An Empirical Research of Industry Geographic Concentration and Trade in Guangxi of China

Li-Yu Chan[1,*] and Wenfang Ou[2]

[1] Department of Finance, Jinwen University of Technology and Science, New Taipei City, Taiwan, China
[2] College of Teacher Education, Jishou University, Jishou City, China
Email: jly@just.edu.tw (L.Y.C.); 945151371@qq.com (W.F.O.)
*Corresponding author
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Abstract—New trade theory points out that economies of scale is an considerable reason for the emergence of international trade. According to the theory of industrial organization, the degree of geographic concentration or agglomeration is an important factor affecting economies of scale. In view of the fact that Guangxi is a major channel for international land-sea trade between China and ASEAN (Association of South East Asian Nations), this paper takes an empirical research to examine the relationship between the degree of geographical concentration and trade of Guangxi. We found that Guangxi's imports & exports has a significant positive correlation with the geographical concentration of overall economic activity during 2011 to 2021, especially the positive correlation of exports is higher than that of imports. In perspective of industry-region level, Nanning, the capital of Guangxi, has become an industrial center for most sectors. The imports & exports has a positive correlation with the intra-industry agglomeration, and the correlation is higher than the degree of specialization in the region. The more geographically concentrated an industry is, the more contributed it is to trade activities, and this is the case for as many as 94.73% of sectors.

Keywords—geographic concentration, agglomeration, trade, Guangxi

I. INTRODUCTION

After World War II, countries in the world showed a new development pattern in trade, intra-industry trade and trade between developed countries increased rapidly, and lots phenomena that could not be explained by traditional trade theory appeared. The main differences between new and traditional trade theories have been the returns of scale, fixed technology, and perfect competition. New trade theory applies concepts and tools from industrial organization, assumes that the market structure is imperfect competition, and assumes that the return to scale is no longer constant. Such changes open up a new perspective in explaining the incentives to trade.

What is the linkage between economies of scale and trade? Generally speaking, economies of scale can be distinguished into internal and external economies of scale. Internal economies of scale refer to the benefits brought by the expansion of production by the manufacturer itself, while external economies of scale refer to the benefits of manufacturers in the industry due to the expansion of the industry scale. Regardless of what kind of economies of scale, manufacturers can reduce production costs and obtain price advantages, making products export-competitive and arising trade activities. However, according to industrial organization theory, industry geographic concentration or agglomeration is conducive to the generation of economies of scale, especially external economies of scale. Based on the discussion above, the motivation of our study is to understand the relationship between industry geographic concentration or agglomeration and trade activities.

As for the empirical research subject, Guangxi, officially the Guangxi Zhuang Autonomous Region (GZAR), is located at the intersection of the east, middle and west regions of China, and has lots locations along the coast, along the border and along the river. It not only connects Southwest, South and Central South China, but most importantly serves as a bridge connecting the vast markets of ASEAN. With the establishment of the China-ASEAN Free Trade Zone, Guangxi provides an ideal transaction and cooperation platform for direct trade, re-export trade and export processing between China, Vietnam and Southeast Asian countries. According to the current situation of Asian economy and trade, Guangxi is the only region connected to the ASEAN market by sea and land in China's promotion of the Belt and Road Portal, which is quite suitable as the research subject of our research. The article will use the 2011 to 2021 statistical data of Guangxi Statistical Yearbook, published by Guangxi Zhuang Autonomous Region Bureau of Statistics, to explore the relationship between the geographic concentration and trade (Guangxi Statistical Yearbook).

II. LITERATURE REVIEW

In this section, we will find out the relationship between economies of scale and trade, and then discuss the connection between industry geographic concentration or agglomeration and economies of scale.

A. Economies of Scale and Trade

After World War II, international trade and economic growth in many countries behaved very differently than classical theory predicted. Since then, joining imperfect competition and economies of scale based on industrial organization theory, the new development of trade and economic growth theory has successfully explained the problems related to intra-industry trade and specialization, and strengthen the traditional trade and economic growth theory.

Since new trade theory cannot endogenize transportation costs, the scholars have extended their research tentacles to the field of economic geography, the concept of industry geographic concentration or agglomeration, hoping to gain new inspiration. Stigler (1968) considered that the geographic concentration or aggregation of manufacturers in an industry will have the effect of increasing the economic

scale of the industry. This is because the geographic concentration of manufacturers will reduce the transportation cost and make the cooperation of manufacturers more efficient. Therefore, the agglomeration of manufacturers in an industry can increase the real effective scale of the industry and further increase the degree of specialization, relative to scattered across the region or country. Helpman (1984) also has a similar view that industry economies of scale refers to the expansion of the entire industry scale, which will increase the degree of specialization of manufacturers, and thus increase the production efficiency of the industry. The outcome of trade policy under imperfect competition would be different from that under perfect competition. The main reason is that the industrial structure plays an important factor affecting the real effect of trade, which leads to the differences in strategies or behaviors of firms (Helpman and Krugman, 1987).

