



Empirical Research on the Relationship between Urbanization and The Development of Tertiary Industry in China

Boyan Zhang^{1*}

¹Faculty of Science, Hebei University of Technology, Tianjin, 300401, China

*Corresponding author's e-mail:Hebuter_190114@163.com

Abstract. To foster the advancement of China's urbanization and the tertiary industry, and provide scientific guides for government decision-making, the paper selects China's time-series data from 1978 to 2019 to empirically analyze the interaction between the urbanization rate and the contribution rate of the tertiary industry, between that and the employment proportion of the tertiary industry through the cointegration relationship test and the Granger causality test. The results show that (1) they have a stable equilibrium relationship over the long term; (2) urbanization is the Granger cause of the contribution rate of the tertiary industry and the employment proportion of the tertiary industry. To be specific, the impact of urbanization on the contribution rate of the tertiary industry can be immediately revealed, while the effect on the employment of the tertiary industry is lagging behind; (3) the contribution rate of the tertiary industry and the employment of the tertiary industry is not the Granger cause of the urbanization rate, indicating that during the growth of urbanization, the effect of the tertiary industry is not prominent.

Keywords: Urbanization, The tertiary industry, EG two-step method, Granger causality.

1 Introduction

After the initiation of the reform and opening-up policy, China's urbanization process has been accelerating, and it is currently at a critical stage of new urbanization construction. The reform and opening up that began in 1978 gradually transformed the planned economy system into a market economy system, bringing about the swift growth of population migration and urbanization. Since the mid-1990s, the percentage of China's population residing in urban areas has exceeded 30%, officially entering the overall accelerated development stage of urbanization from 30% to 70%. Over the following 20 years, there was an increase of more than 1% in the urbanization rate per year on average. After 2010, the share of the total population residing in urban areas has overtaken 50%, which further grew to 66.16% in 2023. It is clear that there is a huge space to improve for urbanization in the middle and late stage of rapid urbanization development. There is no doubt that the accelerated growth of urbanization in China benefits greatly from governments' policies and actions that keep pace with the times. After 2002, the emphasis of urbanization policy has progressively transitioned from prioritizing "quantity" to emphasizing "quality". In the year of 2012, the 18th National Congress of the Communist Party of China distinctly introduced the notion of "new-type urbanization", emphasizing the people-centered urbanization construction. Furthermore, in the year of 2014, National Development and Reform Commission released a directive outlining initiatives to advance the new urbanization process throughout the 14th Five-Year Plan period, which provides guidelines and adherence for promoting high-quality development of urbanization.

Following the policy of reform and opening up, the industrial composition in China has also undergone tremendous changes. Around 2012, China's industrial structure completed the transformation from the second industry to the tertiary industry. After that, the share of the tertiary industry in GDP continued to increase, whereas a dramatic decline in the figure for the primary and the second industry can be seen. In conclusion, industrial structure in China has formed three major industrial pattern in which the second and tertiary industries are dominant, and the share of the primary industry in GDP is less than 8 %. It entered the late stage of industrialization. In addition, considering the proportion of the employed population in the industry, the employment proportion of tertiary industry steadily rises with the process of agricultural conversion. This means that the rise in the share of the tertiary industry

within the economic structure has absorbed large rural populations into the tertiary industry.

Chinese urbanization in the past has been largely based on the transformation from agricultural to industrial economy. With the urban industrial structures becoming more diversified, the demand for new labor in first and second tier cities is dominated by the service sector as the major part of the tertiary industry. To be more specific, the flow of factors of production, including labor, capital, and technological innovation, is closely intertwined and inseparable from the development of urbanization. Therefore, the connection between the construction of urbanization and the development of the tertiary industry has become a realistic problem that deserved to be paid attention to during the course of China's development, and it is a scientific issue that urgently needs theoretical exploration as well.

