

Research Article

Impact of Labour Productivity Differences on Urban-Rural Integration Development and Its Spatial Effect: Evidence from a Spatial Durbin Model

Wei Wang ¹ and Yulin Zhu ^{1,2}

¹School of Economics, Central South University of Forestry and Technology, Changsha 410000, China

²Hunan Research Center for High-Quality Development of Industrial Economy, Changsha 410000, China

Correspondence should be addressed to Yulin Zhu; t19970886@csuft.edu.cn

Received 10 June 2022; Revised 3 September 2022; Accepted 26 September 2022; Published 12 October 2022

Academic Editor: Wen-Long Shang

Copyright © 2022 Wei Wang and Yulin Zhu. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Lewis' dual economic structure theory holds that differences in labour productivity affect urban-rural integration development. Based on this theory, this paper analyses the spatial mechanism of labour productivity affecting the development of urban-rural integration. A multidimensional index system is constructed to estimate the degree of urban-rural integration development, and a spatial Durbin model is used to quantitatively analyse the spatial effect between the difference in labour productivity and the development of urban-rural integration. The results show that there is a significant positive spatial agglomeration phenomenon in urban-rural integration in the Yangtze River Economic Belt. The convergence of labour productivity will not only promote local urban-rural integration but also inhibit the urban-rural integration development of other administrative divisions, but it can still play a positive role in promoting the urban-rural integration development of the whole region. Finally, based on the above research conclusions, this paper puts forward three policy suggestions: optimizing the human capital structure, promoting rural industrial integration, and exploring the land reform system.

1. Introduction

According to the theory of development economics, urban-rural integration is the final result of the development of urban-rural relationships in the later period of industrialization and urbanization [1]. With the development of the economy and the progress of urbanization in recent years, industrialization and urbanization in China have entered the middle and later stages, respectively. Theoretically, the basic conditions of urban-rural integration have been established. Therefore, this paper focuses on the following two questions: ① To empirically prove that the relationship between Chinese urban and rural areas is gradually moving towards integration or separation. ② To explore the factors affecting the integration of urban and rural areas and the characteristics of geographical differentiation.

To answer these questions, we construct a multidimensional urban-rural integration evaluation index system [2], which could be widely popularized in the future. Then, based on the theory of dual economic structure, we focus on the relationship between the difference in labour productivity and urban-rural integration by quantitative analysis. In addition, we incorporate spatial effects into the model, taking the spatial dependence of different geographic regions into account. Finally, we choose the Yangtze River Economic Belt as an example. It is booming but has severely unbalanced urban-rural integration development phenomena.

The main contributions of this paper are as follows: ① A multidimensional index system is constructed based on China's rural revitalization strategy about the contents of production, life, and ecology integration between urban and rural areas, which can scientifically and objectively evaluate

the level of urban-rural integration in a region. ② The impact of labour productivity differences on urban-rural integration development and its spatial effect are explored, which has not been involved in the previous research to the best of our knowledge. ③ Based on the correlation between labour productivity and urban-rural integration development, some policy suggestions to address the unbalanced development of urban-rural integration in the Yangtze River Economic Belt are put forward. The structure of this paper is as follows. Section 1 makes a brief introduction. Section 2 lists some related works. Section 3 analyses the common and spatial influence mechanism of the difference in labour productivity on urban-rural integration development. Section 4 decides the variables and research objects. Section 5 performs an empirical analysis by using a panel spatial Durbin model. Section 6 makes some conclusions and suggestions.

2. Literature Review

In recent years, scholars have performed much research on the interactive relationship between labour productivity and urban-rural integration. In “Economic Development with Unlimited Supplies of Labour”, Lewis (1954) created a dual economic model and revealed that the difference in labour productivity between urban and rural areas was the basic reason that led to a large influx of the labour force from rural to urban areas [3]. Ranis and Fei (1961) revised Lewis’s dual economic structure and emphasized that the convergence of labour productivity between urban and rural areas was the prerequisite for the urban-rural integration development [4]. The aforementioned literature studies [3, 4] are the most basic theoretical starting point of this research.

A country’s labour market reaching “the Lewis Turning Point” symbolizes the beginning of urban-rural integration [5]. At present, it is mainly some developing countries in Asia, especially China, that discuss the relationship between the labour force and the urban-rural integration development. The urban-rural gap is sometimes defined as the urban-rural income gap in a narrow sense [6]. Under the condition of unlimited supplies of labour, wages cannot respond to the supply and demand in a labour market, which leads to the expansion of the income gap between urban and rural areas [6]. But actually, the low-cost flow of labour from inefficient traditional agriculture to efficient modern industry enables the Pareto efficiency of factor allocation [7]. Hence, with the improvement of the dual economic structure [8], the gradual convergence of labour productivity in the industrial and agricultural sectors is conducive to promote the urban-rural integration development [9, 10].

In fact, the discussion of urban-rural integration development in developed countries was earlier. Many scholars have studied the mode of urban-rural integration development, including the urban agriculture [11], suburbanization [12, 13], and counterurbanization [14, 15]. The evaluation of urban-rural integration development is the basis of the transformation from qualitative analysis to

quantitative analysis [16]. Due to the higher urbanization process, labour markets in most developed countries have passed “the Lewis Turning Point” for a long time and scarce labour force made labour productivity between urban and rural basic convergence, so they tend to focus on the quality of urban-rural development [17, 18], which means much more detailed contents [19]. Because of the lag of economic and social development, it is obvious that detailed evaluation index systems [17, 18] are less applicable in developing countries. Therefore, it is necessary to construct a set of broader coverage of an evaluation index system to accurately evaluate the impact of labour productivity to the development of urban-rural integration in China.

In summary, research studies on urban and rural labour productivity and the interaction between urban and rural development have achieved fruitful results, which laid a solid theoretical foundation for this paper. However, the academic discussion of the relationship between these two aspects still has the following deficiencies. ① In terms of research methods, many scholars have analysed the driving factors of urban-rural integration development, but few scholars have broken through the boundary of geographical space to analyse its spatial spillover effect and spatial agglomeration effect [20, 21]. ② In terms of research contents, it has been proven in theory that the difference of labour productivity between urban and rural areas was an important factor affecting the development of urban-rural integration [3, 4], but few scholars have quantitatively analysed the degree of its influence. ③ In terms of the research object, most scholars explore the development of urban-rural integration from the national [22], provincial [23], municipal [24] and even more microscopic view [25], but few scholars take the geographical and economic regions, such as the Yangtze River Economic Belt as the research scale to carry out an empirical analysis.

