

Research Article

A σ -Convergence Model for Analyzing the Balance of Insurance Industry in China

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There are significant regional differences in the development of China's insurance industry. An important question is that such regional differences are expanding or shrinking? Based on Barrow's economic growth convergence model, this paper uses the σ convergence model to analyze the differences in the development of China's insurance industry and its trends. It draws on the statistics data from 1990 to 2020. The empirical results show that the convergence of China's insurance development is not obvious before 2006, but it shows a significant convergence after 2006. And, there are some differences between the Eastern, the Central, and the Western. Furthermore, when considering the spatial correlation, the convergence of insurance development among provinces in China is more obvious. This shows that the flowing of capital, technology, and labor force between regions may be beneficial to the balanced development of insurance among the regions.

1. Introduction

With the rapid growth of China's economy, China's insurance industry has also experienced rapid development. Since China's insurance business resumed in 1980, the insurance premium has grown rapidly from 460 million yuan in 1980 to 4.53 trillion yuan in 2020, with an annual compound growth rate of nearly 30%. The insurance penetration and the insurance density have increased from almost zero to 4.5% and 3,233 yuan, respectively, in 2020. The share of the world market has also grown almost from zero to 12.4% in 2020. However, China is a vast country with large regional differences. While China's insurance industry has made brilliant achievements in the total volume, it also presents a large regional unbalance [1–5]. In 2020, the region with the highest density was 9.65 times that with the lowest density, according to the National Bureau of Statistics. The regional unbalance in the development of insurance industry is not only unfavorable to the formation of effective market competition pattern but also unfavorable to the diversification of insurance market operation risks. And, it will restrict the ability of insurance market opening to the

outside world and even aggravate the unbalance of regional economic development [2].

The report of the 19th National Congress of the Communist Party of China pointed out that “China's social productivity has increased significantly on the whole. The more prominent problem is that our development is unbalanced and inadequate.” Then, is such unbalance in China's insurance industry development gradually expanding or shrinking? The economic growth convergence theory of the neoclassical school of economics can well answer this question: if the development of China's insurance industry exhibits convergence, it indicates a shrinking trend in the unbalanced development of our insurance industry; otherwise, the unbalance in our insurance industry development continues to expand.

The neoclassical economic growth theory thinks that due to the diminishing marginal return of capital, as the capital stock grows, the economic or financial growth of the country or region will slow down, or even stop. At the same time, due to the diminishing marginal return of capital, the backward areas will have faster economic or financial growth than developed areas, that is, there is a phenomenon of

convergence in economic or financial development. Baumol [6] studied and analyzed the per capita income data of 16 countries from 1870–1978 for more than 100 years, finding obvious economic convergence in these countries. Although many scholars subsequently questioned the convergence hypothesis of neoclassical economics [7] and even many empirical studies have shown the inconsistency among the actual situation and the convergence theory, the unique charm of the economic growth convergence hypothesis still attracts many scholars to conduct more extensive and detailed research studies about economic growth convergence, with a view to extending and perfecting the theory of economic growth convergence.

Since the modern neoclassical school of economics put forward the hypothesis of economic growth convergence, researchers have done more and more research studies in this regard [8–15]. Economic growth convergence includes σ -convergence, β -convergence, and club convergence. The so-called economic growth β convergence means there is negative correlation between the growth rate of economic development and its initial level, that is, relatively backward regions have higher economic growth rate than relatively rich regions [16]. In actual research, scholars further divide β convergence into absolute β convergence and conditional β convergence. The former means that the economic growth rate is only related to the initial level, while conditional convergence examines not only the economic growth rate and the initial level but also other factors such as institutional environment and resource endowments. Since conditional convergence can consider factors such as institutional environment and resource endowments, it is often used to analyze the factors influencing economic growth convergence. On this basis, policy recommendations of reducing the economic growth gap between regions are proposed. Exactly because of this, domestic and foreign scholars' research on convergence in the insurance industry development is absolutely dominated by β convergence. Researchers mostly adopt analysis methods of Barro and Sala I. Martin [17], use per capita insurance premium data, and take economic growth models in regression analysis to test and analyze the domestic insurance development convergence. σ -convergence means that the standard deviation of the economic development level between different countries or regions tends to decrease over time. Compared with β convergence analysis which is more susceptible to the selected "initial stage," σ -convergence focuses on changes in the development level differences between countries or regions during the entire research period, which is not easily susceptible to the initial research stage. Therefore, this paper analyzes σ -convergence of our insurance industry development from a spatial perspective to determine the equilibrium status in the development of our regional insurance market. However, we cannot analyze the reasons that cause the convergence using the σ -convergence model.

