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# An empirical study on reshape of industrial structures in the core water source area of the middle route of the South-to-North Water Diversion Project — a case study of Shiyan City in Hubei Province

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**ABSTRACT**

This paper investigates the interactive influence between the local GDP and industrial structures of Shiyan City, Hubei Province between 1991 and 2014, by using the VAR Model, Johansen Co integration Test, Vector Error Correction Model, Granger Causality Test, Impulsive Response Function and Variation Decomposition analysis. The results indicate that there is interactive relationship between the primary industry and the tertiary industry in Hubei Shiyan. With the implementation of the Middle Route of the South-to-North Water Diversion Project, Water Pollution Prevention and Control as well as Water and Soil Conservation in Danjiangkou Reservoir and Upstream Areas (here in after referred as "DAN Comprehensive Treatment") in Shiyan, strategy and policy suggestions on reshape and optimization of the three industrial structures of Shiyan are proposed. These can provide valuable advice or references for industrial structure reshape, economic and social development and ecological environment protection in Shiyan City, Hubei province and the similar reservoir areas and water source areas.

*Keywords:* VAR model; Reshape and optimization of industrial structures; Ecological environment protection; Economic and social development

## 1. Introduction

Water, as the valuable source of life and an essential condition for human and social development, is a matter of national concern, and occupies a central position in public policy. China has, since ancient times, been grappling with the problem of unevenly distributed water resources. In his long history, China has been plagued with southern floods and northern droughts, which have become a major bottleneck to economic and social development.

It has been long faced that what should be done to tackle the increasingly serious problem of water scarcity? Chairman Mao once said in 1952 on the banks of the Yellow River "Water is abundant in the south and scarce in the north. If it is feasible, we could borrow some from south to north." The idea has gone through 50 years of debate and redesign, and was finally put into action in 2002 as the Great National Policy - South-to-North Water Diversion Project, which is the product of the combined efforts of successive Chinese governments and the broad population, offering great prospects for rejuvenation of the Chinese nation.

The South-to-North Water Diversion Project is the biggest project of its kind ever undertaken. The massive engineering challenge was launched to meet water shortages in northern China, particularly in the capital economic zone around Beijing. The Chinese government and people are making an all-out effort to turn the water diversion dream into reality. The mega project will have a far-reaching impact on sustainable development of the Chinese Nation, and will benefit future generations to come.

The Middle Route diverts water from the flood-prone south, the Danjiangkou reservoir on the Han River, a tribu-

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tary of the Yangtse River, via new canals near the west edge of the Huanghuaihai Plain to flow up and cross under the Yellow River, to feed the drought-ridden north, including Beijing, Tianjin, Henan and Hebei Provinces. Upon completion, the first phase project will see a massive 9.5 billion cubic meters of water per year pumped through canals and pipes from the Danjiangkou reservoir in central China's Hubei Province to the northern provinces of Henan and Hebei and to Beijing and Tianjin, benefiting nearly 100 million people. Ten years of hard work has seen the construction of this amazing mega project. The middle route started supplying water on December 12 in 2014 as part of the project's first phase.

Conservation of the environment and ecological protection in the water source area ensuring that the water from south flows elegantly and uncontaminated in a long continuous stream and guaranteeing sustainability of the project, is critical to the success of the water diversion project and the vital interests of the people. Danjiangkou Reservoir and Upstream Areas is the core water source area of the Middle Route of the South-to-North Water Diversion Project. The Water Pollution Prevention and Control, as well as Water and Soil Conservation in Danjiangkou Reservoir and Upstream Areas (hereinafter referred to as "DAN Comprehensive Treatment") are crucial for the water quality protection of the Middle Route Project, as well as the reshape of local industrial structures.

In the planning of the South-to-North Water Diversion Project, to protect water quality in Danjiangkou reservoir, in 2006, the State Council approved the implementation of the 11$^{th}$ Five-Year Plan of Water Pollution Prevention and Control, as well as Water and Soil Conservation in Danjiangkou Reservoir and Upstream Areas (hereinafter referred to as "The 11$^{th}$ Five-Year Plan of DAN Comprehensive Treatment"), involving Shanxi province, Hubei province and Henan province with 7 cities and more than 40 counties in Danjiangkou reservoir and upstream areas. The 12$^{th}$ Five-Year Plan of Water Pollution Prevention and Control, as well as Water and Soil Conservation in Danjiangkou Reservoir and Upstream Areas (hereinafter referred to as "The 12$^{th}$ Five-Year Plan of DAN Comprehensive Treatment") was approved by the State Council in 2012.

