owing to the excessive concentration in Seoul, both, the service and manufacturing industries are expanding in Gyeonggi to enable an efficient supply for the city. Therefore, if it is possible to quantify not only industrial relations between regions, but also how much each region contributes to the demand for a specific industry in another one, it would be possible to understand the industrial relations between the specialized industry of one region with other regions. By identifying these factors, we evaluated Korea's concentration in the metropolitan area, whether the regional economy is well-developed, and which region's economic zone is well-formed. Furthermore, by evaluating the local economy in 2005, 2010, and 2015, we evaluated whether the concentration phenomenon in Seoul improved in 2015 compared to 2005, and analyzed how the local economic zone has changed over time.

Finally, this study attempts to analyze the changes in major industries in each area over 10 years by dividing them into several factors. Several factors affect the size of a region's economy. As regional factors, there are variations in the final demand due to regional growth, in the input–output structure due to changes in technology, and in exports or imports to overseas countries. In addition, size may be affected directly, by changes in demand in the target region, or indirectly, by changes in economic relations among other regions. Therefore, in this study, Korea is divided into the target area, metropolitan area, and other areas, following which the multi-regional structural factor is decomposed and analyzed. Through this analysis, it was possible to determine the degree to which the change experienced by the regions over the 10 years under study, was due to the metropolitan area.

4 Model and data

IO tables are statistical tables that record the trade relationship between industries for a certain period in a matrix format, according to certain principles. Analyzing the interdependence between industries using such tables is called IO analysis or industrial linkage analysis. The Bank of Korea released its 2015 benchmark year table and updated it annually until the 2019 version (Bank of Korea 2020).

An MRIO table was used for the IO analysis of each region. The MRIO table is an IO table that reflects the different production technology structures and transaction types by region and analyzes the interdependence between regions and industries. The latest Korean table is the 2015 table, which uses the 2015 benchmark year IO table.

Korea's regional IO tables for 2005, 2010, and 2015 were used to calculate the interregional inducement effect in this study. Two modifications were required to use these

data together. The first was to unify the industry classification of regional IO tables, and the second, to realize the figures of each IO table expressed in nominal prices.[1]

The Bank of Korea updates the base year IO table every 5 years, and when a new table is released, the industry classification gets modified to reflect the changes in the industrial structure. The regional IO tables for 2005, 2010 and 2015 consist of 77 middle-sized categories, 82 middle-sized categories, and 165 small- and 82 middle-sized categories, respectively. In this study, these classifications were reclassified into 64 categories, based on the 2005–2010 and 2010–2015 matching classification tables published by the Bank of Korea.

In addition, because the IO table is composed as a nominal price, it is necessary to realize the values of each table. In this study, the prices of each industry in 2005 and 2010 were adjusted to those in 2015. The producer, export, and import price indices, released by Statistics Korea, were used for the price list, and the price index of an industry that does not exist was adjusted using a higher category or producer price index.

This study measured the impact of the Korean regions' specific industries on other regions through production inducement effects, using an IO table. To focus more on trade among regions, the effect of imports was excluded using a non-competitive import type IO table, in this study. In addition, exports were treated as an item of final demand. Assuming that A^D is a multi-regional input coefficient, x is the gross output by region, and y is the final domestic demand, their relationship is as follows:

$$A^D x + y = x. \tag{1}$$

As a result, the equation for the total output x is as follows:

$$x = \left(I - A^D\right)^{-1} y = B^D y. \tag{2}$$

$\left(I - A^D\right)^{-1}$ is called the production inducement coefficient or the Leontief inverse matrix. Assuming that the number of regions is n, the number of industries is m, the number of items of final demand is 1, $B^D y$ is an $(m * n) \times 1$ matrix, and b_{ij}^k is the induced effect of industry k input from region i to region j. Because b_{ij}^k is an induced effect from region i for the final demand of region j, it corresponds to the interregional export of industry k to region j in region i and the interregional import of industry k to region i in region j. If this element b_{ij}^k is multiplied by the final domestic demand y_j^k for industry k in region j, the production inducement effect for industry k in region i by the final demand of industry k in region j is obtained.

Investigating the total input-based division of labor has been proposed as a means to consider the spread to exogenous regions and countries by identifying the role of imported intermediate goods that cannot be considered in the normal inverse matrix calculation. In this study, an analysis using the total input-based division of labor is conducted to discuss the division of labor among metropolitan areas and other regions, or areas within each region.

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[1] In the process of realizing the IO table, a double deflator problem occurs wherein the total output and the total input sector are inconsistent. In this study, the differences between the total output and total input sectors are matched by adjusting the value-added sector.

To determine the regional division of labor, imports were introduced into the existing input coefficient matrix. Assuming that the input coefficients of intermediate goods from other regions in Regions 1 and 2 are A^{K1} and A^{K2}, respectively, and that the input coefficients of intermediate imported goods are A^{I1} and A^{I2}, the input coefficients of Regions 1 and 2 can be considered in the following form:

$$A = \begin{bmatrix} A^{11} & A^{12} \\ A^{21} & A^{22} \\ A^{K1} & A^{K2} \\ A^{I1} & A^{I2} \end{bmatrix} = \begin{bmatrix} A^D \\ A^K \\ A^I \end{bmatrix}. \tag{3}$$

This extended input coefficient was multiplied by the Leontief inverse matrix, which represents the spread in the endogenous regions of Regions 1 and 2 $(B^D = (1 - A^D)^{-1})$. Consequently, we obtained the total amount of intermediate goods required for the production of one unit of each sector in the endogenous region, including the inducement effect on the endogenous and exogenous regions. Let this matrix be D:

$$D = A \times B^D = \begin{bmatrix} A^D B^D \\ A^K B^D \\ A^I B^D \end{bmatrix}. \tag{4}$$

In matrix D, the total inducement effect on the endogenous region, exogenous region, and imports of one unit of production of each sector in each region are calculated using the columns of each sector in each region. Then, the ratio of the division of labor based on the total input is calculated by calculating the inducement effect ratio of the self-region occupied by the column, and the ratio to other regions and imports.

Finally, this study adopted the method used by Akita (1999) for factor decomposition analysis, which considers the influence of different regions. The factors affecting economic change are largely final demand F, input structure A, export E, Leontief inverse matrix B, and domestic production share $\widehat{p}$ in the input structure. Let the target area be D, the metropolitan area be M, and other areas be K, let 2015 be t and 2005 be 0. For example, ΔF^{DK} represents the change in final demand transferred from region D to region K. The change in total output X from 2005 to 2015 in the D area can be expressed as follows:

$$\begin{aligned} \Delta X^D =& B_t^{DD}\Big[\hat{p}_t^{DD}\Delta F^{DD} + \Delta F^{DM} + \Delta F^{DK} + \Delta E^D \\ &+ \Delta\hat{p}^D\big(A_0^{DD}X_0^D + F_0^{DD}\big) + \Delta\hat{p}_t^D\Delta A^{DD}X_0^D \\ &+ \Delta A^{DM}X_0^M + \Delta A^{DK}X_0^K\Big] \\ &+ B_t^{DM}\Big[\Delta F^{MD} + \hat{p}_t^M\Delta F^{MM} + \Delta F^{MK} + \Delta E^M \\ &+ \Delta\hat{p}^M\big(A_0^{MM}X_0^M + F_0^{MM}\big) + \Delta A^{MD}X_0^D + \hat{p}_t^M\Delta A^{MM}X_0^M + \Delta A^{MK}X_0^K\Big]. \\ &+ B_t^{DK}\Big[\Delta F^{KD} + \hat{p}_t^K\Delta F^{KK} + \Delta F^{KM} + \Delta E^K \\ &+ \Delta\hat{p}^K\big(A_0^{KK}X_0^K + F_0^{KK}\big) + \Delta A^{KD}X_0^D + \hat{p}_t^K\Delta A^{KK}X_0^K + \Delta A^{KM}X_0^M\Big] \end{aligned} \tag{5}$$

