Research on Interaction Effect Between Rural Roads and Peasants' Income Based on Granger Causality Test

Yiyan Zhou [1], Rui Qiao [1 *]

[1] Research Center of Highway and Integrated Transportation Development, Research Institute of Highway Ministry of Transport, No. 8 Xitucheng Road Haidian District, Beijing, China;

[1] xy205666@163.com, [1 *]605116877@qq.com

Abstract. Rural roads are one of the most important infrastructure in rural areas, directly affecting the production and living standards of rural residents, promoting economic resource exchange between urban and rural areas, and playing an important role in increasing peasants' income and wealth. This study takes the data of rural roads and peasants' income in Sichuan Province from 2000 to 2022 as an example, and uses Granger causality test and VAR model to analyze the interaction effect between rural road mileage and peasants' income growth. The research results indicate that rural road construction has a unidirectional promoting effect on the growth of peasants' income, and will help to increase peasants' income in the long run.

Keywords: Rural roads; Peasants' income; Granger causality test; VAR model.

1. Introduction

Rural roads are the transportation infrastructure with the widest coverage, largest serving population, and strongest public welfare in rural areas. They are an important guarantee for convenient travel of rural residents and an important carrier for smooth flow of urban and rural factors. In recent years, China has vigorously promoted the high-quality development of the "Four Good Rural Roads", and all eligible towns and villages in the country have been paved with hardened roads. As of now, the length of rural roads in China is nearly 4.6 million kilometers. At the same time, the issue of peasants' income is one of the core issues of agriculture, rural areas, and peasants. In promoting rural revitalization and achieving the goal of common prosperity, China proposes to continue to expand channels and spaces for peasants' income growth, further narrow the income gap between urban and rural areas, and solve the problems of imbalance and insufficiency. The smooth access of rural roads has driven the development of rural tourism and characteristic agriculture, as well as provided more employment opportunities and income sources for peasants. Therefore, studying the relationship between rural road construction and peasants' income growth, and proposing practical policy recommendations, is of great significance for promoting the high-quality development of rural roads in China and advancing common prosperity.

2. Literature Review

Domestic and foreign scholars have conducted extensive research on the relationship between transportation infrastructure and peasants' income. Lin (2000) pointed out that the construction of rural infrastructure such as water, electricity, and roads, which are highly related to daily life, can provide non-agricultural employment opportunities for peasants and effectively improve their income [1]. Lanjouw et al. (2001) used survey data from 600 households in urban fringe areas of Tanzania to study the impact of road infrastructure on household non-agricultural income. The results showed that road infrastructure can increase household non-agricultural employment activities, thereby increasing household non-agricultural employment income [2]. Satish (2007) believes that increasing investment in rural infrastructure construction can not only increase peasants' income, but also diversify their sources of income [3]. Mao et al. (2010) studied the relationship between transportation infrastructure and peasants' income based on provincial panel data in China, using the C-D production function and individual fixed effects model. The results showed that transportation infrastructure promotes peasants' household income by increasing non-agricultural employment [4]. Luo et al. (2012) believe that rural roads can help increase the net income and wage income of peasants, but have a negative impact on non wage income in the net income of peasants. They also pointed out that the more developed rural transportation is, the lower the dependence of peasants on land, and the more peasants go out for employment [5]. Hao et al. (2015) found that the positive promotion effect of rural roads on peasants' income is conditional, that is, it depends on the local GDP level. As the local economic level increases, this income growth effect becomes greater [6]. Zhou (2017) studied through county-level panel data that rural roads in Jiangsu Province also contribute to the growth of peasants' income [7]. Wang (2019) used the dynamic spatial Durbin model method to analyze the direct impact and spatial spillover effects of rural roads on urban-rural income distribution. The study showed that rural roads have a positive effect on narrowing the urban-rural income gap and have significant spatial spillover effects [8]. Dong (2022) studied the impact and mechanism of village road hardening mileage on household income, and found that an increase in village road hardening mileage can significantly improve rural household income. For every 1% increase in village road hardening mileage, rural household income will significantly increase by 0.055%, while urban household income will have no significant impact [9]. Based on panel data from 30 sample provinces in China from 2013 to 2019, Gu (2023) used a mediation effect model to study the impact of rural road construction and labor productivity on the urban-rural income gap. The research results verified the hypothesis that there is a mediation effect of agricultural labor productivity between rural road construction and urban-rural income gap [10].

