An Empirical Study of the Relationship among Population Mobility, Industrial Structure Upgrading, and Economic Growth – Based on the SPVAR Model

Bowen Xu, Yang Lu*

School of Economics, Jiangxi University of Finance and Economics, Nanchang 330013, China

***Corresponding author:** Yang Lu, 550575532@qq.com

Abstract: Based on the inter-provincial panel data for 31 provinces in China from 2000 to 2019, and incorporating geospatial factors, a spatial panel vector autoregressive (SPVAR) model consisting of population mobility, industrial structure upgrading, and economic growth is constructed. The space-time impulse response function is used to analyze the space-time conduction of exogenous variables on the impact of three endogenous variables. The study found that first, the population influx barely benefited the industrial structure upgrading and economic growth. Second, the upgrading of the industrial structure would aggravate the population mobility in the province, causing low-level laborers to leave the province in short-term, but in long-term, there would be influx of talents. Third, the economic growth in developed regions plays a significant role in promoting the industrial development of their province and population-rich provinces, but it has less impact on provinces with high-level industrial structure. Finally, policy recommendations are provided in regard to the benign interaction among population mobility, industrial structure upgrading, and economic growth in addition to clarifying the idea of economic development, implementing correct population policies, and promoting the coordinated regional development.

Keywords: Population movement; Industrial structure upgrading; Economic growth; Space panel VAR model

1. Introduction

Over 40 years of reform and opening-up, China's rapid economic growth has created a world-renowned economic miracle. However, the huge gap in the levels of regional economic development cannot be neglected. In the current situation, the level of economic development in the eastern coastal areas is significantly higher than that in the central and western regions. Not only that, the internal economic development level of the same region is also significantly different. Correspondingly, there are huge differences in the industrial structure between regions, where developed areas in the east have long achieved a tertiary industry-based industrial structure, while the central and western regions are still dominated by secondary industries with some agricultural provinces still being the majority of primary industries. The imbalance of economic development and the differentiation of industrial structure encourage the tendency of population flow. With the spontaneous flow of the population, it leads to the phenomenon of both, labor surplus and labor shortage in various regions at the same time, showing the contradiction of "difficult employment" and "job shortage". In regard to this matter, understanding the relationship among population mobility, industrial structure upgrading, and economic development has become an important breakthrough to solve the imbalance of regional economic development.

The interaction among population mobility, industrial structure upgrading, and economic growth is inextricably linked. It is not possible to be only one-way; however, most literatures have selected only two variables for in-depth study. The logical relationship between the three is complex, so it is not appropriate to only use one or two of them as explanatory variables and establish a simple regression relationship to analyze the effects of one or two on the other. At the same time, there is still a lack of literatures in regard to the empirical study of these three links in the perspective of spatial effect. Therefore, this paper integrates the three into a more complete analysis framework, considers the multilateral effect and the two-way effect, as well as establishes the spatial panel vector autoregressive model. On this basis, through the space-time impulse response function, while considering the correlation of the space-time scale, the problem is interpreted at a new angle.

2. Literature review

The academic inquiries on industrial structure and population mobility focused on the one-way effect of both, hence they can be divided into two categories.

The first category is the one-way impact of population mobility on industrial structure. Du Wei's analysis showed that the economic promotion of population inflow depends on the specific industry [1]. If the inflow increases the proportion of men in the tertiary industry, it is not conducive to regional economic development, but if it occurs to the first and second industries, the opposite is true. Xu Qingqing believes that population mobility plays a role in promoting the upgrading of economic and industrial structure, hence provinces should actively promote migration policies so that the effects will last for a long time [2]. Tian Degang found that the interaction effect of population mobility on the spatial transfer of circulation industry was higher than that of the circulation industry transfer on the changes in the population migration pattern [3]. Cao Fangfang suggested that labor mobility promotes the upgrading of urban industries, which is based on the local market effects and human capital accumulations [4]. Tombe argued that the migration of labor from rural to urban areas is hampered by the household registration system in China, resulting in inefficient labor allocation and industrial restructuring [5]. Pennock analyzed the movement of labor between industries and believes that the movement of labor between urban and rural areas is an important way to upgrade the industrial structure, of which the flow of labor from the agricultural sector to the second and third industrial sectors can promote the upgrading of the industrial structure [6].

