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Infrastructure, Agricultural Economic Growth and Increase in Farmers' Income: Based on Spatial Heterogeneity and Dynamic Analysis

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Abstract: Infrastructure, as an important social advance capital, is a key guarantee to realize agricultural modernization, promote agricultural economic growth and increase farmers' income. The economic growth effects and income-increasing effects of infrastructure are examined in this study through the analysis of provincial panel data for China from 1997-2018. The findings indicate that: (1) Irrigation and information technology (IT) infrastructure have a significant contribution to agricultural economic growth and increase in farmers' income. (2) Spatial heterogeneity is evident in the economic growth effects and income-increasing effects of infrastructure. The income-increasing effects of irrigation, transportation, agroelectricity, and IT infrastructure have a clear difference in the main cereal-producing, main cereal-marketing, and balanced supply and marketing areas. (3) In terms of promoting economic growth, the elasticity coefficients of irrigation, transportation, and agroelectricity infrastructure change from M-shaped fluctuations to regional stability, while IT infrastructure indicates a change from growth to stability. The elasticity coefficients of all types of infrastructure in terms of increasing farmers' income manifest a change from continuous growth to W-shaped fluctuations.

Keywords: agricultural and rural infrastructure; agricultural economic growth; increase in farmers' income; system GMM Model; bias-corrected LSDV model

JEL Classification: O13; H54

1. Introduction

In early 2020, the eruption of the Covid-19 vaccine pandemic has a profound and widespread impact on the economy around the world. The problem of inadequate infrastructure is further highlighted during the epidemic by the poor quality of agricultural and rural development in China. The report of the 20th National Congress of the Communist Party of China clearly pointed out that rural agriculture should give priority to development so that speeding up the accomplishment of the modernization of rural agriculture. But the main obstacle to developing rural economy is the weakness of infrastructure. At present, the "Top-down" supply decision-making mechanism ignores the actual needs of rural residents for infrastructure, which leads to the coexistence of the insufficiency of the total supply and the excess supply of the rural infrastructure. The unbalance of the supply and demand structure is mainly reflected in the lower comprehensive benefits and efficiency of infrastructure construction, hindering the rural economic development and the improvement of farmers' living quality. Under the background of agricultural modernization, the improvement of agricultural infrastructure is the basis for the further development of the agricultural economy, and the improvement of rural infrastructure is the key to increasing rural residents' income. Therefore, it is of great significance to scientifically analyze and make up the shortcomings of agricultural and rural infrastructure for agricultural development and promotion of rural revitalization strategy.

The economic growth effect and income-increasing effect of infrastructure have been highlighted in academic attention. Development economists such as Rosenstein-Rodan (1943) first recognized the importance of infrastructure to economic growth. Subsequently, Aschauer (1989) used econometric tools to explore how infrastructure relates to economic growth, and it was expanded by many scholars. From the point of research subjects, technological progress has led to the upgrading of infrastructure. Existing studies mostly use water conservancy irrigation infrastructure (Ye, 2016), rural road infrastructure (Liu & Liu, 2011), agroelectricity infrastructure (Li et al., 2017) as the core variables of infrastructure. With the introduction of new infrastructure, more and more scholars began to bring the digital infrastructure into the scope of research (Min et al., 2020).

Based on the above literatures, studies of the impact of agricultural infrastructure on economic growth and farmers' incomes need to be broadened in the three points below. Firstly, with the vigorous development of digital economy, IT infrastructure should be taken as the core index when selecting research variables. Secondly, most of the previous studies have used methods such as time series data regressions and panel data regressions, ignoring the endogenous issues in the model settings. Thirdly, most studies concentrate on the average effect of infrastructure, which causes the phenomenon that there are limited studies on spatial heterogeneity and dynamic effect. Thus, the estimation of the difference GMM and the system GMM is an attempt to evaluate the impact of agricultural and rural infrastructure on economic growth and farmers' income. Furthermore, the sample is divided into three regions: the main cereal-producing region, the main cereal-selling region, and the balanced supply and marketing region, to examine the heterogeneity. Finally, the dynamic effects of the two effects are examined by means of the nonparametric fixed effects model with time-varying coefficients.

