Spatial and Temporal Patterns of China's High-Tech Industries and Structural Decomposition of Sources of Spatial Variation: 2012-2020

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Abstract. This paper investigates the spatial distribution of high-tech industries in China and the structural decomposition of their sources of spatial variation from 2012 to 2020. The results are visualized by using ArcGis plotting. And the Thiel index is used to quantitatively analyze the overall regional differences, intra-zone differences and inter-zone differences, as well as the contribution rate of intra-zone differences and inter-zone differences to the overall differences in China's high-tech industry from 2012 to 2020. China's high-tech industry is characterised by uneven development within the Eastern, Western, Central and Northeastern Regions. Especially within the Western Region, the development is very uneven. It is recommended to introduce high-tech talents to the less developed areas of high-tech industry; to provide stronger policies to help the local high-tech industry; to further divide the Western Region into developed and less developed areas of high-tech industry in the west, and to provide more precise assistance.

Keywords: High-tech industry; East-West gap; Industry distribution.

1. Introduction

China's high-tech industry has experienced three important transition stages from the initial germination of the founding of the people's Republic of China to the vigorous development today - the primary stage, the innovation research stage and the current stage [1]. At present, the main goal of China's high-tech and industrial development is to strengthen scientific and technological innovation and accelerate the industrialization of scientific and technological achievements [2]. However, the industrialization process of scientific and technological achievements has an obvious tendency of postposition due to cognitive deviation, blocked industrialization channels and other reasons [3].

With the passage of time, the development of high-tech industry is in a state of continuous development. With the reform and opening up, the capital market plays a positive role in the high-tech industry, leading the continuous research and breakthrough of the high-tech industry [4]. However, high-tech industries also have a negative effect on economic development [5]. Since the reform and opening up, the scientific and technological progress brought by high-tech industries has been the most important factor affecting China’s economic growth [6]. Moreover, the WTO has brought rare development opportunities and broad prospects to China's high-tech industry, which enables China to integrate into the global high-tech industry market in time and learn from the advanced technology and experience of developed countries in developing high-tech industries faster and more directly [7]. With the continuous recurrence of the epidemic and the escalation of friction between China and the United States, some high-tech industries in China have also been suppressed. Under the impact of the epidemic, the global demand market was suddenly cold, and the U.S. repressive policy towards China's high-tech industries has severely hit high-tech industries such as semiconductors [8]. In order to solve this dilemma, Xu Yan et al. [9] proposed a merger and acquisition plan. However, due to the influence of overseas policies, the cross-border M & a plan is not satisfactory.

In China, high-tech industries have strong regional differences, mainly in the differences between the East and the West. There are 13 high-tech zones in the west, accounting for 24.5% of the total
number of 53 high-tech zones in China, and the absolute gap with the Eastern and Central Regions is still widening [10]. There are not only regional differences in the development of high-tech industries, but also regional differences in the coordination of high-tech industries - differences between the East and the West [11]. From this point of view, the coordinated regional difference between the East and the West or the regional difference between the East and the west of high-tech industries is one of the causes. Of course, there are many reasons for the gap between the East and the west of high-tech industries, such as the level of science and technology finance, the level of higher education, and the conversion rate of enterprise achievements [12-14]. In terms of enterprise achievement conversion rate, the technical composition of the vast majority of enterprise asset stocks in the western region does not meet the market demand for product development and production [15].

The high-tech industry has also brought many positive effects to the economy and environment. From 1996 to 2005, the degree of specialization and concentration of China's high-tech industry showed an upward trend, slowing down the carbon emissions caused by the upgrading of industrial structure, promoting employment and enhancing the core competitiveness of enterprises [16-18].

To sum up, studying the spatial-temporal pattern of high-tech industry is conducive to analyzing the development trend of China's high-tech industry, providing theoretical guidance for stimulating the development vitality of high-tech industry and promoting the balanced development of the East and the West.

2. Research Methodology and Data

2.1 Research Methodology

Due to the uneven and unequal development of the high-tech industry across regions. China's high-tech industry has a large gap between different zones as well as within their respective zones. This paper focuses on the spatial and temporal patterns of China's high-tech industry and the decomposition of spatial gap sources, which is essential to study the gaps and sources of gaps. In this paper, the Thiel coefficient is chosen as a tool to analyse the spatial disparities in China's high-tech industry.

