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Relationships between Urbanization, Economic Growth, Industrial Structure and Nitrogen Emissions in the Jishui River Basin Based on a VAR Model

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Abstract: Understanding the relationship between environmental pollution and economic development is of great importance for achieving sustainable growth. It is particularly important for managing watershed regions, where rapid urbanization can cause significant environmental damage. This study aimed to determine the relationships between urbanization, economic growth, industrial structure and nitrogen emissions in the Jishui River Basin from 1997 to 2013. Based on the raw data, a vector auto-regression model was built, and the data were analyzed using the Johnson co-integration test, the Granger causality test, impulse response function analysis and variance decomposition analysis. The results showed that there was a long-run equilibrium relationship and a one-way causality between the four variables in the Jishui River Basin. The effects of economic growth and industrial structure on nitrogen emissions were significantly stronger than the effect of urbanization levels. In the long run, economic growth and industrial structure had a strong explanatory power for nitrogen emissions, and the contribution of urbanization levels, economic growth and industrial structure to nitrogen emissions showed some hysteresis. This study clarifies the main drivers of changes in environmental pollution in the Jishui River Basin, and provides a scientific basis for urban development models and regulation of industrial growth.

Keywords: VAR model; urbanization; industrial structure; economic growth; nitrogen emissions; basin

INTRODUCTION

The relationship between environmental pollution and economic development is not only a key issue in ecological economics and environmental economics research, but also an important issue for industrialized countries in the process of managing this relationship [1, 2]. Urbanization is a necessary step in the inevitable trend of modern human and social development that promotes industrial structure adjustment. Optimizing industrial structure adjustment and achieving sustainable development are the main driving forces of economic growth and anthropogenic effects on the ecological environment. Rapid urbanization and economic development often occurs in watershed regions, as water is essential for industrial production processes and daily life; however, this results in serious pollution of the water environment, causing changes in the natural environment and its resources, geography, morphology, structure and function, and even interfering with global ecosystem evolution [3]. Research found that pollution, industrial structure adjustment and optimization of land-use types increased to varying degrees with urbanization, and led to serious deterioration of the water environment [4, 5]. Therefore, evaluation of urbanization, industrial structure adjustment and the impact of pollution, and exploration of the appropriate measures of the effect of economic growth on the ecological environment are necessary to achieve sustainability, economic, social and environmental goals in watershed regions, one of the most important issues in the world today [6, 7].

River basin economies have an important regional economic dominance, and, whether in developed countries or less-developed countries or regions, river basins are an economic ties. In recent years, with the advance and acceleration of the economic integration of watersheds and urbanization, integrated watershed governance and economic development has solved some of the practical problems of how to protect the ecological environment in a healthy and orderly way and promote sustainable economic growth during the process of rapid urbanization and industrial structure optimization. Although, river basin economic integration has been studied in terms of promoting urbanization and industrial structure optimization, the dynamic relationship between economic growth and the water environment, which is either a simple one-way causality between urbanization, industrial structure, economic growth and the water environment, or a very complex interaction of cause and effect relationships, has yet to be studied. The vector auto-regression (VAR) model is a new cointegration analysis method for effectively solving multi-equation models. It can solve the long-term equilibrium relationship between variables, can avoid the the ‘spurious regression’ phenomenon being due to presupposed stationary time series data in the many studies, which in recent years has been widely used for a number of interrelated variables in empirical studies of social, economic and environmental protection [8-13].