Based on the above, as there is no concept of rural roads abroad, existing research has fully affirmed the positive role and impact of transportation infrastructure construction on increasing peasants' income. However, there is relatively little research on the interactive relationship between rural roads and the development of peasants' income. This study selected actual data and further investigated the relationship between rural road construction and peasants' income growth through methods such as time series stationarity test, co-integration analysis, Granger causality test, and impulse response analysis.

3. Research Methods and Data Process

3.1 Granger Causality Test

Granger causality test is a testing method mainly used to analyze the causal relationship between variables, and is usually used to test the mutual influence relationship between variables. The definition of Granger causality test in statistics is that if the predictive effect of variable X is significantly better than that of solely relying on the past information of Y, under the condition of including the past information of variables X and Y, then variable X is considered to be the Granger cause of variable Y. Granger causality test usually involves regressing the following two formulas:

$$Y_t = \beta_0 + \sum_{i=1}^{p} \beta_i Y_{t-i} + \sum_{i=1}^{p} \alpha_i X_{t-i} + \varepsilon_t \tag{1}$$

$$X_t = \phi_0 + \sum_{i=1}^{p} \phi_i X_{t-i} + \sum_{i=1}^{p} \theta_i Y_{t-i} + \varepsilon_t \tag{2}$$

In formulas (1) and (2), p represents the lag order of the variable selection, which can be determined by SIC or BIC criteria. In formula (1), if the parameters of each lagged term of variable X are not zero as a whole, it is considered that variable X is the Granger cause of variable Y. In formula (2), if the parameters of each lagged term of variable Y are not zero as a whole, it is considered that variable Y is the Granger cause of variable X. If both of the above conditions are met simultaneously, it is considered that variable X and variable Y are mutually Granger causes.

3.2 Co-integration Test

Most economic time series are not stationary, but a linear combination of multiple time series of the same order that are monointegrated may also be stationary, which is called a cointegration relationship in the linear combination of the time series. Therefore, for non-stationary time series, cointegration tests are needed to minimize the possibility of spurious regression. There are generally two methods for cointegration testing: Johansen test based on regression coefficients and single equation test based on regression residuals. The former is suitable for multivariate models, while the latter is suitable for bivariate models. Therefore, this study selected Johansen's test.

Assuming there are k time series $Y_{1,} Y_{2......} Y_k$, none of them are stationary. Construct k sequences into a vector and establish a p-order vector autoregressive model VAR (p)

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + ... + \phi_p Y_{t-p} + \mu_t \tag{3}$$

The null hypothesis of the above model is H_0, there are at least r co-integration relationships in the system. If the trace is less than the critical value of 5%, the null hypothesis is accepted. If the trace is greater than the critical value of 5%, it indicates rejection of the null hypothesis and the existence of r+1 or more co-integration relationships in the system.

3.3 Stationarity Test

Before conducting co-integration analysis and Granger causality test, it is necessary to perform stationarity test on the economic time series. The reason is that non-stationary data often leads to spurious regression problems, where two variables have no causal relationship but are highly correlated. Therefore, stationarity testing should be conducted first, which requires unit testing. The unit root stationarity test is generally conducted using the ADF test method. The specific model is as follows:

$$\Delta X_t = \delta X_{t-1} + \sum_{i=1}^{n} \beta_i \Delta X_{t-i} + \varepsilon_t \tag{4}$$

$$\Delta X_t = \alpha + \delta X_{t-1} + \sum_{i=1}^{n} \beta_i \Delta X_{t-i} + \varepsilon_t \tag{5}$$

$$\Delta X_t = \alpha + \beta T + \delta X_{t-1} + \sum_{i=1}^{n} \beta_i \Delta X_{t-i} + \varepsilon_t \tag{6}$$