2. Study Design

The research path of this study is to classify infrastructure reasonably based on its definition, then examine the association between infrastructure and agricultural economic growth and farmers' income-increasing through expanding the traditional model from the perspective of spatial heterogeneity and dynamics.

2.1. Classification of Infrastructure

Referring to the definition standards of the World Development Report (1994) and domestic and foreign scholars (Wharton, 1967), infrastructures are divided into two types: agricultural productive infrastructure and rural living infrastructure. Especially, the information technology infrastructure in the new infrastructure is classified as rural living infrastructure. Specific categories are listed in Table 1.

Table 1. Classification of agricultural infrastructure

Category	Agricultural Producing Infrastructure	Rural Living Infrastructure
Function	To improve agricultural economic development, affect the cross-regional distribution of agricultural products	Increasing the employment of farmers and their income
Specific types	Water conservancy irrigation, transportation infrastructure, fertilizer input, agricultural machinery input	Electricity infrastructure, IT infrastructure, rural education, agricultural research, rural health

2.2. Basic Model

Studies on the relationship between infrastructure and agricultural economic growth and farmers' income-increasing have evolved from neoclassical growth theory (Arrow & Kurz, 1970) to endogenous growth theory (Barro, 1988). Drawing on relevant research, the market function (1) with infrastructure factors is extended to (2):

$$Y_{it} = A_{it}L_{it}^{\alpha}K_{it}^{\beta}G_{it}^{1-\alpha-\beta} \quad (1)$$

where Y_{it} includes two explained variables of agricultural output and rural residents' income, A_{it} is agricultural total factor productivity, L_{it} is agricultural labor force, K_{it} is physical capital stock, G_{it} is infrastructure stock, α and β are coefficients to be estimated, where $\alpha > 0$, $\beta < 1$. In addition, irrigation, transportation, agroelectricity, and IT infrastructure are utilized to represent infrastructure variables, and the model is transformed as follows.

$$Y_{it} = A_{it}L_{it}^{\alpha}K_{it}^{\beta}IR_{it}^{\gamma_1}\,TR_{it}^{\gamma_2}RE_{it}^{\gamma_3}INF_{it}^{\gamma_4} \quad (2)$$

where IR_{it}, TR_{it}, RE_{it}, INF_{it} are respectively effective irrigation area, gross highway mileage, electricity consumption and average number of mobile subscriptions per 100 households in rural regions. Taking logarithm of both sides of formula (2) and controlling time fixed effect and individual fixed effect, the following equation is obtained.

$$lnY_{it} = \alpha lnL_{it} + \beta lnK_{it} + \gamma_1 lnIR_{it} + \gamma_2 lnTR_{it} + \gamma_3 lnRE_{it} + \gamma_4 lnINF_{it} + \mu_i + \delta_t + \varepsilon_{it} \quad (3)$$

where μ is individual fixed effect, and δ is time fixed effect, ε is a random error term. Additionally, the first-order lag term is added to the equation (3) in order to capture the dynamic effect and mitigate the endogenous effect. The final model as follows:

$$\begin{aligned} lnY_{it} = \theta lnY_{it-1} + \alpha lnL_{it} + \beta lnK_{it} + \gamma_1 lnIR_{it} + \gamma_2 lnTR_{it} \\ +\gamma_3 lnRE_{it} + \gamma_4 lnINF_{it} + \mu_i + \delta_t + \varepsilon_{it} \end{aligned} \quad (4)$$

2.3. Research Method

In DGMM (Difference GMM) model, the lagged variable is taken as the instrumental variable in the difference equation to eliminate the influence of fixed effect. However, it makes the problem of endogenous interference and dynamic panel bias (Nickell, 1981).

Regarding the method proposed by Blundell and Bond (1998), the estimation method of system GMM is applied to estimate the economic growth effect and income-increasing effect of infrastructure after over-identification test (Sargan test) and interference item serial correlation test (Abond test).

In addition, agricultural production usually manifests strong regional differences (Wu et al., 2015), dividing the sample into main cereal-producing regions, main cereal-selling regions, and balanced production-marketing regions. The bias-corrected LSDV (LSDVC) model is used to investigate the agricultural economic growth effect and the income-increasing effect of infrastructure in each area.