Krugman (1991) applied the theory of increasing returns to scale and imperfect competition to economic geography. He believes that in order to achieve economies of scale and minimize transportation costs, manufacturers tend to locate in areas with large market demand, or concentrate production activities on a few production units in order to be close to the market. Krugman (1991) summed up three reasons for the geographic concentration of industry. First, it provides a pooled labor market with skilled laborers. Second, industries with a higher agglomeration can support the production of non-trade inputs, which improves the degree of specialization in industries. Third, Information spillover can make geographically concentrated manufacturers have better production capacity than scattered manufacturers, and attract manufacturers to move closer to industrial clusters. He found that for primary industries with high fixed costs, such as cement and coal, the location choice of firms is strongly influenced by the proximity of raw materials for production. In addition, some industries will be affected by historical events, causing the development of the industry to be limited to an area. If the production of an industry is concentrated in a certain area resulting from historical events, the area may not be the best production location.

In summary, economies of scale have a strong impact on trade. Generally speaking, economies of scale can be distinguished into internal and external economies of scale. Regardless of the type of economies of scale, manufacturers can reduce production costs and obtain price advantages, so that products can be exported competitively and arise trade activities.

B. Industrial Geographic Concentration and Economies of Scale

According to industrial economic theory, the geographic concentration or agglomeration of industries is conducive to the generation of economies of scale, especially external economies of scale. Industry economies of scale emphasize that the expansion of the entire industry will increase the specialization of manufacturers, and thus increase the production efficiency (Robinson, 1933). Marshall (1920) proposed that external economies can be achieved through the localization of industries, which shows that the geographic concentration or agglomeration of industries will produce industry economies of scale, or external economies.

Stigler (1968) pointed out that when manufacturers cluster together, there will be an effect of improving the economic scale of the industry.

Ellison and Glaeser (1997) believed that the reason for the agglomeration is that in addition to the industrial spillover effect in the region, the natural cost advantages of the region will also attract manufacturers to cluster together. Natural advantages will lead to differences in production costs, including the proximity of raw materials, supporting manufacturers, airports and ports, as well as the level of water and electricity bills, weather conditions, etc., which is consistent with (Krugman, 1991).

The relationship between geographic concentration of industries and economies of scale mentioned above can also be connected from the perspective of (Helpman and Krugman, 1987). Since Helpman and Krugman discussed the trade policy under imperfect competition, it is mainly caused by the change of industry structure. In fact, the degree of geographic concentration is closely related to the industry structure. The industry geographic concentration means that lots manufacturers of the same or related industries are close to each other in terms of geography and space. In theory, the degree of competition within the industry structure is often measured by market concentration. The higher the market concentration, the lower the competition in the market, and the main factors affecting it are the number of manufacturers in the market and the size of the manufacturers (Tirole, 1998). In a product market, if the manufacturers is more and the competition among them is more intense, it represents a lower degree of market monopoly or concentration. Under the assumption that the number of manufacturers in the market remains constant, if the size of firms is larger, it means that the market has a higher degree of monopoly and a lower competition. Therefore, an important factor to the correlation between industry geographic concentration and market concentration is the regional changes in the number of manufacturers, which calls the mobility of manufacturers in regions.

To sum up, when the agglomeration of manufacturers expands the industry scale to a certain extent, it will change the industry structure and generate external economies. This will increase the productivity of manufacturers, or increase the degree of vertical disintegration in the entire industry. As a result, economic activity will be active and production efficiency will increase, which will help the growth of income, employment and trade. Using data from Canada, the impact of transport costs on trade and geographic concentration is examined (Behrens and Brown, 2018).