3.4 Vector Autoregressive Model

Vector autoregressive models are commonly used to describe the changing relationships between multivariate time series. VAR models are a combination of autoregressive models, hence they are called vector autoregressive models, which mainly include impulse response analysis and variance decomposition. Impulse response analysis, observing how the variables in the model reflect the impact over time, and demonstrating the dynamic response process between x and y; The impulse response function characterizes the impact of an endogenous variable's shock on other endogenous variables in the model, but does not provide the contribution of the impact or the importance of different structural shocks. Therefore, the variance decomposition method is used to further study the importance of x on y.

3.5 Data Analysis

To investigate the impact of rural roads on peasants' income, this study takes Sichuan Province as an example, while considering the availability of data and the timeliness of research time. The observation interval from 2000 to 2022 is selected to study the core issue of this article. The data is sourced from the official website of the National Bureau of Statistics（ https://www.stats.gov.cn/ ）.

In terms of variable selection, since there is no special statistics on rural road mileage in the statistical data, and most of the rural roads in China are third-class or fourth-class roads, the rural road mileage data is represented by the symbol Road, which is the total mileage of roads minus the mileage of roads above second-class. Using the per capita disposable income of rural residents as an indicator to measure the growth of peasants' income, expressed in Income. In order to eliminate the possible heteroscedasticity effects in economic time series, the above variables need to be transformed into natural logarithms, represented by LnRoad and LnIncome respectively.

Table 1. Descriptive Statistics of Variables

Variable	Symbol	Sample size	Mean	Standard deviation	Maximum	Minimum
Rural road mileage	LnRoad	23	3.031	0.511	3.62	2.098
Per capita disposable income of rural residents	LnIncome	23	8.71	0.765	9.835	7.565

4. Static Inspection Analysis

4.1 ADF Test

Using SPSSPRO software, ADF unit root tests were conducted on the logarithm of rural road mileage (LnRoad) and the logarithm of regional gross domestic product (LnIncome), respectively, to test the stationarity of the variables' sequences at various times. The test results are shown in Table 2:

Table 2. Result of Stationary Test for variables

Variable	ADF	P	1% critical value	5% critical value	10% critical value	Result
LnRoad	-1.739	0.411	-3.77	-3.005	-2.643	Non-stationary
△1LnRoad	-3.727	0.004	-3.788	-3.013	-2.646	Stationary
LnIncome	-1.39	0.587	-3.809	-3.022	-2.651	Non-stationary
△1LnIncome	-6.537	0.001	-3.833	-3.031	-2.656	Stationary

The test results indicate that the ADF test values of each variable are greater than the critical value at a significance level of 5%, indicating that all variables are non-stationary. After first-order differencing, it can be found that at the significance level of 5%, the ADF test values of each variable are already below the critical value. Therefore, it can be considered that the selected sequence LnRoad and LnIncome variables are first-order integrated sequences. After determining that both have the same order of co-integration property, co-integration tests can be performed between variables.

4.2 Co-integration Test

The co-integration test reflects the long-term equilibrium relationship between unstable economic variables. From the above test results, it can be seen that these time series are all first-order non-stationary series. Before testing the causal relationship between these variables, it is necessary to test the co-integration relationship between the two variables. This article uses the Johansen co-integration test method and SPSSPRO statistical software to analyze the final optimal lag order of 2. The test results are shown in Table 3

Table 3. Result of Johansen Co-integration Test

Null Hypothesis	Eigenvalue	Trace (the largest root)	10% Critical Value	5% Critical Value	1% Critical Value
No cointegration relationship	0.691	27.083	13.429	15.494	19.935
At most 1 cointegration relationship	0.164	3.579	2.705	3.841	6.635

The results in Table 3 indicate that the null hypothesis is that the trace of at most one co-integration test is less than or equal to the 5% critical value, and the null hypothesis cannot be rejected, indicating that there is one co-integration relationship, that is, the variables of rural road mileage and per capita disposable income of rural residents have a long-term equilibrium relationship, and Granger causality test can be conducted.