3. Influence Mechanism

3.1. The Influence Mechanism of the Difference in Labour Productivity on Urban-Rural Integration Development. On the one hand, the difference in labour productivity will affect the wage gap between urban and rural areas. Lewis’s dual economic structure divided a country’s productive sectors into agriculture and industry [3]. There is a large surplus of labour in the traditional agricultural sector in developing countries. According to the scale of diminishing marginal productivity, the efficiency of agricultural production activities will be very low or even zero. At this point, the supply curve of the urban labour market is in a state of complete elasticity. As long as the wages in the industrial sector meet the basic living needs of the rural labour force, there will be a massive influx of labour into the cities, which is the so-called infinite supply of a labour stage. At this stage, although the urban and rural average wage income levels are low, compared with rural areas, there are still a large number of surplus labour productivity advantages, which will also lead to a large wage gap between urban and rural areas. However, when the expanding industrial sector has

absorbed all the surplus labour, the labour supply curve will no longer be perfectly elastic. In a competitive labour market, the level of wages determines the quantity of supply. At this stage, labour becomes a scarce factor, and the balance of the quantity of the labour force between urban and rural areas will make the gap in labour productivity gradually narrow so that the wage income of urban and rural areas performs a high level of convergence.

On the other hand, labour productivity differences also affect other functional income gaps, particularly in the means of production. In the early stage of urbanization, the rural population base is large, and the labour production efficiency is low. To pursue higher profits, the capital will be concentrated in urban areas, which will lead not only to less rural land and other resources per capita but also to the low price of rural land and other phenomena. However, in the late stage of urbanization, the massive shift of the agricultural population will increase the size of the means of production per capita in rural areas, the human-land relationship in rural areas will gradually improve [26], and the labour productivity of urban and rural areas will gradually converge, production in rural areas no longer will be just a traditional natural economy but also include large-scale farming, some of the urban industrial or commercial transfer, and other modern production activities, resources that distinguish the rural from the urban, such as land, beautiful scenery, and even fresh air, will be scarce, and the value realization of these scarce resources for farmers' income increase will further reduce the urban-rural income gap.

Finally, the convergence of labour productivity can effectively promote the flow of factors between urban and rural areas and thus indirectly promote the development of urban and rural integration. Scholars have discussed the relationship between the factor flow and urban-rural development. Songji and Xiuyong (2013) believed that a mismatch of urban and rural factors was the main reason for the lag of the transformation of China's dual economic structure [27]. Yuewen and Xinwei (2021) proposed that promoting the two-way flow of urban and rural factors was the key to enhancing the development level of urban-rural integration in Guangdong Province, China [28]. When factor owners allocate factors in different economic regions, they usually focus on whether they can maximize their profits. Because of the positive correlation between enterprise productivity and profit, we believe that the convergence of labour productivity is the endogenous driving force to promote the flow of the factors between urban and rural areas free and efficiently. The priority development strategy of heavy industry in the last century has led to the continuous expansion of the difference in productivity between urban and rural areas, which was the primary cause of the long-term factor mismatch and the sluggish transformation of the dual economy in China [29–31]. Promoting the free and effective flow of essential factors between urban and rural areas is beneficial to exert the feedback effect of industry on agriculture, to enliven a large number of rural idle assets in the “sleeping” state [32] and to create more equitable social welfare in urban and rural areas.

Based on the above influence mechanism, this paper proposes the following hypothesis:

H₁: the convergence of urban and rural labour productivity can promote the development of urban and rural integration.

3.2. Spatial Spillover Mechanism of Labour Productivity Differences Affecting Urban-Rural Integration. The convergence of labour productivity differences between urban and rural areas in a region will affect not only the local level of urban-rural integration but also the other regions through the spatial transmission mechanism. On the one hand, the convergence in productivity between urban and rural areas represents a high level of mode of production, the high concentration of capital and factors means that the local geographical space cannot meet the needs of production, the geographical radius of the element configuration is expanding and gradually breaking through the local administrative territorial entity, and the spillover of advanced production factors promotes the development of productive forces in the surrounding areas, which has a positive spillover effect on urban-rural integration. However, on the other hand, in a dual-structure economy, the convergence of urban and rural labour productivity in a region will raise the local average wage level, while the labour force in the surrounding areas that cannot be matched by current wage income will be transferred to this region. The human capital flight causes the surrounding area urban-rural construction to lag, while the accumulation of human capital to the region makes the scale of local industrial capital expand continuously, thus further deepening the siphoning effect of human capital in the surrounding area. From this point of view, the convergence of labour productivity has a negative space spillover effect on urban-rural integration.

Based on the above spatial influence mechanism, this paper proposes the following hypothesis:

H₂: the convergence of labour production efficiency has a positive space spillover effect.

4. Research Object, Variable, Data Source, and Processing

4.1. Selection of the Research Object. The construction of the Yangtze River Economic Belt is one of the three great strategic tasks of China in the new period. The economic belt spans the three major geographical regions of the East, Middle, and West in China, with the natural advantages of the Yangtze River golden waterway, abundant natural resources, and high ecological carrying capacity. The economic belt is at a stage of rapid development. According to the data released by the Chinese National Bureau of Statistics, by 2020, the region's GDP reached 471,580 billion yuan, with a per capita GDP of 77,800 yuan.

Compared with other economic regions in China, such as the Pearl River Delta Economic Circle or Bohai Rim Economic Circle, they are all economically developed and highly urbanized areas. However, the unbalanced development between urban and rural areas is prominent in the

Yangtze River Economic Belt because of its large geographical span, which is in line with the theme of this research domain. Hence, we take the 2008–2020 provincial panel data of the Yangtze River Economic Belt as an example, analyse the geographical differentiation characteristics of the urban-rural integration development, explore the factors that promote the development of urban-rural integration within the region and its spillover effects, and provides the theoretical basis and decision-making reference for the economic belt to realize the goal of “optimizing the layout of urbanization along the river, promoting the free flow of production factors and promoting the efficient allocation of resources.”

4.2. Selection of Variables

4.2.1. Explanatory Variable: Measurement of Urban-Rural Integration. To compare the degree of urban-rural integration (DOURI) development in different provinces of the Yangtze River Economic Belt, the key is to design a complete index system to scientifically measure DOURI [33, 34]. By extensive reading of the literature [28, 35], according to the principles of scientificity, accessibility, and representativeness of index selection [36], and then based on the coastal provinces’ urban-rural integration of the development of the actual process, this paper divides DOURI into 4 criterion layers, i.e., urban-rural economic integration, urban-rural life integration, urban-rural production integration, and urban-rural ecological integration, and then divides the criterion layers into 16 specific indices. The indicator system is shown in Table 1. In this paper, we calculate the DOURI by using the entropy evaluation method.

In addition, we list another classic urban-rural interaction evaluation system [37] (Table 2) to compare with the “DOURI” index system. Since there is no way to judge the accuracy of the calculation results, so in this section we will just do a simple comparison of the indices. In this classic evaluation system, it divides the urban-rural connection into spatial connection, economic connection, and social connection, and includes 28 specific indices, which are very abundant and comprehensive. However, its indices have some deficiencies in reflecting the urban-rural linkage. More specifically, most of the indices in this evaluation system reflect urban development instead of the urban-rural gap. In the “DOURI” evaluation system, we usually use the ratio between urban and rural of a variable to reflect this feature. Besides, some indices in this evaluation system may be less available due to a long history. For example, nowadays, there is almost no illiteracy or semi-illiteracy among the Chinese population over the age of 15 no matter in urban or rural areas. Finally, “the rural revitalization strategy” proposed by the Chinese government put forward production, life, and ecological integration between urban and rural areas, and “DOURI” incorporates these contents into the index system, which is very suitable for this Chinese national strategy.

