Agricultural & Forestry Economics and Management (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/agrfem.2025.080201
ISSN 2616-2202 Vol. 8 Num. 2

A Measurement Study on the Impact of Fixed Asset Investment on China's Industrial Structure Upgrading

Xide Zhang[1], Shaohua Liu[2], Yaxin Guo[2], Xinpeng Ji[2]

[1]*Statistics Bureau of Zibo City, Shandong, Zibo, 255095, China*
[2]*School of Marxism, Shandong University of Architecture, Jinan, 250101, Shandong, China*

Keywords: Fixed Assets Investment; Industrial Structure Upgrading; Granger Causality Test; Dynamic Durbin Space Model

Abstract: This study re-evaluates the causal relationship among investment, economic growth, and industrial structure upgrading in China based on two decades of economic data. A dynamic spatial Durbin model is constructed to explore the temporal and spatial lag effects of fixed asset investment on industrial structure adjustment, with a focus on industrial structure rationalization and upgrading. Granger causality tests show that China's expanded economic scale significantly boosts investment scale, which in turn notably facilitates industrial structure rationalization. Spatial model results further reveal marked regional disparities in investment's impact on industrial structure upgrading: investment in the central and western regions is critical to local industrial structure rationalization, while the eastern region's industrial structure rationalization depends more on its prior-period level; investment in the eastern and central regions significantly advances local industrial structure upgrading, yet there is insufficient evidence confirming that western investment substantially drives this upgrading process.

1. Introduction

Investment, as a key variable linking supply and demand, plays an indispensable role in industrial restructuring. It facilitates resource reallocation across sectors, promotes the upgrading of traditional industries and the reduction of overcapacity, and directs capital towards technology-intensive and emerging industries, thereby optimizing the supply structure [1].

Industrial structural adjustment generally refers to the reallocation of economic activities among sectors. Existing research often focuses on the interaction between fixed-asset investment and economic growth, highlighting a bidirectional relationship [2]. Other studies explore the links between private investment and industrial structure with empirical analyses confirming its positive impact on structural upgrading. Spatial econometric methods have also been applied to examine spatial correlations, such as the spillover effects in industrial structure optimization across regions [3].

This study constructs indicators for industrial structure rationalization and upgrading using China's 2003-2022 annual data to re-examine the causal relationships among investment, economic growth, and industrial structure. Furthermore, based on panel data from 31 provinces (2004-2021), it employs a dynamic spatial Durbin model to measure the temporal and spatial spillover effects of fixed-asset investment on industrial restructuring across the two dimensions [5]. Finally, it analyzes regional disparities between eastern, central, and western China. The paper's contributions are threefold: 1) re-testing causality among the three variables within a unified framework; 2) constructing a dynamic spatial model to capture dual-dimensional spillover effects; and 3) examining regional heterogeneities in these effects [4].

2. Construct Evaluation Indicators for Industrial Structure Adjustment

Industrial structural upgrading essentially involves the reallocation of economic factors across industries, along with resultant differences in industrial sectors' economic activity levels and resource utilization efficiency. It is evaluated from two dimensions: industrial structure rationalization and advancement [6].

2.1 Rationalization of the Industrial Structure

Industrial structure rationalization, denoting inter-industry agglomeration quality, reflects both inter-industry coordination and resource utilization efficiency. Its level is usually measured by the structural deviation degree, with the formula as follows:

$$E=\sum_{i=1}^{n}\left|\frac{Y_i}{L_i}/\frac{Y}{L}-1\right| \tag{1}$$

In Formula (1), E is the structural deviation degree, Y denotes output value, L stands for employment, i represents each industry, and n is the number of industrial sectors. According to the classical economic theory, when the labor productivity levels of all industrial sectors are equal, the flow of production factors between industries stops, and the economy will eventually remain in an equilibrium state.

Gan Chunhui et al. found that the Theil index can also be used to measure the rationalization level of industrial structure. Building upon the degree of structural deviation, they employed the Theil index to assess the rationalization of industrial structure. Its calculation formula is:

$$TL=\sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\ln\left(\frac{Y_i}{L_i}/\frac{Y}{L}\right) \tag{2}$$

Among them, TL denotes the Theil index, the output value of industry i, Y the total industrial output value, and n the number of industrial sectors. In the Theil index formula, Y/L stands for labor productivity. When the economy is in equilibrium, $Yi/Li = Y/L$, and TL equals 0. Thus, a non-zero TL signifies an unbalanced (unreasonable) industrial structure: the larger TL's absolute value, the greater the industrial deviation from equilibrium (the more unreasonable the structure). Conversely, TL closer to 0 indicates a more reasonable industrial structure.