The industrial structure of urban and rural areas is an internal factor affecting the economic function and nature of cities and towns. This implies that This implies that the swift growth of the service sector has a significant impact on the evolution of urbanization. Simultaneously, the development of urbanization not only brings about increase in the size and number of towns and cities, but also leads to the changes in the employment and economic structures of the urbanization population from the primary and secondary industries to the tertiary industry. Consequently, grounded in empirical analysis, this study thoroughly investigates the interconnection between urbanization levels and the progression of the tertiary sector, which provides scientific analysis for the regulation of China's urbanization process and the tertiary industry. Furthermore, there is certain social practical value for guiding the urbanization construction and the advancement of the tertiary industry in China.

2 Literature Review

Currently, numerous scholars have produced a multitude of research findings on the interaction between urbanization and the tertiary sector. It is generally believed that there exists a sustained balanced and positive association between these two influential factors from various countries. By considering the multiple factors of population, land and economy, Baifa Zhang[1] et al. integrated remote sensing data and population data to construct a novel index for urbanization to assess the level of county-level urbanization in China, and studied the unbalanced development model and driving mechanism of county-level urbanization in China from 1995 to 2015. It

was found that when the urbanization ratio exceeded 59 %, the tertiary industry became the main driving force. In a study conducted by Jing Peng[2] et al., the effects of the three principal industries on in-situ urbanization were examined using both the System Generalized Moment Method and the Ordinary Least Squares (OLS) approach. The findings indicated that the tertiary sector's contribution to in-situ urbanization is predominantly evident within the rural service sector and the tourism industry. Utilizing panel data from urban areas within China's Yangtze River Delta metropolitan region between 2008 and 2017, Hengzhou Xu[3] et al. found that The optimization of the industrial structure exerts a positive influence on the process of urbanization. through the regression analysis of urban scale, industrial structure change and urbanization quality. Jiahong Guo[4] et al. found that the key to achieving sustainable and superior development of urbanization in China lies in the transformation of industrial structure that was driven by education and technology. Priscila Mendez[5] et al. used the sample data of 91 countries from 1990 to 2018 to establish a fixed effect and dynamic panel model between urbanization and service industry productivity, and found that urbanization has a promoting effect on the improvement of service industry productivity in developed countries, whereas the impact for developing countries is opposite. Compared with the reasonable industrial structure, Xin Li[6] et al. showed that the excess contribution share of industrial structure contributes more to the comprehensive urbanization level.

Overall, these literatures threw light on the correlation between urbanization and the development of the tertiary industry from different perspectives, focusing on the mechanism of action and the process of mutual influence, but rarely involve the strict cointegration and causality test process. Therefore, it is necessary to use the complete cointegration and causality test theory to conduct empirical research on the short-term and long-term mutual influence between urbanization and the tertiary industry so as to accurately examine the quantitative relationship and causal relationship.

3 The Development of Urbanization and the Tertiary Industry in China

3.1 Trends and Characteristics of Urbanization Development

Since the initiation of the reform and opening-up policy, the development of urbanization starts from a low starting point and shows a monotonic upward trend.

From 1978 to 1983, it was the stage of high-speed urbanization at the start of the rural system reform, with the level of urbanization rising from 17.92% to 21.62%. After 1984, the urban economic system was gradually promoted so that the economic vitality created conditions for the rapid advancement of urbanization. In 2000, the urbanization rate grew rapidly to 36.22%, which was 18.3% higher than that in 1978. Furthermore, there was a significant rise in the urbanization rate from 17.92% in 1978 to 35.18% in 2012, with an average rise of nearly 1% per year. In 2012, the 18th CPC National Congress put forward the strategy of “new urbanization”, which made China's urbanization step into a new era of improving quality and efficiency. After that, with the implementation of the new policy, the urbanization rate has gone up to 66.16% by 2023. In addition, in terms of the speed at which the population moves from rural to urban areas, it was 3.09%, 3.16%, 3.21% and 2.46% respectively for each decade ranging from 1980 to 2020. This means that, after 1978, the urbanization of China's population has begun to show an accelerating development trend even though the speed has slowed down after 2010.