Thiel Index

This paper adopts a one-stage Thiel index decomposition method to calculate and decompose the differences in high-tech industry development between regions based on output value. The Thiel index is an indicator used to measure data differences in inter-regional differences. This paper selects the GE0 index to analyse the inter- and intra-regional differences in China's high-tech industry. GE0 is a Thiel index based on generalised entropy (α=0), a Thiel index weighted by population but only one variable, y (in this paper, the output value of the high-tech industry), is required.

Thiel’s index (total variance)

\[ T = \frac{1}{n} \sum \sum \log \frac{\mu}{y_{ij}} \]  

(1)

Where \( n \) represents the number of all provinces in China (31 provinces, cities and autonomous regions in this paper), \( \mu \) represents the average output value of high-tech industries in the 31 provinces, cities and autonomous regions in the country, and the subscript \( y_{ij} \) represents the output value of high-tech industries in a particular province/municipality.

\( T_i \) (differences between individuals in the region)

\[ T_i = \frac{1}{n_i} \sum \log \frac{\mu_i}{y_{ij}} \]  

(2)
Where \( n_i \) represents the number of provinces and cities included in the ith region, \( \mu_i \) represents the average output value of the high-tech industry in the ith region, and \( y_{ij} \) represents the output value of the high-tech industry in a particular province/municipality.

\[
T_{WR} = \sum_{i=1}^n \frac{n_i}{n} \sum_{j=1}^{n_i} \log \frac{\mu_i}{y_{ij}}
\]  

(3)

Where \( n \) represents the number of all provinces in the country and \( n_i \) represents the number of provinces and municipalities included in the ith region.

\[
T_{BR} = \frac{1}{n} \sum_{i=1}^n \mu_i \log \frac{\mu_i}{\mu}
\]  

(4)

Where \( n \) represents the number of all provinces in the country, \( n_i \) represents the number of provinces and cities included in the ith region, \( \mu \) represents the average output value of the high-tech industry in the 31 provinces, cities and autonomous regions in the country, and \( \mu_i \) represents the average output value of the high-tech industry in the ith region.

\[
T = T_{WR} + T_{BR}
\]  

(5)

Regional differences in China’s high-tech industry can be decomposed into intra-zone differences and inter-zone differences.

2.2 Data

This paper selects the high-tech industry output value of 31 provinces, cities and autonomous regions in China from 2012 to 2020 (including missing data in 2017), and divides each province, city and autonomous region in China into four regions: the Eastern Region, the Central Region, the Western Region and the Northeastern Region. The Eastern, Central, Western and Northeastern Regions are divided according to the traditional zoning method. The Eastern Region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong and Hainan. The central region includes Shanxi, Jiangxi, Henan, Hubei, Hunan and Anhui Provinces. The Western Region includes Chongqing, Sichuan, Guizhou, Yunnan, Tibet Autonomous Region, Shaanxi, Gansu, Qinghai, Ningxia Hui Autonomous Region, Xinjiang Uygur Autonomous Region, Inner Mongolia Autonomous Region and Guangxi Zhuang Autonomous Region. The Northeast Region includes Liaoning, Jilin and Heilongjiang provinces. All data in this article are from the China Urban Yearbook (2012-2020).
3. Empirical Analysis

3.1 Spatial differences

The value of high-tech industry output in the Eastern Region is significantly higher than that in the northeastern, central and Western Regions (Figure 1-4). The value of the high-tech industry in the Central Region is between the Eastern Region, the Northeastern Region and the Western Region. The Northeast and West Regions are disadvantaged areas for high-tech industries. In the Eastern Region, the output value of high-tech industry is the highest in Jiangsu, Zhejiang and Shanghai and Guangdong Province, which are also the regions with the highest output value of high-tech industry in China. In the Eastern Region, Beijing, Shandong, Henan and Fujian provinces, and in the Western Region, Sichuan province are in the second tier of high-tech industry output value. Some regions in the Central Region, such as Shaanxi, Hubei, Hunan, Jiangxi and Anhui, and Liaoning in the northeast, are in the third tier. The rest of the Western and North-eastern Regions are in the fourth tier. Over the period 2012-2020, the general trend in the distribution of high-tech industry output in China does not change much. Locally, Jilin Province falls from the third to the fourth echelon, while Yunnan Province and Guangxi Province move from the fourth to the third echelon.