Finally, to further investigate the dynamic effects of infrastructure, this paper introduced a non-parametric fixed effects model with time-varying coefficients by Li et al. (2011) to capture its dynamic process of change.

2.4. Data, Variables, and Statistical Descriptions

The panel data of 31 provinces (municipalities and autonomous regions) in China from 1997 to 2018 were chosen as the initial samples. Hong Kong, Taiwan, and Macao are excluded for missing data. Raw data are collated from China Statistical Yearbook, China Rural Statistical Yearbook, China Agricultural Statistical Yearbook, provincial statistical yearbooks, and bulletins. The specific variables are presented in Table 2 (see below).

- Explanatory variables. The gross output value of agriculture, forestry, animal husbandry, and fishery (GDP_{it}) and per capita disposable income of rural residents (NI_{it}). The base period is taken to be 1997, this study uses the gross output value index for agriculture, forestry, animal husbandry, and fishery and the price index to construct the deflator.
- Core explanatory variables. (1) Irrigation infrastructure (IR). The effective irrigation area is used as the proxy variable (Gao, 2015). (2) Transportation infrastructure (TR). Lacking provincial data on rural roads, the total road mileage is used to measure it. (3) Agroelectricity infrastructure (RE), which is measured by rural electricity consumption. (4) Information technology infrastructure (INF). Considering the availability of data, the average number of mobile subscriptions per 100 households in rural regions is used as the proxy variable.
- Control variables. The sown area of crops ($land$), agricultural labor ($labor$), total power of agricultural machinery (mac), and the amount of agricultural mixed fertilizer applied in terms of pure quantity (fer) are taken as substitute variables to control the input of traditional factors. The proportion of financial support for agriculture (gov) is applied to reflect the government's behaviour. The share of the total imports and exports of agricultural products and the total output value of agriculture, forestry, animal husbandry, and fishery is used for the estimation of the regional agricultural openness ($open$). The disaster rate (dis) is used to estimate climate change, to further measure the significance of the above-mentioned variables for the growth of the agricultural economy and farmers' income-increasing (Reimers & Klasen, 2013).

Table 2. The detailed variable settings

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
$ln\,GDP$	682	6.7249	1.0999	3.7245	8.6322
$ln\,NI$	682	8.2710	0.5630	7.0776	9.6783
$ln\,IR$	682	7.1360	1.0279	4.6975	8.7192
$ln\,TR$	682	1.9664	0.9293	-0.9163	3.5013
$ln\,RE$	682	4.1877	1.6026	-1.7928	7.5669
$ln\,INF$	682	4.3349	1.4944	-1.6094	5.7066
$ln\,land$	682	8.0966	1.1502	4.6424	9.6093
$ln\,labor$	682	6.4555	1.1207	3.6133	8.1786
$ln\,mac$	682	7.3333	1.0970	4.3496	9.4995
$ln\,fer$	682	4.6084	1.2054	0.9163	6.5738
gov	682	26.3077	49.2617	0.4792	518.9401
$open$	682	3.5714	11.7639	0	108.6647
dis	682	25.0933	16.3416	0	93.5900

Firstly, Locally Weighted Scatterplot Smoothing (Lowess) was used to analyze the connection between infrastructure and the growth of the agricultural economy and the income of farmers. The relevant results of irrigation infrastructure are displayed in Figure 1 (Given the space constraint, please contact the author for the Lowess regression chart of the economic growth effect and income-increasing effect of the other three agricultural infrastructures).