2.2 Upgrading of the Industrial Structure

Industrial structure advancement, essentially measuring the structure's level, refers to the transfer of production factors and resources from lower to higher labor productivity industries. This paper uses industrial labor productivity to gauge industrial structure level: a country or region only has a higher-level industrial structure when higher labor productivity industries account for a larger share. Industrial structure height is measured by the product of industrial proportion and labor productivity, with the calculation formula as follows:

$$H=\sum_{i=1}^{n}S_{it}\times LP_{it} \tag{3}$$

Where i can take values of 1, 2, or 3 (representing the primary, secondary, and tertiary industries respectively) or be written as 1, 2, 3⋯n (representing n distinct sub-industries). S_{it} denotes the proportion of the i-th industry's output value in total GDP during period t. LP_{it} represents the labor productivity of industry i in period t, calculated as $LP_{it}=Y_{it}/L_{it}$, which is the ratio of the i-th industry's value added to its number of employees.

$$LP_{it}^{N}=\frac{LP_{it}-LP_{ib}}{LP_{if}-LP_{ib}} \tag{4}$$

Among them, LP_{it}^{N} represents the labor productivity of the i industry after standardization; represents the labor productivity of the i industry at the starting point of industrialization; LP_{if} represents the labor productivity of the i industry at the end point of industrialization. According to Chenery's (1986) standard structural model, labour productivity determines the starting and ending points of industrialisation based on per capita income.

3. Construction of Spatial Econometric Model

3.1 Measurement of Spatial Correlation

Before using the spatial econometric model to measure the spatial effect, it is necessary to first analyze quantitatively whether there is a certain regular dependence relationship of the explained variable in space. Currently, there are various methods to test spatial correlation, and the most commonly used index is the global Moran's I, and the formula is as follows:

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

Among them, I is the global Moran's index, refers to the observed value of a specific region i , and W represents the non - negative spatial weight matrix of n * n . The value of the Moran's index ranges from -1 to 1. The closer the value of the Moran's index is to 1, the more significant the positive spatial correlation between regions; the closer the value is to -1, the stronger the negative spatial correlation between regions.

3.2 Dynamic Spatial Durbin Model

In spatial econometrics, the spatial Durbin model (SDM) incorporates the characteristics of both the spatial lag model (SLM) and the spatial error model (SEM), adds the spatial lag terms of the explanatory variables and the explained variable, and is more suitable for measuring the spatial effect of panel data . The general form of the spatial Durbin model is:

$$Y_t=\rho WY_t+X_t\beta+WX_t\theta+\gamma_t A+B+\varepsilon_t \tag{6}$$

Among them, $Y_t=(y_{1t},y_{2t},\cdots,y_{nt})'$, is the observed value of the explained variable in region i (i = 1, 2, ⋯n) during period t; $X_t=(x_{1t},x_{2t},\cdots,x_{nt})'$, x_{it} is a vector of $1\times k$, representing k explanatory variables of region i during period t; W is a non - negative spatial weight matrix of n * n; ρ is the spatial autoregressive coefficient; β is the coefficient of the explanatory variable; WXtθ represents the influence from the explanatory variables of other regions, where θ is the corresponding influence coefficient; is the time effect; B is the individual effect ; is the random error term.

The above model, also called the static Spatial Durbin Model (SDM), only accounts for spatial lag effects but ignores time lag effects. In economic research, explanatory variables often exert delayed impacts on explained variables-their changes may not manifest immediately, and full effects usually emerge after a period. Drawing on this, Elhorst (2014) proposed the dynamic SDM. By adding the time lag term of the explained variable to the static SDM, this model measures the explanatory variable's influence from both spatial and temporal dimensions. Its expression is as follows:

$$Y_t=\tau Y_{t-1}+\mu WY_{t-1}+\rho WY_t+X_t\beta+WX_t\theta+\gamma_t A+B+\varepsilon_t \tag{7}$$

Y_{t-1} denotes the first-order time lag term of the explained variable, with τ as its corresponding coefficient; thus, is the time lag term of Y_t. Elhorst (2014) noted that the static Spatial Durbin Model (SDM) only measures long-term effects, while the dynamic SDM captures both long- and short-term effects, serving as an effective tool for spatial effect measurement. To quantify these effects, the model is rewritten as follows:

$$Y_t=(I-\rho W)^{-1}(\tau I+\mu W)Y_{t-1}+(I-\rho W)^{-1}(X_t\beta+ WX_t\theta)+(I-\rho W)^{-1}(\gamma_t A+B)+(I-\rho W)^{-1}\varepsilon_t \tag{8}$$

The direct spatial effect and spillover effect of X on Y can be calculated by performing partial differential matrix operations on the above formula.