It also can be seen that the value of high-tech industry output in the Eastern Regions of Jiangsu, Shanghai and Guangdong is significantly higher than in the other Eastern Regions. The output value of high-tech industries in Sichuan Province in the Western Region is also significantly higher than that of other regions in the west. Figure 3-2 shows that the contribution of intra-regional variation is increasing between 2012 and 2020, rising from 61% in 2012 to 67% in 2020. This includes a low of
61% in 2012 and a high of 67% in 2019 and 2020; the contribution of inter-belt variation is declining, from 39% in 2012 to 33% in 2020. The contribution of inter-belt variation is the highest in 2012 at 39% and the lowest in 2019 and 2020 at 33%. This indicates that for the intra-belt variation in China's high-tech industry, there is an increase between 2012 and 2020, but the magnitude is not significant. For the inter-belt variation in China's high-tech industry, it declines, but the magnitude is still not significant. Overall, the contribution of inter-belt variation to overall variation in China's high-tech industry tends to widen compared to the contribution of intra-belt variation to overall variation.

3.2 Analysis of the characteristics of regional differences in China's high-tech industry

Table 1. Overall Thiel coefficient, intra-zone variation, inter-zone variation for the period 2012-2020

| Year | Overall differences | Intra-regional variation | Inter-regional differences |
|------|---------------------|--------------------------|---------------------------|
| 2012 | 0.554379            | 0.337601                 | 0.216778                  |
| 2013 | 0.537647            | 0.347428                 | 0.190219                  |
| 2014 | 0.519842            | 0.343152                 | 0.17669                   |
| 2015 | 0.490462            | 0.314495                 | 0.175967                  |
| 2016 | 0.485659            | 0.318299                 | 0.16736                   |
| 2018 | 0.481179            | 0.310403                 | 0.170777                  |
| 2019 | 0.471791            | 0.314303                 | 0.157488                  |
| 2020 | 0.481067            | 0.321974                 | 0.159094                  |

Figure 5. Evolution of the overall variation in the output value of China's high-tech industries, within-zone and between-zone variation, 2012-2020

During the period 2012-2020, the overall Thayer Index for the output value of China's high-tech industry gradually decreases from 0.554379 to 0.481067 (Figure 5, Table 1). This indicates that the overall difference between China's high-tech industries is gradually decreasing and the gap is narrowing. Looking at the inter-year variation characteristics of the overall Thiel index for the output value of China's high-tech industry, the changes in China's high-tech industry can be roughly divided into two phases: 2012-2015 and 2015-2020. In particular, the overall difference in the output value of high-tech industries is declining relatively sharply between 2012-2015; between 2015-2020, the overall difference in the output value of high-tech industries is declining relatively slightly, and there is a relatively small rebound between 2019-2020. The trend is that the overall difference in output
value of high-tech industries is declining relatively sharply between 2015 and 2020, and there is a relatively small rebound between 2019 and 2020. We can also see from Figure 5 that within-belt variation is consistently much higher than between-belt variation. Intra-belt variation was high between 2012 and 2014, with an average of 0.342727091, and declined relatively sharply between 2014 and 2015, from 0.343152 to 0.314495, before levelling off after 2015, with occasional small bounces. Between 2015 and 2020, the average within-zone variance is 0.315894655. the between-zone variance of China's high-tech industry gradually and steadily declines from 0.216778 in 2012 to 0.159094.

The overall variance, intra-belt variance, and inter-zone variance were averaged for the first three years (2012-2014) and the last three years (2018-2020), respectively, and then the magnitude of change was calculated. We can find that the decline in overall variance is about 11%, the decline in intra-belt variance is about 3% and the decline in inter-belt variance is about 17%. We find that all three indicators show a decreasing trend, but none of the decreases are significant. This indicates a downward trend in inter-zone, intra-zone and overall variation over the period 2012-2020. The decline in inter-zone variation is relatively large, while the decline in intra-zone variation is relatively small.

Figure 6. Contribution of intra-zone variation and inter-zone variation to overall variation in China's high-tech industry output value, 2012-2020

Figure 7. Trends in the contribution of intra-zone variation and inter-zone variation to overall variation in China's high-tech industry output value, 2012-2020
As can be seen from Figure 3-1, the within-zone variation has always been nearly double that of the within-zone variation, so the differences in high-tech industry output between the Eastern, Central, Western and Northeastern Regions of China are not so great, but rather the within-region variation is the main component of the variation (Figure 6,7).