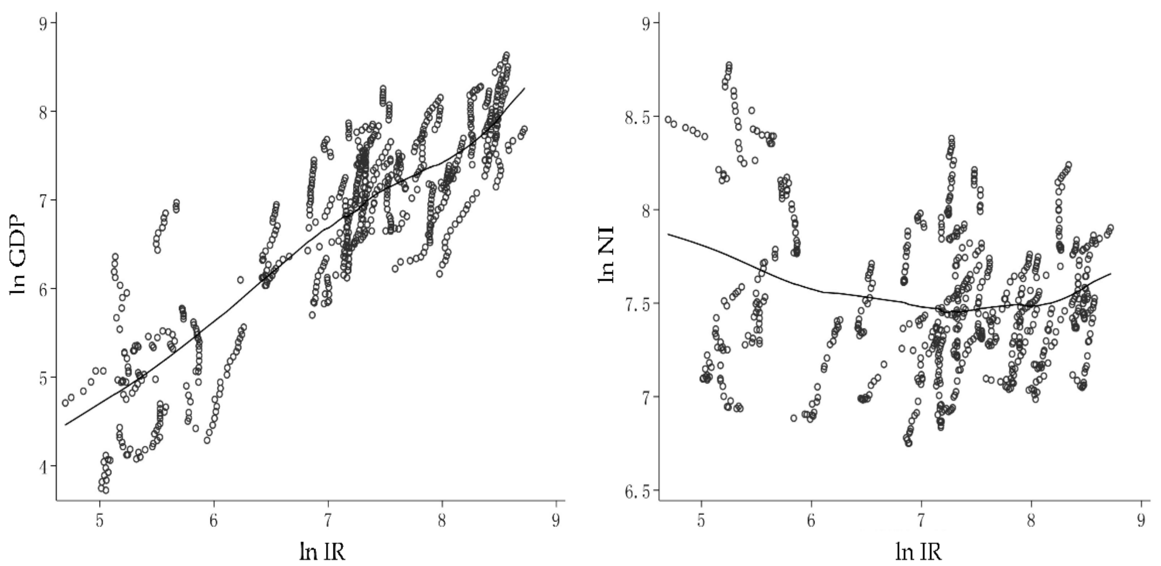

Figure 1. Lowess regression diagram of economic growth effect(left) and income-increasing effect(right) of irrigation infrastructure

Figure 1 indicates that the irrigation, transportation, agroelectricity, and IT infrastructure could promote agricultural economic growth without controlling other variables. The income-increasing effects of agroelectricity infrastructure and IT infrastructure are positive, while those of irrigation infrastructure and transportation infrastructure tend to be stable or even negative.

3. Empirical Results and Analysis

3.1. Baseline Regression Results

Table 3 reveals the economic growth and income-increasing effects of infrastructure. Models (1) and (4) use OLS model to estimate the growth effect of infrastructure on agricultural economy and farmers' income level separately. Among them, the variance inflation factor of Model (4) indicates that there is a serious multicollinearity problem in the model. The variables of $land$, fer, mac, and gov are excluded from the model and then regressed, the results are manifested by Model (5). Model (2) and Model (6) use DGMM (difference GMM) model to evaluate the above two effects. Model (3) and (7) are calculated by the SGMM (system GMM) method.

Table 3. Baseline regression results of economic growth and income-increasing effects