4.2.2. Core Explanatory Variable. This gives the differences in labour productivity between urban and rural areas (LPD). This paper uses the dual structure index to measure LPD. The specific formula is as follows:

$$LPD = \frac{\text{agricultural gross product/agricultural employment}}{\text{nonagricultural gross product/nonagricultural employment}} \quad (1)$$

4.2.3. Control Variables. Scientific and Technological Progress (STP). Science and technology are the primary productive forces; to a certain extent, the progress of science and technology is the internal motive force that affects the development of urban-rural integration. In this paper, the per capita number of patent authorizations is used to express the STP.

Opening Up Level (OUL). There is a strong interactive relationship between OUL and the regional economic development, and it also affects the process of regional urbanization and the urban-rural integration development. In this paper, the volume of import and export trade per 10,000 people is used to express OUL.

Agricultural Input Level (AIL). Agricultural inputs are used to improve agricultural infrastructure, optimize agricultural production conditions, and improve the rural living environment. In this paper, the proportion of agriculture, forestry, and water affairs expenditure in the total financial expenditure is used to express AIL.

4.3. Data Source and Processing. The raw data for this paper are mainly from the provincial “statistical yearbook” 2009–2021, the provincial “statistical bulletin” from 2008–2020, the “Chinese statistical yearbook” from 2009–2021, the “Chinese environmental statistical yearbook” from 2009–2021, the “Chinese labour statistical yearbook” from 2009–2021, and EPSDTAT, and some missing data are filled by interpolation. To alleviate the error of parameter estimation caused by the difference in data magnitude, the natural logarithm of variables is taken in the econometric analysis, and the descriptive statistics of the processed data are shown in Table 3.

5. Empirical Analysis

5.1. Spatial Distribution Characteristics of Urban-Rural Integration in the Yangtze River Economic Belt. On the basis of calculating the degree of urban-rural integration by the entropy evaluation method, the spatial and temporal distribution map (Figures 1–3) of urban-rural integration can be drawn by ArcMap, and the following conclusions can be drawn. First, in terms of the whole area, the average degree of urban-rural integration in the Yangtze River Economic Belt is increasing year by year, from 0.22 in 2008 to 0.58 in 2020. In fact, this change shows that with the development of the economy and urbanization in recent years, the two-way flow between urban and rural factors has become more frequent, and the production and lifestyles of urban and

TABLE 1: Evaluation index system of urban-rural integration.

| Target layer | Criterion layer | Specific index | Index attribute | Weight | |
|--------------|---|---|---|--|-------|
| DOURI | Urban-rural economic integration | Ratio of urban to rural disposable income | - | 0.023 | |
| | | Per capita retail sales of consumer goods | + | 0.115 | |
| | | The proportion of the GDP of the tertiary industry in the overall GDP | + | 0.074 | |
| | | Ratio of urban to rural Engel's coefficient | + | 0.023 | |
| | | Per capita GDP | + | 0.110 | |
| | Urban-rural life integration | Ratio of urban to rural per capita expenditure on cultural, educational, and recreational supplies and services | Per capita living space | + | 0.053 |
| | | | Per capita number of medical beds | + | 0.070 |
| | | | Per capita investment in social fixed assets | + | 0.077 |
| | Urban-rural production integration | The proportion of science and technology expenditure in the total financial expenditure | Level of agricultural mechanization | + | 0.101 |
| | | | The proportion of environmental protection expenditure in the total financial expenditure | + | 0.034 |
| | | Urban-rural ecological integration | Amount of agricultural chemical fertilizer applied per 10,000 yuan of GDP | Amount of pesticide applied per 10,000 yuan of GDP | - |
| | Coverage of sanitary toilets in rural areas | | | + | 0.040 |
| | Centralized sewage treatment rate | | | + | 0.016 |

rural residents in the region have gradually converged. Second, in terms of the geographic region, their DOURI rank basic performance is as follows: the East > the Middle > the West. The DOURI in the 3 eastern provinces has been higher than that of the average level of the economic belt for a long time, although the growth speed has slowed slightly in recent years, but compared to the Middle and the West, they still have a distinct advantage. The early interactive relationship between urban and rural areas in the four middle provinces is relatively backwards, but in recent years, they are catching up with the East, as DOURI in these areas is basically equal to the economic belt average. The main reasons can be attributed to the following points: ① They rely on the natural advantage of water transportation in the middle reaches of the Yangtze River. ② They are adjacent to the Yangtze River Delta city group and thus enjoy the advanced factor spillover effects. ③ An early "Rise of the Middle" strategy was implemented for the Middle region to bring a good policy environment to the social and economic development. The DOURI in the 4 western provinces is relatively low, with the exception of Chongqing, and the remaining three provinces are well below the average level of the economic belt in 2020, which shows that the rural revitalization strategy and urbanization process in these areas need to be further promoted. Third, in terms of the single province, Shanghai's DOURI has always been at the top of the list, and Zhejiang and Jiangsu are next; as the pioneers of reform and opening up and common prosperity, urban and rural residents in these areas enjoy more equal income, employment conditions, infrastructure, social security, and so on. In contrast, Yunnan and other western provinces and cities have ranked last in urban-rural integration for a long time; these areas should develop the characteristic industry with comparative advantage based on resource endowment

and spatial location characteristics, focus on rural industries, expand channels for increasing farmers' incomes, and narrow the gap between urban and rural areas.

5.2. Construction of the Spatial Weight Matrix. The first law of geography states that the interaction relationship between things increases with the shortest geographical distance. However, through the continuous development of the economy and the exchanges of trade in recent years, the economic ties between provinces in the Yangtze River Economic Belt have become increasingly closer, and it is difficult to accurately measure the spatial characteristics of variables using only the traditional geographic adjacency matrix or inverse distance matrix. Therefore, based on the geographical distance between provinces, this paper will consider the economic distance and construct an "economic-distance" nested matrix. The matrix is constructed as follows.

$$W_d = \frac{1}{d(i, j)}, W_e = \frac{1}{|Y_i - Y_j|}, W_{ed} = W_d * W_e^T, \quad (2)$$

where W_d is the inverse geographic distance matrix, W_e is the economic distance matrix, W_{ed} is the geo-economic distance nested matrix, $d(i, j)$ represents the geographic distance between area i and area j according to the calculation of the longitude and latitude of the centre of mass of the two provincial capitals, and Y_i and Y_j represent the average per capita GDP from 2008–2020 for area i and area j , respectively. Since there are 143 sample sections in this study, it is necessary to expand the constructed matrix to a matrix with a size of 143*143. To simplify the calculation process, we need to standardize W_{ed} .

