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The Impact of Agricultural Labor Migration on the Urban–Rural Dual Economic Structure: The Case of Liaoning Province, China

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Abstract: Based on the practical requirements of China's urban–rural integrated development, it is of great theoretical and practical significance to analyze the impact of agricultural labor migration on the urban–rural dual economic structure. This paper empirically examined the impact of agricultural labor migration on the urban–rural dual economic structure by using the spatial Durbin model and the geographically and temporally weighted regression model on the basis of the panel data of 14 regions in Liaoning Province from 2005 to 2020. The results show that agricultural labor migration has an obvious optimization effect and spatial spillover effect on the urban–rural dual economic structure; in terms of space, agricultural labor migration has a stronger impact on the central and western regions and a weaker impact on the southeastern regions; in terms of time, agricultural labor migration can stably promote the integration of urban and rural economies before the second Lewis turning point. Therefore, this paper provides references with regard to increasing investment in rural education and training; improving the structure of government spending; and protecting the rights and interests of rural migrants.

Keywords: Lewis turning point; integrated development; unified urban and rural labor market; spatial spillover effect

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1. Introduction

China's rapid development has long been characterized by a dual economic development pattern of urban and rural opposition. In this situation, industrial and agricultural products cannot be exchanged equally, urban and rural production factors cannot flow smoothly, public goods cannot be allocated in a balanced way, and the contradictions of unbalanced and inadequate development between urban and rural areas are becoming increasingly prominent [1–3]. In 2021, China successfully eliminated absolute poverty. In the new journey towards the second Centennial Goal, the issue of how to further solve the problem of uneven and inadequate development between urban and rural areas and achieve common prosperity has become a common focus of government departments and scholars [4,5]. In 2022, the General Offices of the CPC Central Committee and the State Council issued the 'Opinions on Promoting Urbanization with County Towns as an Important Carrier', which clearly recommended that a number of modern livable counties should be built by 2025 to gradually narrow the gap with neighboring large and medium-sized cities and break the urban–rural dual economic structure. Against this background, it is of great significance to explore the integrated development of the urban–rural dual economy.

Scholars have carried out many meaningful studies to explore effective methods for integrated urban and rural development [6–8]. Among them, research on the impact of agricultural labor migration on urban and rural economic development has become the focus [9,10]. The Lewis turning point theory proposed by Lewis (1954) is considered the most important paradigm in studying the agricultural labor migration of urban and rural

areas [11]. It is generally believed that the period from 2004 to 2010 was the first period exhibiting this transition in China, and the year 2008 is identified as the first turning point. After crossing the second turning point, the dual economy will be transformed into a homogeneous unitary economy [12]. In addition, based on Marx's industrial reserve army model, some scholars believe that the Lewis turning point theory ignores the subordination of labor to capital. In the long run, the industrial reserve army will not disappear but will continue to increase with the improvement of the organic composition of capital [13]. The above research indicates that the surplus agricultural labor force in China will exist for a long time and still has great transfer potential before the second Lewis turning point arrives. In the existing relevant research, the Todaro model and push–pull theory have been generally recognized by scholars [14,15]. Based on these foundations, research on the impact of agricultural labor migration on urban and rural economic development mainly focuses on the following two aspects. First, agricultural labor migration is beneficial to fill the shortage caused by population growth. At present, China is facing the dilemma of a declining fertility rate, the loss of labor dividends, and even a shortage of labor [16,17]. From the supply side, labor shortages directly weaken the fundamental power of economic growth [18]. From the demand side, ageing, the income gap, and the external environmental uncertainty of economic development will lead to insufficient consumption [19]. Second, agricultural labor migration is beneficial in improving agricultural labor productivity. On the one hand, the transfer of surplus agricultural labor to secondary and tertiary industries has changed the relationship between land supply and demand, which is conducive to the promotion of intensive and mechanized production and management to improve the scale efficiency of agricultural production [9,20]. On the other hand, the increase in non-farm income helps to ease the financial constraints of agricultural production and promotes the improvement of agricultural production efficiency through the purchase of agricultural machinery, fertilizers, improved seeds, livestock, and poultry production services [21–23].

On the whole, both alleviating labor shortages and improving agricultural production efficiency are effective strategies for agricultural surplus labor migration to optimize the urban–rural dual economic structure. In fact, the flow of labor often crosses the urban boundary, so the impact of agricultural surplus labor migration on the urban–rural dual economic structure is not only limited to the inner city but also spills over into the neighboring areas [24,25]. Agricultural surplus labor migration can also alleviate the imbalance of regional development and local resource mismatch, improve the efficiency of labor allocation in the transfer-in area, increase capital accumulation in the transfer-out area through the income return effect, and promote the progress of agricultural technology [26,27]. In addition, the increase in nonagricultural income brought by agricultural surplus labor migration will have a demonstration effect and correspondingly affect government decisions and industrial policies in the surrounding areas, and there exists a spatial spillover effect [28,29]. However, there are still few relevant studies from the spatial dimension, and most of the existing research about the impact of agricultural labor migration on the urban–rural dual economic structure focuses on the macro level and lacks theoretical and practical explorations based on specific regions. Furthermore, in recent years, Liaoning Province has seen a net outflow of the population; with a large number of young people and high-quality laborers leaving, the unbalanced and inadequate development between urban and rural areas has become increasingly prominent in this province [30,31]. Therefore, studying the impact of agricultural labor migration on the urban–rural dual economic structure of Liaoning Province is of great theoretical and practical significance to explore the development path of urban-rural integration in areas with a net outflow of population, such as the northeast and western regions of China.