Explanatory Variable	OLS	DGMM	SGMM	OLS	OLS	DGMM	SGMM
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
$ln\,GDP$		0.4780***	0.6870***				
		(0.0861)	(0.1030)				
$ln\,NI$						0.6390***	0.7040***
						(0.0230)	(0.0284)
$ln\,IR$	0.1010**	0.0812***	0.0685***	0.0066	-0.0295*	0.0826***	-0.0088
	(0.0461)	(0.0242)	(0.0211)	(0.0345)	(0.0163)	(0.0202)	(0.0159)
$ln\,TR$	0.0714**	-0.0033	0.0045	-0.0385*	-0.0398**	0.0088*	-0.0008
	(0.0326)	(0.0045)	(0.0055)	(0.0219)	(0.0194)	(0.0050)	(0.0038)
$ln\,RE$	0.1500***	0.0385***	0.0136	0.1770***	0.1820***	0.0367***	0.0214**
	(0.0131)	(0.0113)	(0.0163)	(0.0082)	(0.0078)	(0.0125)	(0.0092)
$ln\,INF$	0.0595***	0.0162***	0.0150***	0.0369***	0.0349***	0.0108***	0.0163***
	(0.0137)	(0.0036)	(0.0034)	(0.0092)	(0.0076)	(0.0015)	(0.0016)
$open$	-0.0128***	-0.0029***	-0.0005	-0.0007	0.0075***	0.0021**	0.0023**
	(0.0029)	(0.0010)	(0.0015)	(0.0202)	(0.0020)	(0.0008)	(0.0010)
dis	-0.0041***	-0.0006***	-0.0007***	-0.0004	-0.0028***	-0.0000	-0.0002**
	(0.0009)	(0.0001)	(0.0001)	(0.0005)	(0.0006)	(0.0000)	(0.0001)
$ln\,labor$	0.1700***	-0.1460***	-0.0135	0.0085***	-0.1710***	-0.0879***	-0.0151
	(0.0399)	(0.0422)	(0.0212)	(0.0020)	(0.0158)	(0.0279)	(0.0142)
$ln\,mac$	-0.1050***	0.0083	-0.0035	-0.0027***			
	(0.0251)	(0.0086)	(0.0104)	(0.0006)			
gov	-0.0014**	0.0001	-0.0001	-0.1420***			
	(0.0007)	(0.0001)	(0.0002)	(0.0286)			
$ln\,land$	-0.1950***	0.0640***	0.0743**	-0.0628*			
	(0.0442)	(0.0244)	(0.0368)	(0.0345)			
$ln\,fer$	0.6760***	0.0019	-0.0057	0.0057			
	(0.0543)	(0.0203)	(0.0314)	(0.0322)			
constant	3.2970***	1.3190***	-0.0687	8.1330***	8.0770***	1.8310***	1.2430***
	(0.2920)	(0.4380)	(0.1010)	(0.1790)	(0.1010)	(0.2680)	(0.1770)
Regional fixed effect	No	Yes	Yes	No	No	Yes	Yes
Time fixed effect	No	Yes	Yes	No	No	Yes	Yes
AR(1)		-3.1221***	-3.1596***			-5.2272***	-4.9551***
AR(2)		-2.3309**	-0.8001			-5.1101***	-5.0608***
Sargan test		24.8155	23.7108			30.7992	30.8498
Observations	682	589	620	682	682	589	620
R^2	0.941			0.774	0.773		

Note: Standard errors are in brackets; *, ** and *** are significant at levels of 10%, 5%, 1%.

- Overall impact of infrastructure on agricultural economic growth

The result of Model (1) indicates that the coefficients of the core variables are significant. In the estimation of model (4), the coefficients of the other three crucial variables are positive, except for the income-increasing effect of irrigation infrastructure, showing basically that infrastructure plays a beneficial role in the promotion of agricultural economic aggregates. The test results of AR(1) and AR(2) manifest that DGMM and SGMM models cannot reject the null hypothesis. Furthermore, the results of the Sargan tests demonstrate that all of these variables are justified, which could not be rejected at the 10% significance level, indicating that the selected instrumental variables are highly valid. In the result of Model (3), the effect coefficient of the IR on the economic growth in the agricultural sector is clearly positive, manifesting that the irrigation infrastructure could significantly provide a better environment for promoting agricultural economic growth. To be specific, agricultural output will increase by 0.0685% with increasing 1% in effective irrigation area. The economic growth effect of transportation infrastructure is positive but not significant. The possible reason lies in the low construction standard and poor quality of transportation infrastructure especially the rural roads in China. The impact of IT on the economy is observably positive, and the elasticity coefficient of specific substitution variables is 0.015.

- Overall effect of infrastructure on farmers' income increase

The income-increasing effect of water conservancy irrigation and transportation infrastructure shown in model (7) is negative but not significant, the potential reason is that rural residents cannot quickly adapt to advanced agricultural technologies, which brings certain difficulties to increase in income. The income-increasing effect of agroelectricity infrastructure is significantly positive. In particular, other conditions being equal, the income of the rural population will rise by 0.0214% for each additional 1% in rural electricity consumption input. IT infrastructure also plays a significantly positive role in improving the income of rural residents. The continuous improvement of IT infrastructure will cut production and living costs, thereby enhancing farmers' income.