Since adoption of "The 11$^{th}$ Five-Year Plan of DAN Comprehensive Treatment", Shiyan paid more attention in particular to the Water Pollution Prevention and Control, as well as Water and Soil Conservation. Through the implementation of the sewage treatment, garbage disposal, industrial point source pollution treatment, garbage treatment around the reservoir, ecological agriculture demonstration area, monitoring capacity building and small watershed management, Shiyan has promoted the reshaping and optimization of the industrial structure and closed hundreds of heavy polluting enterprises. The Shiyan local authorities banned large-scale breeding cages and encouraged fishermen to go ashore to practice ecological agriculture, thereby gradually improving water quality in the Danjiangkou reservoir; carried out the special environmental protection measures and paid more attention to energy saving and emissions controls so that the total amount of major pollutants in the city continued to "double down". As a result, the forest coverage reached 53% through reforestation, natural forest protection project and the establishment of nature reserves with a protected area of 4 million 70 thousand acres accounting for 11% of the land area. Shiyan has become the National Ecological Demonstration Zone with the largest scale and widest range. All this has promoted industrial development whilst at the same time ensuring environmental protection.

Based on the implementation of "The 11$^{th}$ Five-Year Plan of DAN Comprehensive Treatment", "the 12$^{th}$ Five-Year Plan of DAN Comprehensive Treatment" has been improved through the implementation of 10 major categories of 153 projects consisting of urban sewage and garbage disposal, industrial point source pollution control, water and soil conservation, agricultural non-point source pollution prevention and control, reservoir pollution control, construction of ecological isolation zone around reservoir, endogenous pollution control of heavy polluted inflow river, endogenous pollution control in the newly added submerged area and development of water environment monitoring capacity.

Shiyan is located in the northwest of Hubei Province, the upper reach of the Han River. As the core water source of the Middle Route of the South-to-North Water Diversion Project, Shiyan carries the heavy responsibility of providing a continuous supply of clean water to the north. In recent years, Shiyan has closed more than 300 polluting enterprises, and the current standards set for the enterprise to settle in the area have been raised quite high. The raising of the requirements for enterprises also means an increase in the cost and pressure of development in Shiyan. In such an area with high ecological and environmental constraints and rigorous threshold for the development, how to reshape the industrial structure and raise the level of industrial development, so as to achieve "win-win" between economic development and ecological construction, is critical. The local government faces to the challenge of balancing the imperative of maintaining high standards in environmental and ecological protection through tough and stringent measures while at the same time ensuring that the economy grows and contributes to the improvement of the livelihood of the local people. In other words, the local authorities have to see to it that there is harmony between economic growth and ecological protection in the water source areas, a healthy coexistence between man and nature.

There are a number of studies looking at the relationship between the changes in the industrial structure and environment protection as well as the development in reservoir area. For example, Hannan and Yu Weiyang used VAR model to conduct quantitative analysis of influence of industrial structure on environmental pollution in China [1]. Xie and Yuan used the panel VAR model to test the interactive relationship between the reduction of pollution and changes in the industrial structure in order to study the bilaterally dynamic mechanism of pollution control and industrial structure adjustment [2]. Nemat provided an econometric analysis of the relationship between economic development and the quality of the environment [3]. Mohapatra and Giri produced an econometric study of the relationship between economic development and environmental quality in India [4]. Sekar et al. studied the water quality response to economic development by quantifying environmental kuznets curve [5]. Dewick et al. also conducted research on the relationship between technological change, industry structure and the environment [6]. Zhang and Su made a study of low-carbon economy eco-agriculture model and countermeasures in case of three Gorges Reservoir [7]. Hu made research on cultural industry in Three Gorges Reservoir area development model innovation from the perspective of the scientific outlook on development [8]. Tang and Wang made research of low-carbon agriculture strategy in Chongqing Three Gorges Reservoir Area [9].

However, in order to better grasp the strategic direction of the industrial structure reshape, first of all is to study the internal economic relationship of three industries and to analyze the impact of the three industries to each other, which can provide valuable lessons or references for industrial structure reshape [10].

## 2. Method and data

Vector auto regression (VAR) is a stochastic process model used to capture the linear interdependencies among multiple time series. VAR models generalize the univariate autoregressive model (AR model) by allowing for more than one evolving variable. All variables in a VAR enter the model in the same way: each variable has an equation explaining its evolution based on its own lagged values, the lagged values of the other model variables, and an error term. VAR modeling does not require as much knowledge about the forces influencing a variable as do structural models with simultaneous equations: The only prior knowledge required is a list of variables which can be hypothesized to affect each other inter temporally. The VAR modeling method can provide a good analytical tool for analyzing the dynamic influences of different variables.