3.2 Trends and Characteristics of the Tertiary Industry Development

It is apparent that Figure 1 shows changes in the percentage of China's tertiary industry output value from 1978 to 2019. With the advent of the reform and opening up policies in 1978, there has been a consistent rise in the GDP share of China's tertiary industry, catching up with that of the primary industry. For the first time in 2012, the output value of the tertiary industry surpassed that of the secondary sector, accounting for 45.46 %. After that, the proportion of the tertiary industry continued to increase whereas that of the secondary sector witnessed a continuous decline. By the year 2022, the output value of the tertiary industry had risen to account for 52.8% of the total GDP. To sum up, China has reached an advanced stage in its industrialization process, with the service sector emerging as the primary engine for future economic expansion.

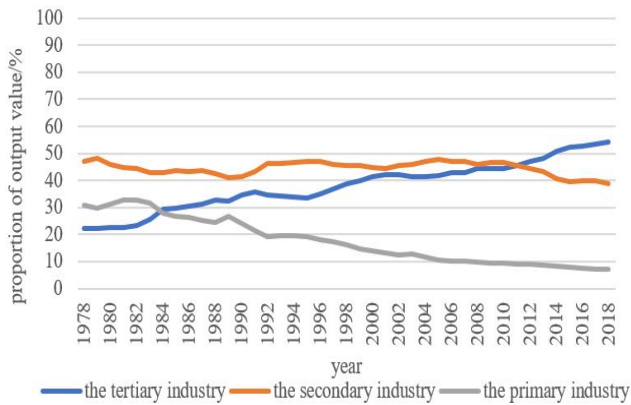


Fig. 1. The changing trend of the share of output value of the three industries in China from 1978 to 2019.

In addition, it can be seen that Figure 2 shows changes in the percentage of employment China's tertiary industry from 1978 to 2019. Initially, with the onset of China's economic reforms and opening up in 1978, the majority of the nation's employment was dominated by the primary and secondary sectors, while the tertiary sector accounted for a mere 12.2% of the workforce. Since then, for the first time in 1994, the employment share in the tertiary sector notably surpassed that of the secondary sector, reaching a significant 23%. Furthermore, in 2011, the tertiary industry's share of employment elevated to 35.7%, marking the first time it exceeded that of the primary industry. By 2022, the percentage of employment in the tertiary industry has reached 47.1 %, which is 23% and 18.3% higher than those of the primary and the secondary industry respectively. To sum up, the tertiary industry has become the main power driving economic growth and alleviating employment pressure.

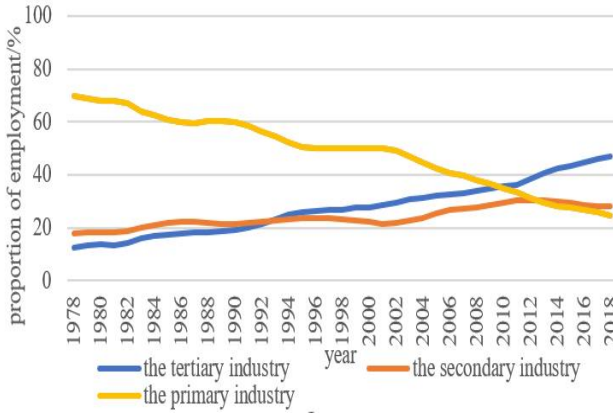


Fig. 2. The changing trend of the percentage of employment of the three industries in China from 1978 to 2019.

4 Data

Drawing from the above analysis of the national urbanization level and the growth status of the tertiary industry in China, the paper selects three indicators from these two aspects. Notably, in order to eliminate the interference of the sudden factor of the COVID-19 from 2020 to 2023, The time-series data selection spans from 1978 to 2019. Firstly, the urbanization rate was selected as the urbanization level index, in which the urban population refers to all the permanent residents residing in the urban area. In addition, in terms of the development of the tertiary industry, it particularly focuses on two aspects: the changes in the employment and economic structure. Specifically, the proportion of employment population in the tertiary industry is selected to measure the change of employment structure. The contribution rate of the tertiary industry which is the ratio of the added value increment of the tertiary industry to the GDP increment is used to represent the change of economic structure.