2. Research Model

According to Barro and Sala I. Martin [17], σ -convergence studies the logarithm dispersion of per capita income between different economic systems. If it tends to decrease over time, it indicates presence of σ -convergence. To describe and

analyze the changes in the differences of the insurance development level among the domestic provinces, this paper uses the standard deviation of logarithm (in $\ln Y_{it}$) of the actual per capita insurance premium in each province to reflect changes in the differences. The calculation formula is as follows:

$$\begin{aligned} y_{it} &= \ln(Y_{it}), \\ \bar{y}_t &= \frac{1}{N} \sum_{i=1}^N y_{it}, \quad i = 1, 2, \dots, N; t = 1, 2, \dots, T, \\ \sigma_t &= \sqrt{\frac{1}{N-1} \sum_{i=1}^N (y_{it} - \bar{y}_t)^2}. \end{aligned} \quad (1)$$

When $\sigma_t > \sigma_{t-1}$, it means that there is σ -convergence in regional insurance development of China.

The logarithmic per capita insurance premium of each province of region in each year is regressed by ordinary least squares (ols) constant term:

$$y_{it} = \bar{y}_t + \varepsilon_{it}, \quad (2)$$

where $i = 1, 2, \dots, N$ and $t = 1, 2, \dots, T$. It can be seen that the variance of the residual term in the regression of equation (2) has an estimated value of σ_t^2 . In the next step, the square root of the variance can be calculated, and the standard deviation σ_t can also be obtained.

However, estimation of σ_t^2 using the residual term ε_{it} of equation (2) means irrelevant insurance development between the provinces. Obviously, this does not comply with the reality [18–21]: Firstly, according to the First Law of Geography, "everything is related to everything else, but near things are more related than distant things." Therefore, there are all kinds of connections in the insurance development among the provinces, and the closer provinces have closer connections. Secondly, it is not independent in the actual economic and financial operation among the provinces. In the literatures, the technology spillover is often regarded as an important mechanism to promote the economic convergence. In the insurance development, the influence of the insurance awareness among residents of various provinces, especially among residents of the neighboring provinces, and the spreading of the insurance management skills are also the important mechanisms to promote the insurance development. Hence, the hypothesis in equation (2) that the insurance development of each region is irrelevant deviates from the reality. Based on this, there may be deviations in the analysis on insurance development convergence of each province. Here, it is necessary to introduce the correlation between regions so that correct judgment on the insurance development convergence in various provinces can be made.

In view of this, this paper considers the spatial correlation based on the ordinary least squares (ols) regression and uses the spatial measurement regression to more accurately analyze the convergence in the domestic insurance industry development. For spatial correlation, based on the fact that there are different variables reflecting the

correlation between institutions or regions in the model, models can be divided into the spatial lag model and spatial error model, that is,

$$\begin{aligned} y_{it} &= \rho\omega y_{it} + \bar{y}_t + \varepsilon_{it}, \\ y_{it} &= \bar{y}_t + \varepsilon_{it}, \\ \varepsilon_{it} &= \lambda\omega\varepsilon_{it} + \mu_{it}, \end{aligned} \quad (3)$$

where the spatial lag model assumes that the insurance industry development in other regions will affect the insurance industry development in the local region; the spatial error model assumes that other factors in other regions will impact the insurance industry development of the local region.

3. Result Analysis

3.1. Data Source and Description. Considering the data's availability, this paper collects the relevant data in 1990 ~ 2020 to study the convergence of our interprovincial actual insurance density (that is, per capita insurance premium) in 31 years. The insurance density of the province is equal to the ratio of the actual insurance premium of the province to the total population of the province at the end of the year, and the insurance premium is deflated based on the price in 1978. The data in the paper comes from the "Compilation of 60-Year Statistical Data of New China" and the "China Insurance Yearbook" of the years. Table 1 below shows the basic information about the actual insurance premium in each year.

The spatial weight matrix herein is a neighbor-order matrix generated based on the China Geographic Vector Map of the National Basic Geographic Information System, where Hainan Island is an independent island, which is set to be adjacent to Guangdong Province here.