TABLE 2: A classic urban-rural interaction evaluation index system.

| Target layer | Criterion layer | Specific index | Index attribute | Weight | |
|---|---------------------|--|---|--------|--------|
| Urban-rural interaction level (Lei Z, Jun L and et al., 2002) | Spatial connection | Proportion of mountain ground to the total area | - | 0.0073 | |
| | | Per capita water resources index | + | 0.0276 | |
| | | Proportion of built-up area to total area | + | 0.0174 | |
| | | Urban density | + | 0.0253 | |
| | | Number of cities with a population of more than 200,000 | + | 0.0637 | |
| | | Number of small towns | + | 0.0401 | |
| | Economic connection | Railway network density | + | 0.0531 | |
| | | Road network density | + | 0.0531 | |
| | | Inland waterways navigation mileage | + | 0.0531 | |
| | | Number of post offices per 10,000 people | + | 0.0531 | |
| | | Treatment rate of waste water, waste gas, and solid waste per capita household electricity consumption | + | 0.0531 | |
| | Social connection | Per capita GDP | + | 0.0211 | |
| | | Proportion of nonagricultural industry in total output value | + | 0.0699 | |
| | Economic connection | Per capita output value of labour force of township enterprises | + | 0.0419 | |
| | | Proportion of transferred labour force in total labour force | + | 0.0510 | |
| | | Number of registered retail and wholesale markets | + | 0.0163 | |
| | | Total retail sales of consumer goods in the whole society | + | 0.0134 | |
| | Social connection | Proportion of agricultural expenditure in total fiscal expenditure | + | 0.0364 | |
| | | Proportion of nonagricultural population in total population | + | 0.0530 | |
| | | Economic connection | Number of illiterates and semi-illiterates over the age of 15 | - | 0.0454 |
| | | | Per capita income of rural households | + | 0.0389 |
| | | Social connection | Urban Engel coefficient | - | 0.0250 |
| | | | Rural Engel coefficient | - | 0.0196 |
| | Social connection | Number of telephones per household | + | 0.0153 | |
| | | Number of medical beds per 10,000 people | + | 0.0261 | |
| | | Social connection | Number of libraries per 10,000 people | + | 0.0144 |
| | | | Greenland coverage rate | + | 0.0123 |

TABLE 3: Descriptive statistics of observation samples.

| Variable | Sample size | Average value | Standard deviation | Minimum value | Maximum value |
|------------|-------------|---------------|--------------------|---------------|---------------|
| ln (DOURI) | 143 | -1.018 | 0.461 | -2.103 | -0.224 |
| ln (LPD) | 143 | -1.584 | 0.368 | -2.68 | -0.483 |
| ln (STP) | 143 | 1.903 | 1.195 | -0.81 | 4.104 |
| ln (OUL) | 143 | 5.719 | 2.136 | 1.613 | 9.506 |
| ln (AIL) | 143 | -2.845 | 0.311 | -3.492 | -1.723 |

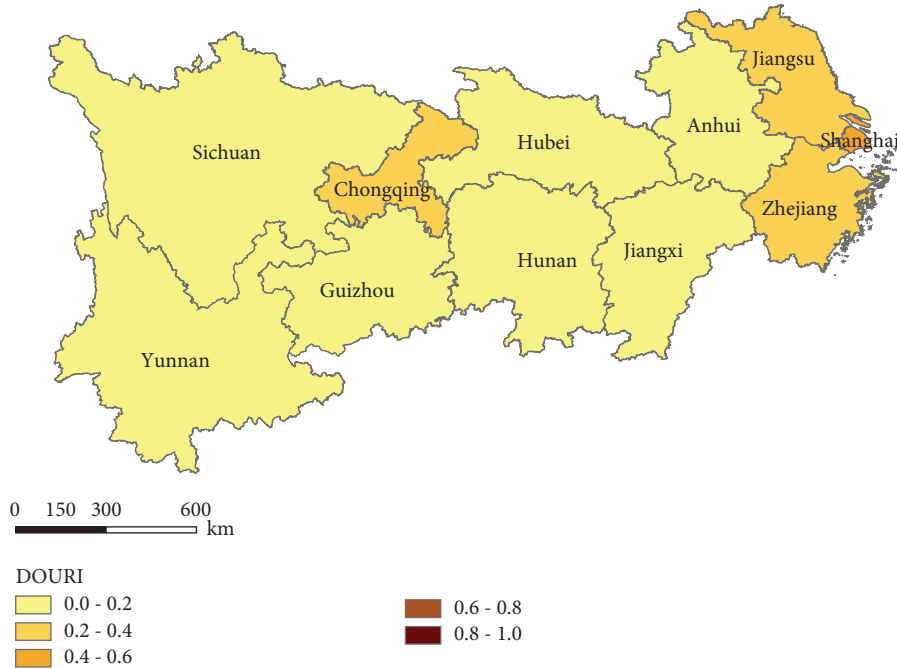


FIGURE 1: Spatial distribution map of the urban-rural integration degree of the Yangtze River Economic Belt in 2008.

5.3. *Spatial Autocorrelation Test.* Before constructing a spatial econometric model, first, we need to test whether the data exhibit spatial autocorrelation, that is, to test whether a variable exhibits spatial autoregression. At present, the main method to measure the spatial autocorrelation of variables is using Moran's I index, which is a value between -1 and 1 . When the value is positive, there is the possibility of spatial autocorrelation being positive; when the value is negative, there is the possibility of spatial autocorrelation being negative.

5.3.1. *Global Moran's I Index.* Global Moran's I index is used to test the spatial agglomeration of a whole cross section data. After the standardization of the spatial weight matrix, its specific formula is as follows:

$$\text{Global Moran's I} = \frac{\sum_{i=1}^n \sum_{j=1}^n w_{ij} (x_i - \bar{x})(x_j - \bar{x})}{\sum_{i=1}^n (x_i - \bar{x})^2}, \quad (3)$$

where i and j represent different provinces, w_{ij} represents the geo-economic distance between i and j , n represents the number of provinces belonging to the Yangtze River

Economic Belt, x_i and x_j are the different variables' observations, and \bar{x} is the mean of the observed value.

The global Moran's I indices of the DOURI and LPD from 2008–2020 are shown in Table 4. Limited by the paper length, the global Moran's I index for each control variable will not be displayed. According to Table 4, the DOURI strongly rejects the null hypothesis “there is no spatial autocorrelation” for all the years, and they are all positive, which indicates that the explained variable DOURI exhibits a significant “H–H” or “L–L” spatial agglomeration phenomenon. The LPD passed the test at the 1% level of significance from 2008 to 2015, which means there is a significant positive spatial autocorrelation, while it is no longer significant since 2016, and its value goes from positive to negative, which indicates that the positive autocorrelation of LPD is decreasing and there exists the possibility of negative autocorrelation; that is, the core explanatory variable LPD has the possibility of an “H–L” spatial agglomeration phenomenon in these years.