4.3 Granger Causality Test

Using SPSSPRO software, a Granger causality test was conducted on the relationship between rural road mileage and peasants' income. The test results are shown in Table 4.

Table 4. Result of Granger Causality Test

Null Hypothesis	F	P	Result
LnRoad cannot cause Granger induced LnIncome	2.612	0.104	Accept
LnIncome cannot cause Granger induced LnRoad	3.788	0.045	Reject

According to Table 4, at a significant level of 5%, rural road mileage is a one-way Granger cause of per capita disposable income of rural residents, while per capita disposable income of rural residents is not a Granger cause of rural road mileage. Prove that rural road construction has a unidirectional promoting effect on peasants' income growth. The reason analysis is that rural road construction can drive the development of local agricultural industries, create relevant employment opportunities, and thereby promote the growth of peasants' income; The growth of peasants' income is determined by various factors such as economic development and education level, and cannot directly drive the construction of rural roads.

5. Dynamic Inspection Analysis

The preceding study discovered that the growth in rural road mileage facilitates the enhancement of peasants' income. This approach assesses the unidirectional influence between two variables from a static viewpoint over the same period. To investigate the dynamic effect of changes in rural road mileage on peasants' income, this study employs two methods: impulse response and variance decomposition.

5.1 Stability Test

To ensure the reliability of the impulse response and variance decomposition model results, it is necessary to test the stability of the VAR model, which can be based on the values of the variable eigenvalues. When all values are less than 1, it indicates that the current VAR model is stable.

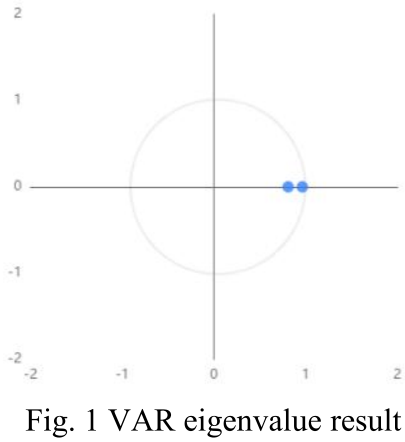

Fig. 1 VAR eigenvalue result

As shown in Figure 1, all eigenvalues are located within the unit circle, which is less than 1, indicating that the estimation model has high stability.

5.2 Impulse Response Analysis

Figure 2 shows the long-term impact on the development of peasants' income after the impact of rural road mileage. It can be observed that the impact of rural road mileage on peasants' income remains positive in the long term, with a significant driving effect in the early stages and gradually stabilizing in the later stages. This result indicates that the rapid development of rural roads not only promotes peasants' income in the current period, but also contributes to the long-term increase in peasants' income.