3.2. Empirical Results. According to Tobler [22] First Law of Geography, everything is related to everything else, but near things are more related than distant things. Based on this, we believe that certain correlation exists between the province-level regions in domestic insurance development, and there is stronger relevance in the neighboring provinces on the insurance development. Due to the complexity of spatial correlation, there are many methods and indicators to measure spatial correlation, among which the Moran index is more prevalent [23]:

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{s^2 \sum_{i=1}^n \sum_{j=1}^n w_{ij}}, \quad (4)$$

where $s^2 = (\sum_{i=1}^n (x_i - \bar{x})^2/n)$ is the sample variance, w_{ij} is the (i, j) element of the spatial weight matrix used to measure the distance between the province i and the province j , and $\sum_{i=1}^n \sum_{j=1}^n w_{ij}$ is the sum of all the spatial weights. If the spatial weight matrix is row-normalized, then $\sum_{i=1}^n \sum_{j=1}^n w_{ij} = n$. At this time, Moran index I can be written as

$$I = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n \sum_{j=1}^n (x_i - \bar{x})^2}. \quad (5)$$

If the spatial weight matrix is a row-normalized matrix, the value of Moran index I is between -1 and 1 . A value greater than 0 indicates positive autocorrelation, that is, high value is adjacent to high value, while low value is adjacent to low value. On the contrary, a value smaller than 0 indicates negative correlation, that is, high value is adjacent to low value. If the Moran index I approaches 0 , it means that the spatial distribution is random and there is no spatial correlation.

In this paper, the weight matrix adopts the simple geographic adjacency weight matrix, that is, for the 31 provinces in Mainland China, if they are geographically adjacent, the corresponding weight is 1 ; otherwise, it is 0 . In addition, for Hainan Province which is not adjacent to any other province, to facilitate calculation, it is assumed that Hainan Province is adjacent to its nearest Guangdong Province. At the same time, row normalization is performed on the weight matrix, that is, the sum of each row in the matrix is 1 .

As shown in Table 2 below, the results show significantly positive Moran index of insurance density in each province from 1990 to 2017, indicating that there is significant spatial positive correlation in the provincial insurance development.

4. Discussions

Figure 1 below is a time series diagram regarding the standard deviation of the logarithm of the per capita insurance density in each province without considering spatial correlation. It can be seen that, from the national perspective, before 2006, the logarithmic variance of our interprovincial insurance density waved between 0.49 and 0.68 and did not show a significant downward trend, that is, our interprovincial insurance development did not reveal obvious convergence. After 2006, the logarithmic variance of insurance density dropped from 0.60 in 2006 to 0.22 in 2020 and exhibited a clear downward trend, that is, after 2006, interprovincial insurance development displayed obvious convergence in our country.

Furthermore, we divide the country into the Eastern, Central, and Western regions and analyze σ -convergence of the insurance development among the provinces and cities in the Eastern, Central, and Western. It can be seen that, before 1998, the insurance density logarithm among the provinces in the Eastern region showed a significant increase, increased from 0.32 in 1990 to 0.67 in 1998, while between 1998 and 2005, the logarithm variance of insurance density in the Eastern region showed a relatively stable, waved between 0.62 and 0.72 . And, after 2006, the Eastern provinces exhibited obvious convergence, dropped from 0.62 in 2006 to 0.21 in 2020, while the Central and the Western provinces are relatively stable in the research span.

Finally, we further consider σ -convergence with the spatial correlation. As mentioned above, the insurance

TABLE 1: Statistics on the actual insurance premium of each province from 1990 to 2017 (unit: 100 million yuan).

Year	Minimum	Maximum	Median	Mean	Standard deviation	Total premium
1990	0.031	8.340	1.752	2.269	1.827	70.352
1991	0.032	10.666	2.182	2.895	2.414	89.731
1992	0.039	15.851	2.965	4.186	3.633	129.773
1993	0.052	19.562	3.362	4.554	4.156	141.161
1994	0.048	21.422	3.122	4.408	4.245	136.657
1995	0.073	21.400	3.329	4.696	4.320	145.578
1996	0.076	21.678	3.996	5.670	4.939	175.760
1997	0.091	24.189	5.508	7.956	6.872	246.622
1998	0.104	27.855	6.196	9.027	7.318	279.847
1999	0.130	35.720	6.742	10.548	8.747	326.973
2000	0.162	44.658	9.297	12.239	10.124	379.415
2001	0.182	56.596	9.870	15.557	13.890	482.273
2002	0.201	72.588	15.864	22.683	19.641	703.175
2003	0.234	87.359	20.631	28.453	24.256	882.031
2004	0.315	95.685	22.848	30.537	25.758	946.632
2005	0.338	107.594	26.251	34.246	30.081	1061.614
2006	0.413	128.955	29.931	38.514	32.677	1193.944
2007	0.543	163.960	31.507	45.352	38.867	1405.913
2008	0.622	215.225	48.058	59.627	49.142	1848.444
2009	0.773	237.219	53.636	68.343	56.291	2118.646
2010	0.944	265.189	64.022	85.219	68.267	2641.776
2011	1.345	279.463	60.835	80.707	66.515	2501.916
2012	1.646	291.896	63.021	84.822	69.641	2629.471
2013	1.922	319.924	69.331	92.940	75.084	2881.133
2014	2.103	385.962	78.581	106.017	87.303	3286.542
2015	2.822	457.472	95.372	125.679	102.167	3896.057
2016	3.546	608.846	111.267	157.111	134.952	4870.434
2017	4.394	675.231	136.315	183.071	155.498	5675.209
2018	5.139	716.529	138.133	188.021	155.574	5840.621
2019	5.524	820.543	142.132	205.121	174.413	6366.826
2020	5.799	823.430	143.863	212.371	178.851	6952.425