Given that selected data are time-series, in order to eliminate the effects of heteroscedasticity and dimensions and further to enhance the stability of data, the above index data are logarithmically processed. To be specific, $LNPRO$ is used to denote the contribution rate of the tertiary industry, $LNEMP$ is used to denote the employment proportion of the tertiary industry, and $LNURB$ is used to denote the urbanization rate. Noticeably, the data for the above indicators come from the relevant

modules of “Population”, “National Economic Accounts” and “Employment and Wages” in the China Statistical Yearbook 2023 so that the selected data are authentic and reliable.

5 Empirical Analysis

5.1 Stationarity Test

To subsequently examine the cointegration links between the urbanization rate and the contribution rate and between that and the percentage of employment in the tertiary industry in the next step. It is essential to identify the order of integration for each variable in advance. Therefore, the research employs the Augmented Dickey-Fuller Test, a widely recognized technique for unit root analysis, to test the *LNURB*, *LNPRO* and *LNEMP* sequences respectively with EViews10 software. Significantly, *DLNURB*, *DLNPRO* and *DLEMP* respectively Denote the first-order differenced series of their own original sequences. The test results are as follows:

Table 1. ADF unit root test results.

variable	ADF	critical values at various			P-val ue	Stationarity
	test	significance levels				
	statistic	1%	5%	10%		
<i>LNURB</i>	0.640	3.60	2.93	2.60	0.849	non-station
	8	56	69	69	9	ary
<i>DLNURB</i>	4.943	3.60	2.93	2.60	0.000	stationary
	6	56	69	69	6	
<i>LNPRO</i>	1.112	3.60	2.93	2.60	0.701	non-station
	4	56	69	69	6	ary
<i>DLNPRO</i>	11.21	3.60	2.93	2.60	0.000	stationary
	60	56	69	69	0	
<i>LNEMP</i>	1.052	3.61	2.94	2.60	0.724	non-station
	0	56	11	91	5	ary

<i>DLNEMP</i>	3.275	3.61	2.94	2.60	0.004	stationary
	4	56	11	91	2	

From the empirical results of Table 1, by compared the ADF test statistics with corresponding critical values, and the P value, it can be concluded that *LNURB*, *LNPRO* and *LNEMP* are non-stationary sequences whereas *DLNURB*, *DLNPRO* and *DLNEMP* are stationary sequences. In conclusion, *LNURB*, *LNPRO* and *LNEMP* are all $I(1)$ sequences, namely first-order single-integer sequences.

5.2 Cointegration Test

The traditional time series analysis model tends to require the sequence to be stationary. However, considering the actual application of the situation, the majority of economic time series exhibit non-stationary characteristics. Consequently, the differential approach is frequently used to remove the volatile trend present within the series, which can obtain the stationary sequence to meet the prerequisites for the establishment of the model. Nevertheless, the sequence after the difference transformation limits the scope of the economic problems discussed, and even some difference sequences lack clear economic interpretations, leading to the subsequent time series models not easy to provide straightforward explanations. Therefore, based on the non-stationarity of the selected original series, this research applies the co-integration theory as its analytical methodology to try to establish their linear combination relationship then analyze the stability of their combination, which can be explained as a persistent equilibrium correlation among these variables.

Under the premise that the unit root test reveals that *LNURB*, *LNPRO* and *LNEMP* all have the same order of integration, the residual-based cointegration test method is adopted, which means that the regression equation is established to perform the unit root test on its residuals. If the test is successful, the unexplained segment of the dependent variable by the independent variable becomes a stable residual sequence, which implies that the dependent variable is interpretable by the linear combination of the independent variables. The test in this paper is carried out according to the EG two-step method.