- Effects of controlled variables on economic growth in the agricultural sector and farmers' income increase

The economic growth effect of sown area is evidently positive, probably because it plays a role in rising the gross output value of agriculture, forestry, animal husbandry, and fishery, and then promotes economic growth in the agricultural sector. The rate of disasters acts as a brake on the growth of the agricultural economy and the income of farmers, the feasible reason is that the occurrence of natural disasters will cause damage to agricultural infrastructure and further affect the income of rural residents. The agricultural openness can promote the rise of farmers' income. With the opening of the agricultural market, the agricultural products trading market trend to move toward diversification gradually, as a result, rural residents are increasingly motivated to produce, and then constantly raising their income.

3.2. Heterogeneity Analysis

Referring to the 2001 State Council Opinions on Further Deepening the Reform of the Grain Circulation System, 31 provinces are divided into the main cereal-producing, main cereal-marketing and balanced supply and marketing regions. Kiviet (1995) found that the bias-corrected LSDV (LSDVC) method would be more accurate in showing the growth effect of infrastructure in each producing area.

Table 4. The regression results of three regions

Explanatory variable	Main cereal-producing area		Main cereal-selling area		Balanced Supply and marketing area	
	Model (1)	Model (4)	Model (2)	Model (5)	Model (3)	Model (6)
$\ln GDP$	1.4590***		1.7730***		1.4650***	
	(0.0001)		(0.0001)		(0.0002)	
$\ln NI$		0.8590***		0.8060***		0.9410***
		(0.0331)		(0.0439)		(0.0357)
$\ln IR$	0.0226	0.0122***	0.06750***	0.0233***	0.0051	-0.0126
	(0.0184)	(0.0041)	(0.0156)	(0.0055)	(0.0218)	(0.0099)
$\ln TR$	0.0079	-0.0027	0.0059	-0.0246***	-0.0145	0.0012
	(0.0054)	(0.0018)	(0.0085)	(0.0075)	(0.0141)	(0.0057)
$\ln RE$	-0.0629***	0.0031	0.0904***	0.0043	0.0641***	-0.0015
	(0.0126)	(0.0038)	(0.0064)	(0.0029)	(0.0149)	(0.0050)
$\ln INF$	-0.0087	0.0012	0.1740***	0.0125***	-0.0100*	0.0019
	(0.0061)	(0.0020)	(0.0042)	(0.0047)	(0.0059)	(0.0028)
$open$	-0.0031	-0.0001	0.0008***	0.0003*	-0.0321*	-0.0070
	(0.0067)	(0.0022)	(0.0003)	(0.0002)	(0.0168)	(0.0072)
dis	-0.0008***	0.0001	0.0001	0.0001*	-0.0010***	0.0001
	(0.0001)	(0.0001	(0.0001)	(0.0001)	(0.0001)	(0.0001)
$\ln labor$	-0.0656***	0.0058	-0.2450***	-0.0116	-0.0839***	0.0026
	(0.0237)	(0.0060)	(0.0093)	(0.0084)	(0.0228)	(0.0101)
$\ln mac$	0.0033		-0.1240***		-0.0112	
	(0.0090)		(0.0159)		(0.0152)	
gov	0.0026***		0.0010***		0.0004***	
	(0.0007)		(0.0001)		(0.0001)	
$\ln land$	-0.0772***		0.0877***		-0.0402	
	(0.0241)		(0.0108)		(0.0321)	
$\ln fer$	-0.0814***		-0.0865***		-0.1100***	
	(0.0215)		(0.0169)		(0.0247)	
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Regional fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observation	273	273	147	147	231	231

Note: (1) The brackets are bootstrapped standard errors; (2) *, ** and *** indicate significance at the levels of 10%, 5% and 1%.

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- The regional difference of infrastructure economic growth effect

Models (1), (3), and (5) measure the economic growth effect of infrastructure in three regions, respectively. The impact of irrigation infrastructure on economic growth is significantly positive in the main cereal-marketing area, but not significant in the other two areas. At present, the main cereal-marketing area is primarily in the eastern coastal region, which has complete water conservancy irrigation supporting infrastructure. And the main cereal-producing areas ravaged by natural disasters are concentrated in the central and northeast regions, impacting agricultural economic growth inevitably. The irrigation technology and its efficiency in the balanced supply and marketing area are relatively backward compared to the other areas.