Table 1 Total output share by region. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005	2010	2013	Unit: % 2015
Metropolitan	**37.7**	**38.2**	**38.1**	**40.4**
Seoul	16.0	16.2	15.8	16.4
Incheon	4.9	4.6	4.4	4.3
Gyeonggi	16.8	17.4	17.9	19.7
Chungcheong	**9.6**	**10.3**	**11.0**	**10.7**
Daejeon	1.7	1.5	1.5	1.7
Chungbuk	2.5	2.6	2.7	3.0
Chungnam	5.4	6.1	6.8	6.0
Jeolla	**10.1**	**9.3**	**8.8**	**8.4**
Gwangju	1.8	1.8	1.7	1.8
Jeonbuk	2.5	2.3	2.4	2.4
Jeonnam	5.7	5.2	4.7	4.2
GyeongBuk	**9.0**	**8.6**	**8.6**	**8.5**
Daegu	2.5	2.3	2.3	2.4
Gyeongbuk	6.5	6.3	6.3	6.0
GyeongNam	**17.2**	**16.2**	**15.8**	**15.5**
Busan	4.5	4.1	3.9	4.1
Ulsan	6.2	5.4	5.6	5.5
Gyeongnam	6.5	6.7	6.3	6.0
Gangwon, Jeju	**2.6**	**2.0**	**2.0**	**2.4**
Gangwon	2.0	1.4	1.4	1.7
Jeju	0.6	0.6	0.6	0.7
Import	**13.8**	**15.4**	**15.7**	**14.1**
Total	**100.0**	**100.0**	**100.0**	**100.0**

In the above equation, $B_t^{DD}\widehat{p}_t^{DD}\Delta F^{DD}$ is influenced by changes in final demand in D region, $B_t^{DD}\Delta\widehat{p}_t^D\Delta A^{DD}X_0^D$ is affected by changes in the input–output structure in D region, $B_t^{DD}\Delta E^D$ is influenced by changes in exports in D region, and $B_t^{DD}\Delta\widehat{p}^D(A_0^{DD}X_0^D + F_0^{DD})$ is influenced by the import share in D region. In addition, $B_t^{DD}(\Delta F^{DM} + \Delta A^{DM}X_0^M)$ indicates a direct effect of the metropolitan area, an equation related to B_t^{DM} indicates an indirect effect of the metropolitan area, $B_t^{DD}(\Delta F^{DK} + \Delta A^{DK}X_0^K)$ is a direct effect of other regions, and an equation related to B_t^{DK} indicates an indirect effect of other regions.

5 Results and discussion

5.1 Output share and main industries

Table 1 shows Korea's total output share by region from 2005 to 2015.

The total output share proportion of the metropolitan area, and the relatively nearby Chungcheong, increased in all industries from 2005 to 2015. Meanwhile, the rest of the area showed a slight decrease. Gyeonggi showed the highest growth rate in all regions, increasing by 2.9%, from 16.8% in 2005 to 19.7% in 2015. This is interpreted as a more remarkable growth in Gyeonggi, where the proportion of the manufacturing industry, with more active intermediary transactions, is growing, as Korea's

Table 2 Total output share by region in manufacturing industry. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005	2010	2013	Unit: % 2015
Metropolitan	**25.3**	**25.6**	**25.3**	**27.6**
Seoul	3.3	3.9	3.2	3.4
Incheon	5.0	3.8	3.6	3.8
Gyeonggi	17.0	17.9	18.5	20.5
Chungcheong	**11.1**	**12.5**	**14.0**	**13.6**
Daejeon	1.0	0.9	0.9	1.2
Chungbuk	2.9	3.2	3.4	4.0
Chungnam	7.2	8.4	9.7	8.4
Jeolla	**12.1**	**10.9**	**10.4**	**9.2**
Gwangju	1.8	1.7	1.6	1.7
Jeonbuk	2.4	2.3	2.4	2.4
Jeonnam	8.0	6.9	6.4	5.0
GyeongBuk	**10.5**	**10.6**	**10.7**	**9.9**
Daegu	1.9	1.8	1.7	1.9
Gyeongbuk	8.7	8.8	9.0	8.0
GyeongNam	**22.5**	**21.0**	**19.8**	**19.6**
Busan	3.0	2.9	2.5	2.7
Ulsan	11.6	9.3	9.4	9.4
Gyeongnam	8.0	8.8	8.0	7.5
Gangwon, Jeju	**1.1**	**0.8**	**0.8**	**0.9**
Gangwon	0.9	0.7	0.7	0.8
Jeju	0.1	0.1	0.1	0.1
Import	**17.4**	**18.6**	**19.0**	**19.1**
Total	**100.0**	**100.0**	**100.0**	**100.0**

economic power is concentrated in the metropolitan area, but Seoul's economy is relatively service-oriented.

The South Korean economy can be divided into manufacturing- and service-oriented regions. The service sector, which deals with people, is the key sector in big cities, where population and economic power are concentrated. However, the economy of regions with relatively low land costs and a smaller population density is primarily driven by manufacturing. Table 2 shows the proportion of total output in the country, limited to manufacturing.

Similarly, the metropolitan area has the largest share of the manufacturing sector. However, considering that the population in the metropolitan area accounts for approximately 50% of the country, it is more plausible to interpret that the manufacturing industry is relatively dispersed throughout the country. Clearly, the market share is lower in each economic area's central city and higher in the remainder of the region, than in all industries within each area.

Table 3 shows the proportion of the national total output limited to the service industry.

The concentration of the service industry is the most prominent in the metropolitan area. Within each region as well, the proportion of the service industry in the central city is relatively large. The metropolitan area, which constitutes the central region of

Table 3 Total output share by region in the service industry. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005	2010	2013	Unit: % 2015
Metropolitan	**55.7**	**58.6**	**59.6**	**58.5**
Seoul	33.8	36.1	36.5	34.1
Incheon	4.7	4.9	4.8	4.6
Gyeonggi	17.2	17.7	18.3	19.8
Chungcheong	**7.7**	**7.1**	**7.2**	**7.3**
Daejeon	2.7	2.5	2.6	2.4
Chungbuk	2.1	1.9	1.9	2.0
Chungnam	2.8	2.6	2.8	2.9
Jeolla	**7.4**	**6.7**	**6.5**	**6.9**
Gwangju	2.2	2.1	2.1	2.0
Jeonbuk	2.4	2.2	2.1	2.2
Jeonnam	2.8	2.4	2.2	2.7
GyeongBuk	**7.5**	**6.4**	**6.4**	**6.6**
Daegu	3.6	3.3	3.4	3.2
Gyeongbuk	3.8	3.1	3.1	3.4
GyeongNam	**12.6**	**11.8**	**11.6**	**11.8**
Busan	6.4	6.1	6.1	5.7
Ulsan	1.6	1.7	1.7	1.8
Gyeongnam	4.6	4.0	3.9	4.2
Gangwon, Jeju	**3.7**	**3.0**	**3.0**	**3.5**
Gangwon	2.7	2.0	1.9	2.3
Jeju	1.0	1.1	1.0	1.2
Import	**5.4**	**6.5**	**5.7**	**5.4**
Total	**100.0**	**100.0**	**100.0**	**100.0**

Korea's overall economy, is sufficiently large to account for more than half of the service industry. In the metropolitan area, the proportion increased by 2.8%, from 55.7% in 2005 to 58.5% in 2015, thereby increasing dependence on the metropolitan area. In the remaining regions, i.e., Chungcheong, Jeolla, Gyeongbuk, and Gyeongnam, the proportion of the service industry is observed to be declining.

Table 4 shows the proportion of Korea's top three industries within the region and the ranking of the scale within the region, calculated based on the total output in 2015. The third-ranked industry is real estate services, not semiconductors, but it was excluded because of the features of the industry.

The wholesale and retail trade and commodity brokerage services industry occupy the largest proportion in the regions corresponding to the central cities in each area. However, the proportion of the motor vehicle industry is larger than that of wholesale and retail trade in Gwangju, a central city in the Jeolla area, which is considered to have a relatively small economic scale compared to its geographic size. The main industries differ in each region. The semiconductor and other electronic component industries account for the largest portion of Gyeonggi and Chungcheong, while the main industry in the Jeolla region is the motor vehicle industry. The proportion of the steel industry in Gyeongbuk is the largest, while the maritime and motor vehicle industries are the largest in Gyeongnam.