4. Granger Causality Test Based on VAR Model

This study utilizes China's annual economic data from 2003 to 2022 for Granger causality tests. Data are sourced from the China Statistical Yearbook, the official website of the National Bureau of Statistics, and the Wind database [7]. Economic scale and investment scale are represented by the logarithm of GDP (Ingdp) and the ratio of fixed asset investment to GDP (invratio), respectively. Industrial structure upgrading is measured by its rationalization (isTLds) and upgrading (isHL) indices. All variables are adjusted to constant prices using 2003 as the base period [8].

4.1 Unit Root Test

To avoid spurious regression in VAR models with non-stationary time series, stationarity must be tested prior to conducting Granger causality analysis. This study applies the Augmented Dickey-Fuller (ADF) test for unit roots [9].

As shown in Table 1, the variables lngdp, invratio, isTLds, and isHL are non-stationary at the 1%, 5%, and 10% significance levels. Their first-differenced series-denoted as D.lngdp, D.invratio, D.isTLds, and D.isHL-are all stationary. Hence, these variables are integrated of order one.

Table 1: Results of Unit Root Tests for Variables

Variable	ADF test value	Test type (c,t,p)	p-value	Conclusion
1ngdp	-1.577	(c,t,0)	0.802	Non-stationary
invratio	-3.293	(c,t,3)	0.668	Non-stationary
isTLds	-1.906	(c,t,3)	0.652	Non-stationary
isHL	-2.682	(c,t,1)	0.244	Non-stationary
D.lngdp	-4.059	(c,t,1)	0.007	Stationary
D.invratio	-2.485	(c,n,0)	0.012	Stationary
D.isTLds	-4.968	(c,t,2)	0.000	Stationary
D.isHL	-2.648	(c,n,0)	0.084	Stationary

4.2 Cointegration Test

The cointegration test is to identify long-term stable equilibrium relationships between variables. Unit root test results indicate that lngdp, invratio, isTLds, and isHL are all first-order integrated sequences. Thus, prior to Granger causality tests, it is necessary to verify their cointegration relationships. This paper adopts the Johansen cointegration test (based on VAR model and using trace statistics) to examine the cointegration among economic scale, investment scale, and industrial structure upgrading, with results presented in Table 2.

Table 2: Results of Johansen Cointegration Test

Variable	Null hypothesis	Trace test statistic value	5% critical value	Whether to reject the null hypothesis
isTLds and invratio	r=0	23.654	18.170	Reject
	r≤1	1.779	3.740	Do not reject
isHL and invratio	r=0	12.620	18.170	Do not reject
	r≤1	2.417	3.740	Reject
lngdp and invratio	r=0	16.287	15.410	Reject
	r≤1	3.590	3.760	Do not reject
1ngdp and isHL	r=0	22.944	18.170	Reject
	r≤1	0.009	3.740	Do not reject
lngdp and isTLds	r=0	35.909	18.170	Reject

As shown in Table 2, several cointegration relationships are identified: between isTLds (industrial structure rationalization) and invratio (investment scale), indicating their long-term stable equilibrium; between lngdp (economic level) and invratio, reflecting a long-term equilibrium between economic level and investment scale; between lngdp and isHL (industrial structure upgrading), and between lngdp and isTLds, both signifying long-term stable equilibrium between economic level and industrial structure indicators. Notably, no cointegration relationship is found between isHL and invratio, meaning their equilibrium relationship cannot be detected.

4.3 Granger Causality Test

The Granger causality test is to verify whether sequence X Granger-causes sequence Y. Studies indicate that cointegrated variables have at least one-way Granger causality. As shown in the cointegration test results, four variable pairs (isTLds & invratio, lngdp & invratio, lngdp & isHL, lngdp & isTLds) are cointegrated, so the Granger causality test is applicable to examine their causal relationships. The lag order for the test is selected based on AIC and BIC criteria, with specific results presented in Tables 3–6.