5.3.2. *Local Moran's I index.* The local Moran's I index can be used to test the characteristics of local spatial distribution, and its specific formula is as follows:

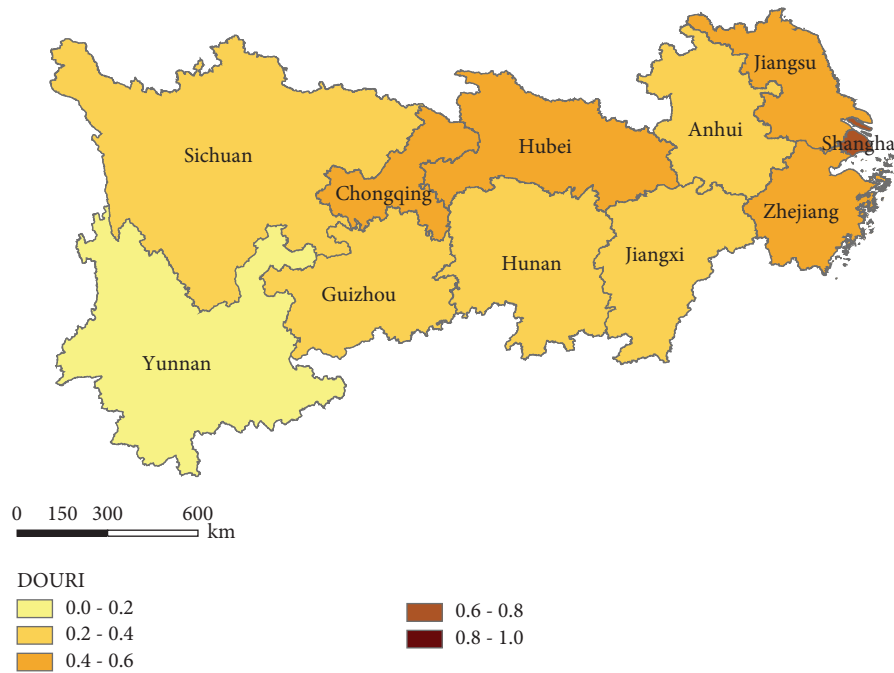


FIGURE 2: Spatial distribution map of the urban-rural integration degree of the Yangtze River Economic Belt in 2015.

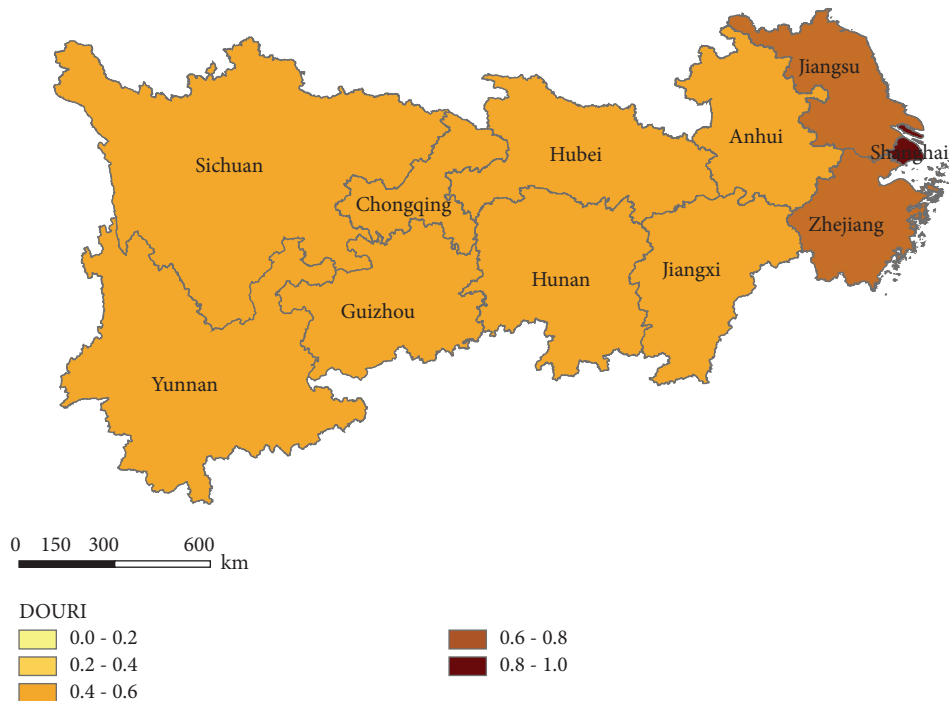


FIGURE 3: Spatial distribution map of the urban-rural integration degree of the Yangtze River Economic Belt in 2020.

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

where S^2 is the sample variance, and the other variables are the same as in formula (3).

This section uses cross-sectional data from 2020 as an example, calculates the local Moran's I index of the DOURI for each province in the Yangtze River Economic Belt, and based on the calculation result, draws a scatterplot for the local Moran's I of this year by using Stata. According to

TABLE 4: Global Moran's I index test.

| Year | DOURI | | MPD | |
|------|-----------------|---------|-----------------|---------|
| | Moran's I index | P value | Moran's I index | P value |
| 2008 | 0.539*** | 0.004 | 0.528*** | 0.003 |
| 2009 | 0.505*** | 0.004 | 0.485*** | 0.004 |
| 2010 | 0.537*** | 0.004 | 0.546*** | 0.002 |
| 2011 | 0.554*** | 0.004 | 0.496*** | 0.003 |
| 2012 | 0.564*** | 0.003 | 0.359** | 0.022 |
| 2013 | 0.594*** | 0.003 | 0.333** | 0.028 |
| 2014 | 0.607*** | 0.002 | 0.309** | 0.044 |
| 2015 | 0.619*** | 0.002 | 0.227* | 0.1 |
| 2016 | 0.579*** | 0.003 | 0.109 | 0.2 |
| 2017 | 0.573*** | 0.003 | 0.039 | 0.29 |
| 2018 | 0.569*** | 0.003 | -0.063 | 0.435 |
| 2019 | 0.555*** | 0.004 | -0.163 | 0.379 |
| 2020 | 0.538*** | 0.004 | -0.298 | 0.179 |

Note: *** represents significance at the level of 1%; ** represents significance at the level of 5%; * represents significance at the level of 10% (the same in the following tables).

Figure 4, Zhejiang, Jiangsu, and Shanghai are located in the first quadrant of the scatterplot; i.e., these three provinces exhibit the “H–H” agglomeration phenomenon of the DOURI, while Jiangxi, Hunan, Anhui, Yunnan, and Guizhou are located in the third quadrant of the scatterplot; i.e., these three provinces exhibit the “L–L” agglomeration phenomenon of the DOURI. In addition, this figure also shows once again that the level of urban-rural integration in

the Yangtze River Economic Belt is “high in the East and low in the West”, which highlights the regional imbalance of urban and rural development.