Table 4 Three main industries' share and rank based on total output in 2015. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

Rank	Wholesale and retail trade and commodity brokerage services		Motor vehicles		Semiconductor and other electronic components	
Total	6.5%	1	5.1%	2	4.4%	4
Seoul	15.2%	1	0.02%	48	0.3%	30
Incheon	4.9%	4	5.5%	3	1.9%	22
Gyeonggi	5.5%	2	5.1%	4	10.8%	1
Daejeon	7.2%	1	1.2%	25	3.1%	11
Chungbuk	3.1%	10	3.2%	8	11.2%	1
Chungnam	2.1%	16	8.7%	2	11.4%	1
Gwangju	6.2%	2	18.6%	1	0.5%	35
Jeonbuk	4.3%	4	11.0%	1	0.9%	36
Jeonnam	2.5%	13	0.1%	52	0.1%	53
Daegu	7.9%	1	5.0%	7	0.8%	31
Gyeongbuk	2.6%	12	4.6%	4	5.9%	3
Busan	8.3%	1	4.1%	8	0.7%	34
Ulsan	1.3%	13	17.4%	2	0.1%	44
Gyeongnam	3.5%	8	6.2%	3	0.5%	38
Gangwon	5.4%	6	2.4%	14	0.0%	57
Jeju	9.0%	3	–	–	0.4%	30

In this study, the industrial characteristics of each region and industry were analyzed by calculating the interregional production inducement effect and regional division of labor for wholesale and retail trade and commodity brokerage services, semiconductors and other electronic components, and motor vehicle industries, in consideration of the economic structure and primary industries of each region.

5.2 Interregional production inducement effect

In 2010 and 2015, the wholesale and retail trade and commodity brokerage services industries contributed the most to Korea's total output. Owing to the characteristics of the industry, it is concentrated not only in the metropolitan area, which serves as the center of the entire nation, but also in the central city of each area. The wholesale retail trade and commodities brokerage services industry's export and import effects on the production incentive effects are displayed in Table 5 by year and region.

If an area's economy is split into central and peripheral regions, the former's economy is typically more consumption-, service-, and distribution-oriented. In any given year, the metropolitan area accounts for the highest percentage in the wholesale, retail, and product brokerage service sectors, of which Seoul possesses a significant proportion. In the metropolitan area, the export effect in Incheon and Gyeonggi regions are large in scale, but the import effect is larger, because it is larger as importer in the metropolitan area than the exporter effect in the central area of Korea as a whole. As of 2005, it appears that for all central cities in each region, denoted in bold in Table 5, the export effect outweighs the import effect. Even though the size of the outweighing effect is small compared with the metropolitan area, it can be said that it serves as a core city for the surrounding area.

Table 5 Interregional production inducement effects in the wholesale and retail and commodity brokerage services industry in the whole country. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005			2010			Unit: billion won 2015		
	Export	Import	Net export	Export	Import	Net export	Export	Import	Net export
Seoul	**39,196**	**20,508**	**18,688**	**67,470**	**32,365**	**35,106**	**83,893**	**38,145**	**45,748**
Incheon	3550	5608	− 2058	5892	8308	− 2416	7232	9660	− 2428
Gyeonggi	15,743	24,085	− 8342	24,461	33,407	− 8946	31,170	43,517	− 12,347
Daejeon	**2405**	**1995**	**411**	**3619**	**4688**	**− 1069**	**4015**	**5256**	**− 1242**
Chungbuk	1733	2282	− 549	2374	4510	− 2135	2750	5518	− 2768
Chungnam	2146	3486	− 1340	2997	6944	− 3947	3615	7727	− 4111
Gwangju	**2686**	**2172**	**513**	**3517**	**4123**	**− 607**	**3801**	**4815**	**− 1015**
Jeonbuk	2197	3018	− 821	3119	5276	− 2157	3645	5708	− 2063
Jeonnam	1975	3679	− 1704	2549	5746	− 3197	3249	6964	− 3715
Daegu	**3989**	**3683**	**306**	**6521**	**6803**	**− 282**	**6780**	**8064**	**− 1284**
Gyeongbuk	2502	4898	− 2395	3770	8110	− 4341	3677	9216	− 5540
Busan	**6780**	**6177**	**603**	**10,849**	**9896**	**954**	**11,447**	**10,707**	**740**
Ulsan	1291	2115	− 824	1529	3328	− 1799	1503	4323	− 2820
Gyeongnam	3709	5833	− 2124	5729	9085	− 3356	6141	10,895	− 4754
Gangwon	2147	2443	− 296	2562	4295	− 1733	3400	5781	− 2381
Jeju	820	887	− 68	1498	1573	− 75	2142	2164	− 21

Export represents the value transferred to other regions, and import means the value transferred from other regions

Table 6 Interregional production inducement effects in the wholesale and retail and commodity brokerage services industry in each area. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005			2010			Unit: billion won 2015		
	Export	Import	Net export	Export	Import	Net export	Export	Import	Net export
Seoul	**26,161**	**15,902**	**10,259**	**39,062**	**25,263**	**13,799**	**51,467**	**33,191**	**18,276**
Incheon	2359	4345	− 1986	3453	6228	− 2775	5474	8546	− 3072
Gyeonggi	10,503	18,776	− 8273	13,995	25,019	− 11,024	22,669	37,873	− 15,204
Daejeon	**521**	**377**	**143**	**999**	**741**	**258**	**2320**	**1888**	**432**
Chungbuk	399	419	− 21	567	586	− 18	1607	1749	− 143
Chungnam	496	619	− 122	690	930	− 240	1951	2240	− 289
Gwangju	**950**	**625**	**325**	**1433**	**962**	**471**	**2547**	**1974**	**573**
Jeonbuk	783	821	− 39	885	1110	− 225	2309	2318	− 9
Jeonnam	706	993	− 287	950	1196	− 247	2051	2615	− 564
Daegu	**1225**	**845**	**380**	**2444**	**1765**	**679**	**4818**	**3852**	**966**
Gyeongbuk	698	1077	− 380	971	1650	− 679	2254	3221	− 966
Busan	**2808**	**2030**	**778**	**4395**	**3200**	**1195**	**6965**	**5450**	**1515**
Ulsan	389	680	− 291	460	858	− 398	962	1531	− 568
Gyeongnam	1422	1909	− 487	2083	2880	− 797	4348	5295	− 947

Export represents the value transferred to other regions, and import means the value transferred from other regions

Table 7 Interregional production inducement effects in the motor vehicle industry in 2005, 2010, and 2015. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005			2010			2015		Unit: billion won
	Export	Import	−Net export	Export	Import	−Net export	Export	Import	−Net export
Seoul	67	10,884	− 10,817	147	14,302	− 14,154	17	18,704	− 18,687
Incheon	2689	4512	− 1824	2947	3564	− 617	4074	3937	137
Gyeonggi	**11,256**	**9742**	**1514**	**14,751**	**12,930**	**1821**	**17,135**	**16,647**	**487**
Daejeon	366	1181	− 815	258	1730	− 1472	496	2172	− 1676
Chungbuk	722	1279	− 557	1143	1621	− 477	1688	2195	− 507
Chungnam	**6262**	**1866**	**4396**	**7778**	**2169**	**5610**	**8456**	**2823**	**5633**
Gwangju	**3301**	**1019**	**2282**	**4898**	**1822**	**3075**	**5807**	**1868**	**3940**
Jeonbuk	**3794**	**1445**	**2349**	**3669**	**2117**	**1552**	**4953**	**2699**	**2254**
Jeonnam	51	2448	− 2397	34	1998	− 1964	76	2657	− 2581
Daegu	1660	2038	− 378	1592	2582	− 990	2044	2982	− 938
Gyeongbuk	2371	2679	− 309	2035	2771	− 736	3926	3831	95
Busan	1990	5426	− 3436	3911	4184	− 273	2738	4236	− 1498
Ulsan	**13,030**	**1478**	**11,552**	**11,423**	**2022**	**9400**	**16,771**	**2093**	**14,678**
Gyeong-nam	2560	2859	− 299	4435	3380	1054	5638	4321	1317
Gangwon	653	1361	–	386	1543	–	613	2368	–
Jeju	0	552	–	0	673	–	0	899	–

Export represents the value transferred to other regions, and import means the value transferred from other regions

In 2010 and 2015, the import effect was greater than the export effect in all regions, except Seoul and Busan. However, it cannot be interpreted that the central cities of all provinces, except Busan, lost their role as central cities. In this study, to interpret this phenomenon, the export and import effects within each area were calculated by region. Table 6 summarizes the interregional production-inducement effects in their own areas.