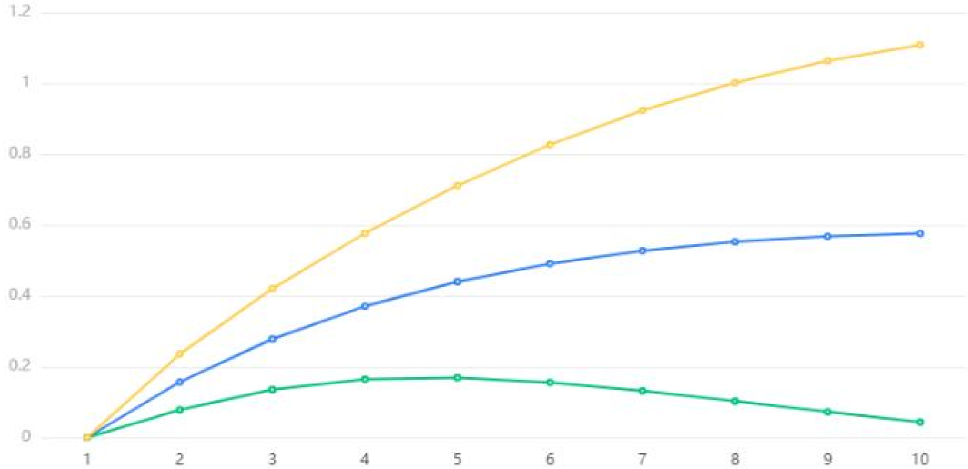

Fig. 2 5.2 Result of Impulse Response Analysis

5.3 Variance Analysis

Table 5. Result of Variance Analysis

Order	Standard deviation	LnIncome(%)	LnRoad(%)
1	0.029	100	0
2	0.042	87.939	12.061
3	0.056	71.712	28.288
4	0.071	58.053	41.947
5	0.085	47.908	52.092
6	0.1	40.559	59.441
7	0.113	35.19	64.81
8	0.126	31.192	68.808
9	0.139	28.151	71.849
10	0.15	25.791	74.209

Table 5 presents the results of variance decomposition of rural economic development over the long term. From the results table, it can be seen that as the prediction order increases, that is, when considering longer-term effects, the variation in the prediction error of per capita disposable income of rural residents is significantly increased, with the portion caused by self impact and the portion contributed by changes in rural road mileage. Specifically, in the initial stage of prediction (Phase 1), the prediction error of per capita disposable income of rural residents is completely explained by its own fluctuations, and the changes in rural road mileage have not yet shown their direct impact on income. However, with the extension of the prediction period, the contribution rate of rural road mileage to the prediction error of per capita disposable income of rural residents has rapidly increased, from 12.061% in the second period to 74.209% in the tenth period, indicating that the improvement of rural road infrastructure has a significant and sustained promoting effect on increasing the income level of rural residents in the medium and long term. At the same time, the standard deviation of the prediction error of per capita disposable income of rural residents gradually increases with the increase of prediction periods, reflecting the increasing uncertainty over time, which may be due to the cumulative effect of external shocks or the increasing dynamic complexity within the system. However, the high contribution rate of rural road mileage to income forecasting errors highlights the role of rural road construction as an important driving force for rural economic development, emphasizing that management departments should continue to pay attention to and increase investment in rural roads when promoting rural economic growth.

6. Conclusions and Recommendations

6.1 Research Conclusion

This study takes the data of rural roads and peasants' income in Sichuan Province from 2000 to 2022 as an example, and investigates the interactive relationship between rural roads and economic growth from both static and dynamic perspectives. The conclusions are as follows: firstly, rural road construction is a one-way Granger cause of peasants' income growth, that is, rural road construction will promote peasants' income increase; Secondly, the improvement of rural road infrastructure has a significant and sustained promoting effect on increasing the income level of rural residents in the medium and long term.

6.2 Policy Recommendations

(1) Promote the construction of rural roads. Strengthen the accessibility of rural roads in industrial zones, plantations, and other zones in rural areas, improve the convenience of connecting rural roads between main roads and tourist attractions, and optimize the overall structure of rural road networks from both horizontal and vertical dimensions, making the layout of rural roads more convenient for the people.

(2) Ensure the transportation of agricultural products. Pay attention to the daily inspection and maintenance of rural roads, maintain the achievements of rural road construction, and ensure the safe and convenient passage of roads, especially for transportation sections such as fruit and fragile goods, which require high road smoothness and rely more on timely maintenance and repair of rural roads.

(3) Expand new channels for rural roads to assist agriculture. Actively carry out work for relief during the construction period of rural roads, and promote local employment for peasants along rural roads. In daily maintenance, select simple and easy to learn job content, set up public welfare positions, attract local residents, and drive peasants' employment and income growth.

(4) Vigorously develop the rural economy. Actively open up export channels for agricultural products, select agricultural park locations and agricultural product processing plant locations based on the principles of convenient and efficient transportation, and try to locate them along rural roads as much as possible. Developing tourism, vacation, leisure and recuperation resources and supporting facilities in rural areas, attracting and retaining tourists, and stimulating the endogenous driving force of economic growth in rural areas.

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