The second category is the one-way effect of industrial structure upgrading on population mobility. Yang Victory stated that the upgrading of industrial structure has a greater income effect on certain migrant populations: men, married, young, urban, cross-provincial, highly educated, and long-term migrants [7]. Yang Wei found that urban industrial upgrading significantly increases the probability of labor migration for employment [8].

In terms of the relationship between population mobility and economic growth, most scholars have a positive attitude toward the phenomenon of population mobility, believing that it has been playing a role in promoting the economic growth, which can also be reflected in today's population policies of the provinces. Shen Yingchun found that the population mobility rate in Beijing-Tianjin-Hebei area has been influenced by the household registration policy and the size of the resident population has an important impact on the economic development in the region. It was also noted that the overall economic development of Beijing-Tianjin-Hebei urban group has the characteristic of economic convergence in addition to the conduciveness of its economic growth in promoting the rational flow of the population in the region [9]. Gu Yannan found that a moderate-scale population mobility can promote economic development to a greater extent through labor transfer mechanisms, but excessive mobility would burden the social development [10]. Using the Yangtze River Delta urban agglomeration as an example, Shi Guifen came to a conclusion that population mobility would change the size and structure of regional labor force, reshape the pattern of population

distribution, promote the accumulation of human capital, and promote the economic growth by optimizing industrial structure, promoting scientific and technological innovations, and increasing household consumptions [11]. Wang Wei found that interregional labor mobility can promote the release of labor allocation efficiency dividend, hence as labor mobility increases, this effect becomes more obvious. As more labor flows into a local area, the more it would facilitate the release of labor allocation efficiency dividend [12]. Through the analysis of Beijing's urban circle, Jin Tianlin concluded that the population concentration in Beijing Metropolitan Area has a downward-type relationship between the first rise and fall of the economic growth, and the sustained growth of the population size is characterized by the crowding effect and tight circles in Beijing Metropolitan Area, which negatively impact economic growth, whereas with opportunity circles, it is more of a concentration effect, which significantly promotes output growth [13]. Lima and other researchers studied the relationship between population movements and economic growth in Brazil. They found that there is a strong spatial dependency between the population and the economy in the sample region, and that investment in materials and human capital is critical to the economic growth in Brazil [14]. Some scholars focused on the analysis of economic growth as an important guiding role in population mobility. Huang Lucheng believes that the regional economic development level is the preemption factor of talent inflow, where the flow of population is not in a disorganized manner but based on the regional economic and industrial structure differences of rational circulation [15].

In view of the relationship between industrial structure upgrading and economic growth, scholars have many angles to explore, but their main choice is on the adjustment of the second and third industrial structure. Zhu Fenghui stated that with the process of industrial structure upgrading, China's green TFP (total factor productivity), as a whole, is on the rise, with a spatial spillover effect [16]. Liu Xia believes that for the central region, the vigorous development of green finance is in line with the general trend of the economic development [17]. Wang Keliang believes that structural transformation, especially the rationalization of industrial structure, can significantly promote economic growth from the perspective of green TPF [18]. Some scholars also hold opposing views on the role of industrial restructuring in promoting economic growth. As Li Xiang believes, overemphasizing industrial structure upgrading in the current context would have a negative impact on economic growth [19]. Wei Houkai believes that China's current "over-industrialization" would have a serious negative impact on its' economic growth [20]. Chen Guanghan found that the industrial structure service inhibited the economic growth by reducing labor productivity [21]. Hu Wei believes that resource-based cities should be aware of the growth of resource-export dividends and the weak effect of industrial structure on urban poverty [22].

Based on the findings above, there is a complex relationship and interaction among population mobility, industrial structure upgrading, and economic growth. Therefore, it is necessary to include all three into a more complete analysis framework while considering the multilateral effect and two-way effect in addition to the SPVAR model which combines the spatial panel data and the panel vector autoregressive model to establish the spatial panel vector autoregressive model space-time impulse response function, which does not only consider the correlation of the time scale, but also considers the relevance of the spatial scale in order to create a new angle for interpretation of the problem.

3. Space panel data model settings and indicator selection

Based on the research about the interaction among population mobility, industrial structure upgrading, and economic growth, the spatial panel vector autoregressive (SPVAR) model is established to analyze the space-time conduction of the three endogenous variables that impact each other.