Table 7 shows the results of calculating the production inducement effect between the regions mentioned above, only in the areas to which the region belongs. For example, the export of Seoul's production inducement effect refers to the production inducement effect supplied from Seoul to Incheon and Gyeonggi, and import refers to the production inducement effect supplied from Gyeonggi and Incheon to Seoul. Looking at the interregional production inducement effect within the area, as in 2005, in both 2010 and 2015, the export effect was greater than the import effect in the central city of each region, and displayed an increasing trend. In other words, each central city still functions as a central city. However, the effect of national concentration on the metropolitan area overwhelms this effect, and the import effect on the metropolitan area is greater than the export effect within each area.

The motor vehicle industry is Korea's primary industry, along with the semiconductor industry, which is highly dependent on trade. In contrast to wholesale and retail trade and product brokerage services, the motor vehicle industry appears to be clearly specialized in particular regions. The industry in Korea is primarily concentrated in two large companies, Hyundai and Kia, and the factories of both companies are

Table 8 Interregional production inducement effects in the semiconductor and other electronic components industry in 2005, 2010, and 2015. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005			2010			2015 (Unit: billion won)		
	Export	Import	−Net export	Export	Import	−Net export	Export	Import	−Net export
Seoul	120	594	−473	351	1943	−1591	291	2720	−2429
Incheon	165	172	−7	352	605	−253	424	594	−170
Gyeonggi	**1327**	**893**	**435**	**1964**	**2358**	**−394**	**5959**	**4277**	**1681**
Daejeon	38	78	−40	110	381	−270	427	431	−4
Chungbuk	**243**	**111**	**132**	**1680**	**170**	**1509**	**1718**	**345**	**1373**
Chungnam	**465**	**219**	**247**	**1349**	**1514**	**−166**	**1521**	**722**	**799**
Gwangju	53	71	−18	244	264	−20	49	304	−255
Jeonbuk	60	99	−39	158	422	−264	140	330	−190
Jeonnam	15	141	−126	1188	930	259	36	559	−523
Daegu	56	131	−75	187	423	−236	135	500	−366
Gyeong-buk	**506**	**260**	**246**	**3941**	**1342**	**2598**	**2550**	**952**	**1598**
Busan	101	196	−95	216	565	−349	448	722	−274
Ulsan	119	91	28	161	217	−56	72	456	−384
Gyeong-nam	117	217	−100	178	594	−416	315	718	−403
Gangwon	8	96	−88	5	269	−264	4	349	−345
Jeju	1	27	−26	9	96	−86	10	118	−108

Export represents the value transferred to other regions, and import means the value transferred from other regions

located in Ulsan, Gyeonggi, Chungnam, Jeonbuk, and Gwangju. Therefore, the export effect in these regions was observed to be large.

The automobile industry has been developing in line with the regions it is located in as it is not easy to relocate the center of the industry unless there is a sudden change in operations, such as the establishment, relocation, or closure of a new factory, owing to the characteristics of the industry. In addition, it is expected that it will be difficult to establish factories in the centers of regions because of the characteristics of the consumption- and service-oriented metropolitan economy. In fact, it is interpreted that this trend is expected to be maintained, since the establishment of new factories is being planned mainly in peripheral regions. However, among the central regions, Gwangju has a large motor vehicle industry, which could be because the economy and population of the Jeolla area are relatively small compared with other areas (Table 8).

The semiconductor and other electronic components industry, including the motor vehicle industry, is concentrated in the regions, where its factories are located. The semiconductor and other electronic parts industry encompasses semiconductors and display parts. Semiconductors are concentrated in Gyeonggi and Chungbuk, and the display industry factories are concentrated in Gyeonggi, Chungnam, and Gyeongbuk. Gyeonggi, where several semiconductor and display factories are located, is growing annually. On the other hand, the size of Gyeongbuk is gradually decreasing, which is interpreted as the stagnation of LG Display located in Gyeongbuk.

Table 9 Regional division of labor in the wholesale and retail trade and product brokerage services industry. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005				2015			
	Intra-region	Intra-area	Metropolitan area	Others	Intra-region	Intra-area	Metropolitan area	Others
Metropolitan								
Seoul	60.3	15.9	76.2	23.8	56.5	17.1	73.6	26.4
Incheon	43.9	31.4	75.3	24.7	43.7	33.6	77.3	22.7
Gyeonggi	47.9	27.8	75.7	24.3	48.6	27.3	75.9	24.1
Chungcheong								
Daejeon	45.0	12.3	26.1	16.6	44.6	8.9	27.7	18.9
Chung-buk	48.3	9.6	25.7	16.3	44.0	5.4	32.0	18.6
Chung-nam	45.7	10.4	25.7	18.2	44.5	6.4	30.1	19.0
Jeolla								
Gwangju	47.3	11.6	22.7	18.5	47.3	7.4	25.4	19.9
Jeonbuk	47.8	11.2	22.4	18.6	44.2	5.7	28.1	22.0
Jeonnam	49.3	8.7	21.8	20.1	43.8	8.9	27.1	20.2
GyeongBuk								
Daegu	51.7	4.6	21.0	22.6	48.3	6.8	23.5	21.5
Gyeong-buk	48.8	8.0	20.7	22.5	44.7	8.0	25.3	22.0
GyeongNam								
Busan	56.5	8.2	19.5	15.8	52.6	8.3	21.2	17.8
Ulsan	42.6	21.7	18.6	17.2	40.5	13.8	24.9	20.9
Gyeong-nam	51.9	13.1	18.9	16.1	49.2	11.6	22.5	16.8
Others								
Gangwon	55.6	0.0	25.1	19.3	46.0	0.0	32.5	21.5
Jeju	51.7	0.0	22.8	25.5	46.9	0.0	27.5	25.6

5.3 Division of labor by region based on total input

As seen in the previous section, wholesale and retail trade and product brokerage services are closely related to the metropolitan area and other regions across the country. Therefore, the division of labor for 2005 and 2015 was calculated by dividing it into four categories: intra-regional, intra-area, metropolitan area, and others.

Among all regions, Seoul and Busan, exceed 50%, and the rest of the regions produce wholesale and retail trade and product brokerage services in their own regions, slightly below 50% as of 2015. Looking at the dependence on the metropolitan area, as of 2005, all regions, except for the Gyeongnam area, depended on the metropolitan area for a little over 20%. Daejeon, Gwangju, Daegu, and Busan, which are the central cities of each area, showed an increase in dependence of approximately 1.5–2.7%, and the increase in the remaining regions was approximately twice that of the central region. However, the dependence on the region to which one belongs generally decreases, and this trend is more pronounced in regions other than the central areas. Therefore, each region's dependence on the metropolitan area was higher in 2005 than on itself, but in 2015, this trend intensified. The Gyeongnam region, which had a relatively greater dependence on

Table 10 Regional division of labor in the motor vehicle industry in 2005. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

Unit: %

	Seoul	Incheon	Gyeonggi	Daejeon	ChungBuk	ChungNam	Gwangju	JeonBuk	JeonNam	Daegu	GyeonBuk	Busan	Ulsan	GyeongNam
Seoul	**16.0**	5.8	5.8	2.8	2.8	3.1	3.3	3.3	3.4	2.3	2.3	2.6	2.4	2.2
Incheon	26.2	**41.6**	4.9	5.2	5.1	4.5	3.7	3.8	3.7	2.4	2.3	2.5	2.4	2.4
Gyeonggi	**20.4**	**12.9**	**48.7**	**16.9**	**16.6**	**14.6**	**13.1**	**13.3**	**12.4**	**7.4**	**6.8**	**8.7**	**8.7**	**7.4**
Daejeon	0.8	0.9	1.0	**12.2**	1.0	3.5	1.9	1.9	1.0	0.8	0.7	1.3	1.4	0.6
ChungBuk	1.3	1.4	1.5	6.0	**28.1**	1.1	2.0	2.0	2.0	1.7	1.5	1.6	1.7	1.1
ChungNam	5.2	5.4	5.6	16.4	5.5	**31.4**	7.8	7.9	7.3	5.6	5.0	6.6	7.2	3.0
Gwangju	0.6	0.6	0.7	1.5	1.6	1.7	**27.1**	5.5	2.9	0.6	0.5	1.2	1.2	1.1
JeonBuk	0.6	0.4	0.5	2.2	2.2	1.8	5.4	**25.8**	10.9	1.0	1.0	1.1	1.0	1.4
JeonNam	2.6	3.0	3.2	2.9	3.1	3.0	4.7	5.7	**25.3**	2.0	2.7	2.2	1.9	2.6
Daegu	1.2	1.0	0.9	3.4	3.2	2.7	1.9	1.8	1.2	**26.9**	3.0	4.9	5.0	4.3
GyeongBuk	3.6	3.1	3.0	8.1	7.8	6.6	3.9	3.7	3.3	12.6	**37.2**	10.6	10.2	10.2
Busan	2.0	1.9	1.9	2.1	2.1	1.9	2.2	2.4	2.9	4.2	3.9	**26.5**	6.1	5.1
Ulsan	4.9	4.9	5.4	5.9	6.4	5.9	5.3	5.4	4.3	12.6	11.6	2.6	**30.8**	3.7
GyeongNam	4.2	4.6	4.6	4.8	4.7	4.6	4.9	5.2	5.5	9.5	8.6	16.3	6.8	**43.0**
Gangwon	0.2	0.2	0.2	0.8	0.8	0.7	0.5	0.5	0.2	0.6	0.6	0.2	0.2	0.1
Jeju	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.3	0.3	0.0	0.0	0.0	0.0	0.0
import	10.1	12.3	12.2	8.8	9.0	12.8	12.1	11.5	13.4	9.8	12.1	11.1	12.9	11.6