III. DATA AND MEASUREMENT METHODS

A. Data Sources

Taking a comprehensive look at the current economic and trade situation in Asia, Guangxi is the only region that is connected to the ASEAN market by sea and land as China promotes the Belt and Road Portal. The status of ASEAN in Guangxi's foreign trade is more prominent. In 2014, the foreign trade between Guangxi and ASEAN exceeded 100 billion RMB, and in 2018 it exceeded 200 billion RMB. In 2021, Guangxi's imports & exports to ASEAN are 282.16 billion yuan, with an average annual growth rate of 16.4% in

the past 10 years, which is 7.2 percentage points higher than the average annual growth rate of the country's foreign trade with ASEAN in the same period. The proportion of ASEAN in Guangxi's foreign trade has risen from 40.9% in 2012 to 47.6% in 2021, an increase of 6.7 percentage points. As of 2021, ASEAN has maintained Guangxi's largest trading partner status for 22 years. As mentioned above, this paper will use the data of Guangxi Zhuang Autonomous Region Bureau of Statistics, and take Guangxi as the main research subject to explore the correlation between industry geographic concentration and trade. In 2011 to 2021 Guangxi Statistical Yearbook, we can obtain the required statistical data, such as the number of employees and the volume of foreign economic and trade.

Krugman (1991) considers that administrative region cannot be consistent with market-oriented economic region. However, the most relevant literature on industry geographic concentration or agglomeration still uses the administrative regions. The current divisions of administrative regions in China mainly include four levels: provincial level, prefecture level, county level and township level. Guangxi currently governs 14 prefecture-level cities, 40 municipal districts, 8 county-level cities, 51 counties, and 12 autonomous counties. In theory, using a larger division of administrative region, it is easy to count many manufacturers in different locations in the same area, which will increase the value of the industry geographic concentration index. Due to the limitation of data acquisition, our study uses prefecture-level administrative divisions, including 14 prefecture-level cities.

The industry classification of data can also be large or small. According to the "Industrial Classification for National Economic Activities" issued by the National Bureau of Statistics of China, the national economic activities are divided into four levels: Sector, Major Category, Medium Category and Small Category. Due to data acquisition limitations, we use national economic statistics at the sector level, with a total of 19 sectors.

B. Measurement of Geographic Concentration

Industry geographic concentration can observe the geographical distribution of the entire industrial activity in a country, such as locational Gini coefficient (Krugman, 1991) or EG index (Ellison and Glaeser, 1997). The industry geographic concentration represents the disparity of geographical distribution, and it cannot show whether the degree of agglomeration of industrial economic activities in a certain area is related to other economic performances in the area, such as profit margins, R&D activities and trade. Another measurement concept is simply to observe the number of establishments or employments in a region or area. Holmes (1999) measures the geographic concentration in the region by the number or share of the same industry's employment in the region, and some literature uses the term agglomeration to express it. The two types of measurement indicators have different economic implications and can complement each other depending on research needs.

In order to distinguish the above two different geographic concentrations, we refer to the locational Gini coefficient, geographic entropy or E index as the overall industry geographic concentration, and the number or share of employments or establishment of the industry in the region as the local agglomeration.

To present the overall industry geographic concentration, we select geographic entropy index and locational Gini coefficient (Krugman, 1991) in this paper. Geographic entropy uses the concept of entropy index to measure the industry geographic concentration, and takes the logarithm of share of employment as the weight. The geographic entropy index, E, is defined as (Garrison and Paulson, 1973; Brülhart and Traeger, 2005):

$$E = \sum_{i=1}^{M} s_i \ln s_i^{-1} \tag{1}$$

s_i is region i's share of employment in a particular industry and M is the number of regions where the industry is distributed in a country. When geographic entropy is smaller and approaches zero, it means that the industry is more geographically concentrated. However, geographic entropy still has its shortcomings. It only presents the spatial concentration of economic activities in a single industry, and does not consider the spatial distribution relative to the overall economic activities.

The locational Gini coefficient of Krugman is to observe the difference between the share of employment in entire manufacturing sector and a particular industry in a region. The greater the difference, the greater the employment of the industry in the region deviates from the employment of the manufacturing industry, and the more geographically concentrated the industry is. The measurement concept is to use the calculation of the area enclosed by the 45-degree line and the Lorenz curve, and the coefficient will be between 0 and 0.5 (Krugman, 1991). In order to compare with other indicators of industry geographic concentration, we calculate the area surrounded by the 45-degree line and the Lorenz curve, so that the locational Gini coefficient is between 0 and 1. We define modified locational Gini coefficient by:

$$G = (1/2\bar{L}) \sum_{i}^{M} \sum_{j}^{M} |L_i - L_j| (e_i e_j / E^2) \tag{2}$$

L_i and L_j represent the number of employments in a certain industry in regions i and j, and $\bar{L}$ is the average of industry employments in the country. Then weighted by the share of employment in the manufacturing industry in the region, e_i and e_j are the manufacturing employments in regions i and j respectively, E is the manufacturing employments in the country, and M is the number of regions distributed