Table 3: Granger Test Results ofisTLds and invratio

Null hypothesis	$\chi 2$ Statistic	p-value	Whether to reject the null hypothesis
invratio is not the Granger cause ofisTLds	9.908	0.007	Reject
isTLds is not the Granger cause ofinvratio	3.587	0.166	Do not reject

Table 4: Granger test results of lngdp and invratio

Null hypothesis	$\chi 2$ Statistic	p-value	Whether to reject the null hypothesis
invratio is not a Granger cause of lngdp	3.161	0.531	Do not reject
lngdp is not a Granger cause ofinvratio	16.233	0.003	Reject

Table 5: Granger test results of lngdp and isTLds

Null hypothesis	χ2 Statistic	p-value	Whether to reject the null hypothesis
isTLds is not the Granger cause of lngdp	0.436	0.804	Do not reject
lngdp is not the Granger cause ofisTLds	7.343	0.025	Reject

Table 6: Granger test results of lngdp and isHL

Null hypothesis	χ2 Statistic	p-value	Whether to reject the null hypothesis
isHL is not the Granger cause of lngdp	5.245	0.073	Reject
lngdp is not the Granger cause ofisHL	1.795	0.408	Do not reject

Granger causality test results show the following: At the 1% significance level, investment scale growth Granger-causes industrial structure rationalization (isTLds), while isTLds does not Granger-cause investment scale expansion; economic scale (lngdp) expansion Granger-causes investment scale growth, but not vice versa-indicating China's economic expansion significantly drives investment scale up.

In addition, at the 5% significance level, lngdp expansion Granger-causes isTLds, but not the other way around, meaning economic growth promotes industrial structure rationalization. Finally, at the 10% significance level, industrial structure upgrading (isHL) Granger-causes lngdp expansion, while lngdp does not Granger-cause isHL-suggesting higher industrial structure height facilitates economic growth.

5. Empirical Test on the Impact of Fixed Asset Investment on the Upgrading of Industrial Structure

5.1 Data Source and Variable Selection

5.1.1 Data Sources

This paper conducts empirical analysis using panel data of 31 Chinese provinces from 2004 to 2021, sourced from the China Statistical Yearbook, the National Bureau of Statistics official website, and the Wind database. Relevant variables are adjusted to constant prices with 2003 as the base period; for individual provinces with missing annual data, mean interpolation is used based on values from the nearest available year.

5.1.2 Variable Selection

Drawing on existing research on investment and industrial structure upgrading, this paper sets the explained variable as the industrial structure upgrading indicator, subdivided into industrial structure rationalization and advancement. The core explanatory variable is fixed-asset investment scale, with additional control variables considered, as presented in Table 7.

Table 7: Variable Definition and Explanation

Category	Name	Variable Symbol	Variable Explanation
Explained Variable	Rationalization Coefficient of Industrial Structure	isTL	Calculated according to the formula of industrial structure rationalization
	Upgrading Coefficient of Industrial Structure	isHL	Calculated according to the formula of industrial structure upgrading
Core Explanatory Variable	Scale of Fixed Asset Investment	finv	Proportion of Fixed Asset Investment in GDP
Control Variable	Scale of R & D Investment	rd	Proportion of Internal Expenditure on R & D Funds in GDP

	Wage level of employed persons	income	Logarithm of the average annual wage of employed persons
	Educational level	edu	Logarithm of the number of students in institutions of higher learning
	Trade level	ITval	Ratio of total annual imports and exports to GDP
	Degree of economic marketization	meco	Ratio of the number of employees in state-owned units
	Scale of fiscal expenditure	fise	Ratio of government expenditure to GDP

For the spatial weight matrix, we select one that reflects both geographical and economic information. First, a geographical distance matrix is constructed based on the reciprocal square of road distances between provincial capitals. Then, economic factors-specifically the average real per capita GDP of each province from 2004 to 2021-are incorporated. Finally, the data are standardized to form the economic spatial weight matrix W.

5.2. Spatial Test and Model Selection

5.2.1 Spatial Autocorrelation Test

Before using the spatial econometric model to measure the spatial effect, first use the R studio software to calculate the global Moran's Index of the industrial structure upgrading indicators of 31 provinces and municipalities in China from 2004 to 2021. Here, the geographical - economic spatial weight matrix W is used for the test, and the test results are shown in Table 8.