In this context, we selected Liaoning Province as the study area. Based on the panel data of 14 regions from 2005 to 2020, we carried out empirical research on the impact of agricultural labor migration on the urban–rural dual economic structure from the spatial dimension to compensate for the shortcomings of existing research, which ignores the spatial flow of agricultural labor and underestimates its effect in optimizing the urban–rural dual

economic structure. We also introduced the geographically and spatiotemporally weighted regression model to investigate the heterogeneity of the spatiotemporal dimensions and finally extracted policy suggestions to promote urban–rural integrated development.

Regarding the rest of this paper, the theoretical analysis is described in Section 2. The methodology and materials are described in Section 3. The results of the impact of agricultural labor migration on the urban–rural dual economic structure is described in Section 4. Finally, the discussion and conclusions are provided in Sections 5 and 6, respectively.

2. Theoretical Analysis

2.1. Lewis' Theory of Dual Economy and Urban–Rural Dual Economic Structure

At present, an important manifestation of and reason for the rural–urban dual economic structure is the division of the labor market between urban and rural areas. To break the rural–urban dual economic structure and realize the integrated development of urban and rural industries, the unified labor market of urban and rural areas must be established [32]. From the perspective of explaining the reasons for the current urban and rural labor market segmentation and putting forward targeted solutions, the existing research can be roughly divided into the category of institutional economics and the category of neoclassical economics. The former believes that the current urban and rural labor market segmentation is due to the insufficient institutional reform of the government, so it is necessary to further promote the reform of the administrative system; eliminating institutional discrimination in employment and social security can achieve urban and rural labor market integration [6,33,34]. However, the latter insisted on the views of neoclassical economists represented by Marshall, Pigou, and Hicks, who believed that the market played a decisive role in determining the wage level of labors, labor resource regions, and industrial allocation, and that the long-term segmentation of urban and rural labor markets was the result of inadequate economic development and incomplete market system construction. It is an important manifestation of the unbalanced initial allocation of resources and low level of economic development [35,36]. In fact, these two views are unified opposites. The shortage of institutional supply is an important reason for the long-term unbalanced development of urban–rural relations in China. Therefore, the construction of a unified urban–rural labor market requires the joint efforts of the government and the market, which requires the basic logic of adhering to the market allocation of resources [37]. By deepening the reform, removing the institutional obstacles in the administrative system that are inconsistent with the phased characteristics of the labor force and the development of the unified urban and rural labor market, and giving better play to the role of the government's macro-control on the basis of following the law of the market allocation of labor resources, we may minimize the loss of production efficiency caused by the distortion of the factor market [38].

Lewis' dual economic theory explains the path and standard of urban–rural integration development from the perspective of labor flow between urban and rural industries. "The infinite expansion of industrial sector and the continuous outflow of labor force within agricultural sector" will eventually cause the income of the industrial sector and agricultural sector to reach a balance—that is, the "second turning point" of labor flow. The realization of the integration of urban and rural labor market allocation coincides with the basic market logic, realization approach, and vision of urban and rural unified labor market construction. In fact, Lewis' dual economic theory was proposed in describing the process of labor mobility to achieve urban–rural integration with two turning points [13]. The first turning point was that the surplus agricultural labor force changed from an infinite supply to a limited supply and the wage level of the transferred labor force began to rise. The second turning point was the convergence of marginal returns between agricultural and non-agricultural industries [6,13]. Between the two turning points is the Lewis turning interval, where the surplus labor and wage rise coexist. The industrial allocation of the agricultural labor force in pursuit of higher returns changed the element structure of traditional agricultural labor density, and gradually increased the ratio of land to labor and capital to labor in agricultural production, thus beginning the process of the modernization

of traditional agriculture. The transformation process of the dual economic structure is combined with the agricultural development stage. The two turning points basically divide the agricultural development into three stages: traditional agriculture, industrial agriculture, and modern agriculture. It is a perspective from which to judge the Lewis turning point to analyze the conditions that need to be met in the transition stage, especially the conditions of the transition from industrial agriculture to modern agriculture [12].

On the one hand, the key to crossing the first turning point lies in breaking the Malthusian Equilibrium of agricultural production. Endowment resources such as labor and land are the basic inputs of traditional agriculture. Due to the large amount of surplus labor force in agricultural production, labor-intensive technological progress has narrow space and low efficiency, and the increase in per capita output brought by limited technological progress only translates into population growth. Per capita income has been in the Malthusian Equilibrium steady state for a long time, and its marginal rate of return is zero or even negative before crossing. An external factor that breaks the equilibrium state is the rural–urban migration caused by the excessive factor yield gap between the industrial and agricultural sectors. When the absorption rate of the urban labor force is greater than the growth rate of the rural population (labor), it is conducive to triggering large-scale capital entry into agricultural production, the capital return rate starts to rise, and the agricultural production function is transformed into the Solow Model.