The local agglomeration measures the clustering of industry economic activities within a single region and uses employment or establishment for measuring the degree of agglomeration. We calculate the share of employment of the industry within the region to represent the relative agglomeration of the industry, which can be measured from two different perspectives (Chan *et al.*, 2012). If we calculate the share of an industry in a region relative to other distributive regions, then this indicates its intra-industry importance. In other words, it represents the degree of localization economies.

$$SI_{ir} = \sum_{p \in I, p \in R} emp_e / \sum_{p \in I} emp_e \tag{3}$$

ir denotes a particular industry i in a region r and p denotes plants or establishment. I denotes the set of plants in industry

i, while *R* denotes the set of plants in region *r*. Thus, if *p* is in sets *I* and *R*, then *p* belongs to industry *i* and is located in region *r*. emp_p is the number of employment in plant *p*.

On the other hand, if the share of an industry relative to other industries within a local region is calculated, then this indicates its intra-region importance.

$$SR_{ir} = \sum_{p \in I, p \in R} emp_e / \sum_{p \in R} emp_e \qquad (4)$$

Whether it is the overall industry geographic concentration or the local agglomeration, they all contain different economic meanings, can complement each other, and will also be applied in our empirical research.

IV. EMPIRICAL RESULTS

Using the data of Guangxi Bureau of Statistics, we first calculated the geographic entropy index, *E*, and locational Gini coefficient of sectors, *G*, in 2011, 2016 and 2021. According to the empirical results, we found that the sectors with the highest Gini coefficient in 2011, *G11*, were Resident Services and Other services, Leasing and Business services, and Accommodation and Catering, while the lowest were the Production and Supply of Electricity, Gas and Water. By 2021, the sectors with the highest regional Gini coefficients will be Construction, Accommodation and Catering, and Scientific Research and Technical Services, while the lowest will be Public Management and Social organizations. The geographic concentration of Guangxi's sectors has changed greatly in the past 10 years.

In Table 1, we list the 3 sectors with the highest and lowest geographic concentration in 2011, 2016 and 2021, sorted by the 2021 locational Gini coefficient in descending order. In case of Construction sector, with the highest locational Gini coefficient in 2021, the locational Gini coefficient has gradually increased from 0.441 in 2011, 0.628 in 2016 to 0.663 in 2021, indicating that the sector is becoming more and more geographically concentrated. At the same time, the geographic entropy index, *E*, has decreased from 0.877 to 0.686 year by year, which also means that the sector is becoming more and more geographically concentrated, because of the negative correlation between *E* and the degree of geographic concentration. The trend of industry geographic concentration increasing year by year exists in most sectors of Guangxi.

Table 1. 3 Most and least concentrated sectors rank by *G* in 2021

Sectors	E11	G11	E16	G16	E21	G21
Construction	0.877	0.441	0.725	0.628	0.686	0.663
Hotels and Catering Services	0.765	0.581	0.748	0.577	0.685	0.635
Scientific Research and Technical Services	0.828	0.474	0.789	0.523	0.708	0.588
Health and Social Service	0.942	0.301	0.940	0.303	0.929	0.334
Education	0.948	0.287	0.946	0.293	0.945	0.281
Public Management, Social Security and Social Organization	0.957	0.259	0.964	0.239	0.9612	0.248

We calculated the 2011, 2016 and 2021 geographic entropy and locational Gini coefficient and find the correlation between them. Since the smaller the geographic entropy index, the higher the geographic concentration, Table 2 shows that the locational Gini coefficient and the geographic entropy index are both significantly negatively correlated, and the correlation coefficient decreases with time. At the same time, it is also found that the locational Gini coefficient in 2021 is positively correlated with that in 2016 and 2011, and the correlation coefficient decreases with time.

Table 2. The correlation of geographic concentration in 2011, 2016 and 2021

Concentration in 2021	Concentration in 2011, 2016 and 2021				
	E11	G11	E16	G16	E21
E21	0.401	−0.412	0.753	−0.681	--
G21	−0.508	0.542	−0.853	0.812	−0.966

After observing the sector geographic concentration in Guangxi, we further explore the correlation with trade. Taking the number of employments and establishment as the agglomeration subjects, we measured Guangxi's geographic entropy index and locational Gini coefficient from 2011 to 2021, and observed the correlation between Guangxi's geographic concentration and imports, exports, and foreign direct investment. In Table 3, we find that the correlation coefficient between the geographic entropy weighted by the number of employments and imports & exports is –0.932, and the correlation coefficient between the locational Gini coefficient and imports & exports is 0.873, both mean that the imports & exports of Guangxi has a significant positive correlation with its geographic concentration (Gervais and Jensen, 2019). We can find that the correlation between exports and geographic concentration is higher than that of imports and imports & exports. However, Guangxi's geographic concentration has an insignificant negative correlation with FDI. Meanwhile, the correlation between geographical concentration, weighted by the number of firms, and trade is lower than that of weighted by employment. Although the correlation is lower, the inferences are similar to those mentioned above.