3.1. Variables and data descriptions

(1) Industrial structure upgrading index (*iuc*)

Based on Xu Deyun's research, this paper includes the first, second, and third industries to construct an overall industrial structure upgrading index to fully reflect the connotation of industrial structure upgrading [23].

$$iuc = \sum_{i=1}^{3} i \times y_i = y_1 + 2y_2 + 3y_3 \tag{1}$$

The index on the left side of the equation reflects the selected index for industrial structure upgrading in this article, and the specific meaning on the right side of the equation is the proportion of the output value of *i* industry included in the GDP (gross domestic product) of the region. The value of is positively correlated with the degree of industrial structure upgrading.

(2) Population movement (*MP*)

Based on existing relevant research results, this paper uses the ratio of the difference between the resident population and household registration population to measure the size of the floating population. The greater the difference, the greater the scope and scale of population mobility.

(3) Gross regional product (*GDP*)

In order to eliminate the impact of price fluctuations, this article treats GDP as a flattening of the GDP in 2000.

In this paper, the regional gross domestic product and consumption level data are from China's National Bureau of Statistics (2000-2019) while the rest are from China Statistical Yearbook 2000-2019 and the statistical yearbooks of the provinces. For the division of regions, the division method of the National Bureau of Statistics is used. The variable descriptive statistics are shown in **Table 1**.

Table 1. Variable descriptive statistics

	Minimum	Maximum	Mean	Standard deviation	Median
Industrial structure upgrading index	2.06898	2.831998	2.317298	0.131276	2.292273
Floating population	-460	2578	485.1242	489.7129	379.5
Regional GDP	117.8	107671.1	14756.98	16550.97	9329.1

The statistics in **Table 1** show that the population mobility and GDP of the region have a large data span within the sample range, indicating that the rate of population mobility and GDP vary greatly among the provinces in China. Relatively speaking, the industrial structure of each province is not that different.

3.2. Space panel vector autoregressive model construction

The SPVAR model is set up as follows:

$$Y_t = \beta_{IN} Y_{t-1} + \theta W Y_t + \lambda W Y_{t-1} + \varepsilon_t \tag{2}$$

$$Y_t = \begin{bmatrix} iuc_t \\ MP_t \\ GDP_t \end{bmatrix}, Y_{t-1} = \begin{bmatrix} iuc_{t-1} \\ MP_{t-1} \\ GDP_{t-1} \end{bmatrix}, W = \begin{bmatrix} 0 & D(1,2) & \cdots & D(1,N) \\ D(2,1) & 0 & \cdots & D(N,2) \\ \vdots & \vdots & \ddots & \vdots \\ D(N,1) & D(2,N) & \cdots & 0 \end{bmatrix} \tag{3}$$

$$\beta = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix}, \quad \varepsilon = \begin{bmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \\ \varepsilon_{3i} \end{bmatrix} \tag{4}$$

Y_t is the form of vector for the industrial structure upgrading index (iuc_t), population flow (MP_t), and economic growth (GDP_t); $D(i, j)$ for the spatial attribute between the city and the time; β for the time and space lagging one period of the item's coefficient matrix; ε for the variable cross-section of the individual fixed impact vector.

3.3. Moran's I index testing and statistics

This paper first uses the geospatial weight matrix to examine the industrial structure upgrading index, population mobility rate, and the Moran's I index of regional GDP, then, makes a visual analysis of these three indicators.

Table 2. Floating population, industrial structure upgrading index, and Moran's I index of regional GDP

| Name of variable	I	E(I)	SD(I)	Z	P-value
Floating population	0.428***	-0.033	0.116	3.964	0.000
Industrial structure upgrading index	0.243***	-0.033	0.107	2.581	0.010
Regional GDP	0.185**	-0.033	0.114	1.912	0.056

Note: ***, **, and * indicate statistically significant levels of 1%, 5%, and 10%, respectively, and the following are the same.

It can be seen from **Table 2**, the floating population, industrial structure upgrading index, and Moran's I index of regional GDP of 31 provinces in China were significant during the sample period, indicating that the three variables showed strong spatial correlation.