Jishui River is one of the larger tributary of the Le'an River in Jiangxi Province of China. The river basin has a total area of about 557 km^2, of which 501 km^2 is occupied by the urban territory of Dexing. Jishui River is the second largest river in Dexing, which is called the Dexing Mother River. In recent years, the river basin has experienced rapid urban and industrial growth, and the concurrent increase in pollution has caused serious stress to environmental resources. Most of the river basin water is of class III and IV quality, but some of the water is class V [14], where water pollution is the most serious. In 2008, the Jiangxi provincial government proposed a strategic vision for the Poyang Lake ecological economic zone, which includes the Jishui River Basin as a basic unit. The construction of an ecological economic zone to accelerate the economic development cycle has become an inevitable choice for the Jishui River and the implementation of new industrialization. How to resolve the conflicts between the river basin urbanization, economic growth, industrial structure and water pollution and clarify the main drivers of changes in the water quality of the environment has become a problem at this stage. Thus, this study used sequence data for the Jishui River from 1997 to 2013 to determine the long-term dynamic relationships between river basin urbanization, industrial structure, economic growth and river basin nitrogen emissions using a VAR model and dynamic econometric analyses (Johnson cointegration test, Granger causality test, impulse response function analysis and variance decomposition analysis), to investigate the effects of urbanization, industrial structure and economic growth on river basin nitrogen emissions. The main aims of this study were to clarify the main drivers of changes in environmental water quality, and provide a scientific basis for urban development models and regulation of industrial structure optimization.

MODEL DESIGN AND VARIABLE SELECTION

1) Model Design

Vector auto-regression (VAR) is based on the statistical properties of a data model, and is a regression that investigates the dynamic relationships among all the endogenous variables in a system based on hysteresis effects between changes in the values of each endogenous variable in the model and the resulting changes in the other endogenous variables. The VAR model considers the interactions between variables in the model, and reflects a basic economic impact on other economic variables bring much impact and shock response size. It can measure one standard deviation of the impact from the disturbance effect on the current and future endogenous variables, and also through the system impulse response function and variance decomposition analyses to infer the connotations of the VAR.

The mathematical expression of the VAR(*p*) model is:

$$\begin{aligned} y_t &= \sum_{k=1}^{p} \Phi_k y_{t-k} + Hx_t + \varepsilon_t \qquad \varepsilon_t \sim IID\left(0,\Omega\right) \qquad t = 1,2,\cdots,T \\ &= \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \cdots + \Phi_p y_{t-p} + Hx_t + \varepsilon_t \end{aligned} \tag{1}$$

In the equation (1), y_t is endogenous variable vector, x_t is exogenous variable vector, p is the lag order number, $\Phi$are parameter matrices with rank $k\times k$, H is the estimates coefficient matrix, IID is covariance matrix with rank $k\times k$, Ω is the variance and covariance matrix with rank $k\times k$, and T is time segment. ε_t is the random-error column vector with rank $k\times 1$, which can be in the same period related to each other, but with their own lagged value and the right side of the equation are unrelated. If Σ is the covariance matrix of ε_t, $(k \times k)$ is a positive definite matrix. The above equation (1) can be expressed as:

$$\begin{bmatrix} y_{1t} \\ y_{2t} \\ \vdots \\ y_{kt} \end{bmatrix} = \Phi_1 \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ \vdots \\ y_{kt-1} \end{bmatrix} + \Phi_2 \begin{bmatrix} y_{1t-2} \\ y_{2t-2} \\ \vdots \\ y_{kt-2} \end{bmatrix} + \cdots + \Phi_p \begin{bmatrix} y_{1t-p} \\ y_{2t-p} \\ \vdots \\ y_{kt-p} \end{bmatrix} + H \begin{bmatrix} x_{1t} \\ x_{2t} \\ \vdots \\ x_{dt} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \vdots \\ \varepsilon_{kt} \end{bmatrix}, \tag{2}$$

In the equation (2) contains k time series variables for a VAR(p) model composed of k equations.