Table 8: Results of the Global Moran's I Test

Year	Rationalization of industrial structure		Upgrading of industrial structure	
	Moran's I	P value	Moran's I	P value
2004	0.224	0.002	0.190	0.008
2005	0.245	0.002	0.220	0.002
2006	0.259	0.001	0.200	0.005
2007	0.257	0.001	0.154	0.023
2008	0.257	0.001	0.159	0.021
2009	0.257	0.001	0.155	0.024
2010	0.257	0.002	0.205	0.005
2011	0.252	0.002	0.219	0.003
2012	0.256	0.002	0.187	0.010
2013	0.260	0.002	0.181	0.012
2014	0.257	0.002	0.195	0.008
2015	0.224	0.006	0.194	0.008
2016	0.242	0.003	0.196	0.008
2017	0.232	0.004	0.220	0.003
2018	0.231	0.005	0.231	0.002
2019	0.232	0.005	0.240	0.002
2020	0.236	0.004	0.253	0.001
2021	0.219	0.007	0.231	0.002

Results show that during 2004–2021, Moran's I indices of industrial structure rationalization and upgrading indicators are positive and pass the 5% significance test, indicating their non-random spatial distribution and significant positive spatial autocorrelation.

5.2.2 Spatial Model Selection

Next, based on the residuals of the panel fixed effects model, the data is diagnosed to judge the rationality of using the spatial econometric model, and the Hausman test is used to screen the fixed effects model and the random effects model in the spatial model.

As shown in Table 9, all LM test statistics are significant at 5%, rejecting the null hypothesis of no spatial effects and supporting a spatial econometric model. The Hausman test also rejects the null of no difference between fixed and random effects, indicating a fixed-effects spatial model should be used.

Table 9: Results of Model Selection Tests

Test type	Rationalization of industrial structure		Upgrading of industrial structure	
	Statistical value	P value	Statistical value	P value
LM_LAG test	9.257	0.002	40.965	0.000
LM_ERR test	3.296	0.069	21.483	0.000
Robust LM_LAG test	13.620	0.000	5.497	0.019
Robust LM ERR test	7.659	0.006	26.970	0.000
Hausman test	48.901	0.000	91.294	0.000

5.3 Model Design

Considering that the impact of fixed asset investment on the upgrading of the industrial structure may have a time lag, that is, the effects brought by fixed asset investment may take some time to fully act on the adjustment of the industrial structure. Therefore, this paper adds a time lag term to the static spatial Durbin model and constructs the following dynamic spatial Durbin model:

Model 1:

$$isTL_{it} = \tau isTL_{i(t-1)} + \mu WisTL_{i(t-1)} + \rho WisTL_{it} + \beta_1 finv_{it} + \beta_2 rd_{it} + \beta_3 lnincome_{it} + \beta_4 edu_{it} + \beta_5 ITval_{it} + \beta_6 meco_{it} + \beta_7 fise_{it} + \sum_{j=1}^{n} W_{ij} (\theta_1 finv_{it} + \theta_2 rd_{it} + \theta_3 lnincome_{it} + \theta_4 edu_{it} + \theta_5 ITval_{it} + \beta_6 meco_{it} + \beta_7 fise_{it}) + \gamma_t A + B_i + \varepsilon_{it} \quad (9)$$

Among them, $isHL_{i(t-1)}$ is the time lag term of the rationalization of the industrial structure; $WisTL_{it}$ is the spatial lag term of the rationalization of the industrial structure; $\mu WisTL_{i(t-1)}$ is the time and spatial lag term of the rationalization of the industrial structure, and the meanings of the remaining variables are referred to Table 7.

Model 2:

$$isHL_{it} = \tau isHL_{i(t-1)} + \mu WisHL_{i(t-1)} + \rho WisHL_{it} + \beta_1 finv_{it} + \beta_2 rd_{it} + \beta_3 lnincome_{it} + \beta_4 edu_{it} + \beta_5 ITval_{it} + \beta_6 meco_{it} + \beta_7 fise_{it} + \sum_{j=1}^{n} W_{ij} (\theta_1 finv_{it} + \theta_2 rd_{it} + \theta_3 lnincome_{it} + \theta_4 edu_{it} + \theta_5 ITval_{it} + \beta_6 meco_{it} + \beta_7 fise_{it}) + \gamma_t A + B_i + \varepsilon_{it} \quad (10)$$

Among them, $isHL_{i(t-1)}$ is the time lag term of the upgrading of industrial structure; $WisHL_{it}$ is the spatial lag term of the upgrading of industrial structure; $\mu WisHL_{i(t-1)}$ and $WisHL_{it}$ are respectively the time and spatial lag terms of the upgrading of industrial structure. The meanings of the remaining variables are shown in Table 7.