4. Result analysis of the space-time impulse response function

Unlike the VAR of the traditional time series, the impulse response of the space panel VAR is reflected in both dimensions: space and time. An impact source (a variable in one place produces an impact) produces an impulse response plot, n*K (n is the number of individuals and K is the number of endogenous variables). The purpose of this paper is to explore the space-time relationship among interregional population mobility, industrial structure upgrading, and economic growth. Therefore, combining with the regional representation and research purposes, through many trial calculations, this paper finally selected three regions as the main research subjects.

The areas with high population outflow are mainly in the central part of China, while the provinces with higher population inflow, higher levels of economic development, and industrial structure are mainly in the eastern coastal areas of China. If the individual spatial span is large, it is difficult to obtain meaningful results, so Jiangxi Province was selected as a sample in this paper due to large population mobility in central provinces. Shanghai was also selected in this paper as the representative area with high-level industrial structure while Guangdong was selected as the representative area with high economic level. In the figures below, solid lines represent Guangdong Province, dashed lines represent Shanghai, and the dotted lines represent Jiangxi Province.
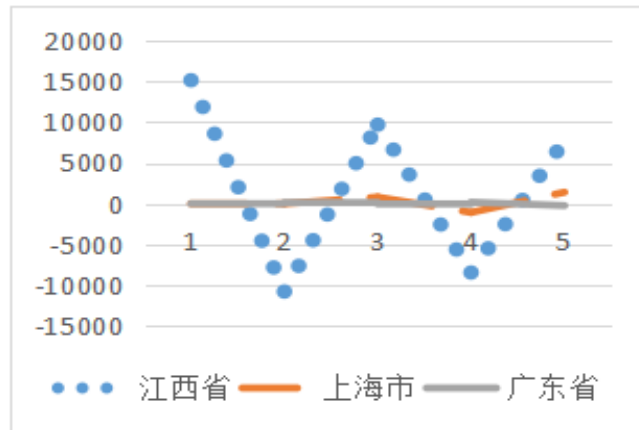
Figure 1. Impulse response graph of the population mobility in Shanghai and Guangdong with the population mobility of Jiangxi Province
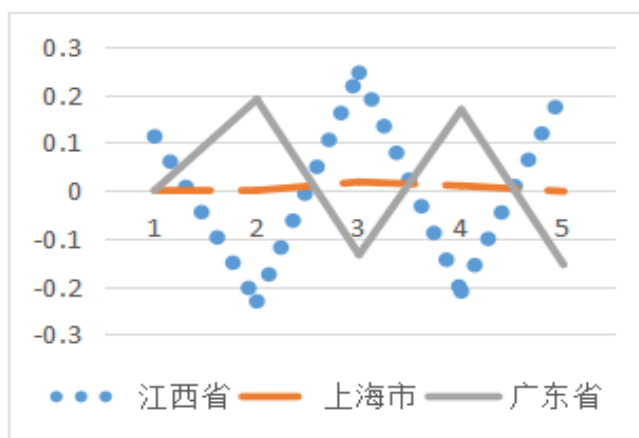
Figure 2. Impulse response graph of the industrial structure upgrading in Jiangxi, Shanghai, and Guangdong with the population mobility of Jiangxi Province
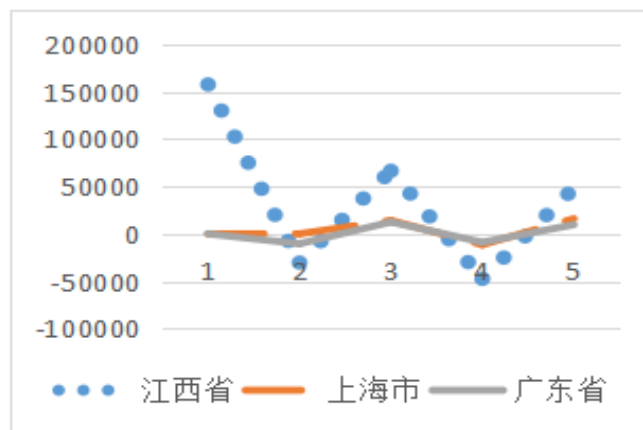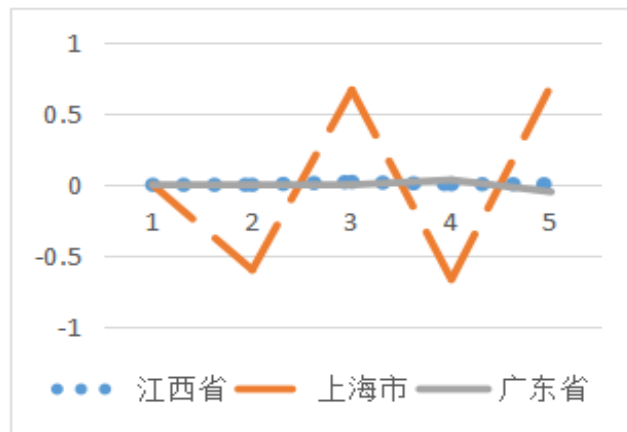