2) Variable Selection and Data Processing

Level of urbanization, economic growth, industrial structure and nitrogen emissions for the Jishui River Basin were selected as the empirical research objects, based on the specific Jishui River Basin developed environment and the availability of data. The time length of the data series was from 1997 to 2013. The data sources were the *Jiangxi Statistical Yearbook* and *Dexing' National Economic and Social Development Statistics Bulletin in Jiangxi Province of China*. The details of the four chosen variables are as follows:

i. Level of urbanization. According to operational and targeted principles, the proportion of non-agriculture population of the total population was the level of urbanization (%).

ii. Economic growth. To eliminate the influence of population size, this study used gross domestic product (GDP) per capita to represent economic growth. The data were calculated in accordance with current prices (millions).

iii. Industrial structure. The primary industry output value proportion of GDP was used to measure the change in industrial structure (%).

iiii. Concentration of total nitrogen (mg/L). Considering the main forms of nitrogen emissions data collection for the Jishui River, changes in the Jishui River total nitrogen concentrations can reflect changes in the nitrogen emissions for the whole river basin. Therefore, this study used nitrogen emission data for the Jishui River to represent the entire watershed. The nitrogen emission levels monitoring data were provided by the Jiangxi Provincial Environmental Monitoring Center Station. Nitrogen concentration field measurements are carried out in the Dexing City, Tianmen village and Yinshan station every April, August and December (the average water period, wet period and dry period). JU, JE, JI and JN represent the urbanization level, economic growth, industrial structure and total nitrogen concentration, respectively, for the Jishui River Basin. The natural logarithm of the time series data transformation does not change the characteristics of the data, and can linearize the data trend and partly eliminate heteroscedasticity in the time sequence; therefore, the linearized values were used in the empirical analysis to represent JU, JE, JI and JN (that is, LNJU, LNJE, LNJI and LNJN, respectively). Eview8.0 software was used for the data processing and analysis.

RESULT AND DISCUSSION

1) Data Stability Test

To establish the VAR mode based on the time sequence data, first, the variable stability needs to be ensured, otherwise it will lead to the 'spurious regression' phenomenon. This research adopted the augmented Dickey-Fuller (ADF) test to operate the unit root text on LNJN, LNJE, LNJI and LNJU. If $P > 0.05$ (or 0.1), or the threshold is below the 1%, 5% and 10% levels, is less than the assumed ADF data, the null hypothesis can not be reject and the data are unstable. Rejection of the null hypothesis indicates that the data are stable [15]. Adopting the results from the Eview6.0 software shows that testing LNJN, LNJE, LNJI and LNJU as time sequences reveals that they all are unstable sequences ($P > 0.05$). The ADF test was conducted on the four time sequences after the second order difference showed all four sequences were stable, which indicates that the LNJN, LNJE, LNJI and LNJU are second-order single-whole sequences (Table 1). Therefore, this research established the VAR mode of DLNJN, DLNJE, DLNJI and DLNJU to analyze the level of urbanization, economic growth and the dynamic relationship between the industrial structure adjustment and river basin nitrogen emissions.

Table1: Results of ADF test of variables. *c*: constant term; *t*: tendency; D: second order difference for the variable

Variable	Test method	ADF test value	1% critical value	5% critical value	10% critical value	*P*-value	Conclusion
LNJU	(c, t, 0)	-2.056355	-3.920350	-3.065585	-2.673459	0.2626	unstable
LNJE	(c, t, 0)	1.417561	-3.920350	-3.065585	-2.673459	0.9979	unstable
LNJI	(c, t, 0)	-1.580183	-3.920350	-3.065585	-2.673459	0.4691	unstable
LNJN	(c, t, 0)	-2.023691	-3.920350	-3.065585	-2.673459	0.2747	unstable
DLNJU	(c, t, 1)	-5.413666	-4.057910	-3.119910	-2.701103	0.0011	stable
DLNJE	(c, t, 0)	-4.832478	-4.004425	-3.098896	-2.690439	0.0023	stable
DLNJI	(c, t, 0)	-5.215211	-4.004425	-3.098896	-2.690439	0.0012	stable
DLNJN	(c, t, 0)	-4.415732	-4.004425	-3.098896	-2.690439	0.0048	stable

2) Lag Structure test

Before the establishment of VAR, the lag order of the model needs to be confirmed. Generally, it is hoped that the lag is large enough to completely reflect the dynamic characteristics of the constructed model. If the lag is too long, then more parameters need to be estimated, leading to fewer degrees of freedom and a reduction in the explanatory power of the model parameters [16]. Therefore, adopting Akaike's information criterion and the Schwarz information criterion rules, the best lag order takes the minimum Schwarz information criterion and Akaike's information criterion statistics. Table 2 shows the maximum lag order for several types of information standard. The best lag order in this study was two, which is the reason to build the VAR mode.