A VAR model describes the evolution of a set of k variables (called endogenous variables) over the same sample period (t = 1, ..., T) as a linear function of only their past values. The variables are collected in a k × 1 vector , $y_t$ which has as the $i^{th}$ element, $y_{i,t}$, the observation at time "t" of the $i^{th}$ variable. For example, if the $i^{th}$ variable is GDP, then $y_{i,t}$ is the value of GDP at time t. A p-th order VAR, denoted VAR(p), is

$$y_t = c + A_1 y_{t-1} + A_2 y_{t-2} + ... + A_p y_{t-p} + e_t \quad (1)$$

where the l-periods back observation $y_{t-1}$ is called the l-th lag of y, c is a k × 1 vector of constants (intercepts), $A_i$ is a time-invariant k × k matrix and $e_t$ is a k × 1 vector of error terms satisfying

1. $E(e_t) = 0$, every error term has mean zero;
2. $E(e_t)\ (e_t') = \Omega$ the contemporaneous covariance matrix of error terms is Ω (a k × k positive-semidefinite matrix);
3. $E(e_t)\ (e'_{t-k}) = 0$, for any non-zero k — there is no correlation across time; in particular, no serial correlation in individual error terms.

A pth-order VAR is also called a VAR with p lags. The process of choosing the maximum lag p in the VAR model requires special attention because inference is dependent on correctness of the selected lag order.

Since there are fewer constraints based on existing theories and assumptions and all the variables in the VAR system are regarded as endogenous and can enter every assessment equation symmetrically, so VAR model is selected for the use of analysis.

By using the VAR model, Johansen co-integration test, vector error correction model, Granger causality test, impulsive response function and variation decomposition analysis, the interactive influence between the GDP (local GDP output vlaue), G1 (the added value of primary industry), G2 (the added value of secondary industry) and G3 (the added value of the tertiary industry) of Shiyan City, Hubei Province is investigated.

The sample space in this study is from 1991 to 2014. The original data of this paper is sourced from the Shiyan Statistical Yearbook (2012), Shiyan Statistical Bulletin of the National Economic and Social Development (2004–2014), so as to ensure the reliability and authority of the data. In addition, the author conducted field surveys to supplement the data, as shown in Table 1. In order to eliminate the impact of price changes on the relationship between variables, the experimental data is computed by using the industry chain index based on the constant prices with the data in 1991 as basis, as shown in Table 2. At the same time, in order to eliminate the presence of heteroskedasticity, we take natural logarithms of the four variables of GDP, G1, G2 and G3, the results are recorded as LNGDP, LNG1, LNG2, LNG3. The corresponding differential sequences are recorded as DLNGDP, DLNG1, DLNG2, DLNG3. Eviews 6.0 Analysis software is used for all tests in this paper.

## 3. Results and discussion

### 3.1. Unit root test

The stationary of the variables should be tested before building the VAR model and applying the Co-integration test. The regression analysis with non stationary time series may cause "pseudo regression". Therefore, ADF (Augmented Dickey-Fuller Test) is used to test stationary of these variables. The unit root test results are shown in Table 3.

From Table 3, LNGDP LNG1 LNG2 and LNG3 are non-stationary, while the corresponding differential sequences DLNGDP, DLNG1, DLNG2, DLNG3 are stationary, which means LNGDP, LNG1, LNG2 and LNG3 satisfy I(1) and therefore meet the premise of the co integration test.

### 3.2. Johansen co-integration test

The reasonable co-integration lag order should be determined firstly, in order to ensure the statistical credibility of the co-integration relationship. In VAR (p) model, the Johansen co-integration test lag order can be determined by the optimal lag order of VAR(p) through repeated tests based on AIC, SC, LR, FPE and other standards. The optimal lag order for a VAR model ranges from level 3 to level 1, in descending order.

In this paper, according to AIC and SC standards,the optimal lag order of the VAR (p) model of LNGDP, LNG1, LNG2, LNG3 is 3.