On the other hand, the key to crossing the second turning point lies in the transition from the industrial agriculture stage to the modern agriculture stage. As labor left the agricultural sector and capital entered agricultural production on a large scale, the agricultural production function changed, and the relative scarcity of labor made the marginal output of agriculture rise continuously until it was equal to the actual wage level of labor, resulting in the return of human capital represented by knowledge and skills higher than the marginal rate of return of labor [39]. The return on capital has experienced a process from low to high to low. In the early stage, due to the relative scarcity of capital, capital represented by agricultural technology such as machinery and fertilizer has a high rate of return, replacing labor as a key input in agricultural production. In the later stage, under the influence of the law of diminishing marginal returns, capital cannot become the source of sustainable growth in agricultural production, and the rate of return drops. In this way, the capital–labor ratio keeps increasing, forcing labor to invest in human capital to match the high material agricultural production. Abundant capital input will reduce the return on capital, provide a wide profit space for the total factors represented by technology, promote agricultural upgrading, and realize the final transformation of the dual economic structure.

The research of Fei Jinghan and Ranis supplemented Lewis' theory, arguing that in the process of labor transfer, the non-agricultural sector will also show a rise in labor productivity; they believed that this phenomenon occurred because, in the process of labor transfer, the supply of agricultural labor to non-agricultural industries changed from infinite to limited and then became scarce [40,41]. At this time, the structure of factor input was optimized within agriculture due to labor transfer, thus improving the output level of the transferred labor [42]. However, it focuses on the description of this process and does not analyze the causes of this process from the perspective of factor input and the production process.

2.2. The Influence Mechanism of the Impact of Agricultural Labor Migration on the Urban–Rural Dual Economic Structure

In the "Liu-Fei-La Model", proposed by Lewis (1954) and perfected by Fei Jinghan and Ranis (1961), developing countries coexist with the traditional sector represented by agriculture and the modern sector represented by industry [43], and the traditional sector contains an almost infinite supply of surplus labor. Due to the gap in labor productivity and rate of return between the two sectors, the modern sector can absorb labor from the traditional sector at low wages, so as to gain profits between wages and productivity and expand reproduction, while the surplus labor in the traditional sector further flows out.

With the diminishing marginal returns of the industrial sector, the marginal productivity of the traditional sector continues to rise, and the labor productivity of the two sectors gradually converges, finally realizing the transformation from the dual structure to the unitary structure [44].

It is important to note that the "Liu-Fei-La Model" actually implies a series of assumptions when it emphasizes the transformation of the urban–rural dual economic structure through the cross-sector flow of the rural labor force. For example, the rural labor force is homogeneous, the labor market runs smoothly (or the transaction cost is zero), and the rural labor force flow can realize the synchronous transformation of "occupation and identity" [43]. However, there is a certain distance between these assumptions and the current situation in China. The rural labor force is heterogeneous, with differences between human capital and material capital. Considering the strict household registration system, the self-selectivity of the rural labor force in the flow process should not be ignored, and the relevant institutional barriers, including the household registration system, should be regarded as the "entry threshold" of rural labor force flow. Only rural labor with high human capital or certain material capital can overcome institutional barriers to realize cross-sector mobility, and the transformation of identity lags significantly behind that of occupation. When rural labor flows from traditional sectors to modern sectors and from rural areas to urban areas, although the diminishing marginal returns mechanism of labor promotes regional economic convergence to a certain extent, it may also cause the loss of rural human capital and material capital, which is not conducive to the transformation of the urban–rural dual economic structure [45].

3. Materials and Methodology

3.1. Model Construction

To explore the impact of agricultural surplus labor migration on the urban–rural dual economic structure, this paper specifically constructed a spatial Durbin model (SDM) for analysis. Compared with existing spatial analysis models, such as the spatial lag model (SLM) and spatial error model (SEM), SDM can simultaneously consider the spatial interaction effects of explained variables, explanatory variables, and error terms and has been widely used in spatial analysis research [46–48]. Based on reference to existing research, the specific model of this paper is constructed as follows:

$$DUAL_{it} = \varphi_0 + \rho WDUAL_{it} + \phi_1 WRTL_{it} + \varphi_1 RTL_{it} + \phi_2 WControl_{it} + \varphi_2 Control_{it} + \varepsilon_{it} \quad (1)$$

where $DUAL_{it}$ represents the urban–rural dual economic structure of the region i in year t; RTL_{it} represents the agricultural labor migration of the region i in year t; $Control_{it}$ represents the control variables; ρ represents the spatial autoregressive coefficient; W represents the spatial weight matrix; Φ_1 and Φ_2 represent the spatial spillover coefficients of agricultural labor migration and other control variables, respectively.