Table2: Selected results of optimal lag order. The asterisk indicates data with the best order. LogL: maximum estimation function of numerical; LR: likelihood ratio test statistics sequence adjustment (5% significant level); FPE: final prediction error; AIC: Akaike's information criterion; SC: Schwarz information criterion; HQ: Hannan Quin information criterion

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	23.21165	NA	1.07e-06	-2.401457	-2.208310	-2.391566
1	88.10321	89.22589*	2.57e-09*	-8.512901*	-7.547166*	-8.463448*

3) Model Parameter Estimation and Test

a) VAR Model Parameter Estimation

Using Eview8.0 software, the parameter estimation for the VAR model equation took the concrete form:

$$\begin{bmatrix} DLNJN \\ DLNJE \\ DLNJI \\ DLNJU \end{bmatrix} = \begin{bmatrix} 6.4353 \\ 2.6336 \\ 3.3024 \\ -3.5792 \end{bmatrix} + \begin{bmatrix} 0.2043 & 0.1803 & 2.4512 & 0.2904 \\ -0.1329 & 1.8450 & 0.0566 & 0.5294 \\ 0.0750 & -3.0019 & -2.1198 & -1.4187 \\ 0.2045 & 0.9866 & 1.0603 & 0.3834 \end{bmatrix} \begin{bmatrix} DLNJN_{t-1} \\ DLNJE_{t-1} \\ DLNJI_{t-1} \\ DLNJU_{t-1} \end{bmatrix} +$$

$$\begin{bmatrix} -1.0602 & -3.4750 & -2.4512 & -1.0926 \\ 0.1180 & -1.0816 & 0.8678 & -0.6901 \\ 0.0533 & 3.3952 & -1.0251 & 1.5098 \\ -0.0704 & -1.9377 & -0.5643 & 0.4799 \end{bmatrix} \begin{bmatrix} DLNJN_{t-2} \\ DLNJE_{t-2} \\ DLNJI_{t-2} \\ DLNJU_{t-2} \end{bmatrix} + \qquad (3)$$

$$\begin{bmatrix} -0.2450 & 4.6797 & 0.7827 & -1.4696 \\ -0.1432 & 0.2004 & -0.8926 & -0.5749 \\ 0.5704 & -1.5374 & 1.2354 & 1.0215 \\ -0.1435 & 1.3828 & 0.2958 & 0.6016 \end{bmatrix} \begin{bmatrix} DLNJN_{t-3} \\ DLNJE_{t-3} \\ DLNJI_{t-3} \\ DLNJU_{t-3} \end{bmatrix}$$

$R^2_{DLNJN} = 0.9941$, $R^2_{DLNJE} = 0.9991$, $R^2_{DLNJI} = 0.9880$, $R^2_{DLNJU} = 0.9987$, $F-statistic_{DLNJN} = 14.1772$, $F-statistic_{DLNJE} = 97.1090$, $F-statistic_{DLNJI} = 6.8483$, $F-statistic_{DLNJU} = 64.7872$.

From Equation (3), it was found that the four adjusted equations showed a high fitting degree (>0.98); therefore, this model was used for the following analyses.

b) Model stability test

The stability test is used as the basis for judging the effectiveness of all tests. If the reciprocals of all the root modes are <1, that is, all inside the unit circle, and the mode is stable, the corresponding test is also effective [17]. From Figure 1, it can be seen that all the reciprocals were <1 in the VAR model and hence inside the unit circle, which indicates that the VAR model system satisfies the stable-state conditions and is effective for the following impulse response function and variance decomposition analyses.