Considering the test of cointegration relationship between $LNEMP$ and $LNURB$. Firstly, the OLS cointegration regression equation of the two sequences is established as follows:

$$LNEMP = -0.4722 + 1.0421LNURB + u_{t1} \quad (1)$$

$$t = (-5.04) \quad (39.65)$$

$$R^2 = 0.9752, DW = 0.18$$

$$LNURB = 0.5297 + 0.9358LNEMP + u_{t2} \quad (2)$$

$$t = (6.92) \quad (39.65)$$

$$R^2 = 0.9752, DW = 0.18$$

Furthermore, the ADF unit root test is performed on the residual sequences of the two regression equations, namely u_{t1}, u_{t2} . The ADF statistics of u_{t1}, u_{t2} are -2.5678 and -2.4523 respectively. At the three significant levels of 1%, 5%, and 10%, the P values were all less than 0.05, so the residual sequence u_{t1}, u_{t2} was stationary.

As a result, although $LNEMP$ and $LNURB$ are I (1) variables, there is a specific stationary linear combination between $LNEMP$ and $LNURB$ during the sample period.

$$u_{t1} = LNEMP + 0.4722 - 1.0421LNURB \quad (3)$$

$$u_{t2} = LNURB - 0.5297 - 0.9358LNEMP \quad (4)$$

This means that when the national urbanization rate increases by 1%, the proportion of tertiary industry employment increases by 1.0421% on average. Similarly, when the proportion of employment in the tertiary industry increases by 1%, the national urbanization rate increases by 0.9358% on average.

In addition, considering the test of cointegration relationship between $LNPRO$ and $LNURB$. Firstly, the OLS cointegration regression equation of the two sequences is established as follows:

$$LNPRO = 1.4731 + 0.6107LNURB + u_{t3} \quad (5)$$

$$t = (6.02) \quad (8.88)$$

$$R^2 = 0.6636, DW = 1.59$$

$$LNURB = -0.4091 + 1.0867LNPRO + u_{t4} \quad (6)$$

$$t = (-0.917) \quad (8.88)$$

$$R^2 = 0.6636, DW = 1.06$$

Furthermore, the ADF unit root test is performed on the residual sequences of the two regression equations, namely u_{t3} , u_{t4} . The ADF statistics of u_{t3} , u_{t4} are -5.1869 and -2.3781 respectively. At the three significant levels of 1%, 5%, and 10%, the P values were all less than 0.05, so the residual sequence u_{t3} , u_{t4} was stationary.

As a result, although $LNPRO$ and $LNURB$ are I (1) variables, there is a specific stationary linear combination between $LNPRO$ and $LNURB$ during the sample period.

$$u_{t3} = LNPRO - 1.4731 - 0.6107LNURB \quad (7)$$

$$u_{t4} = LNURB + 0.4091 - 1.0867LNPRO \quad (8)$$

This means that when the national urbanization rate raises by 1%, the contribution rate of the tertiary industry raises by 0.6107% on average. Similarly, when the proportion of the contribution rate of the tertiary industry raises by 1%, the urbanization rate raises by 1.0867% on average.

5.3 Granger Causality Test

Based on the long-term equilibrium the correlation between the country's degree of urbanization and the growth of the tertiary industry revealed by the cointegration test, this paper continues to analyze the causal relationship among these selected variables. Granger[7] proposed that if the variable x is the cause of another variable y , x can be ahead of y . Considering the mean square error (MSE) of n-period prediction of y_t , if it satisfies

$$MSE[E(y_{t+n}|y_t, y_{t-1}, \dots)] = MSE[E(y_{t+n}|y_t, y_{t-1}, \dots, x_t, x_{t-1}, \dots)], \quad (9)$$

It can be concluded that x does not Granger cause y . The test for this causal relationship is based on whether the earlier information on x facilitates a reduction in MSE in the prediction of y . If there is a contribution, it is said that x has a causal relationship with y in the Granger sense. However, it is worth noting that the outcomes of the Granger causality test are highly responsive to the selection of lag

order numbers. Therefore, this paper detects whether there is significant Granger causality effect between *LNURB* and *LNPRO*, between *LNURB* and *LNEMP* respectively for different lag orders.