Subsequently, the administrative center distance matrix (W_1) is constructed to quantify the relationship between spatial units, which is shown as Equation (2). In addition, this paper assumes that there is a connection between any two spatial units, so no threshold value is set. Among them, d_{ij} represents the great arc distance of each district's administrative center (the shortest distance calculated by latitude and longitude on the Earth's surface), and the data source is the National Geographic Center for Basic Information (http://www.ngcc.cn/ (accessed on 13 May 2021)).

$$w1_{ij} = \begin{cases} 1/d_{ij}^2, i \neq j \\ 0, i = j \end{cases} \quad (2)$$

Finally, the adjacency distance matrix (W_2) is constructed to test the robustness of the empirical results, which is shown as Equation (3). If the two spatial units are adjacent,

i.e., the two regions have a common boundary, the value is set as 1; otherwise, the value is set as 0.

$$w2_{ij} = \begin{cases} 1, \text{if region } i \text{ and region } j \text{ are adjacent} \\ 0, \text{other} \end{cases} \quad (3)$$

3.2. Variables

3.2.1. Explained Variable: The Urban–Rural Dual Economic Structure (DUAL)

Based on the dual economic structure theory proposed by Lewis et al., Chinese scholars mainly measure the urban–rural dual economic structure in the following three ways: comparative labor productivity, the dual comparison coefficient, and the dual contrast coefficient. Among them, the dual contrast coefficient can effectively measure the degree of deviation between the proportion of output value and labor and scientifically reflect the rationality of the spatial allocation of production factors; thus, this measure has been widely used [49]. Therefore, this paper selected the dual contrast coefficient to quantify the urban–rural dual economic structure in Liaoning Province, and the specific formula is as follows:

$$DUAL = \left| \frac{Y_2}{Y} - \frac{L_2}{L} \right| \quad (4)$$

where Y represents the total output value; Y_2 represents the total output value of non-agricultural industry; L represents the total number of on-duty workers; L_2 represents the total number of non-agricultural industry on-duty workers. The greater the dual contrast coefficient, the more significant the urban–rural dual economic structure.

3.2.2. Explanatory Variable: Agricultural Labor Transfer (RTL)

This paper referred to the research of Lewer et al. (2008) and selected the gravity model to measure the factor flow [50]. According to the gravity model, the flow of factors in different regions has a positive correlation with the economic level and a negative correlation with the spatial distance, which can measure the overall flow direction of factors. The specific formula is as follows:

$$M_{ij} = K \times N_i^{\alpha} \times N_j^{\alpha} \times R_{ij}^{-b} \quad (5)$$

where M_{ij} represents the number of factors flowing from the ith region to the jth region; K represents the gravity coefficient between the ith region and the jth region; N represents the measurement of relevant economic variables; α represents the gravity parameter; R_{ij} represents the spatial distance between the ith region and the jth region; b represents the distance decay index. Generally, K and α take the value of 1, and b takes the value of 2.

On the basis of Equation (5), the average wage of the secondary industry in each region was taken as the attractive factor of the destination, and the labor endowment of the destination was represented by the number of on-duty workers at the end of the primary industry to measure the rural labor migration. The specific formula is shown as follows:

$$RTL_{ij} = \ln l_i \times \ln wage_j \times R_{ij}^{-2} \quad (6)$$

where RTL_{ij} represents the number of agricultural laborers migrating from the ith region to the jth region; l_i represents the number of agricultural on-duty workers at the end of the year in the ith region; $wage_j$ represents the average wage of secondary industry workers in the jth region; R_{ij} represents the great arc distance between the administrative centers of the two regions, which can be calculated from the longitude and latitude coordinates, and the data source is the National Geographic Center for Basic Information. On this basis, the total number of agricultural labor migrations from the ith region to other regions (RTL_i) was further calculated, the specific formula is shown as follows:

$$RTL_i = \sum_{j=1}^{n} RTL_{ij} \quad (7)$$

3.2.3. Control Variables

In view of the regional economic scale, the income distribution, agricultural economic growth, and agricultural production technology level will all have an impact on the transformation of the urban–rural dual economic structure, and, based on existing research [51–53], the above variables were selected as control variables in this paper. The regional economic scale (*PGDP*), income distribution (*ID*), agricultural economic growth (*AEG*), and agricultural production technology level (*GTL*) were control variables. Among them, *PGDP* is represented by the per capita GDP; *ID* is represented by the proportion of general public budget revenue of local finance in the GDP of each region; *AEG* is represented by the ratio of the total output value of agriculture, forestry, husbandry, and fishery to the number of on-duty workers in the primary industry; and *GTL* is represented by the output of grain production per unit area.

3.3. Data Source

The relevant data of this paper were obtained from the Statistical Yearbook of Liaoning Province (2006–2021) and the statistical bulletin of national economic and social development of each region (Table 1).

Table 1. Descriptive statistics.

Variables	*N*	Mean	Standard Deviation	Min	Max
DUAL	224	0.12	0.08	0.03	0.34
RLT	224	0.15	0.09	0.02	0.37
PGDP	224	43,505.04	23,726.41	6280.00	110,682.00
ID	224	8.65	2.16	2.90	12.60
AEG	224	1286.20	2939.70	4.68	27,834.67
GTL	224	6075.98	1948.13	360.70	9665.86

4. Results

4.1. Correlation Test

In this paper, we use the Moran index to test whether the data have spatial correlation among the regions in Liaoning Province. Moreover, $I > 0$, $I = 0$, and $I < 0$ indicate that the research objects have a positive spatial correlation, independent spatial correlation, and negative spatial correlation, respectively. Table 2 shows the Moran index of the *DUAL* results, which indicates that there is a significant positive spatial correlation of *DUAL* among the regions in Liaoning Province, and the spatial econometric model can further be used to carry out subsequent research.

Table 2. The Moran Index of DUAL results (2005–2020).