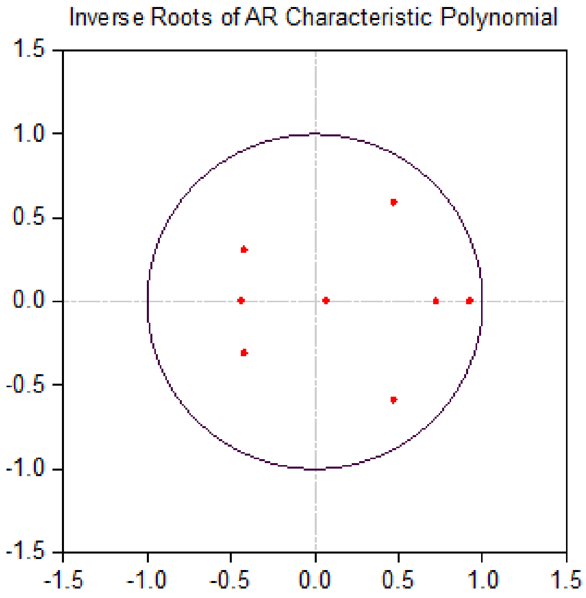

Fig-1: The unit root test of the VAR model

c) Johnson cointegration test

The cointegration test is an important method in economic analysis for determining whether there is a long-term equilibrium relationship between economic variables, and is a way to study the long-term effects of the relationships between economic variables [18]. However, before the cointegration test of economic variables, variable data must first meet the ‘same order’ conditions, that is, the variable data sequence must be stable and in the same order. From the previous ADF test, we know that LNJN, LNJE, LNJI and LNJU are in a stable condition in the second order difference. Therefore DLNJN, DLNJE, DLNJI and DLNJU in the same order integration conditions are suitable for the cointegration test. The EG two-step method and the Johnson test method are commonly used in macro-econometric cointegration tests. However, Johnson test method was chosen to test the cointegration relationship between DLNJE, DLNJI, DLNJU and DLNJN, and the ‘trace’ test and the ‘maximum eigenvalue’ test of Johnson test method was used to determine the number of cointegration equation in this study. Both test results are displayed at the 5% significance level for the three cointegration equations, and we chose a representative cointegration mathematical expression:

$$\underset{\qquad}{DLNJN} = \underset{[-5.53384]}{-1.177940DLNJE} \underset{[-4.64439]}{-2.541896DLNJI} + \underset{[1.87771]}{0.893210DLNJU} + 3.262956 \quad (4)$$

The numbers in square brackets are the *t*-test statistic, at the 5% significance level. From Equation (4), it was found that, in the long run, the economic growth, the proportion of primary industry output value and the level of urbanization increased by one percentage point. Nitrogen emissions were reduced by 1.18 and 2.54 percentage points and increased by 0.89 percentage points, respectively. This suggests that the long-term economic growth, industrial structure adjustment and reasonable adjustment of the level of urbanization patterns improve the river basin nitrogen emissions, which is consistent with theory and practice.

d) Granger causality test

There is a long-term and stable cointegration relationship between the variable levels of urbanization, economic growth, industrial structure adjustment and river basin nitrogen emissions, but this balanced relationship needs to balance the relationships between the causes and effects of the variables [19]. Using the Granger causality test to solve the problem of causality between variables, if the calculated value is greater than a given threshold, then the null hypothesis is rejected and there is a causal relationship; in contrast, if the null hypothesis is accepted, then there is no causal relationship. Table 3 shows DLNJU, DLNJE and DLNJI do not Granger Cause DLNJN, so the null hypothesis is rejected for DLNJU, DLNJE and DLNJI at a 5 percent level, which mean that the river basin urbanization level, industrial structure adjustment and economic growth are the reasons for the river basin’s nitrogen emissions. However, DLNJN does not Granger Cause of DLNJU, DLNJE and DLNJI, the null hypothesis is not reject at a 5 percent level, which shows that there is no significant effect of river basin nitrogen emissions on the river basin urbanization level, industrial structure adjustment and economic growth. The Granger test results showed that the river basin urbanization level, industrial structure adjustment and economic growth constitute a one-way causal relationship for river basin nitrogen emissions. Therefore, from the long-term trend, it is feasible to realize reasonable adjustments of the river basin urbanization patterns, accelerate the adjustment and optimization of industrial structure, and promote sustainable economic growth, in theory and practice.