itself, also showed about twice as much dependence on the metropolitan area, and more severe dependence in other regions, in 2015.

Some regions are highly specialized for the motor vehicle sector, and dependence on these regions is anticipated to be significant. For this reason, Table 9 details the regional division of labor in the motor vehicle industry for all regions, not just the metropolitan area and outlying regions (Table 10).

As of 2005, the region contributing the most to the motor vehicle industry was Gyeonggi, which has the largest economy. In addition to the metropolitan area, Gyeonggi significantly affected the Chungcheong and Jeolla regions. There are some motor vehicle plants in the Chungcheong region, contributing significantly to Daejeon. It also makes a significant contribution to other regions. In the Jeolla area, there are automobile plants in Gwangju and Jeonbuk, but the impact on other regions is not significant, while Gyeonggi contributed significantly to the Jeolla region. As there are automobile component factories in Gyeongbuk and several automobile factories in Gyeongnam, the interdependence between the two areas was found to be high. Overall, the regions in which the automobile industry has developed have close industrial relationships within their own areas (Table 11).

Compared with 2005, the proportion of all regions of Gyeonggi was higher in 2015. The contribution to other regions was found to be high in Chungnam, Gyeongbuk, and Gyeongnam. The Gyeongnam and Gyeongbuk areas show a high level of contribution within their own regions, but the dependence between the two areas has decreased since 2005.

Table 12 shows the regional division of labor in the semiconductor and other electronic component industries. The first column of each year represents the division of the labor rate within the region, the second represents that induced by other regions within its area, the third represents that induced by other regions, and the last represents the proportion of imports.

The semiconductor and other electronic component industry has a lower division of labor within the region, compared to other industries, because its factories are concentrated in several regions. Gyeonggi has the largest plants in Korea for both, the semiconductor and display industries, and reflecting this, Gyeonggi has the highest rate of division of labor in its region, despite the largest final demand. Gyeonggi also accounts for the highest proportion of labor in other regions. The division of labor in other regions outside the metropolitan area is higher, because the industry in Gyeonggi is larger and more important.

In addition, compared to other industries, the semiconductor and other electronic component industry is heavily dependent on imports, relying largely on the United States, Japan, and recently China for materials and components. Compared to 2005, the proportion of imports in 2015 decreased in all regions, which can be interpreted as a result of steady localization efforts by the Korean semiconductor industry. Nevertheless, the input sector of the semiconductor industry, one of Korea's main industries, relies considerably on imports.

Table 11 Regional division of labor in the motor vehicle industry in 2015. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

Unit: %

	Seoul	Incheon	Gyeonggi	Daejeon	ChungBuk	ChungNam	Gwangju	JeonBuk	JeonNam	Daegu	GyeonBuk	Busan	Ulsan	GyeongNam
Seoul	**17.6**	6.6	7.5	4.8	5.5	4.9	5.6	5.1	5.2	3.8	4.4	3.9	4.3	4.0
Incheon	3.8	**23.7**	4.6	3.7	3.8	2.6	3.3	2.9	2.1	3.3	2.0	1.6	1.3	1.9
Gyeonggi	**15.9**	**21.5**	**40.1**	**9.5**	**35.5**	**20.3**	**12.1**	**7.5**	**10.2**	**9.1**	**8.8**	**6.1**	**13.1**	**10.0**
Daejeon	1.4	0.6	0.8	**30.2**	1.0	1.5	1.0	1.7	0.5	0.4	0.7	0.3	0.8	0.3
ChungBuk	3.2	2.8	4.6	1.9	**17.5**	2.1	2.0	3.3	4.5	2.0	1.8	1.5	2.8	1.6
ChungNam	8.7	9.2	8.8	5.0	5.3	**31.4**	11.0	7.2	7.0	6.6	6.6	6.2	4.7	5.6
Gwangju	1.9	0.7	1.1	1.6	0.6	0.6	**33.3**	3.8	5.8	1.4	0.6	1.0	0.7	0.7
JeonBuk	3.1	1.2	0.7	8.2	1.7	3.0	1.8	**25.9**	3.5	1.4	3.6	1.1	0.6	1.3
JeonNam	1.1	1.2	1.7	0.6	1.3	1.1	5.2	2.0	**25.1**	2.0	3.6	2.2	1.6	1.5
Daegu	3.7	1.2	1.2	2.3	1.9	1.4	0.7	3.6	1.3	**31.6**	6.5	3.3	3.9	3.8
GyeongBuk	5.8	3.6	4.2	14.4	6.6	6.3	4.7	14.6	8.1	15.4	**36.2**	9.5	13.8	7.0
Busan	2.0	0.9	1.0	2.0	1.6	1.3	1.2	2.3	3.5	2.2	1.9	**30.8**	6.0	10.0
Ulsan	4.4	9.3	2.4	0.7	2.4	1.4	1.2	2.2	3.2	4.9	5.0	9.8	**23.7**	4.2
GyeongNam	5.2	5.1	8.3	3.5	4.8	7.9	3.4	4.1	4.6	4.0	4.8	8.3	10.0	**36.6**
Gangwon	0.8	0.9	0.5	1.6	0.5	1.1	0.3	1.8	0.5	0.6	1.1	1.3	0.3	0.5
Jeju	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1
import	21.1	11.4	12.3	10.0	9.8	13.0	13.0	11.9	14.6	11.2	12.2	12.8	12.5	10.8

Table 12 Regional division of labor in the semiconductor and other electronic components industry. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	2005				2015			
	Own region	Own area	Other regions	Imports	Own region	Own area	Other regions	Imports
Metropolitan								
Seoul	28.2	18.4	12.7	40.8	19.7	18.1	25.9	36.2
Incheon	24.1	23.0	15.3	37.7	27.1	22.6	20.1	30.3
Gyeonggi	30.2	14.1	14.0	41.7	33.0	10.8	19.1	37.1
Chungcheong								
Daejeon	13.4	10.1	38.8	37.7	11.8	16.7	30.1	41.4
Chung-buk	17.9	9.8	34.7	37.7	24.9	5.0	35.7	34.4
Chung-nam	26.1	6.1	31.4	36.4	24.9	4.2	36.9	33.9
Jeolla								
Gwangju	8.5	6.0	20.7	64.8	24.8	5.5	35.1	34.7
Jeonbuk	13.8	9.7	38.2	38.3	20.3	4.5	40.4	34.8
Jeonnam	15.9	5.3	40.1	38.7	21.7	7.1	43.7	27.5
GyeongBuk								
Daegu	19.9	9.0	38.6	32.5	19.5	6.5	46.0	27.9
Gyeong-buk	26.2	2.6	38.4	32.8	30.8	3.7	32.0	33.6
GyeongNam								
Busan	26.2	10.4	32.1	31.3	31.7	9.0	32.7	26.5
Ulsan	14.9	13.5	44.1	27.5	23.9	6.7	29.2	40.2
Gyeong-nam	23.5	8.6	32.8	35.1	30.5	11.1	29.9	28.6
Others								
Gangwon	23.4	–	53.9	22.6	20.5	–	51.0	28.4
Jeju	8.2	–	24.2	67.5	10.6	–	43.9	45.3

Unit: %

5.4 Multi-regional structural decomposition analysis

This section analyzes the extent to which each factor has contributed to regional growth in the 10 years from 2005 to 2015 for the three industries covered so far. The regional classification is classified into each economic area, and the factors affecting it are classified into eight categories. The impact of the regions they are located in, includes final demand, input and output structure, exports and imports, and direct and indirect effects for the metropolitan area and other regions. The direct effect is caused by an increase in demand for the target area in the metropolitan area or other regions, while the indirect effect arises from economic relations among other regions.