Table 3. The correlation between geographic concentration and trade

	E	G	E	G
	(weighted by employments)		(weighted by establishments)	
Imports & exports	−0.932	0.873	−0.566	0.528
Exports	−0.955	0.901	−0.615	0.586
Imports	−0.870	0.811	−0.493	0.446
FDI	0.210	−0.138	0.4202	−0.410

Next, in the perspective of local agglomeration, we calculated the employment share of each sector in 14 regions, and the center of the industry is defined to be the region with the highest share of employment in the sector (Holmes, 1999). We can find that the great majority of industry centers are in Nanning, the capital of Guangxi. In Table 4, we can observe the change of center location. In 2011, the centers of 4 sectors were not located in Nanning. The center of mining is in Hechi, the center of Service to Households, Repair and Other Services is in Liuzhou, and the center of Agriculture, Forestry, Animal Husbandry and Fishery is in Chongzuo. In 2016, there were 3 sector centers not located in Nanning, and there

is only 1 center in Hechi in 2021. In addition, until 2021, the center of the mining sector has not been Nanning, and such a discovery is in line with expectations. Because the mining sector is related to environmental resources, which represent natural cost advantage (Ellison and Glaeser, 1999), and belongs to local production activities, the center is not easy to relocate.

Table 4. The center of sectors in 2011, 2016 and 2021

	Sectors	Center
2011	15 industrial sectors	Nanning
	Mining	Hechi
	Service to Households, Repair and Other Services	Liuzhou
	Agriculture, Forestry, Animal Husbandry and Fishery	Chongzuo
	Production and Supply of Electricity, Heat, Gas and Water	Guilin
2016	16 industrial sectors	Nanning
	Mining	Baise
	Agriculture, Forestry, Animal Husbandry and Fishery	Chongzuo
	Manufacturing	Liuzhou
2021	18 industrial sectors	Nanning
	Mining	Hechi

We use the imports and exports data of each region to observe the relationship with the intra-industry agglomeration, *SI*, and the intra-region agglomeration, *SR*. In Table 5, we found that the average of correlation between imports & exports and *SI* is higher than that between imports &exports and *SR*. In other words, the higher the intra-industry agglomeration is, the more conducive it is to trade, and the correlation between intra-region agglomeration and the trade is not obvious. In addition, the proportion of sectors showing a positive correlation was 73.68% in 2011, slightly reduced to 68.42 in 2016, and as high as 94.73% in 2021. The above figures are higher than the part of intra-region agglomeration, *SR*. But we also found that the intra-region agglomeration has gradually had a positive correlation with trade, and the proportion of sectors showing a positive correlation has increased year by year to 68.42%. To sum up, the industry agglomeration in regions has a positive impact on trade, while the regional specialization of sectors does not have a significant positive impact.

Table 5. The import & exports correlation with agglomeration

	Correlation with *SI*		Correlation with *SR*	
	Average	Percentage	Average	Percentage
2011	0.103	73.68%	−0.033	42.11%
2016	0.046	68.42%	0.042	57.89%
2021	0.235	94.73%	0.096	68.42%

V. CONCLUSION

Through the two measurement methods, overall industry concentration and local agglomeration, we obtained some meaningful empirical results. First of all, the industry geographic concentration increases year by year in most sectors of Guangxi, and Guangxi's imports & exports has a significant positive correlation with the overall geographic concentration during 2011 to 2021. Secondly, in terms of industry-region agglomeration, the industry agglomeration in regions has a positive impact on trade activities, while the regional specialization of sectors does not have a significant positive impact. In other words, the intra-industry

agglomeration is more conducive to trade activities.

In terms of policy, this study supports the importance of strengthening the agglomeration of supply chains in the face of the current collapse of globalization. Due to the limitation of data acquisition, the economic variables we can connect to and use are not much, and it is difficult to use econometric regression methods that can be explored in depth.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Li-Yu Chan wrote the paper. Wenfang Ou organized and analyzed the data. All authors had approved the final version.

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