development in all the provinces is significant spatial correlate. Therefore, the σ -convergence analysis without considering the spatial correlation would be inaccurate. We, respectively, adopt the spatial autocorrelation model (sar), the spatial error model (sem), and the model that considering the spatial autocorrelation and the spatial error term at the same time (sae). Figures 2–5 show the standard deviations of the spatial models of the national, Eastern, Central, and Western provinces, respectively. At the same time, we also show the results without considering the spatial correlation (ols) to compare.

It can be seen from Figure 2 that the standard deviation of the spatial error model (sar) is basically the same as that of the ordinary least squares model without considering the spatial correlation, not only the same trend but also the little difference in value. And, the standard deviation of the spatial autocorrelation model is basically the same as that of the model that considering the spatial autocorrelation and the spatial error at the same time (sae). Although the standard deviation of the spatial autocorrelation model has basically the same trend as that of the spatial error model and the ordinary least squares model, the standard deviation value has dropped significantly. This suggests that, after considering the spatial autocorrelation, the divergence of the insurance development among the provinces has decreased

significantly. This means that the insurance development in the province can be affected by the neighboring provinces.

Finally, in the regional analysis of the three regions in the Eastern, Central, and Western regions, as shown in Figures 3–5, the standard deviations of regions with or without considering the spatial correlation show great differences:

Firstly, compared with the national model with or without spatial correlation, the standard deviation of the ordinary least square model without the spatial correlation in the Eastern and the Western regions is numerically smaller than that of the model with spatial correlation, while the standard deviation of the model with or without spatial correlation in the Central region has little difference.

Secondly, there is no obvious upward or downward trend in the standard deviation of the ordinary least squares model, and the standard deviation of the spatial error model shows a downward trend after a rising beginning, that is, if we do not consider the spatial correlation, the insurance development of the Western provinces shows no loose or convergence characteristics. However, when considering the spatial correlation, it shows the characteristic of the divergence at the beginning and the convergence finally.

TABLE 2: Moran index of logarithm of insurance density in each province from 1990 to 2017.

Year	Moran index I	$E(I)$	$sd(I)$	z	p value*
1990	0.314	-0.033	0.107	3.240	0.001
1991	0.369	-0.033	0.108	3.734	≤0.001
1992	0.409	-0.033	0.108	4.098	≤0.001
1993	0.324	-0.033	0.107	3.340	0.001
1994	0.274	-0.033	0.105	2.916	0.004
1995	0.269	-0.033	0.106	2.848	0.004
1996	0.205	-0.033	0.106	2.253	0.024
1997	0.237	-0.033	0.104	2.603	0.009
1998	0.216	-0.033	0.104	2.394	0.017
1999	0.192	-0.033	0.104	2.157	0.031
2000	0.203	-0.033	0.105	2.255	0.024
2001	0.226	-0.033	0.105	2.484	0.013
2002	0.242	-0.033	0.105	2.626	0.009
2003	0.277	-0.033	0.105	2.960	0.003
2004	0.310	-0.033	0.105	3.260	0.001
2005	0.271	-0.033	0.104	2.929	0.003
2006	0.266	-0.033	0.105	2.859	0.004
2007	0.254	-0.033	0.105	2.727	0.006
2008	0.226	-0.033	0.105	2.461	0.014
2009	0.228	-0.033	0.105	2.493	0.013
2010	0.236	-0.033	0.104	2.584	0.010
2011	0.234	-0.033	0.105	2.531	0.011
2012	0.228	-0.033	0.105	2.481	0.013
2013	0.227	-0.033	0.106	2.463	0.014
2014	0.221	-0.033	0.105	2.420	0.016
2015	0.248	-0.033	0.105	2.677	0.007
2016	0.240	-0.033	0.105	2.592	0.010
2017	0.256	-0.033	0.106	2.738	0.006