5.4. Model Selection. The current mainstream spatial panel models include the spatial Durbin model (SDM), spatial autoregression model (SAR), and spatial error model (SEM), all of which have an excellent explanation for the sample spatial effect [38]. The specific model selection steps are as follows: ① perform the LM test to verify whether the sample has spatial lag or spatial error; ② perform the LR and Wald tests to verify whether SDM can be nested into SAR or SEM; and ③ perform the Hausman test to verify whether the spatial panel model has a fixed effect or random effect. By performing the preceding operations by Stata, we can obtain the results shown in Table 5. According to Table 5, the statistics of the LM test all pass the significance test, and it can be concluded that the sample exhibits both spatial error and spatial lag effects, which shows that using a general panel OLS regression or mixed OLS regression to estimate parameters will result in missing spatial effects. In addition, the LR test and Wald test both significantly reject the null hypothesis “SDM can be nested into SEM or SAR”; therefore, in this paper, it is reasonable to choose SDM, which can measure both spatial error and the spatial lag effect. Finally, the Hausman test rejects the null hypothesis “using the random effect model,” so the fixed spatial panel model should be constructed. The specific equation is as follows:

$$\begin{aligned} \ln(\text{DOURI})_{it} = & \mu_i + \alpha \sum_{j=1}^n W_{ij} \ln(\text{DOURI})_{jt} + \beta_1 \ln(\text{LBD})_{it} + \beta_2 \ln(\text{STP})_{it} + \beta_3 \ln(\text{OUL})_{it} + \beta_4 \ln(\text{AIL})_{it} \\ & + \gamma_1 \sum_{j=1}^n W_{ij} \ln(\text{LBD})_{jt} + \gamma_2 \sum_{j=1}^n W_{ij} \ln(\text{STP})_{jt} + \gamma_3 \sum_{j=1}^n W_{ij} \ln(\text{OUL})_{jt} + \gamma_4 \sum_{j=1}^n W_{ij} \ln(\text{AIL})_{jt} + \lambda_{it}, \end{aligned} \quad (5)$$

where i and j represent different provinces; t represents the year; n is the number of provinces belonging to the Yangtze River Economic Belt, $n = 11$; W_{ij} is the constructed geographic distance nested matrix; β_1 – β_4 is the coefficient of the explanatory variables; γ_1 – γ_4 is the coefficient of the spatial lag of the explanatory variables; α is the coefficient of spatial autoregression; λ_{it} represents the spatial error effect; and μ_i represents the random disturbance term.

5.5. Results. Table 6 presents the parameter estimation results for the common panel regression, SDM with random effects and SDM with fixed effects. These kinds of regression models all have high goodness of fit. The attribute of the parameter estimate value is basically the same (namely, the parameter's positive and negative relations), which shows that the influence direction of each explanatory variable on the degree of urban-rural integration is consistent in these models, but there are differences in the degree of influence. Since the above tests have proven that SDM is suitable for

this research, the following analysis will focus on the parameter estimation of SDM.

In the quantitative regression results of SDM with fixed effects, ρ is positive and passes the significance test with a 1% confidence interval, which shows that the DOURI exhibits obvious spatial spillover and agglomeration effects in the Yangtze River Economic Belt; it concretely performs “H–H” gathering in the East and “L–L” gathering in the West. The parameter estimation result of the core explanatory variable $\ln(\text{LPD})$ is 0.147 and significant at the 1% level. On the one hand, it verifies the establishment of Lewis's dual economic structure theory that the difference in the productivity between urban and rural labours will have an impact on the level of urban and rural integration. On the other hand, it is found that the level of local urban-rural integration will increase by 0.147 for every 1% increase in the urban-rural dual structure index (confirming H_1). However, the spatial effect of $\ln(\text{LPD})$ is negative and significant at the 5% level, which indicates that the increase in the local urban-rural dual structure index will reduce the DOURI in other

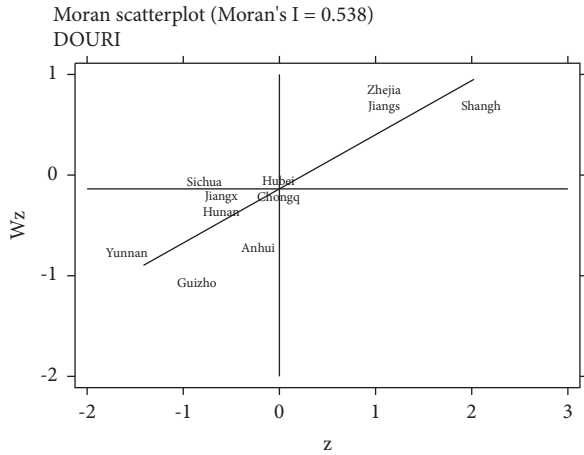


FIGURE 4: Distribution map of local Moran scattered points in the Yangtze River Economic Belt in 2020.

TABLE 5: Test results for LM, LR, Wald, and Hausman tests.

| Statistics or null hypothesis | Value | P value |
|----------------------------------|-----------|---------|
| LM test based on spatial error | | |
| Moran's I | 4.191*** | 0.001 |
| LM | 15.322*** | 0.001 |
| Robust LM | 15.281*** | 0.001 |
| LM test based on spatial lag | | |
| LM | 74.996*** | 0.001 |
| Robust LM | 74.955*** | 0.001 |
| LR test | | |
| H0: SDM could be nested into SAR | 40.77*** | 0.001 |
| H0: SDM could be nested into SEM | 50.3*** | 0.001 |
| Wald test | | |
| H0: SDM could be nested into SAR | 7.79* | 0.09 |
| H0: SDM could be nested into SEM | 34.69*** | 0.001 |
| Hausman test | | |
| H0: Model with random effect | 63.74*** | 0.001 |

provinces in the economic belt (rejecting H_2). This is mainly because with the gradual convergence of local urban and rural labour productivity, the unlimited supply of labour turns into a shortage of labour supply. Only by raising wages can business owners hire a sufficient number of workers, while an overall increase in local wages would have a siphoning effect on the labour market in the surrounding areas, and a large number of highly educated and skilled workers will move out, leading to the loss of talent in urban and rural construction. Then, by decomposing the effect of $\ln(\text{LPD})$, the absolute value of the direct effect is larger than that of the indirect effect, and the total effect is positive. It can be concluded that the convergence of urban and rural labour productivity in a region can promote the urban-rural integration development of the provinces and cities in the Yangtze River Economic Belt. Focusing on the control variables, STP and OUL perform a highly positive correlation with the local DOURI, which is basically as expected, but AIL becomes a factor to restrain urban and rural integration development. Analysis from the raw data shows

that most of the provinces with high AIL are concentrated in the relatively less developed western regions. For example, the proportion of agriculture, forestry, and water affairs expenditure in the total financial expenditure in Shanghai in 2020 was 5.8%, while in Chongqing, Sichuan, Guizhou, and Yunnan, it was 8.5%, 12%, 17.8%, and 15.8%, respectively. Most of the agricultural investment funds in these areas were used for the construction of backwards agricultural infrastructure, which can improve the production and living conditions of rural residents to a certain extent, but the income-increasing effect on rural households was not obvious. The traditional family-based mode of production can still meet only the most basic needs of life, and the high level of investment in agriculture reduced some of the resource allocation space to other industries, when in fact, the productivity of modern industries such as advanced service industry and high-tech industries was far higher than that of the traditional agricultural production. For the spatial effect, $\ln(\text{STP})$ and $\ln(\text{AIL})$ fail to pass the significance test, which shows that their spatial effects are not obvious. The parameter estimation of $\ln(\text{OUL})$ is positive and significant. Due to the growing foreign investment, some industries moved to surrounding economies, which is beneficial to their urban-rural integration development to a certain extent.