The agroelectricity infrastructure has an observably negative impact on economic growth in agricultural sector in the main cereal-producing areas, but has an evidently beneficial impact on the main cereal-selling areas and the supply-marketing balance areas. The reason why there is a phenomenon that the rural electricity supply cost becomes higher and utilization efficiency of agricultural electricity becomes lower is perhaps that the main cereal-producing areas of our country are mainly concentrated in the central hilly areas, which scatters a lot of villages.

The impact of IT infrastructure on the growth of economy is significantly positive in the main cereal-marketing areas, negative in the balanced supply and marketing areas, but not significant in the main cereal-producing areas. The logical reason is that the main cereal-selling areas are mainly clustered around the southeastern coastal regions, with more developed economy and lower cost of information transmission, promoting agricultural economic growth. The impact of transportation infrastructure on agricultural economic growth in each region is not significant similarly.

- The regional difference of infrastructure income-increasing effect

The results of models (2), (4), and (6) illustrate the income-increasing of infrastructure in three regions respectively. The irrigation infrastructure in the main cereal-selling area does not indicate an obvious income-increasing effect. The income-increasing effect of transportation infrastructure in the main cereal-marketing areas is observably negative, while the effect in other areas is not significant. In main cereal-marketing areas, the increasing effect of IT infrastructure is significantly positive, but not significant in other areas.

3.3. Dynamic Analysis of Economic Impact of Infrastructure

Aimed at revealing the dynamic process of economic growth effect and income-increasing effect of various infrastructures intuitively, this paper draws their dynamic effect diagrams as displayed in Figure 2 and Figure 3.

- Dynamic analysis of economic growth effect of infrastructure

The economic growth effect demonstrated by Figure 2 indicates that the elasticity coefficients of irrigation infrastructure fluctuate in an M-shape from 1997 to 2006, and the economic growth effect tends to be stable after 2006. The elasticity coefficients of transportation and agroelectricity infrastructure also manifest M-shaped fluctuation from 1997 to 2006. The economic growth effect of IT infrastructure illustrates a change from growth to stability, and its elasticity coefficients rise from 0.0004 in 1997 to 0.0254 in 2006. Since then, its elasticity coefficients fluctuate around 0.0280.

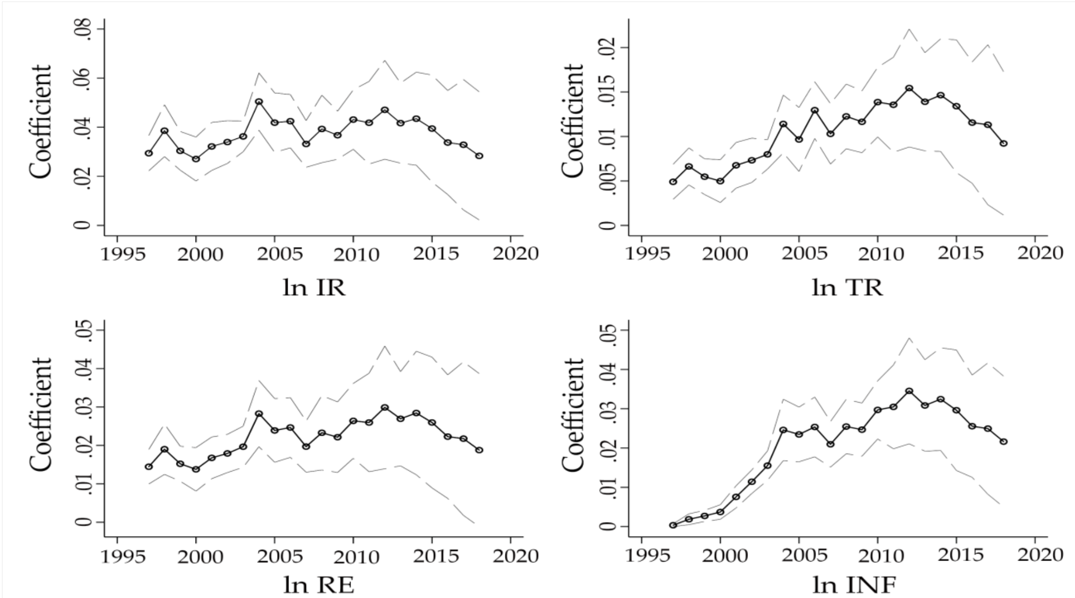

Figure 2. The dynamic effect of infrastructure on agricultural economic growth

- Dynamic analysis of infrastructure income-increasing effect

As can be seen from the income-increasing effect estimated in Figure 3 that the four major infrastructure, especially the IT infrastructure, declares a continuous growth trend from 1997 to 2012. After 2012, the infrastructure has been characterized by W-shaped fluctuations.