Table 1
The original data of GDP, G1, G2 and G3 and the corresponding industry chain index between 1991 and 2014

| Year | GDP | G1 | G2 | G3 | GDP index | G1 index | G2 index | G3 index |
|---|---|---|---|---|---|---|---|---|
| 1991 | 50.68 | 10.77 | 30.58 | 9.34 | | | | |
| 1992 | 67.74 | 12.84 | 43.48 | 11.43 | 1.218 | 1.093 | 1.285 | 1.148 |
| 1993 | 105.11 | 14.91 | 69.60 | 20.60 | 1.327 | 1.119 | 1.342 | 1.534 |
| 1994 | 142.06 | 24.23 | 87.14 | 30.69 | 1.005 | 1.069 | 0.97 | 1.262 |
| 1995 | 141.33 | 29.02 | 71.92 | 40.39 | 0.966 | 0.999 | 0.879 | 1.18 |
| 1996 | 157.38 | 34.90 | 73.67 | 48.81 | 1.036 | 1.113 | 1.009 | 1.044 |
| 1997 | 168.94 | 35.08 | 77.03 | 53.83 | 1.029 | 1.025 | 1.017 | 1.058 |
| 1998 | 178.58 | 35.68 | 85.02 | 57.88 | 1.091 | 1.027 | 1.117 | 1.082 |
| 1999 | 168.63 | 23.66 | 83.92 | 61.05 | 0.97 | 0.7 | 1.004 | 1.073 |
| 2000 | 180.12 | 25.66 | 86.91 | 67.55 | 1.058 | 1.11 | 1.034 | 1.085 |
| 2001 | 203.43 | 27.66 | 99.99 | 75.78 | 1.135 | 1.058 | 1.176 | 1.105 |
| 2002 | 233.18 | 28.87 | 119.97 | 84.34 | 1.139 | 1.051 | 1.182 | 1.107 |
| 2003 | 245.05 | 30.42 | 116.94 | 97.69 | 1.041 | 1.047 | 0.981 | 1.139 |
| 2004 | 292.90 | 34.85 | 149.53 | 108.52 | 1.163 | 1.04 | 1.255 | 1.072 |
| 2005 | 306.63 | 36.08 | 144.71 | 125.84 | 1.048 | 1.029 | 0.964 | 1.138 |
| 2006 | 338.15 | 39.15 | 154.57 | 144.43 | 1.09 | 1.082 | 1.05 | 1.14 |
| 2007 | 411.42 | 45.76 | 187.44 | 178.22 | 1.164 | 1.043 | 1.243 | 1.115 |
| 2008 | 487.36 | 57.77 | 223.21 | 206.38 | 1.107 | 1.063 | 1.068 | 1.163 |
| 2009 | 550.96 | 66.51 | 254.76 | 229.69 | 1.141 | 1.057 | 1.174 | 1.127 |
| 2010 | 736.78 | 77.84 | 402.06 | 256.88 | 1.195 | 1.051 | 1.347 | 1.106 |
| 2011 | 851.25 | 96.91 | 451.88 | 302.46 | 1.11 | 1.045 | 1.108 | 1.132 |
| 2012 | 955.70 | 121.20 | 490.30 | 344.30 | 1.146 | 1.043 | 1.113 | 1.112 |
| 2013 | 1080.60 | 143.00 | 547.00 | 390.60 | 1.165 | 1.050 | 1.281 | 1.131 |
| 2014 | 1200.80 | 151.20 | 610.10 | 439.50 | 1.108 | 1.026 | 1.097 | 1.109 |

Data source: Shiyan Statistical Yearbook (2012) [11], Shiyan Statistical Bulletin of the National Economic and Social Development (2004–2014) [12].

From Table 4, the optimal lag order of the co-integration test of LNGDP, LNG1, LNG2, LNG3, is 2, which means the lag interval of the co-integration test is 1–2, as shown in Table 5.

According to the trace statistic, at 5% significant level, null hypothesis r = 0 (none co-integration relationship), trace statistic 90.6436 is greater than the critical value 47.8561 with p-value 0.0000, which indicates that null hypothesis should be rejected, that is there is at least one co-integration relationship. Null hypothesis r ≤ 1 (at most 1 co-integration relationship), trace statistic 47.0097 is greater than the critical value 29.7971 with p-value 0.0002, which indicates that null hypothesis should be rejected, that is there is at least two co-integration relationship. Null hypothesis r ≤ 2 (at most 2 co-integration relationship), trace statistic 9.3888 is less than the critical value 15.4947 with p-value 0.3306, which indicates that null hypothesis should be accepted, that is there is at most two co-integration relationship. From Table 5, there are two co-integrating relationship between LNGDP, LNG1, LNG2, LNG3.