Table 13 shows the growth factors for the wholesale and retail trade and commodity brokerage service industries. The last two rows show the average annual growth rate for the 10 years under consideration, and the total output as of 2015.

The biggest causal factor for the growth of the wholesale and retail industry is the increase in final demand. This can be observed from the fact that Korea's economy grew significantly from 2005 to 2015. In both, the metropolitan area and outside, the factors within own areas were the main growth factors. In particular, the wholesale and retail

Table 13 Growth factors of the wholesale and retail industry in each area between 2005 and 2015. Source: Author's calculation based on the Korean regional IO table (https://ecos.bok.or.kr)

	Metropolitan	Chungcheong	Jeolla	Gyeongbuk	Unit: %, trillion won Gyeongnam
Final demand	35.7	51.4	66.8	61.9	57.1
IO structure	8.4	40.8	51.0	44.1	48.7
Export	20.7	29.9	18.2	31.2	14.3
Import	0.1	− 1.3	− 4.5	− 1.0	− 2.4
Regional total	**64.8**	**120.9**	**131.5**	**136.3**	**117.8**
Direct from metropolitan	–	**− 20.9**	**− 14.6**	**− 12.0**	**− 10.6**
Indirect from metropolitan	–	12.3	11.4	9.0	9.6
Metropolitan total	–	**− 8.6**	**− 3.2**	**− 3.0**	**− 1.0**
Direct from others	**22.6**	**− 19.8**	**− 38.2**	**− 42.5**	**− 25.4**
Indirect from others	12.5	7.5	10.0	9.2	8.7
Other regions total	**35.2**	**− 12.2**	**− 28.3**	**− 33.3**	**− 16.8**
Annual growth (2005–2015)	7.9	6.2	4.7	5.3	4.8
Output 2015 (Trillion won)	167.9	15.2	14.2	15.6	27.6

Table 14 Growth factors of the motor vehicle industry in each area between 2005 and 2015. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	Metropolitan	Chungcheong	Jeolla	Gyeongbuk	Unit: %, trillion won Gyeongnam
Final demand	45.9	7.5	9.5	8.1	12.1
IO structure	− 23.1	− 9.6	− 4.4	3.4	− 5.0
Export	62.6	50.6	63.4	50.9	60.2
Import	− 26.9	− 7.4	− 5.5	− 1.7	− 5.7
Regional total	58.5	41.1	63.0	60.7	61.5
Direct from metropolitan	–	27.0	19.3	0.1	26.8
Indirect from metropolitan	–	9.6	1.4	4.4	6.2
Metropolitan total	–	36.5	20.8	4.5	33.0
Direct from others	22.2	5.4	11.2	5.3	− 1.6
Indirect from others	19.4	17.0	5.0	29.5	7.0
Other regions total	41.5	22.4	16.2	34.8	5.4
Annual growth (2005–2015)	3.6	5.7	5.9	8.2	3.9
Output 2015 (Trillion won)	55.1	28.4	26.9	17.8	66.1

industry developed due to growth in the area, except for the metropolitan area, which, along with other areas, has a negative impact. Only the metropolitan area is positively affected by other regions, and it is more intuitive to know the dependence on the metropolitan area, which is confirmed by the production-inducement effect among regions.

Table 14 lists the growth factors of the motor vehicle industry.

All automobile industry regions are significantly affected by exports as growth factors. Overall, the input and output structures have a negative impact, as do imports, owing to the increased demand for imported cars, especially in metropolitan areas. This is interpreted as a result of the increase in demand for foreign cars, especially in metropolitan areas, as the economy develops. The demand for the automobile industry in the metropolitan area has increased significantly, which not only has a great

Table 15 Growth factors of the semiconductor and other electronic components industry in each area between 2005 and 2015. Source: Author's calculation based on Korean regional IO table (https://ecos.bok.or.kr)

	Metropolitan	Chungcheong	Jeolla	Gyeongbuk	Unit: %, trillion won Gyeongnam
Final demand	1.6	0.1	2.6	0.9	20.6
IO structure	− 1.0	− 0.5	− 24.2	− 4.9	45.7
Export	84.3	80.0	− 201.4	55.0	− 226.3
Import	2.7	− 0.9	39.0	5.3	118.9
Regional total	87.5	78.8	− 184.0	56.4	− 41.1
Direct from metropolitan	–	5.0	− 0.4	15.9	− 14.4
Indirect from metropolitan	–	12.9	58.5	21.9	45.5
Metropolitan total	–	17.9	58.1	37.8	31.1
Direct from others	4.0	0.7	− 17.2	0.4	− 135.0
Indirect from others	8.4	2.7	43.1	5.5	44.9
Other regions total	12.5	3.4	25.9	5.8	− 90.0
Annual growth (2005–2015)	16.3	17.0	− 2.1	7.4	− 1.4
Output 2015 (trillion won)	99.9	47.5	1.5	16.8	3.0

impact on growth in the metropolitan area, but also serves as a major growth factor in regions other than Gyeongbuk. Since Gyeongbuk is not specialized in the automobile industry, it has been indirectly affected by the relationships among automobile industries in other regions. In summary, an increase in exports and a significant increase in final demand in the metropolitan area accounted for the majority of the growth components in the motor vehicle industry. The importance of the metropolitan area as a center for consumption has also increased significantly.

The semiconductor industry's growth factors are displayed in Table 15.

The semiconductor industry itself is not very active in the Jeolla and Gyeongnam regions; hence, the factors for growth do not have much significance, and there has been limited development in 10 years under study. The growth of the semiconductor industry depends on exports. Exports accounted for the largest factor in the Seoul metropolitan area, and Chungcheong and Gyeongbuk, especially the two regions with the largest semiconductor industry, with a growth factor of more than 80%, i.e., both, Seoul metropolitan area and Chungcheong. Compared with the wholesale, retail, and motor vehicle industries, the semiconductor industry has relatively few growth factors owing to direct demand in the metropolitan area. In other words, the direct impact on the metropolitan area is small. Nevertheless, the semiconductor industry itself is concentrated in the metropolitan area, as production factories are concentrated there, especially in Gyeonggi.

6 Conclusion

In this study, the interregional production inducement effect of wholesale and retail trade and commodity brokerage services, the motor vehicle industry, the semiconductor and other electronic component industries, and the division of labor by region are calculated using Korea's MRIO table for 2005, 2010, and 2015. Using this indicator, the dependence of each region on the metropolitan area and the influence of an area's primary industry on other regions were analyzed. The wholesale and retail trade and commodity brokerage services industries are most active in the central region and in large cities. If a region functions

as the central region for surrounding areas, the export effect to the latter increases. Large cities in each region, such as Seoul, Daejeon, Daegu, Busan, and Gwangju, function as central cities in terms of the size of industry and its impact on the surrounding areas. However, in Gwangju, the impact was less than that in other central cities. In addition, compared to 2005, central cities, except Seoul and Busan, had a greater import, than export effect in 2015 because of greater concentration in the metropolitan area. In other words, each central city, except Seoul, plays a greater role as a surrounding metropolitan area than as a central city.

The concentration of the motor vehicle, semiconductor, and other electronic component industries, which are representative manufacturing industries in Korea, is also increasing in the metropolitan area. In the case of the motor vehicle industry, Gyeonggi accounted for the second largest portion in 2005 and the largest in 2015. The division of labor in other regions also accounted for the largest portion as a whole, and the share increased from 2005 to 2015. The semiconductor and other electronic component industries increased rapidly in Gyeonggi over time, becoming the largest major industry. The division of labor for final demand in other regions is larger than that in the motor vehicle industry, which leads to a significantly increased dependence of the major manufacturing sectors on the metropolitan area.