Table3: Results of Granger causality

Original hypothesis	Observations	F value	P value	Conclusion
DLNJU does not Granger Cause DLNJN	16	5.01230	0.0433*	Reject
DLNJN does not Granger Cause DLNJU		3.90133	0.0699	Accept
DLNJE does not Granger Cause DLNJN	16	9.00219	0.0102*	Reject
DLNJN does not Granger Cause DLNJE		2.16138	0.1653	Accept
DLNJI does not Granger Cause DLNJN	16	8.08562	0.0138*	Reject
DLNJN does not Granger Cause DLNJI		0.52408	0.4819	Accept

e) Impulse response function analysis

The impulse response function is used to measure how the standard impact of random confounding variables influences present-day and future values of endogenous variables. It can visually illustrate dynamic interactions and their effect between variables [18]. Therefore, the impulse response function was used to study the urbanization level, economic growth, and directions and degrees of interaction between adjustments of industrial structure and watershed nitrogen emissions. In Figure 2, the horizontal axis represents the lag phase impact number (unit: years), while the vertical axis represents the corresponding responses to the impact of the variables. From Figure 2, it can be seen that a one standard deviation impulse of watershed nitrogen emissions, when affected by economic growth, industrial structure adjustment and urbanization level, shows a negative reaction from period 1 to period 3, in which the negative reaction reaches a maximum. Consequently, the negative reaction weakens from period 4 to period 7. But from period 8 to period 11, the reaction strengthens until period 11, in which it reaches a maximum again. This reaction then weakens once again until period 15, in which the impulse stabilizes as time passes. In conclusion, in the long term, the impact from economic growth and industrial structure adjustment is comparatively obvious, and encourages the improvement of polluted water environment conditions and watershed nitrogen emissions.

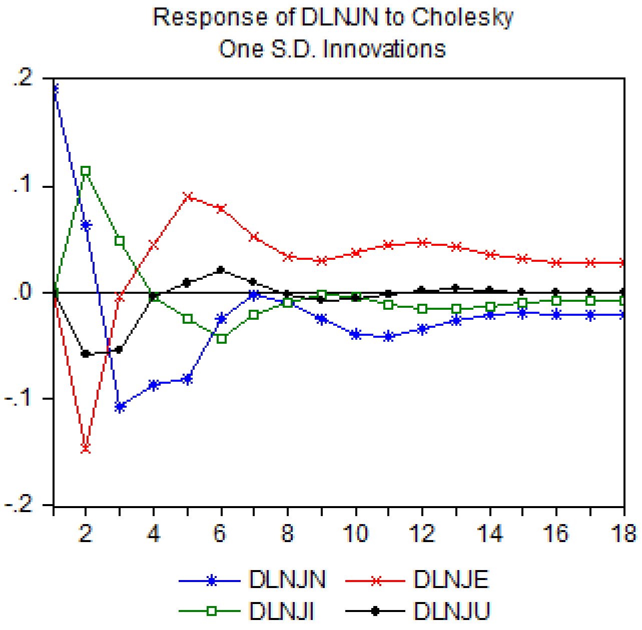

Fig-2: The impulse response function based on VAR

f) Variance decomposition analysis

Variance decomposition offers a different method of examining VAR dynamics. Impulse response functions trace the effects of a shock to an endogenous variable on the variables in the VAR. By contrast, variance decomposition decomposes variation in an endogenous variable into the component shocks to the endogenous variables in the VAR. The variance decomposition gives information about the relative importance of each random shock to the variables in the VAR [20].