Figure 3. Impulse response graph of the GDP in Jiangxi, Shanghai, and Guangdong with the population mobility of Jiangxi Province

The impulse response analysis with large population mobility province as the source of impact:

(1) In **Figure 1**, it can be seen that a positive impact on the population mobility in Jiangxi Province would have a positive impact on itself, but this effect would fluctuate up and down with the number of response periods; this includes positive and negative fluctuations, which is in line with the economic law. The laborers in the province move to other provinces with labor shortage, in which

significant gains are obtained. This is bound to drive the province's other labor force to work in the province. When the labor in other provinces is saturated or even overflowing, the provincial labor wage drops. In addition to that, the jobs offered in the province, being closer to home and having higher wages, result in laborers moving back to the province. Subsequently, the labor force in the province once again becomes saturated, which then lead to the outflow of laborers from the province, thus the cycle continues.

(2) As can be seen from **Figure 2** and **Figure 3**, the population mobility of Jiangxi Province has brought a significant impetus to the industrial structure and economic growth of the province, as well as to the industrial structure upgrading in Guangdong Province, and a small impact on the industrial structure and GDP in Shanghai. This is due to the large number of people moving out from the province, filling the labor shortage in the economic province, thus leading to industrial structure upgrading. However, they are only involved in low-level labor, thus there is a weak impact on the relatively high-level industry in Shanghai. After some time, the outflow of people due to the phenomenon of labor surplus eases, which forces the province to optimize and upgrade its industrial structure, leading to the development of emerging industries, thus bringing progress.

Figure 4. Impulse response graph of the population mobility in Shanghai, Jiangxi, and Guangdong with Shanghai's industrial structure upgrading
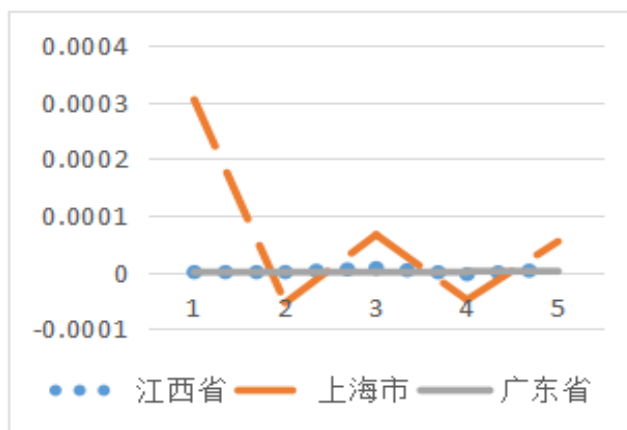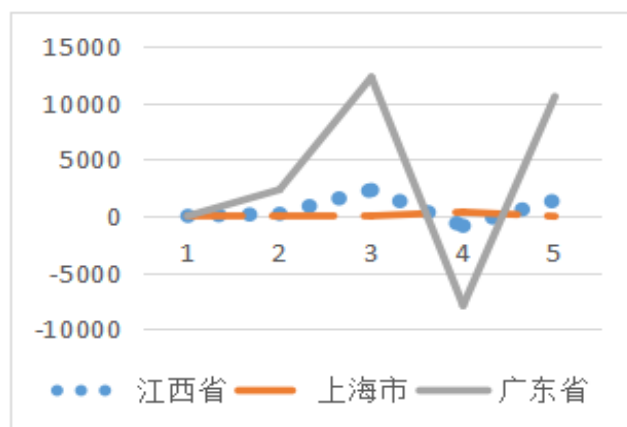