Year	*I*	*Z*	*P*	Year	*I*	*Z*	*P*
2005	0.23	1.38	0.08	2013	0.26	1.46	0.07
2006	0.20	1.30	0.10	2014	0.17	1.11	0.14
2007	0.17	1.15	0.12	2015	0.19	1.14	0.13
2008	0.16	1.12	0.13	2016	0.26	1.42	0.08
2009	0.30	1.70	0.05	2017	0.15	1.03	0.15
2010	0.25	1.49	0.07	2018	0.19	1.16	0.12
2011	0.23	1.39	0.08	2019	0.28	1.49	0.07
2012	0.22	1.33	0.09	2020	0.32	1.65	0.05

Based on this, we determined the model with the LM test according to the criterion of Anselin et al. (2013) [54]. The results are shown in Table 3. Moran's I rejects the null hypothesis at the 1% level, indicating that there is a spatial effect and that the spatial effect model should be adopted. LM-ERROR and LM-LAG reject the null hypothesis at the 1% level, indicating that both SEM and SLM are applicable, and the more general SDM can also be used. Subsequently, we further evaluated whether SDM can degenerate into SEM or SLM with the LR and Wald test according to Lesage and Pace (2009) [55]. The test results

all reject the null hypothesis at the 1% level, indicating that SDM cannot be degenerated into SEM or SLM, and it is reasonable to select SDM in this paper. Finally, the Hausman test was used to determine whether to select the fixed effect model or the random effect model, and the results accepted the null hypothesis, so we selected the random effect model.

Table 3. Test results.

Test Method	Statistic	Result
Moran's *I*	12.77 ***	SDM
LM Error	150.26 ***	
Robust LM Error	4.09 **	
LM Lag	154.08 ***	
Robust LM Lag	7.91 ***	
Wald Error	37.54 ***	rejection to simplification
Wald Lag	53.62 ***	
LR Error	49.52 ***	rejection to simplification
LR Lag	49.59 ***	
Hausman	3.22	random effect model

Note: ** and *** represent 5%, and 1% significance, respectively.

4.2. Spatial Analysis

To further explore the impact of agricultural labor migration on the urban–rural dual economic structure from the spatial dimension, we selected the administrative center distance matrix (W_1) and the adjacency distance matrix (W_2) for SDM estimation.

Table 4 shows the results of SDM. When W_1 is introduced into the model, the coefficients of RTL and its spatial lag term (W × RTL) are −0.42 and −1.00, respectively, which are both significant at the 1% level, indicating that agricultural labor migration has played a certain role in optimizing the urban–rural dual economic structure in this region and adjacent regions. The spatial lag term of the dual contrast coefficient (ρ) is significantly positive at the 5% level, indicating that the elimination of the urban–rural dual economic structure in this region will also benefit the urban–rural integration development in the surrounding regions; Cai (2021) reached similar conclusions [13]. The PGDP is significantly negative at the 1% level, while its spatial lag term (W × PGDP) is significantly positive at the 1% level, indicating that regional economic growth is conducive to the integrated development of urban and rural areas in the local region and has an inhibitory effect on neighboring regions. This can be explained by the siphon effect; that is, the rapid economic development of a certain region will absorb the production factors of the surrounding regions, leading to the further widening of the gap between urban and rural areas. ID is significantly positive at the 1% level, indicating that a mature income redistribution system helps to narrow the income gap and achieve social equity. The GTL is significantly positive at the 1% level, while its spatial lag term (W × GTL) is significantly negative at the 5% level, indicating that the improvement of local production technology will lead to the substitution of some surplus agricultural labor, and the outflow of this surplus labor will play a regulating role in the allocation of production factors in surrounding regions.

On this basis, we introduced the adjacency distance matrix (W_2) for further testing. The coefficients of RTL and its spatial lag term (W × RTL) are −0.54 and −1.00, respectively; the spatial lag term of the dual contrast coefficient (ρ) is 0.19; and all are significant at the 1%, 1%, and 5% levels, indicating that agricultural labor migration is not only conducive to the convergence of urban and rural labor productivity and the optimization of the dual economic structure but can also help to solve the problems of insufficient funds and labor shortages in the surrounding areas and realize the rational allocation of factors. PGDP and ID are significantly negative at the 1% level, and their spatial lag terms (W × PGDP and W × ID) are significantly positive at the 1% level, indicating that the regional economic scale and financial strength had a strong agglomeration effect in the competition with the surrounding region. The spatial lag term of AEG (W × AEG) is significantly negative at the 1% level, indicating that agricultural economic growth has a certain demonstration

effect, which is conducive to the narrowing of the gap between urban and rural areas in the surrounding regions. The results of introducing W_2 are not significantly different from those of introducing W_1, indicating that the results are robust and reliable.

Table 4. The results of SDM.