Table 2. Results of *LNPRO* and *LNURB* Granger causality tests under different lag orders.

Lag Orders	<i>LNPRO</i> does not Granger Cause <i>LNURB</i>		<i>LNURB</i> does not Granger Cause <i>LNPRO</i>	
	F-statistic	P-value	F-statistic	P-value
1	0.1018	0.7514	17.5100	0.0002
2	1.2920	0.2875	3.4689	0.0422
3	1.8833	0.1523	3.9853	0.0161
4	2.9549	0.0366	2.3283	0.0798
5	1.4803	0.2302	2.2304	0.0815
6	2.1017	0.0924	2.6556	0.0417
7	2.4647	0.0537	4.2780	0.0049
8	1.8562	0.1351	4.5650	0.0041

From Table 2, it can be seen that in the lag orders from one to eight, excluding the fourth-order lag and fifth-order lag, *LNURB* is the Granger cause of *LNPRO*, but only on the premise of fourth-order lag, *LNPRO* is the Granger cause of *LNUNB*. As a result, there is not a bidirectional causality between the urbanization rate and the tertiary industry contribution rate. Meanwhile, in the first-order lag, the urbanization rate is the Granger cause of the tertiary industry contribution rate, which means that the effect of urbanization rate on the tertiary industry contribution rate is immediately apparent. On the contrary, the contribution rate of the tertiary industry has a lag effect on its urbanization rate, which takes a long time to take action.

Table 3. Results of *LNEMP* and *LNURB* Granger causality tests under different lag orders.

Lag Orders	<i>LNURB</i> does not Granger Cause <i>LNEMP</i>	<i>LNEMP</i> does not Granger Cause <i>LNUEB</i>

	F-statistic	P-value	F-statistic	P-value
1	0.3770	0.5429	2.2501	0.1419
2	3.0469	0.0603	1.4427	0.2500
3	2.1159	2.1159	1.7794	0.1709
4	3.2961	0.0242	1.6264	0.1944
5	1.9637	0.1179	1.1647	0.3529
6	3.8176	0.0087	1.4683	0.2329
7	3.7638	0.0092	2.4956	0.0513
8	3.2108	0.0206	2.4152	0.0602

From Table 3, it can be seen that in the lag orders from one to eight, *LNURB* is the Granger cause of *LNEMP* from the fourth-order lag and the sixth-order lag, suggesting that the rate of urbanization exerts a delayed influence on the employment share within the tertiary industry, which becomes more significant in the later period. However, *LNPRO* is not the Granger cause of *LNUNB*, so there is not a bidirectional causality between the urbanization ratio and the contribution rate of the tertiary industry.

6 Conclusions

The paper selects time-series data from 1978 to 2019 in China to empirically analyze the interaction between urbanization and the progression of the tertiary industry through the cointegration relationship test and the Granger causality test. The following conclusions are reached.

From the ADF unit root test results, the selected time series *LNPRO*, *LNEMP*, and *LNURB* are all first-order integrated sequences, which meet the requirements of the same-order integration for the subsequent test of cointegration variables.

From the E-G method to test the results of co-integration analysis, there exists a long-term steady equilibrium relationship between the urbanization rate and the contribution rate of the tertiary industry, between that and the employment proportion of the tertiary industry. In the long run, when the urbanization ratio rises by 1%, the employment proportion of the tertiary industry increases by 1.0421% on average.

Correspondingly, when the urbanization ratio rises by 1%, the contribution rate of the tertiary industry increases by 0.6107% on average.

From the Granger causality test results, there is no directional Granger causality between the urbanization rate and the contribution rate of the tertiary industry, between that and the employment proportion in the tertiary industry. However, the urbanization rate is the Granger cause of the tertiary industry contribution rate and the employment proportion of tertiary industry respectively. Moreover, it's essential to point out that changes in the urbanization ratio can have an immediate impact on the tertiary industry contribution rate, while the impact on the tertiary industry employment population has a lagging effect. In general, the improvement of urbanization level provides strong support for the development of the tertiary industry. However, the contribution rate of the tertiary industry and the employment of the tertiary industry is not the Granger cause of the national urbanization rate, indicating that during the urbanization process, the effect of the tertiary industry is not prominent.