This study used variance decomposition analysis to determine the impact of each variable on the change in DLNJN contribution rate, and obtain the importance of the impact of different variables. Figure 3 shows the variance decomposition results for nitrogen emissions and the level of urbanization, industrial structure and economic growth, that is, the contribution of urbanization, industrial structure and economic growth to the watershed nitrogen emissions. The horizontal axis shows lag periods (unit: year) and the vertical axis represents the variance contribution of the four endogenous variables to the river basin nitrogen emissions rate (unit: percentage). Figure 3 shows that for periods 1 to 15, the contribution rate of nitrogen emissions to its own variance fell most sharply, from 100% to 43%. The contribution rate of economic growth to nitrogen emissions from periods 1 to 15 increased from 0 to 36% and the contribution rate of industrial structure to nitrogen emissions increased from 0 to 15%; however, the contribution rate of urbanization level to nitrogen emissions from periods 1 to 15 increased from 0 to 5%. After period 15, the contribution rate of the four variables remained stable. This agrees well with the impulse response analysis results (Figure 2). This shows that relative to nitrogen emissions, over a long period of time, the contribution level of urbanization, industrial structure adjustment and economic growth to changes in nitrogen emissions have a lag effect, and the effects of economic growth and industrial structure adjustment on watershed nitrogen emissions play the leading roles.

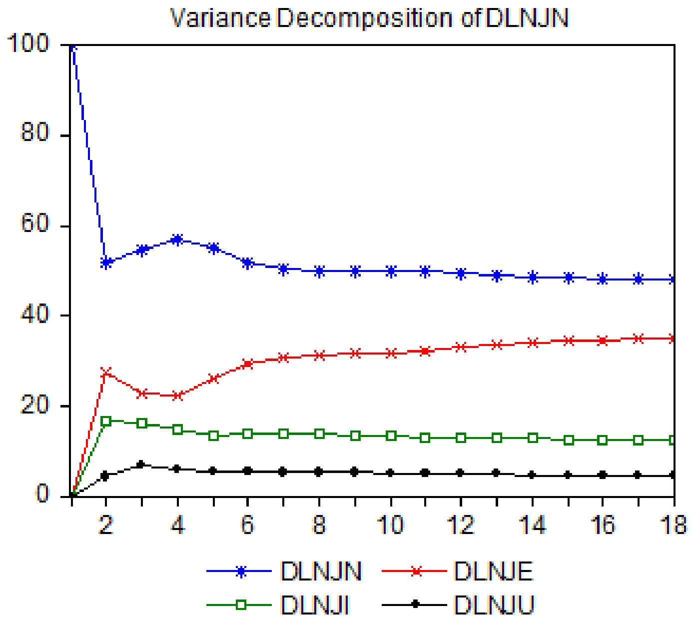

Fig-3: The variance decomposition based on VAR

CONCLUSIONS

A cointegration relationship exists between the Jishui River Basin urbanization, economic growth, industrial structure adjustment and nitrogen emissions, namely, a long-term equilibrium relationship.

The Granger causality test shows that there is a one-way causal relationship between watershed urbanization level, industrial structure, economic growth and watershed nitrogen emissions, that is, the watershed urbanization level, economic growth and industrial structure adjustment has a significant influence on the watershed nitrogen emissions, and watershed nitrogen emissions do not have an obvious effect on the urbanization level, industrial structure adjustment and economic growth level.

In the long term, the effect of economic growth and industrial structure adjustment on nitrogen emissions is obvious, and is conducive to the improvement of watershed nitrogen pollution and the water environment status. The contribution level of urbanization, industrial structure adjustment and economic growth have a lag effect on the changes in nitrogen emissions, with economic growth and industrial structure adjustment playing the leading roles in watershed nitrogen emissions.