Var	W_1		W_2	
	Main	W_x	**Main**	W_x
RTL	−0.42 ***	−1.00 ***	−0.54 ***	−1.00 ***
	(−3.83)	(−5.14)	(−4.48)	(−3.02)
PGDP	−0.00 ***	0.00 ***	−0.00 ***	0.00 ***
	(−3.86)	(4.27)	(−3.33)	(3.91)
ID	−0.01 ***	0.01 **	−0.01 ***	0.00 ***
	(−3.82)	(2.24)	(−4.21)	(2.88)
AEG	0.00	−0.00 ***	−0.00	−0.00 ***
	(0.19)	(−4.52)	(−0.53)	(−3.75)
GTL	0.00 **	−0.00 **	0.00	−0.00
	(2.32)	(−2.17)	(0.54)	(−0.34)
_cons	0.37 ***		0.35 ***	
	(7.07)		(4.88)	
ρ	0.22 **		0.19 **	
	(2.49)		(2.17)	
σ^2	0.00 ***		0.00 ***	
	(10.17)		(10.19)	
Log-likelihood	526.23		516.43	
N	224		224	
R^2	0.33		0.30	

Note: ** and *** represent 5%, and 1% significance, respectively.

4.3. Heterogeneity Analysis

The results of SDM show that agricultural labor migration can significantly promote the integrated development of urban and rural areas in local and adjacent regions, which provides empirical evidence to analyze the impact of agricultural labor migration. However, the previous analysis only focused on the average impact of agricultural labor migration on the dual contrast coefficient, and further research is required on the difference or imbalance between spatial units. Additionally, Liaoning Province is a large province with forestry and characteristic industries in the eastern part, farming and agriculture in the central part, and animal husbandry in the western part. Due to different factors such as resource endowment and industry types in different regions, agricultural labor migration will have different impacts on the urban–rural dual economic structure. Therefore, it is necessary to carry out further heterogeneity analysis. To address this need, this paper selected the geographically and temporally weighted regression (GTWR) model proposed by Huang et al. (2010) for further analysis [56]. The GTWR model added the three-dimensional spatial and temporal positions of the explained variables on the basis of the ordinary linear regression model to further explore the spatiotemporal differences of various factors affecting the urban–rural dual economic structure. The specific formula is as follows:

$$Y_i = \lambda_0(u_i, v_i, t_i) + \sum_k \lambda_k(u_i, v_i, t_i) X_{ik} + \varepsilon_i \quad (8)$$

where (u_i, v_i, t_i) represents the spatiotemporal coordinate of the ith region composed of longitude, latitude, and time; Y_i represents the explained variable of the ith region at location (u_i, v_i, t_i); X_{ik} represents the kth explanatory variable of the ith region at location (u_i, v_i, t_i); $\lambda_k(u_i, v_i, t_i)$ represents the kth explanatory variable regression coefficient of the ith region at location (u_i, v_i, t_i).

Table 5 shows the regression parameter results of the GTWR model. The influencing factors of *RLT*, *PGDP*, *ID*, *AEG*, and *GTL* have different effects in different regions and times. According to the average value, the influences of *RLT*, *PGDP*, *ID*, and *GTL* are

consistent with the results of W_1, while the influence of *AEG* is consistent with the results of W_2, indicating that the effect of agricultural economic growth on different regions is quite different.

Table 5. The regression parameter results of GTWR model.

Variables	Mean	Std. Dev.	Min	Max
RLT	−0.38	0.25	−1.10	0.04
PGDP	−0.00	0.00	−0.00	0.00
ID	−0.00	0.01	−0.03	0.02
AEG	−0.00	0.00	−0.00	0.00
GTL	0.00	0.00	−0.00	0.00

On this basis, the coefficients of agricultural labor migration in 2005 and 2020 were visualized through ArcGIS10.2, and the "natural discontinuity point" method was used to maximize the division of differences between various types of data to observe the overall spatiotemporal evolution trend of agricultural labor migration on the urban–rural dual contrast in Liaoning Province (Figure 1). All coefficients were negative, indicating that agricultural labor migration generally promoted the integrated development of urban and rural areas, which was consistent with previous results. In addition, the relatively low values of the coefficients shifted to the east and west, which may be due to the rapid accumulation of non-agricultural capital stock in the central region, which leads to the loss of non-agricultural capital transfer efficiency and the consequent reduction in the non-agricultural sector's ability to absorb surplus labor, slowing down the transformation of the urban–rural dual economic structure.

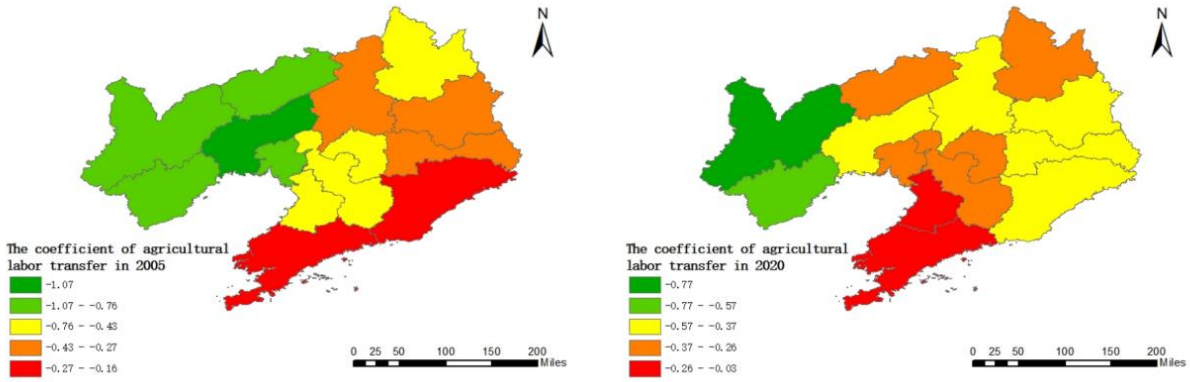

Figure 1. The impact of agricultural labor transfer on the urban–rural dual contrast.