Figure 5. Impulse response graph of the industrial structure upgrading in Jiangxi and Guangdong with Shanghai's industrial structure upgrading
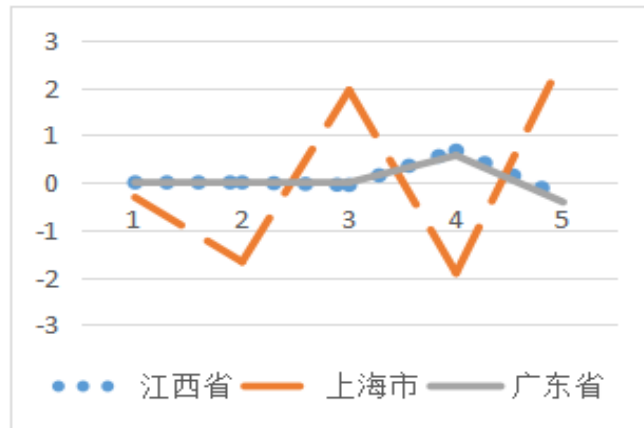
Figure 6. Impulse response graph of the GDP in Shanghai, Jiangxi, and Guangdong with Shanghai's industrial structure upgrading

The impulse response analysis with Shanghai's industrial structure upgrading as the source of impact:

(1) In **Figure 4**, it can be seen that the floating population of the province fluctuates greatly due to the impact of industrial structure upgrading, with only minimal impact on other provinces. After the short-term industrial structure upgrading in the province, some low-level labor workers have been replaced, resulting in a large outflow of workers. The industrial structure upgrading, which attracts talents, requires a period of time, hence in the long run, there would be large population inflow.

(2) From **Figure 5**, it can be seen that the upgrading of industrial structure greatly improves the level of industrial development initially, but it would not be sustainable in the long run, as well as with less impact on other provinces.

(3) As can be seen from **Figure 6**, the role of industrial structure upgrading on GDP requires a relatively long response period. The upgrading of industrial structure reduces the GDP of the province in the short term, but it promotes the GDP of the province and other provinces in the long run. This is because the upgrading of industrial structure requires a lot of capital investment. In short-term, it is difficult to convert into income-generating industries, thus it would reduce the province's GDP. In the long run, the upgrading of industrial structure can greatly increase the GDP of the province and influence other provinces around it, driving the growth of GDP in these provinces.
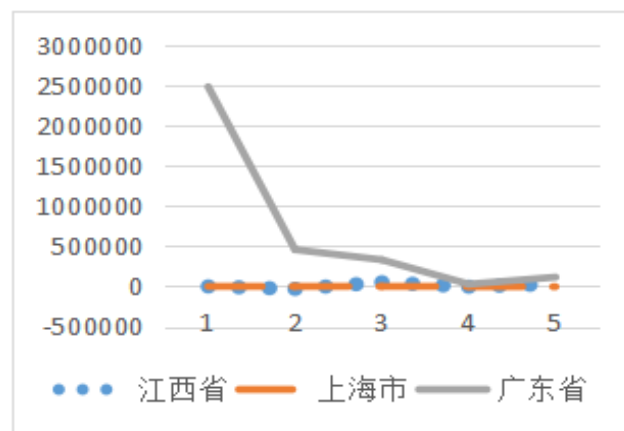

Figure 7. Impulse response graph of population mobility in Guangdong, Jiangxi, and Shanghai with the GDP growth in Guangdong
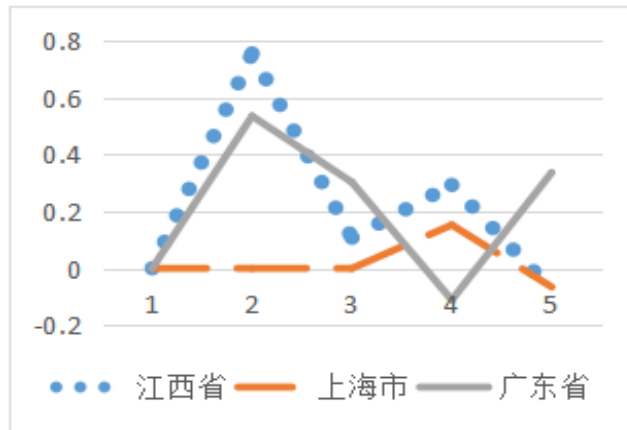
Figure 8. Impulse response graph of the industrial structure upgrading in Guangdong, Jiangxi, and Shanghai with the GDP growth in Guangdong

Figure 9. Impulse response graph of the GDP in Jiangxi and Shanghai with the GDP growth in Guangdong

The impulse response analysis with Guangdong Province as the source of impact:

(1) From **Figure 7**, it can be seen that the impact of Guangdong's economic growth drives its own population inflow, which would have less impact on other provinces, even large population provinces, because the inflow mainly consists of high-quality talents from surrounding provinces or high-income people desiring to settle down.