However, in the wholesale and retail industries, the final demand in the Seoul metropolitan area increased rapidly, but the final demand in other regions decreased significantly, reducing the impact of demand in the metropolitan area. This trend is expected to worsen as many manufacturing industries flock into Gyeonggi. An increase in final demand for the automobile industry from the metropolitan area greatly affects both, the metropolitan area and other regions. In addition, the growth of exports, in line with the development of Korea's automobile industry, has also been identified as a major factor, confirming that overseas demand can also play an important role, in addition to domestic demand from the metropolitan area. In the semiconductor industry, overseas exports account for an absolute proportion as a growth factor, and because of the features of the industry, they are not significantly related to the final demand in the Seoul metropolitan area. However, in terms of economic structure, the demand in the metropolitan area is small, but considering other factors, such as people's preference for jobs in the metropolitan area or logistics movement, the metropolitan area and the Chungcheong area are applicable; therefore, various factors should be considered together.

Korea's concentration in the Seoul metropolitan area has emerged as a serious problem over time. The metropolitan area previously functioned as an area, wherein the consumer and service industries flourished, creating an economic structure centered on manufacturing in areas other than the metropolitan area. Furthermore, central cities also functioned in such areas. However, over time, the metropolitan area also witnessed a greater concentration of manufacturing. In other words, it is anticipated that the function currently served by the metropolitan area will progressively transfer to Seoul, whereas the current role of outlying regions will gradually shift to Gyeonggi. The most recent data included in this study were from 2015, which was more than 5 years ago. It is anticipated that an additional in-depth discussion of the current concentration phenomenon in the Seoul metropolitan region will be possible once more recent MRIO data are available.

Appendix

See Tables 16, 17, 18.

Table 16 Correspondence table from 2005 Korean IO table to reclassified IO table. Bank of Korea (2009) Regional input-output statistics, vol 2005. Bank of Korea

Code 2005	Name 2005	New code	Name
01	Crops	01	Crops
02	Animals	02	Animals
03	Forest products	03	Forest goods
04	Fishery products	04	Fishery goods
05	Agriculture, forestry and fishing-related services	05	Agriculture, forestry and fishing-related services
06	Mining of coal, crude petroleum and natural gas	06	Coal, crude petroleum and natural gas
07	Metal ores	07	Metal ores and non-metallic minerals
08	Non-metallic minerals	07	Metal ores and non-metallic minerals
09	Meat and dairy products	08	Foods
10	Processed seafood products	08	Foods
11	Polished grains, flour and milled cereals	08	Foods
12	Other food products	08	Foods
13	Beverages	09	Beverages
14	Prepared livestock feeds	08	Foods
15	Tobacco products	10	Tobacco products
16	Fiber yarn and fabrics	11	Textiles and apparels
17	Apparels and other textiles	11	Textiles and apparels
18	Leather and fur products	12	Leather products
19	Wood and wooden products	13	Wood and wooden products
20	Pulp and paper	14	Pulp and paper products
21	Printing and reproduction of recorded media	15	Printing and reproduction of recorded media
22	Coke and hard-coal	16	Petroleum and coal products
23	Refined petroleum products	16	Petroleum and coal products
24	Basic chemical products	17	Basic chemical products
25	Synthetic resins and synthetic rubber	18	Synthetic resins and synthetic rubbers
26	Chemical fibers	19	Chemical fibers
27	Fertilizers and agricultural chemicals	21	Fertilizers and pesticides
28	Drugs, cosmetics, and soap	20	Medicaments
29	Other chemical products	22	Other chemical products
30	Plastic products	23	Plastic products
31	Rubber products	24	Rubber products
32	Glass products	25	Glass products
33	Ceramic ware	26	Other non-metallic mineral products
34	Cement and concrete products	26	Other non-metallic mineral products
35	Other nonmetallic mineral products	26	Other non-metallic mineral products
36	Pig iron and crude steel	27	Primary iron and steel products
37	Primary iron and steel products	27	Primary iron and steel products
38	Nonferrous metal ingots and primary nonferrous metal products	28	Non-ferrous metal ingots and primary Non-ferrous metal products
39	Fabricated metal products except machinery and funiture	29	Metal foundries, Fabricated metal products, except machinery and furniture
40	Machinery and equipment of general purpose	35	General-purpose machinery and equipment
41	Machinery and equipment of special purpose	36	Special-purpose machinery and equipment
42	Electrical equipment, and supplies	34	Electrical equipment
43	Electronic components and accessories	30	Semiconductor and other electronic components

Table 16 (continued)

Code 2005	Name 2005	New code	Name
44	Audio, video and communications equipment	32	Telecommunication, video, and audio equipment
45	Computer and office equipment	31	Computer and peripheral equipment
46	Household electrical appliances	34	Electrical equipment
47	Precision instruments	33	Precision instruments
48	Motor vehicles and parts	37	Motor vehicles
49	Ship building and repairing	38	Ships
50	Other transportation equipment	39	Other transport equipment
51	Furniture	40	Other manufactured products
52	Other manufactured products	40	Other manufactured products
53	Electric utilities	41	Electricity supply
54	Gas and water supply	42	Gas, steam, hot water and water supply
55	Building construction and repair	44	Constructions and repairs of buildings
56	Civil engineering	45	Civil engineering
57	Wholesale and retail trade	46	Wholesale and retail trade and commodity brokerage services
58	Accommodation and food services	50	Food services and accommodation
59	Land transport	47	Land transport services
60	Water and air transport	48	Water and air transport services
61	Storage and support activities for transportation	49	Storage services and supporting services for transportation
62	Communications services	51	Communications, broadcasting and information services
63	Broadcasting	51	Communications, broadcasting and information services
64	Finance and insurance	53	Financial and insurances services
65	Real estate	54	Real estate services
66	Research and development	55	Research and development services
67	Business services	56	professional services
68	Other business services	57	Business support services
69	Public administration and defense	58	Public administration, defense, and social security services
70	Education	59	Education services
71	Medical and health services	60	Medical and health care services
72	Social work activities	61	Social care services
73	Sanitary services	43	Sanitary services
74	Publishing and cultural services	52	Publishing and cultural services
75	Amusement and sports activities	62	Sports, amusement and recreational services
76	Social organizations	63	Services of membership organizations
77	Other services	64	Repair and other personal services

Table 17 Correspondence table from 2010 Korean IO table to reclassified IO table. Bank of Korea (2015) 2010/2013 Regional input-output statistics. Bank of Korea

Code 2010	Name 2010	New code	Name
001	Crops	01	Crops
002	Animals	02	Animals
003	Forest goods	03	Forest goods
004	Fishery goods	04	Fishery goods
005	Agriculture, forestry and fishing-related services	05	Agriculture, forestry and fishing-related services
006	Coal, crude petroleum and natural gas	06	Coal, crude petroleum and natural gas
007	Metal ores and non-metallic minerals	07	Metal ores and non-metallic minerals
008	Foods	08	Foods
009	Beverages	09	Beverages
010	Tobacco products	10	Tobacco products
011	Textiles and apparels	11	Textiles and apparels
012	Leather products	12	Leather products
013	Wood and wooden products	13	Wood and wooden products
014	Pulp and paper products	14	Pulp and paper products
015	Printing and reproduction of recorded media	15	Printing and reproduction of recorded media
016	Petroleum and coal products	16	Petroleum and coal products
017	Basic chemical products	17	Basic chemical products
018	Synthetic resins and synthetic rubbers	18	Synthetic resins and synthetic rubbers
019	Chemical fibers	19	Chemical fibers
020	Medicaments	20	Medicaments
021	Fertilizers and pesticides	21	Fertilizers and pesticides
022	Other chemical products	22	Other chemical products
023	Plastic products	23	Plastic products
024	Rubber products	24	Rubber products
025	Glass products	25	Glass products
026	Other non-metallic mineral products	26	Other non-metallic mineral products
027	Primary iron and steel products	27	Primary iron and steel products
028	Fabricated iron and steel products	27	Primary iron and steel products
029	Non-ferrous metal ingots and primary Non-ferrous metal products	28	Non-ferrous metal ingots and primary Non-ferrous metal products
030	Metal foundries	29	Metal foundries, Fabricated metal products, except machinery and furniture
031	Fabricated metal products, except machinery and furniture	29	Metal foundries, Fabricated metal products, except machinery and furniture
032	General machinery and equipment	35	General-purpose machinery and equipment
033	Special machinery and equipment	36	Special-purpose machinery and equipment
034	Electrical equipment	34	Electrical equipment
035	Semiconductor and related devices	30	Semiconductor and other electronic components
036	Electronic signal equipment	30	Semiconductor and other electronic components
037	Other electric components	30	Semiconductor and other electronic components
038	Computer and peripheral equipment	31	Computer and peripheral equipment
039	Telecommunication, video, and audio equipment	32	Telecommunication, video, and audio equipment
040	Household electrical appliances	34	Electrical equipment