Additionally, we further analyzed the spatial differences in the estimation results of the urban–rural dual contrast influencing factors. Taking the X-axis as the longitudinal direction and the Y-axis as the latitudinal direction, we constructed a three-dimensional perspective of the means of the estimated parameters of the agricultural labor migration and the control variables, as well as the projected trend lines in the X-axis and Y-axis directions (Figure 2). From the numerical point of view, the mean of the estimated RTL increases from west to east in the longitudinal direction and shows a U shape in the latitudinal direction, indicating that agricultural labor migration in the central and western regions has a greater effect on the optimization of the urban–rural dual economic structure. The means of the estimated PGDP and GTL show an inverted U shape in both the longitude and latitude directions, indicating that the optimization effect of the regional economic scale and agricultural technology level is stronger in the peripheral regions but weaker in the central region. This may be because the central region is the traditional old industrial base, including Shenyang, Anshan, Liaoyang, etc., and the longstanding structure of heavy industry and light agriculture is difficult to change [57]. The mean estimated AEG shows

a U shape in both the longitude and latitude directions, indicating that the agricultural economic growth of the central region in Liaoning Province plays a stronger guiding role in the integrated development of urban and rural areas. Specifically, the influence on Chaoyang, Huludao, Tieling, Benxi, and Dandong is positive, while the influence on Fuxin, Jinzhou, and Panjin is negative, showing a staggered distribution in space, which further shows the spatial differences among different regions in Liaoning Province.

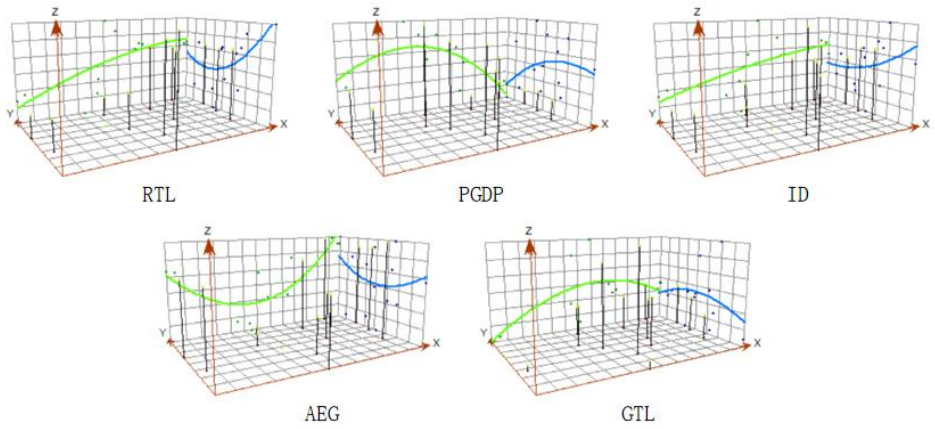

Figure 2. The spatial evolution trend of parameter estimated means.

Additionally, the time difference of each estimated influencing factor parameter of the urban–rural dual contrast was further analyzed by calculating the provincial mean value of each influencing factor parameter estimation result from 2005 to 2020 (Figure 3). The influence of RTL is always negative; on the whole, its influence decreases slowly and reaches stability after 2013, indicating that agricultural labor migration can stably promote the integrated development of the urban and rural dual economy after the first Lewis turning interval; this is also consistent with the previous theoretical analysis. The influence of PGDP is also negative, while the degree of influence fluctuates greatly over time, with a weak influence in 2005 and 2012 and a strong influence in 2008 and 2018, indicating that the improvement of the regional economy has a significant positive impact on the integrated development of urban and rural areas. The influences of ID and AEG show a large negative value in 2007, while they show a small fluctuation near 0 after 2008, indicating that the positive impact of income distribution and agricultural economic growth on the integrated development of urban and rural areas is gradually weakening.

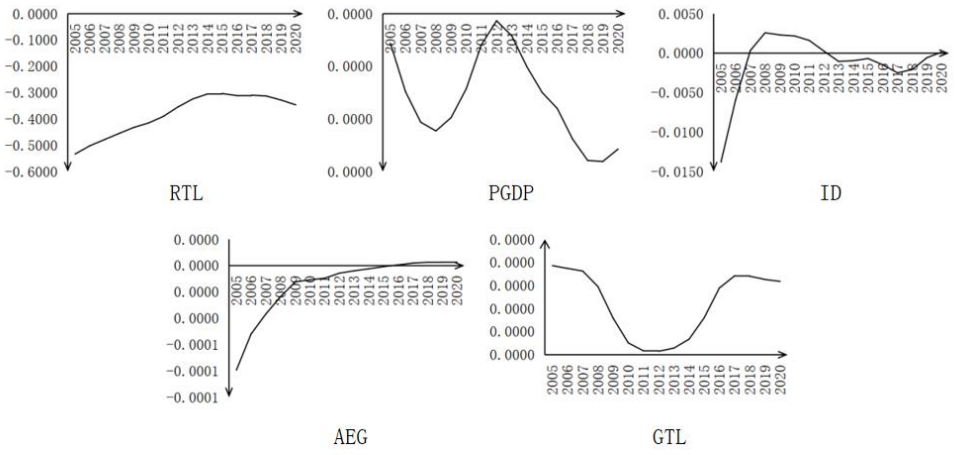

Figure 3. The time series analysis of parameter estimation results.