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REFERENCES

1. Tilmant, A., & Kinzelbach, W. (2012). The cost of noncooperation in international river basins. *Water Resources Research*, *48*(1), 1-12.
2. Xu, B. S. (2013). Progress of remanufacturing engineering and future technology expectation. *Advances in Manufacturing*, *1*(1), 8-12.
3. Ai, J. Y., Feng, L., Dong, X. W., Zhu, X. D., & Li, Y. F. (2015). Exploring coupling coordination between urbanization and ecosystem quality (1985–2010): a case study from Lianyungang City. *China. Frontiers of Earth Science*, pp1-19. DOI: 10.1007/s11707-015-0531-6.
4. Ma, L., Jin, F. J., Song, Z. Y., & Liu, Y. (2013). Spatial coupling analysis of regional economic development and environmental pollution in China. *Journal of Geographical Sciences*, *23*(3), 525-537.
5. Cui, B. S., He, L., Gu, H. B., Bai, J. H., & Liu, X. H. (2016). China’s coastal wetlands: understanding environmental changes and Human impacts for management and conservation. *Wetlands*, *36*(S1), 1-9.
6. Rees, W. E. (2003). Economic development and environmental protection: an ecological economics perspective. *Environmental Monitoring and Assessment*, *86*(1), 29-45.
7. Aziz, A., Bajwa, I. U., Ahmad, I., Mayo, S. M., & Rahman, A. (2013). Assessing environmental degradation in new paradigm to achieve sustainable development (a case study of Lahore). *Pakistan Journal of Science*, *65*(2): 277-287.
8. Hassene, B. M. & Hager, B. R. (2011). Equilibrium exchange rate and exchange control level: an empirical analysis using a time-series cointegration VAR model (the case of Tunisia). *International Journal of Financial Services Management*, *5*(1), 21-33.
9. Park, N., & Jeong, D. B. (2011). An empirical strategy for applying VAR model to the analysis of macroeconomic responses. *International Journal of Innovattion and Learning*, *9*(2), 163-183.
10. Xiao, Q., Gao, Y., Hu, D., Tan, H., & Wang, T. X. (2011). Assessment of the interactions between economic growth and industrial wastewater discharges using co-integration analysis: a case study for China’s hunan province. *International Journal of Environmental Research and Public Health*, *8*, 2937-2950.
11. Liu, H. F., Lei, L., Yu, J. C., & Ye, C. X. (2012). The social-economic influence of developing mineral resources in Yan’an City. *International Business and Management*, *5*(1), 3-9.
12. Nyberg, H., & Saikkonen, P. (2014). Forecasting with a noncausal VAR model. *Computational statistics & data analysis*, *76*, 536-555.
13. Tan, F. F., & Lu, Z. H. (2015). Study on the interaction and relation of society, economy and environment based on PCA–VAR model: as a case study of the Bohai Rim region, China. *Ecological Indicators*, *48*, 31-40.
14. Wan, X., & Wan, J. B. (2005). Research on measures of ecological restoration for copper mining area. *Jiangxi Science*, *23*, 233-235. (In Chinese)
15. Ray, S. (2012). Testing granger causal relationship between macroeconomic variables and stock price behaviour: evidence from India. *Advances in Applied Economics and Finance*, *3*(1), 470-481.
16. Mouriño, H., & Barão, M. I. (2013). Maximum Likelihood Estimation of the VAR(1) Model Parameters with Missing Observations. *Mathematical Problems in Engineering*, *5*, 1-13.
17. Lükepohl, H. (1991). Introduction to Multiple Time Series Analysis. New york: Springer-Verlag.
18. Zhao, Y. B., & Wang, S. J. (2015). The relationship between urbanization, economic growth and energy consumption in China: An Econometric Perspective Analysis. *Sustainability*, *7*, 5609-5627.
19. Feng, T. W., Sun, L. Y., & Zhang, Y. (2009). The relationship between energy consumption structure, economic structure and energy intensity in China. *Energy Policy*, *37*, 5475-5483.
20. Thuku, G. K., Paul, G., & Almadi, O. (2013). The Impact of Population Change on Economic Growth in Kenya. *International Journal of Economics and Management Sciences*, *2*(6), 43-60.