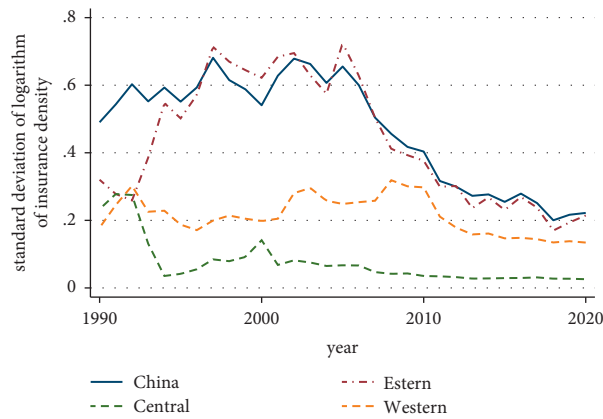


FIGURE 1: Time series diagram on the standard deviation of logarithm of the insurance density in China during 1990–2020.

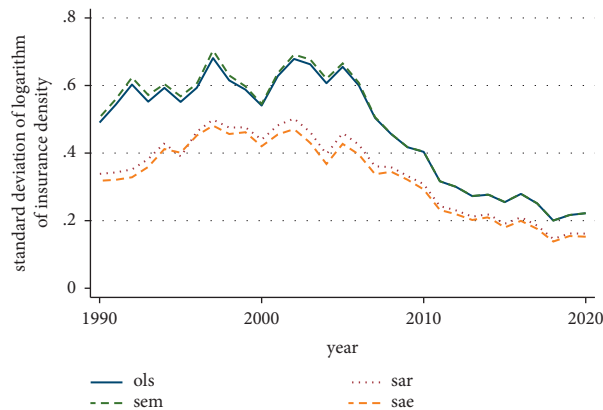


FIGURE 2: Time series diagram on the standard deviation of logarithm of the insurance density in China during 1990–2020.

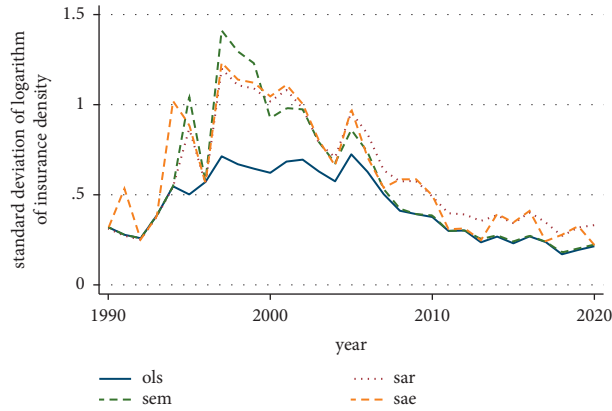


FIGURE 3: Time series diagram on the standard deviation of logarithm of the insurance density in eastern China during 1990–2020.



FIGURE 4: Time series diagram on the standard deviation of logarithm of the insurance density in central China during 1990–2020.

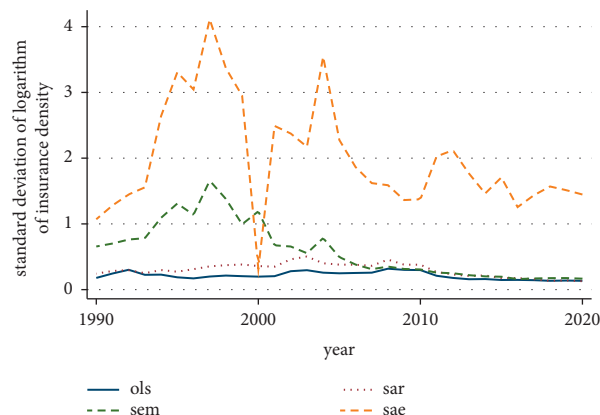


FIGURE 5: Time series diagram on the standard deviation of logarithm of the insurance density in western China during 1990–2020.