5.4 Empirical Analysis

5.4.1 Estimation Results Based on 31 Regions across the Country

(1) Regression Results for Investment and Industrial Structure Rationalization

The estimation results under the geographical and economic distance spatial weight matrix are presented in Column 2 of Table 10. A positive isTL(-1) and a negative W×isTL(-1) indicate that a province’s industrial structure rationalization is negatively influenced by its own prior level but positively influenced by that of neighboring provinces. The significantly negative spatial autoregressive coefficient (ρ) confirms positive spatial dependence in rationalization among provinces in the current period.

Investment exerts a significant positive direct effect on local industrial structure rationalization. Its spatial lag term is significantly negative, suggesting that investment also generates a positive spatial spillover, indirectly promoting rationalization in neighboring provinces. This spillover effect strengthens with closer geographical or economic proximity. Moreover, the larger magnitude of the spatial lag coefficient implies that investment has a greater impact on the rationalization of nearby provinces’ industrial structures than on the local one.

Table 10: Estimation Results of the Dynamic Spatial Durbin Model

Variable	Rationalization of industrial structure	Upgrading of industrial structure
	isTL	isHL
is(-1)	1.223***	1.006***
	(19.097)	(35.112)
W*is(-1)	-1.396***	1.300***
	(-2.766)	(13.918)
finv	-0.048***	-0.003
	(-3.632)	(-0.292)
rd	-0.646	0.021
	(-1.021)	(0.072)
income	-0.227***	-0.136***
	(-8.387)	(-2.635)
edu	0. 019**	0.000
	(2.261)	(0.039)
ITval	-0.073***	-0.016
	(-2.580)	(-1.014)
meco	-0.054	-0.491
	(-0.085)	(-1.807)
fise	0.060***	0.013
	(4.642)	(0.914)
W*finv	-0.342***	0.168***
	(-16.444)	(7.341)
W*rd	0.524	1.134
	(0.611)	(1.232)
W*income	0.754***	-2.317**
	(2.875)	(-10.387)
W*edu	-0.211***	0.033
W*ITval	(-5.766)	(0.582)
	-0.168	0.089**
	(-1.515)	(2.239)
W*meco	0.253	0.878
	(0.130)	(1.518)
W*fise	-0.582***	0.007
	(-17.268)	(0.154)
ρ	-1.481***	-0.906***
	(-4.797)	(-5.757)

Note: **** **, and * indicate significance at the 1%, 5%, and 10% significance levels respectively; the t- values are in parentheses; the closer the industrial structure rationalization index in the second column is to 0, the more it tends to a reasonable state. Therefore, the coefficient of the variable is negative, indicating a positive impact effect.

Regarding other control variables, wage levels promote local industrial structure rationalization but exhibit negative spatial spillover. Trade enhances local rationalization without significant spillover effects. Larger fiscal expenditure scales reduce local rationalization while increasing it in neighboring provinces, possibly due to structural or efficiency issues in local fiscal spending.

As shown in Table 11, investment has significantly positive short-term and long-term effects on industrial structure rationalization, with the short-term effect being stronger. However, neither its direct nor spillover effects are significant in either the short or long term.

Table 11: Direct and Indirect Effects of Investment and Rationalization of Industrial Structure

Variable	Rationalization of industrial structure					
	Short-term effect			Long-term effect		
	Direct effect	Spillover effect	Total effect	Direct effect	Spillover effect	Total effect
finv	0.147	-0.309	-0.162***	0.012	-0.159	-0.147*
rd	-0.173	1.643	-0.070	1.361	-1.419	-0.058
income	-1.030	1.226	0.196**	0.562	-0.366	0.195**
edu	0.193	-0.273	-0.080***	-0.077**	0.004	-0.073
ITval	-0.027	-0.066	-0.093**	0.086	-0.176	-0.090**
meco	-0.235	0.431	0.196	-0.109	0.204	0.094
fise	0.558	-0.775	-0.217**	-0.231***	0.034	-0.197***

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% significance levels, respectively.

(2) Regression Results for Investment and Industrial Structure Upgrading

Results in Column 3 of Table 10 show that both isHL(-1) and W×isHL(-1) are positive, indicating industrial structure upgrading is positively influenced by its own past level and that of neighboring provinces. The significantly negative spatial autoregressive coefficient (ρ) reveals an inverse inhibitory effect between local and neighboring regions' upgrading levels, with stronger effects under closer geographical or economic proximity.

Investment does not show a significant direct effect on local industrial upgrading. However, its spatial lag term is significantly positive, suggesting a positive spatial spillover that indirectly promotes upgrading in adjacent provinces.