Table 17 (continued)

Code 2010	Name 2010	New code	Name
041	Precision instruments	33	Precision instruments
042	Motor vehicles	37	Motor vehicles
043	Ships	38	Ships
044	Other transportation equipment	39	Other transport equipment
045	Other manufactured products and out-sourcing services	40	Other manufactured products
046	Electricity supply	41	Electricity supply
047	Gas, steam, hot water supply	42	Gas, steam, hot water and water supply
048	Water supply	42	Gas, steam, hot water and water supply
049	Sewage and wastewater treatment services	43	Sanitary services
050	Waste management	43	Sanitary services
051	Building construction and repair	44	Constructions and repairs of buildings
052	Civil engineering	45	Civil engineering
053	Wholesale and retail trade	46	Wholesale and retail trade and commodity brokerage services
054	Land transport	47	Land transport services
055	Water transport	48	Water and air transport services
056	Air transport	48	Water and air transport services
057	Storage and support activities for transportation	49	Storage services and supporting services for transportation
058	Food services and accommodation	50	Food services and accommodation
059	Communications	51	Communications, broadcasting and information services
060	Broadcasting	51	Communications, broadcasting and information services
061	Information services	51	Communications, broadcasting and information services
062	Computer software development and computer-related services	51	Communications, broadcasting and information services
063	Publishing	52	Publishing and cultural services
064	Video and audio production and distribution	52	Publishing and cultural services
065	Financial services	53	Financial and insurances services
066	Insurance	53	Financial and insurances services
067	Services auxiliary to finance and insurance	53	Financial and insurances services
068	Residential building rental services	54	Real estate services
069	Real estate services	54	Real estate services
070	Renting and leasing; except real estate	57	Business support services
071	Research and development	55	Research and development services
072	Business-related professional services	56	professional services
073	Scientific and technical services	56	professional services
074	Business support services	57	Business support services
075	Public administration and defense	58	Public administration, defense, and social security services
076	Educational services	59	Education services
077	Medical and health care services	60	Medical and health care services
078	Social work activities	61	Social care services
079	Cultural services	52	Publishing and cultural services
080	Sports and amusement activities	62	Sports, amusement and recreational services
081	Social organizations	63	Services of membership organizations
082	Repair and other personal services	64	Repair and other personal services

Table 18 Correspondence table from 2015 Korean IO table to reclassified IO table. Bank of Korea (2020) Regional input-output statistics, vol 2015. Bank of Korea

Code 2015	Name 2015	New code	Name
01	Crops	01	Crops
02	Animals	02	Animals
03	Forest goods	03	Forest goods
04	Fishery goods	04	Fishery goods
05	Agriculture, forestry and fishing-related services	05	Agriculture, forestry and fishing-related services
06	Coal, crude petroleum and natural gas	06	Coal, crude petroleum and natural gas
07	Metal ores and non-metallic minerals	07	Metal ores and non-metallic minerals
08	Foods	08	Foods
09	Beverages	09	Beverages
10	Tobacco products	10	Tobacco products
11	Textiles and apparels	11	Textiles and apparels
12	Leather products	12	Leather products
13	Wood and wooden products	13	Wood and wooden products
14	Pulp and paper products	14	Pulp and paper products
15	Printing and reproduction of recorded media	15	Printing and reproduction of recorded media
16	Petroleum and coal products	16	Petroleum and coal products
17	Basic chemical products	17	Basic chemical products
18	Synthetic resins and synthetic rubbers	18	Synthetic resins and synthetic rubbers
19	Chemical fibers	19	Chemical fibers
20	Medicaments	20	Medicaments
21	Fertilizers and pesticides	21	Fertilizers and pesticides
22	Other chemical products	22	Other chemical products
23	Plastic products	23	Plastic products
24	Rubber products	24	Rubber products
25	Glass products	25	Glass products
26	Other non-metallic mineral products	26	Other non-metallic mineral products
27	Primary iron and steel products	27	Primary iron and steel products
28	Non-ferrous metal ingots and primary Non-ferrous metal products	28	Non-ferrous metal ingots and primary Non-ferrous metal products
29	Metal foundries	29	Metal foundries, Fabricated metal products, except machinery and furniture
30	Fabricated metal products, except machinery and furniture	29	Metal foundries, Fabricated metal products, except machinery and furniture
31	Semiconductor and related devices	30	Semiconductor and other electronic components
32	Electronic signal equipment	30	Semiconductor and other electronic components
33	Other electronic components	30	Semiconductor and other electronic components
34	Computer and peripheral equipment	31	Computer and peripheral equipment
35	Telecommunication, video, and audio equipment	32	Telecommunication, video, and audio equipment
36	Precision instruments	33	Precision instruments
37	Electrical equipment	34	Electrical equipment
38	General-purpose machinery and equipment	35	General-purpose machinery and equipment
39	Special-purpose machinery and equipment	36	Special-purpose machinery and equipment
40	Motor vehicles	37	Motor vehicles

Table 18 (continued)

Code 2015	Name 2015	New code	Name
41	Ships	38	Ships
42	Other transport equipment	39	Other transport equipment
43	Other manufactured products	40	Other manufactured products
44	Manufacturing services and repair services of industrial equipment	40	Other manufactured products
45	Electricity supply	41	Electricity supply
46	Gas, steam, hot water supply	42	Gas, steam, hot water and water supply
47	Water supply	42	Gas, steam, hot water and water supply
48	Sewage and wastewater treatment services	43	Sanitary services
49	Waste treatment and disposal services	43	Sanitary services
50	Constructions and repairs of buildings	44	Constructions and repairs of buildings
51	Civil engineering	45	Civil engineering
52	Wholesale and retail trade and commodity brokerage services	46	Wholesale and retail trade and commodity brokerage services
53	Land transport services	47	Land transport services
54	Water transport services	48	Water and air transport services
55	Air transport services	48	Water and air transport services
56	Storage services and supporting services for transportation	49	Storage services and supporting services for transportation
57	Postal services and transport services of parcels	47	Land transport services
58	Food services and accommodation	50	Food services and accommodation
59	Communications	51	Communications, broadcasting and information services
60	Broadcasting	51	Communications, broadcasting and information services
61	Information services	51	Communications, broadcasting and information services
62	Computer software development and other IT services	51	Communications, broadcasting and information services
63	Newspaper and publishing	52	Publishing and cultural services
64	Video and audio production and distribution	52	Publishing and cultural services
65	Financial services	53	Financial and insurances services
66	Insurance services	53	Financial and insurances services
67	Services auxiliary to financial and insurance services	53	Financial and insurances services
68	Rental or leasing services of residential property	54	Real estate services
69	Other real estate services	54	Real estate services
70	Research and development services	55	Research and development services
71	Business-related professional services	56	professional services
72	Scientific, technical, and other professional services	56	professional services
73	Leasing or rental services concerning equipment, goods and intellectual property rights	57	Business support services
74	Business support services	57	Business support services
75	Public administration, defense, and social security services	58	Public administration, defense, and social security services
76	Education services	59	Education services
77	Medical and health care services	60	Medical and health care services

Table 18 (continued)

Code 2015	Name 2015	New code	Name
78	Social care services	61	Social care services
79	Cultural- and tour-related services	52	Publishing and cultural services
80	Sports, amusement and recreational services	62	Sports, amusement and recreational services
81	Services of membership organizations	63	Services of membership organizations
82	Repair and other personal services	64	Repair and other personal services

Abbreviations
GRDP   Gross regional domestic product
MRIO   Multi-regional input–output
IO   Input–output
OECD   Organization for Economic Co-operation and Development

Availability of data and materials
The data sets generated and analyzed during the current study are available from the Bank of Korea's Economic Statistics System repository (https://ecos.bok.or.kr).

Declarations

Competing interests
The authors declare that they have no competing interests.

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