6. Discussion

This paper measures the level of urban-rural integration in the Yangtze River Economic Belt from 2008 to 2020 by constructing the index system of urban-rural integration. After analysis, in the time series, the entire DOURI increases year by year, which is in line with the overall trend of urban-rural integration development in China [1]. In the spatial distribution, "H-H" agglomeration exists in the East, and "L-L" agglomeration exists in the West. Kuznets S (1955) proposed the inverted U-shaped relationship between economic development and income inequality [39]. In this paper, a high level of urban-rural integration does not necessarily represent the absolute equality of income between urban and rural areas. In the Yangtze River Economic Belt, the economic developed areas are mainly concentrated in the east, while the less developed areas are mainly concentrated in the west. Chinese economy reached near the top of the Kuznets' curve around 2011 [40]. Therefore, the geographical concentration characteristics of urban-rural integration development in the Yangtze River Economic Belt also verifies the establishment of the Kuznets curve to a certain extent.

Then, an SDM is constructed to study the linear relationship and spatial spillover effect between labour productivity and urban-rural integration development. The empirical analysis shows that the direct, indirect, and overall effects of LPD are positive, negative, and positive, respectively. That is, the convergence of labour productivity between urban and rural areas will promote local urban-rural integration development. Meanwhile, it will also restrain urban-rural integration development in other provinces of the Yangtze River Economic Belt, but for the urban-rural

TABLE 6: Regression estimation results of the three models.

| | OLS regression | SDM with random effect | SDM with fixed effect |
|-----------------------------|------------------|------------------------|-----------------------|
| ln (LPD) | 0.091** (0.028) | 0.116*** (0.002) | 0.147*** (0.000) |
| ln (STP) | 0.424*** (0.000) | 0.167*** (0.000) | 0.175*** (0.000) |
| ln (OUL) | 0.084** (0.028) | 0.012 (0.364) | 0.031** (0.049) |
| ln (AIL) | -0.136 (0.263) | -0.174*** (0.003) | -0.140** (0.015) |
| $W \times \ln$ (LPD) | | -0.116** (0.019) | -0.106** (0.035) |
| $W \times \ln$ (STP) | | 0.018 (0.54) | 0.001 (0.967) |
| $W \times \ln$ (OUL) | | 0.009 (0.39) | 0.041* (0.067) |
| $W \times \ln$ (AIL) | | 0.125 (0.177) | 0.834 (0.359) |
| R-square | 0.7789 | 0.8845 | 0.8222 |
| Rho | | 0.561*** (0.000) | 0.529*** (0.000) |
| Direct effect of ln (LPD) | | 0.100** (0.016) | 0.138*** (0.000) |
| Indirect effect of ln (LPD) | | -0.100* (0.084) | -0.061* (0.094) |
| Overall effect of ln (LPD) | | 0.001* (0.078) | 0.077* (0.088) |

integration development of the whole economic belt, it is still a positive motivator. This conclusion not only empirically tests the dual economic structure theory proposed by Lewis A [3] but also points out that there is a geographical spatial effect of labour productivity on urban-rural integration development, enriching Lewis' dual economic structure theory from a spatial perspective.

In summary, the key to promoting urban-rural integration development is to continuously reduce the difference in labour productivity between urban and rural areas; therefore, the following suggestions are proposed.

- (1) Optimizing the structure of human capital in urban and rural areas. The government should establish a more equal education system in urban and rural areas, promote the construction of high-quality rural schools, adequately solve the education problems of children from poor families, and strengthen policy support for those who go to rural areas to provide voluntary education. Then, promoting higher education and vocational education at the same time is necessary to cultivate a group of high-tech talent as well as highly educated talent. Enterprises should carry out vocational skills training for employees and regard human capital as an important support for the long-term development of enterprises.
- (2) Promoting the integrated development of the rural industry. Rural enterprises should take the opportunity of rural revitalization strategy, make full use of the scarcity of the rural natural landscape, and develop rural ecotourism and its supporting industries [41]; they also should rely on the abundant ecological diversity and excellent ecological resource endowment of the rural areas, give full play to the comparative advantages of rural areas, introduce advanced manufacturing technology in the city, and promote the deep processing of rural ecological products and the development of the whole industrial chain.
- (3) Innovating the new system for land reform [42]. The local government should explore land systems that are in line with local realities, promote the listing and trading of collectively managed construction land, and invigorate the rural collective economy; they

should also give full play to the “back-feeding” role of cities and industries, and new market entities should be introduced into agricultural production activities, promote the intensive use of rural land, carry out scale agricultural production, constantly improve agricultural productivity, and provide new channels for farmers to increase their incomes.

Data Availability

The raw data for this paper are mainly from the provincial “statistical yearbook 2009–2021”, the provincial “statistical bulletin” from 2008–2020, the “Chinese statistical yearbook” from 2009–2021, the “Chinese environmental statistical yearbook” from 2009–2021, the “Chinese labour statistical yearbook” from 2009–2021, and EPSDTAT.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

This work was supported by the Natural Science Fund Project of Hunan Province, China (grant no. 2020JJ4950).

References

- [1] J. Zhiheng and Z. Yan, “Spatiotemporal differences and influencing factors of urban-rural coordination development in China,” *China Agricultural University Journal of Social Science*, vol. 27, no. 7, pp. 235–249, 2022.
- [2] W. L. Shang, J. Chen, H. Bi, Y. Sui, Y. Chen, and H. Yu, “Impacts of COVID-19 pandemic on user behaviors and environmental benefits of bike sharing: a big-data analysis,” *Applied Energy*, vol. 285, Article ID 116429, 2021.
- [3] W. A. Lewis, “Economic development with unlimited supplies of labour,” *The Manchester School*, vol. 22, no. 2, pp. 139–191, 1954.
- [4] G. Ranis and J. C. Fei, “A theory of economic development,” *The American Economic Review*, vol. 51, no. 4, pp. 533–565, 1961.
- [5] D. Yang, “Labor market transition, new technological change and urban-rural Integrated Development,” *Frontiers*, no. 2, pp. 28–35, 2021.