5. Conclusions

The balanced development of China’s insurance among provinces not only affects the formation of an orderly market competition pattern but also is conducive to the spread of insurance business risks and even affects the balanced development of the interprovincial economy. Based on Barrow’s economic growth convergence model, this paper uses

the σ convergence model to analyze the differences in the development of China’s insurance industry and its trends. On the whole, the development of the insurance industry among China’s provinces shows the characteristics of σ -convergence, and we draw the conclusion that the development imbalance of the insurance industry among China’s provinces declines. Insurance is one of the effective means of the risk management in social and economic

development and plays an important role in the loss compensation, the fund financing, and the social management. Therefore, the convergence of the insurance industry is related to the stability of the insurance market and even affects the economic and social development of the whole country. Based on the traditional disregard of the mutual influence of insurance development among regions, this paper uses the method of spatial econometrics to emphasize the spatial correlation of the development of insurance in the different provinces and to analyze and test the convergence of the development of insurance industry in China.

Firstly, according to the First Law of Geography, the insurance development may be relevant among the provinces. This paper calculates the Moran index of the insurance density of the domestic provinces in 1990–2020, and the results indicate that insurance development in domestic provinces is indeed spatially correlated. This means that each province's insurance development is affected by the neighboring insurance development. Therefore, there are deviations in the traditional σ -convergence analysis, and we should consider σ -convergence considering the spatial correlation.

Secondly, regardless of whether spatial correlation is considered, on the whole, there has been a σ -convergence in China's insurance development since 2006, but when considering the spatial correlation, the standard deviation should be lower. It means that the difference of insurance development among provinces should be smaller. Based on the neoclassical economic growth model, the insurance development of a province is only related to the development stage of the insurance industry in the province. However, in actual economic development, the insurance development is affected by many factors. And, according to the neoclassical economic growth model, even if the provinces are independent of each other, the law of diminishing marginal returns will still make insurance development converge. In the real economy, the flow of talent, capital, and technology among provinces will further promote the convergence of insurance between provinces.

Thirdly, the country is divided into three regions: Eastern, Central, and Western. There are some differences when the spatial correlation is considered or not among them. In the Central regions, there are little differences on the convergence between considering the spatial correlation and not considering the spatial correlation. However, in the Eastern and Western regions, when the spatial correlation is excluded, the Eastern region exhibits convergence after 2006, same as the whole country. However, when considering the spatial correlation, convergence is displayed since 1998. For the Western region, when the spatial correlation is excluded, no convergence is shown during the entire inspection period, but when considering the spatial correlation, it also displays convergence since 1998.

It must be pointed that all the results are based on the hypothesis that the spatial matrix is spatially contiguous, that is, we believe that the spatial effect only occurred between the neighbor provinces. But in reality, there are many communications among the different provinces.

6. Recommendations and Enlightenment

Based on the results, we can get some recommendations and enlightenments:

Firstly, on the whole, regardless of whether the spatial correlation is considered, insurance industry development in domestic provinces tends to diverge at the beginning and then converge since 1990. However, when considering the spatial correlation, imbalance in insurance industry development among the provinces is greatly reduced. It suggests that the government can lower the interprovincial insurance technical barriers and promote and encourage the flow of insurance talents, capital, and technology, thereby enhancing the effective interaction of insurance industry between the provinces, reducing the differences in the insurance development level between the provinces.

Secondly, there are many differences in convergence between the Eastern, Central, and Western regions. When the spatial correlation is not considered, there is unobvious convergence in the insurance industry development in the Central and the Western provinces, while the Eastern provinces exhibit the characteristics of first divergence and then convergence. When considering spatial correlation, the Eastern and the Western provinces have shown convergence in recent years. Therefore, in the Eastern and Western provinces, policy makers should pay more attention to strengthening the mutual communication and exchanges in insurance development among the provinces to further strengthen the mutual influence between insurance development, thereby enhancing the convergence of insurance development and reducing the unbalanced insurance development among the provinces.

Finally, the convergence characteristics of the economic growth according to the neoclassical economics have been verified in the insurance field of our country. According to the neoclassical growth theory, the gap in per capita output or income among the countries or regions is a result of different capital-labor ratios: if the savings rate remains unchanged, under the lower initial capital-labor ratio of a country or region, the labor-capital ratio grows faster, so the poorer countries (regions) will grow faster than the richer countries (or regions). This law has been verified in our insurance industry. Hence, for the insurance companies, in terms of the future regional development and layout, they can increase investment in those provinces that the insurance development is relatively slow at present so that it is possible to achieve the faster growth.

Data Availability

The data in the paper comes from the "Compilation of 60-Year Statistical Data of New China" and the "China Insurance Yearbook" of the years.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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