(2) In **Figure 8**, it can be seen that the economic growth in developed regions would play a significant role in promoting the industrial development in their own province and populous provinces, but have less impact on high-level development areas, such as Shanghai. This is due to the increase in the purchasing power of the general public in high-level development areas, which result in the purchase of higher quality products and services, forcing regions with low industrial structure to further optimize their industries to meet the demands. The industrial structure of high-level development areas along with their supply of products are able to meet the demands, thus the effect on these areas is minimal.

(3) In **Figure 9**, it can be seen that the impact of economic growth would depend on its role as an economic center to "radiate" to other regions in driving regional economic development.

5. Conclusion and policy recommendations

5.1. Conclusion

This paper used the difference in geographical locations to construct a spatial weight matrix of adjacent matrix, investigated the spatial spillover effect of industrial structure upgrading on economic growth under the background of ordinary geographical distance, constructed a spatial panel vector autoregressive model on this basis, used the space-time impulse response function, and analyzed the space-time conduction of exogenous variables on the impact of three endogenous variables through data. The conclusions are as follows:

Judging from the spatial dynamics of population mobility, industrial structure upgrading, and economic growth, the economic development data of 31 provinces in China from 2000 to 2019 showed that there was a clear phenomenon of geospatial agglomeration in regional GDP, and in 2010, the industrial structure was more balanced in space and did not show obvious regional agglomeration. After 2010, there were obvious differences in the rate of industrial structure adjustment in various provinces, imbalance of geographical distribution in industrial structure, and the level of industrial upgrading in various regions. The population mobility rates of all 31 provinces also showed strong spatial relevance.

From the impulse response analysis of a large population mobility province as the impact source, the population flow in the province has a positive impact on itself, but this effect would fluctuate up and down with the number of response periods, including positive and negative fluctuations.

From the impulse response analysis of a high-level industrial structure province as the impact source, industrial structure upgrading in short-term would cause the outflow of low-level labor force, whereas in long-term, it would increase the influx of talents of the province.

From the pulse response analysis of an economically developed province as the source of impact, the economic growth shock of economically developed provinces would drive their own population inflow while having less impact on other provinces.

5.2. Policy recommendations

Based on the above conclusion, the following recommendations are made in this paper:

First, to guide the movement of people by reasonable measures. Governments at all levels, in regard to relatively underdeveloped provinces, have the responsibility to encourage the return of labor and the introduction of talents. Only by the rational and efficient flow of human resources, the development of China's regional economy can be further promoted.

Second, balance the long-term and short-term contradictions between the upgrading of industrial structure and economic development. It is no longer possible to rely on low-level industries for support in the sustained and rapid economic growth in China. China's industrialization process has entered at a late stage and by adjusting the industrial structure, promoting the upgrading of industrial structure for the promotion of employment rate, as well as promoting talent and job docking would have important roles in this. At the same time, the upgrading of industrial structure is conducive to the development of income-generating industries in the long run, and eventually improve the efficiency of economic growth. However, we should also pay attention to the negative effect of industrial structure upgrading on the economic growth in the short term. Hence, we should not blindly pursue industrial structure upgrading, but based on the rationalization of industrial structure, it is necessary to formulate industrial policies in line with the stage of regional economic development and promote the benign interaction of secondary and tertiary industries.

Third, when implementing the strategy of regional economic synergy, it is necessary to have macro-control over the allocation of resources in order to promote economic growth in an all-rounded way while

gradually eliminating regional differences. In this way, the "radiation capacity" of economic growth and industrial upgrading in economically developed areas can be enhanced and the economic development in and around the region can be promoted. Efforts should be made to change the backward situation of central regions by increasing the financial support and optimizing the industrial structure while contributing to the economic development of the region and even the country.

Disclosure statement

The authors declare that there is no conflict of interest.

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