5. Discussion

The results of this paper show that agricultural labor migration has a significant positive effect on the integrated development of urban and rural areas. Existing studies also generally agree that rural labor migration can not only reduce the waste of labor resources, but also improves labor productivity in traditional sectors. Moreover, the return effect of income brought by labor flow can increase the accumulation of capital in traditional sectors, promote the progress of agricultural technology, and help to narrow the gap between urban and rural economic development. In spite of this, combined with the actual situation of social and economic development in Liaoning Province, we can see that there are still problems, such as urban–rural separation and a large income gap in some areas. This may be due to the heterogeneity of the rural labor force. Due to the restrictions of the household registration system, only the rural labor force with high human capital can realize stable occupational transformation through this "system screening". Such a flow is bound to cause the simultaneous loss of rural human capital and material capital, thus weakening the basis of sustainable economic development and inhibiting the transformation of the urban–rural dual economic structure. The quality of the labor force has become the key factor hindering the transformation of the urban–rural dual economic structure.

The results of this paper also show that the income distribution system has an obvious role in optimizing the urban–rural dual economic structure, but the effect has been weakening in recent years, indicating that the current income distribution system still has difficulty meeting the needs of social and economic development. Additionally, basic public services are unequal and incomplete urbanization will also hinder the transfer of the agricultural labor force. To some extent, the inequality degree of urban and rural residents enjoying basic public services is even larger than the income gap. For example, the gap between the urbanization rate of permanent residents and the urbanization rate of the registered residence population is 18.5%, a total of 260 million people, most of whom are migrant workers and cannot enjoy the same basic public services as the registered population, including children's education, social security, and subsistence allowances. In fact, it is the result of both the system and market that the urban and rural labor market is imperfect at present. In particular, under the urban–rural dual system, influenced by the development strategy of production factors favoring cities, the distribution system favoring citizens, and the industrial structure favoring heavy industry, there are certain institutional obstacles preventing workers from freely choosing jobs in urban and rural industries, which also forms a group of "migrant workers" with Chinese characteristics. This group has both the identity of farmers and citizens in life and participates in the production activities of both agricultural and non-agricultural industries. Therefore, solving the duality of the identity and employment of "migrant workers" is also a key step to realize the integration of urban and rural development. Moreover, the existing household registration system results in the incompleteness of urbanization, which further reduces social mobility. The lack of social mobility is reflected in many aspects, among which informal employment is an important factor. At present, informal employment accounts for at least 30% of all employment in China; this phenomenon is an important reason for the low wages and the high proportion of people with low wages.

Therefore, to further exploit the positive influence of the transformation of agricultural labor migration on the urban–rural dual economic structure, the first step is to improve the quality of the agricultural labor force, and at the same time offer more help and convenience to the agricultural labor force through the reform of the system and mechanism, so as to better realize the optimization of the labor market structure.

6. Conclusions

In this paper, we constructed an SDM to explore the impact of agricultural labor migration on the urban–rural dual economic structure from the spatial dimension based on the panel data of 14 regions from 2005 to 2020 in Liaoning Province, and we also investigated the spatiotemporal heterogeneity through the GTWR model. We found that,

first, agricultural labor migration has an obvious optimization effect and spatial spillover effect on the urban–rural dual economic structure. Second, in terms of space, agricultural labor migration has a stronger impact on the central and western regions and a weaker impact on the southeastern regions. Third, in terms of time, agricultural labor migration can stably promote the integration of urban and rural dual economies before the second Lewis turning point.

Based on these findings, the political implications of this research include the following aspects. Firstly, increasing investment in rural education and training will improve the comprehensive quality and employment ability of labor. In view of the fact that the technical threshold of urban spare jobs is increasingly becoming the transfer bottleneck of agricultural surplus labor, it is necessary to strengthen the vocational skills training of rural low-skilled laborers, help migrant workers to master the corresponding skills, and expand the employment range of migrant workers. The training for new types of professional farmers should also be strengthened, and the physical threshold for aged and female laborers to engage in agricultural production should be lowered to stimulate an endogenous impetus for the development of modern agriculture and reduce the uncertainty of the career transfer of the young and middle-aged labor force.

Secondly, it is necessary to improve the structure of government spending. In order to improve the efficiency of financial support for agriculture, we should constantly optimize the structure of support for agriculture; increase investment in agricultural research and development, agricultural technology innovation, and agricultural mechanization; and provide a guarantee in accelerating the pace of agricultural modernization.

Finally, protecting the rights and interests of rural migrants is essential. Accelerating the reform of the household registration system, it is necessary to create an equal employment environment for the rural migrant population and urban residents, establishing a public service supply mechanism covering the rural migrant population; to accelerate the reform of the education system, providing equal access to school for the children of the migrant agricultural population and improving the stability of the migrant agricultural population's migration; to promote the social integration of the migrant agricultural population and urban residents; and to realize the citizenization of the migrant agricultural population.

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