For other controls, wage levels inhibit both local and neighboring regions' upgrading. Foreign trade scale has a positive spatial spillover effect, likely because it introduces advanced technologies and industries, thereby promoting upgrading in nearby areas.

Table 12: Direct and indirect effects of investment and the upgrading of industrial structure

Variable	Upgrading of industrial structure					
	Short-term effect			Long-term effect		
	Direct effect	Spillover effect	Total effect	Direct effect	Spillover effect	Total effect
finv	-0.038	0.125 ***	0.087**	-0.382	-0.066	-0.448**
rd	-0.328	0.890	0.561	-0.174	-3.088	0.287
income	0.318	-1.623***	-1.305***	0.117	0.981	6.590***
edu	-0.006	0.020	0.014	-0.084	-0.013	0.080
ITval	-0.034*	0.072 ***	0.038*	-0.010	-0.174	-0.184*
meco	-0.726**	0.916**	0.019	-3.410	2.603	-0.806
fise	0.016	-0.006	1.010	0.117	-0.174	-0.058

Note: *** **, and * indicate significance at the 1%, 5%, and 10% significance levels respectively.

The regression results in Table 12 show that in the short run, investment exerts a significantly positive spatial spillover effect on industrial structure upgrading. A 1-percentage-point increase in the local investment rate raises the industrial structure upgrading level in neighboring regions by 0.125 percentage points.

5.4.2 Regression Results Based on the Eastern, Central, and Western Regions

To examine potential regional heterogeneity, the sample is divided into eastern, central, and western regions. Regression results indicate in Table 13 that industrial structure rationalization in each region is negatively influenced by its own prior level. Notably, differences emerge across regions: investment in the central and western regions significantly promotes local rationalization, while the eastern region relies more heavily on its prior structural rationalization level. Furthermore, investment in the eastern region exhibits a positive spatial spillover on neighboring regions' rationalization, whereas the opposite holds for the central and western regions. This may be due to fiercer investment competition and greater industrial homogeneity in the central and western regions, causing the negative spillover of investment to outweigh its positive effects, thereby inhibiting rationalization in adjacent areas.

Table 13: Regression Results of Industrial Structure Rationalization by Region

Variable	Rationalization of industrial structure		
	Eastern region	Central region	Western region
isTL (-1)	1.172***	0.979	0.859***
W*isTL (-1)	-0.116	0.127	0.176
finv	0.008	-0.082***	-0.036*
rd	0.257*	-1.353*	-2.183***
income	-0.008	0.113**	-0.156***
edu	0.003	-0.043***	-0.152**
ITval	0.006	0.163***	0.041
meco	0.180*	-0.238	-0.287
fise	-0.033**	0.029	-0.127
W*finv	-0.024*	0.114***	0.187**
W*rd	0.204	3.226	-1.800
W*income	0.044	-0.678**	-0.257*
W*edu	0.045**	0.716***	-0.945***
W*ITval	0.017**	1.377**	0.111
W*meco	-0.049	1.586	-0.217
W*fise	-0.010	1.164***	0.256
ρ	0.248*	-0.431***	-0.342***
Short-term direct effect of finv	0.006	-0.092***	-0.052***
Short-term spillover effect of finv	-0.028	0.115***	0.171**
Long-term direct effect offinv	-0.072	-0.018	-0.992
Long-term spillover effect of finv	0.121	0.137	2.190

Note: *, **, and *** indicate significance at the 1%, 5%, and 10% significance levels respectively.

Regional results indicate in Table 14 that industrial upgrading in all three regions is positively influenced by their own prior levels. Investment in the eastern and central regions significantly promotes local industrial upgrading, with central-region investment also generating positive spillovers to neighboring areas. In contrast, investment in the western region suppresses both local upgrading and that of adjacent regions, reflecting relatively lower investment efficiency compared to the east and center.

Table 14: Regression Results of the Upgrading of the Industrial Structure by Region

Variable	Upgrading of industrial structure		
	Eastern region	Central region	Western region
isHL (-1)	1.223***	0.411***	1.399**
W*isHL (-1)	1.939**	-3.291***	0.131
finv	0.176**	0.109***	-0.155***
rd	1.196	-0.463	-0.469
income	-1.198**	0.008	-0.260***
edu	-0.026	-0.010	0.069
ITval	0.032	-0.212***	-0.067
meco	-1.811	-0.281	-1.037
fise	0.210*	-0.138***	-0.289**
AW*finv	0.344	0.329***	-0.432***
W*rd	1.644	3.595	7.349**
W*income	-2.133***	0.359	-0.139
W*edu	-0.125	-0.427**	-0.680***
W*ITval	0.096***	-0.716***	-0.149
W*meco	1.604	1.116	3.530
W*fise	-0.068	-1.233***	-0.127
ρ	-1.382***	-1.060	-0.204***
Short-term direct effect of finv	0.169	0.056***	-0.134***
Short-term spillover effect of finv	0.060	0.160***	-0.353***
Long-term direct effect ofinv	-0.582	-3.013	-0.611
Long-term spillover effect of finv	-0.220	3.022	2.133

Note: *** **, and * indicate significance at the 1%, 5%, and 10% significance levels respectively.