- [6] G. Gang and Y. Guang, "Analysis of China's unequal distribution of income from the perspective of functional income distribution," *Social Sciences in China*, no. 2, pp. 54–68, 2010.
- [7] J. Chengwu, "A critical reference to contemporary theories of development economics: a theoretical synthesis based on Chinese urban–rural integrated development," *Economic Research Journal*, vol. 54, no. 8, pp. 183–197, 2019.
- [8] Z. Zhuoran, "Influence of dual economic structure on the income gap between urban and rural residents under the process of marketization," *Inquiry into Economic Issues*, no. 12, pp. 102–111, 2019.
- [9] T. Shengwei, "Strategic orientation and realization route of urban–rural integrated development," *Macroeconomics*, vol. 10, no. 4, pp. 103–116, 2020.
- [10] L. Jinzhou, *Research on Dual Economic Structure and Urban–Rural Overall Development in China*, Huazhong University of Science and Technology, 2012.
- [11] L. J. Pearson, L. Pearson, and C. J. Pearson, "Sustainable urban agriculture: stocktake and opportunities," *International Journal of Agricultural Sustainability*, vol. 8, no. 1–2, pp. 7–19, 2010.
- [12] H. Baeyens, "De suburbanisatie rondom Brussel," *Mens en Maatschappij*, vol. 37, no. 6, pp. 429–437, 1962.
- [13] R. N. Zondag, "Towards a dual city? Suburbanization and centralization in Spain's largest cities," *Revista Espanola de Investigaciones Sociologicas*, vol. 176, pp. 35–38, 2021.
- [14] T. Bjarnason, A. Stockdale, I. Shuttleworth, M. Eimermann, and M. Shucksmith, "At the intersection of urbanisation and counterurbanisation in rural space: microubanisation in Northern Iceland," *Journal of Rural Studies*, vol. 87, pp. 404–414, 2021.
- [15] K. Hoggart, "Rural migration and counter-urbanization in the European periphery: the case of andalucia," *Sociologia Ruralis*, vol. 37, no. 1, pp. 134–153, 1997.
- [16] W. L. Shang, Z. Gao, N. Daina et al., "Benchmark analysis for robustness of multi-scale urban road networks under global disruptions," *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–11, 2022.
- [17] S. Polyzos, O. Christopoulou, D. Minetos, and W. L. Filho, "An overview of urban-rural land use interactions in Greece," *International Journal of Agricultural Resources, Governance and Ecology*, vol. 7, no. 3, pp. 276–296, 2008.
- [18] R. Van Maarseveen, "The urban–rural education gap: do cities indeed make us smarter?" *Journal of Economic Geography*, vol. 21, no. 5, pp. 683–714, 2021.
- [19] M. Shucksmith, S. Cameron, T. Merridew, and F. Pichler, "Urban–rural differences in quality of life across the European union," *Regional Studies*, vol. 43, no. 10, pp. 1275–1289, 2009.
- [20] L. Zujun, W. Li, and Y. Wei, "Economic agglomeration and development of regional urban–rural integration: an empirical analysis based on spatial econometric model," *Soft Science*, vol. 33, no. 8, pp. 54–60, 2019.
- [21] L. Xiangdong and Q. Qiyue, "Producer services and urban–rural integrated development from the perspective of factor allocation: an analysis based on the spatial Dubin model," *Macroeconomics*, vol. 13, no. 4, pp. 113–127, 2021.
- [22] Z. Jiangyan and B. Yongxiu, "The time series' fluctuation and regional difference of the urban–rural development integration level in China," *China Industrial Economics*, vol. 117, no. 2, pp. 5–17, 2014.
- [23] Y. Naman, X. Dichu, and H. Jingbo, "Urban and rural balanced development evaluation in Hunan province," *Economic Geography*, vol. 34, no. 3, pp. 58–64, 2014.
- [24] X. Songlin and L. Muchen, "Research on the measurement and promotion path of urban rural integration development level in Hefei," *Journal of Anhui Jianzhu University*, vol. 28, no. 5, pp. 28–34, 2020.
- [25] X. Yibo, "Study on rural regional function evaluation and revitalization path in Henan province from the perspective of urban–rural integration," *Chinese Journal of Agricultural Resources and Regional Planning*, vol. 42, no. 8, pp. 173–181, 2021.
- [26] G. Fan and Y. Chen, "Evolution of urbanization and agricultural labor productivity in the context of China's economic transformation," *Seeking Truth*, vol. 47, no. 4, pp. 70–79, 2020.
- [27] W. Songji and B. Xiuyong, "Resource misallocation between urban and rural department and China's dual economy transformation hysteretic: theory and empirical research," *China Industrial Economics*, no. 7, pp. 31–43, 2013.
- [28] G. Yuewen and G. Xinwei, *Annual Report on Urban–Rural Integration of Guangdong Province (2021)*, pp. 28–111, Social Sciences Academic Press(CHINA), Beijing, 2021.
- [29] L. Yifu and C. Binkai, "Development strategy and urban–rural consumption inequality," *Zhejiang Social Sciences*, vol. 35, no. 4, pp. 10–16, 2009.
- [30] Y. Qiang, "View the income differences between the urban and rural areas from the different system Arrangements of city and town," *Journal of Fujian Teachers University (Philosophy and Social Sciences Edition)*, no. 3, pp. 16–22, 2001.
- [31] L. Xiaofang and L. Shengji, "A new angle of view on the study of rural problems: A preliminary study on the phenomenon and theory of urban–rural environmental difference," *Science and Technology Review*, vol. 61, no. 8, pp. 14–17, 2003.
- [32] W. Tiejun, L. Shixuan, D. Xiaodan, and L. Yahui, "The innovative form of value realization of ecological resources under the background of rural vitalization," *China Soft Science*, vol. 95, no. 12, pp. 1–7, 2018.
- [33] W. L. Shang, Y. Chen, H. Bi, H. Zhang, C. Ma, and W. Y. Ochieng, "Statistical characteristics and community analysis of urban road networks," *Complexity*, vol. 2020, pp. 1–21, 2020.
- [34] W. L. Shang, Y. Chen, and W. Y. Ochieng, "Resilience analysis of transport networks by combining variable message signs with agent-based day-to-day dynamic learning," *IEEE Access*, vol. 8, pp. 104458–104468, 2020.
- [35] Y. Rongnan, "Preliminary study on urban–rural integration and its evaluation index system," *Urban Research*, no. 2, pp. 19–23, 1997.
- [36] H. Bi, W. L. Shang, Y. Chen, and K. Wang, "Joint optimization for pedestrian, information and energy flows in emergency response systems with energy harvesting and energy sharing," *IEEE Transactions on Intelligent Transportation Systems*, pp. 1–15, 2022.
- [37] Z. Lei, L. Jun, and L. Qi, "Construction of evaluation indicator system of urban–rural interaction and the comparative analysis of regional urban–rural correlative-degree in China," *Geographical Research*, no. 6, pp. 763–771, 2002.
- [38] X. Dongyang and L. Xiaohui, "Impact of infrastructure on the real exchange rate: evidence from China's provincial data by spatial Dubin model," *World Economy Studies*, vol. 16, no. 3, pp. 33–53, 2022.

- [39] S. Kuznets, "Economic growth and income inequality," *The American Economic Review*, no. 45, pp. 1–28, 1955.
- [40] S. Hongwei and J. Tao, "The Kuznets' inverted-U curve of income distribution: a cross-section and panel data re-verification," *China Industrial Economics*, no. 4, pp. 22–38, 2016.
- [41] A. D. Abbe, W. Bibo, and Y. Abreti, "Evolution, reflection and trend of the integrated development of urban and rural areas in China," *Regional Economic Review*, no. 2, pp. 93–102, 2020.
- [42] C. Jiming and L. Mengmeng, "Breaking the barriers of the dual system and promoting the integration of urban and rural development," *Hebei Academic Journal*, vol. 39, no. 4, pp. 139–145, 2019.