The corresponding policies are put forwards:

First of all, the government should improve the strategy of new urbanization and enhance the overall collaborative effect of city clusters and metropolitan circles. This means that governments should increase the investment in urban construction, expand the scale of cities and towns, improve the comprehensive service function of cities and towns, and enhance the capacity of urban areas to absorb population and pull the tertiary industry. Significantly, on the basis of actively developing the construction of small and medium-sized towns, the rational development of urban agglomerations and the improvement of the comprehensive service function in these cities should be assigned the highest priority. This is of great significance for giving full play to the growth and evolution of China's tertiary sector, especially the emerging tertiary industry.

In addition, the government should advance the construction of the human resource market system and enhance the employment absorption capacity of the tertiary sector. In the short term, the increase of urbanization rate does not exert an immediate effect on the tertiary sector's employment levels, and this conclusion is not accidental. Nowadays, the marketization of China's labor market is still in infancy, and there are still a series of problems such as employment treatment, social security, and regional discrimination, which have become a major obstacle to the smooth transfer of surplus labor. Therefore, it is of great significance to construct a complete labor employment

security system to promote the transfer of rural labor force. In addition, the knowledge and technical level of China's excess workforce is not high, and most of them are engaged in manual work. Therefore, it is essential to develop a comprehensive training system for the purpose of transferring labor force, which is conducive to improve the competitiveness of the transferred labor force. In addition, it is also beneficial for gradually forming a fair employment environment, and providing high-quality labor resources for the growth and evolution of China's tertiary sector.

Moreover, the government should optimize the composition and organization the tertiary industry and improve the growth mechanism and institutional framework of the tertiary industry. Around 2012, although China's industrial structure has completed the shift from the second industry to the tertiary industry, there are still a series of problems behind the swift growth of the service sector, such as the relatively short process of technological innovation, the low proportion of emerging service industries and the significant differences in regional development. Therefore, the restructuring and enhancement within the tertiary sector is the top priority to enhance the comprehensive competitiveness of China's tertiary industry. For example, we can take advantage of the power of agglomeration and specialization, which supports China's transformation to high-tech manufacturing and service industries. The government should strive to achieve the simultaneous growth of the tertiary sector and the urbanization process as soon as possible in order to achieve a bidirectional Granger causality between urban growth and the advancement of the tertiary sector.

References

1. Zhang B, Zhang J, Miao C. Urbanization level in Chinese counties: imbalance pattern and driving force[J]. *Remote Sensing*. 2022, 14(9):2268.
2. Peng J, Liu Y, Hong Q. Research on the development mechanism of In-situ Urbanization driven by industry--evidence from 87 cities in central China[C]//E3S Web of Conferences. EDP Sciences, 2023, 372: 01007.
3. Xu H, Jiao M. City size, industrial structure and urbanization quality—a case study of the Yangtze River Delta urban agglomeration in China[J]. *Land Use Policy*. 2021, 111: 105735.
4. Guo J, Yu Z, Ma Z, et al. What factors have driven urbanization in China? [J]. *Environment, Development and Sustainability*. 2022, 24(5): 6508-6526.

5. Mendez P, Atienza M, Modrego F. Urbanization and productivity at a global level: new empirical evidence for the services sector[J]. *Regional Science Policy & Practice*. 2023, 15(9): 1981-1998.
6. Li, X.; Zhuang, X. Eco-City problems: Industry–City–Ecology, urbanization development assessment in resource-exhausted cities[J]. *Sustainability*. 2023, 15, 166.
7. Granger, Clive WJ. Investigating causal relations by econometric models and cross-spectral methods[J]. *Econometrica: Journal of the Econometric Society*. 1969: 424-438.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