![Figure 8. Evolution of differences within the four regional zones of China's high-tech industry, 2012-2020](image)

During the period 2012-2020, the intra-belt provinces in the Western Region have the largest differences, the intra-belt provinces in the Eastern Region, followed by the second largest intra-belt variation, and the smallest intra-belt variation between provinces in the Northeast and Central Regions, with the intra-belt (Figure 8).

The degree of intra-belt variation is similar. In the period 2012-2014, the intra-belt variation in the Western Region was high, with a mean value of 0.587908, and decreased in the period 2014-2015. The intra-belt variation in the Western Region was relatively low in 2015 and beyond, with a mean value of 0.50224, a decrease of 17%. The decline was 17 per cent. As can be seen, the intra-western zone variation between provinces declined relatively sharply between 2014 and 2015. The difference between provinces in the Western Region has declined significantly between 2014 and 2015 and has rebounded slightly since 2015. Intra-belt variation in the Eastern Region has been rising moderately, from 0.297502183 in 2012 to the increase is around 8%. The highest point was 0.323947254 in 2018.

In contrast, the within-belt variation in the Northeast declined between 2012 and 2015, but has been rising since 2015, from 0.04833 in 2015 to 0.1323 in 2020, a staggering 174% increase. For the Central Region, the period 2012-2015 has been in a slow upward phase, it started to slowly decline in 2015 and beyond, but the decline between 2016 and 2018 was relatively the decline was relatively large between 2016 and 2018. For the Northeast, the intra-belt variation in the Central Region was similar from 2012 to 2015, but since 2016, the intra-belt variation in the Northeast has been relatively large.

However, since 2016, the intra-belt differences in the Northeast Region have been on the rise, and have been increasing in distance from the Central Region. In 2020, the intra-belt variation is nearly double that of the Central Region. In 2012, the intra-regional disparities are, from largest to smallest Western Region, Eastern Region, Central Region and Northeast Region. By 2020, the intra-regional disparities will be, from largest to smallest Western Region, Eastern Region, Northeast Region and Central Region. It can be seen that in the eight years from 2012 to 2020, the Northeast Region the intra-regional gap in the Northeast Region exceeds the intra-regional gap in the Central Region.
4. Conclusions and Recommendations

This paper has characterised and deconstructed the disparities in China's high-tech industries by conducting the Thiel Index calculation, and has drawn the following conclusions and recommendations.

4.1 Conclusions

(1) China's high-tech industries are still mostly distributed in the eastern coastal zone, while the Western Region, with the exception of Sichuan Province and the Northeast Region as a whole are not optimistic in terms of the development of the high-tech industry. This shows that the gap between the east and the west of China's high-tech industry, and the gap between the north and the south of the country is still a concern.

(2) During the period 2012-2020, China's high-tech industry will be divided into four major regions, namely the East, Central, West and Northeast. The intra-regional differences in China's high-tech industry are significantly higher than the inter-regional differences in China's high-tech industry. This suggests that for the development of high-tech industries today, the main contradiction is not only the gap between the development of east and west, in the Western Region, the difference in development between different provinces. The development gap between different provinces is also large.

(3) The overall differences in China's high-tech industry are on a declining trend and, overall. The level of development of the country's high-tech industries should be constantly being brought closer together. Intra-belt differences and inter-belt differences are also declining. However, in recent years, there has been a slight rebound. This indicates a tendency to widen the gap.

4.2 Policy recommendations

(1) The government should pay attention to the less developed areas of high-tech industry and implement high-tech talent introduction policies to prevent brain drain. At the same time, a more powerful policy of supporting and incubating high-tech micro and small enterprises in the less developed areas of high-tech industry should be implemented.

(2) The development of high-tech industries in the Western Region is unbalanced, which should be re divided into the Western Region with developed high-tech industries and the Western Region with relatively backward high-tech industries. The development of high-tech industries in the Western Region is unbalanced. At the same time, there are also significant regional differences in the Eastern Region. The overall high-tech industry in the Eastern Region is more developed than other regions, but the Eastern Region is also facing the problem of unbalanced development of high-tech industry. In the current situation. The unbalanced development of high-tech industries in the Eastern Region cannot be ignored because they are relatively developed on the whole. Encourage talents to flow to the relatively underdeveloped areas in the East.

(3) Although inter-regional differences are not as great as intra-regional differences, they should not be taken lightly. It is important to continue to guide the flow of talent to the Western Region for importation and to continue to narrow the gap between the East and West Regions.

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