6. Conclusions and Policy Recommendations

6.1 Main Conclusions

(1) Results indicate that investment expansion significantly promotes industrial structure rationalization. Economic growth drives both investment expansion and industrial structure rationalization, while industrial structure upgrading supports economic growth.

(2) Investment directly advances local industrial structure rationalization and indirectly benefits neighboring regions. Empirically, investment does not significantly improve local industrial structure upgrading but indirectly promotes it in adjacent areas.

(3) Investment effects vary regionally: central and western regions see significant local rationalization from investment, whereas the eastern region relies more on prior rationalization levels. Investment in eastern and central regions boosts local upgrading, but in the west, it hinders local upgrading and negatively affects neighboring regions.

6.2 Policy Recommendations

China's industrial structure still faces imbalances. Accelerating a modern industrial system requires deepening supply-side reforms and fostering new growth drivers.

(1) Coordinate regional development. The government should address the east-west investment gap by guiding capital to the central and western regions through credit and tax policies. It should

leverage the advanced regions to drive the neighboring areas and encourage private investment in emerging sectors.

(2) Maintain moderate investment growth. Reasonable fixed asset investment drives economic sustainability by boosting both demand and supply. Relevant departments should avoid over-investment and reduce funding for low-value, high-consumption projects, while curbing repetitive investment in popular industries.

(3) Increase high-tech investment. Authorities should boost innovation in high-end, smart, and green manufacturing. They should strengthen support for research and development (R&D) and industrial application. In the services sector, policymakers should focus on modern industries such as information technology (IT), e-commerce, and R&D to develop high-tech clusters and promote industrial upgrading.

References

[1] Qiu Dongyang. Research on the Relationship between Fixed Asset Investment Structure and Economic Growth under Innovation-driven Development Strategy[J]. National Economy, 2020, 313(03) : 85- 97.

[2] Song Lizhi. Re-examination of the Relationship between China's Fixed Asset Investment and Economic Growth: 1980-2010 [J]. Macroeconomic Research, 2011(11): 17-21.

[3] Cui Hongkai, Wei Xiao. Private Investment, Industrial Structure and Economic Growth:Empirical Analysis Based on China's Provincial Dynamic Panel Data [J]. Economic Problems, 2018(01): 15-19.

[4] Li Fuyou, Sha Chunzhi, Liu Xizhang. Private Investment and Industrial Structure Upgrading-Theo- retical Analysis and Empirical Test [J]. Financial Forum, 2020, 25(01): 20-27.

[5] Li Xiang, Deng Feng. Research on the Economic Growth Effect of Technological Innovation and Industrial Structure Optimization-An Empirical Analysis Based on the Dynamic Spatial Panel Model [J]. Inquiry into Economic Issues, 2018(06): 144-154.

[6] Jin Zhen, Zhao Jing. The Economic Growth Effect of the Adjustment of Urban Agglomeration Spatial Structure in Western China: A Test Based on Dynamic Spatial Econometric Model [J] . Western Economic Management Forum, 2024, 35 (4) : 38-53, 96 .

[7] Gan Chunhui, Zheng Ruogu, Yu Dianfan. The Impact of China's Industrial Structure Changes on Economic Growth and Fluctuations[J]. Economic Research Journal, 2011, 46 (05) : 4-16.

[8] Fang Xingcun, Zhou Yongqi. Green Tax, Industrial Structure Upgrading and Carbon Emissions in the Yangtze River Delta - An Empirical Analysis Based on the Dynamic Spatial Durbin Model [J]. Journal of Anhui University of Science and Technology (Social Science Edition), 2023, 25(01) :9-19.

[9] Li Guanghui, Shi Fucai. Opening and Development of China's Border Areas: An Empirical Analysis of the Belt and Road Initiative on 9 Border Provinces from 1992 to 2020 [J]. Journal of Guangxi University (Philosophy and Social Sciences Edition), 2023(03) :171-178.