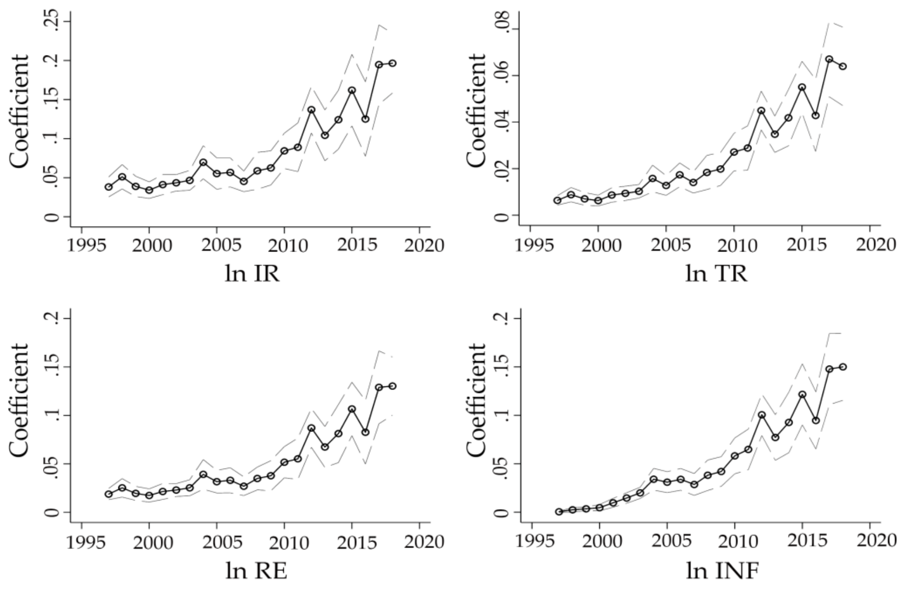

Figure 3. The dynamic effect of infrastructure on farmers' income (the dotted line is the upper and lower bounds of the 95% confidence interval)

4. Conclusions and Policy Recommendations

This study uses the dynamic panel model and non-parametric time-varying coefficient fixed-effect model to test the overall, heterogeneous, and dynamic effects of agricultural infrastructure on economic growth in the agricultural sector and farmers' income increase based on the panel data including 31 provinces in China from 1997 to 2018. The empirical results reveal that: (1) Irrigation and IT infrastructure have a significant promoting effect on agricultural economic growth and increase in farmers' income, and the income-increasing effect of agroelectricity infrastructure is observably positive. (2) The economic growth effect and income-increasing effect of infrastructure indicate spatial heterogeneity. The economic growth effect and income-increasing effect of irrigation infrastructure are positive in principal cereal-producing areas, but not in other areas. (3) From the viewpoint of dynamic effect changes, the elasticity coefficients of the economic growth effect of irrigation, transportation, and agroelectricity infrastructure change from M-shaped fluctuation to regional stability. Concerning the income-increasing effect, the elasticity coefficients of all types of infrastructure manifest a change from continuous growth to W-shaped fluctuations.

Based on the above research conclusions, this paper proposes the following three political recommendations. Firstly, due to the weakness of the actual situation of agricultural infrastructure, it should be changed as soon as possible by establishing and improving the investment and financing system for agricultural infrastructure. Relevant government departments should actively guide financial institutions, private and enterprise capital to jointly build a government-guided diversified investment and financing system. Secondly, government departments should do a good job in farmer training, and thus establish a large professional farmer team to improve the management level and utilization efficiency. Last but not least, it is considered crucial to vigorously develop digital and smart agriculture, and speed up the application and development of digital technologies in agricultural production and rural life.

Conflict of interest: none

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