### 3.3. Vector error correction model (VECM)

According to Table 4, the lag order is analyzed to be 2.

$$ECM_{t-1} = LNGDP_{t-1} - \underset{-8.3062}{0.1975LNG1_{t-1}} - \underset{-26.3875}{0.5317LNG2_{t-1}} - \underset{-22.1991}{0.3438LNG3_{t-1}} - 0.7213$$

From above, LNG1, LNG2, LNG3 and LNGDP are positive correlated, where LNGDP increases 0.1975% by every 1% increase of LNG1, LNGDP increases 0.5317% by every 1% increase of LNG2, LNGDP increases 0.3438% by every 1% increase of LNG3.

The "DAN Comprehensive Treatment" by promoting green development has resulted in the growth and development of the improvement of the second industry. In order to ensure the water quality and safety of the reservoir area, Shiyan has closed and converted 560 enterprises (closed 329 "15 small businesses"; closed 106 turmeric processing enterprises; relocated 125 enterprises), so as to actively promote the development of new industry and promote industrial structure adjustment. Through the transformation or elimination of enterprises that pollute water and the environment, the transformation and upgrading of the industrial structure has been promoted, and the proportion of light and heavy industry has gradually shifted to a reasonable range.

At present, Shiyan's industrial structure is "231", where the third industry has not become the driving force of economic growth.

### 3.4. Granger causality test

Johansen Co-integration Test indicates that there is a long-term stationary equilibrium relationship between GDP and three industries. Granger Causality Test is used to test

Table 2
The experimental data of GDP, G1, G2 and G3, computed by using the industry chain index based on the constant prices with the data in 1991 as basis, as well as their natural logarithms between 1991 and 2014

| Year | GDP | G1 | G2 | G3 | LNGDP | LNG1 | LNG2 | LNG3 |
|---|---|---|---|---|---|---|---|---|
| 1991 | 50.68 | 10.77 | 30.58 | 9.34 | 3.93 | 2.38 | 3.42 | 2.23 |
| 1992 | 61.73 | 11.77 | 39.29 | 10.72 | 4.12 | 2.47 | 3.67 | 2.37 |
| 1993 | 81.92 | 13.17 | 52.73 | 16.44 | 4.41 | 2.58 | 3.97 | 2.80 |
| 1994 | 82.33 | 14.08 | 51.15 | 20.75 | 4.41 | 2.64 | 3.93 | 3.03 |
| 1995 | 79.53 | 14.06 | 44.96 | 24.48 | 4.38 | 2.64 | 3.81 | 3.20 |
| 1996 | 82.39 | 15.65 | 45.37 | 25.56 | 4.41 | 2.75 | 3.81 | 3.24 |
| 1997 | 84.78 | 16.04 | 46.14 | 27.04 | 4.44 | 2.78 | 3.83 | 3.30 |
| 1998 | 92.49 | 16.48 | 51.53 | 29.26 | 4.53 | 2.80 | 3.94 | 3.38 |
| 1999 | 89.72 | 11.53 | 51.74 | 31.40 | 4.50 | 2.45 | 3.95 | 3.45 |
| 2000 | 94.92 | 12.80 | 53.50 | 34.07 | 4.55 | 2.55 | 3.98 | 3.53 |
| 2001 | 107.74 | 13.54 | 62.92 | 37.64 | 4.68 | 2.61 | 4.14 | 3.63 |
| 2002 | 122.71 | 14.24 | 74.37 | 41.67 | 4.81 | 2.66 | 4.31 | 3.73 |
| 2003 | 127.74 | 14.90 | 72.95 | 47.46 | 4.85 | 2.70 | 4.29 | 3.86 |
| 2004 | 148.57 | 15.50 | 91.56 | 50.88 | 5.00 | 2.74 | 4.52 | 3.93 |
| 2005 | 155.70 | 15.95 | 88.26 | 57.90 | 5.05 | 2.77 | 4.48 | 4.06 |
| 2006 | 169.71 | 17.26 | 92.67 | 66.01 | 5.13 | 2.85 | 4.53 | 4.19 |
| 2007 | 197.54 | 18.00 | 115.19 | 73.60 | 5.29 | 2.89 | 4.75 | 4.30 |
| 2008 | 218.68 | 19.13 | 123.03 | 85.60 | 5.39 | 2.95 | 4.81 | 4.45 |
| 2009 | 249.52 | 20.23 | 144.43 | 96.47 | 5.52 | 3.01 | 4.97 | 4.57 |
| 2010 | 298.17 | 21.26 | 194.55 | 106.70 | 5.70 | 3.06 | 5.27 | 4.67 |
| 2011 | 330.97 | 22.21 | 215.56 | 120.78 | 5.80 | 3.10 | 5.37 | 4.79 |
| 2012 | 379.29 | 23.17 | 239.92 | 134.31 | 5.94 | 3.14 | 5.48 | 4.90 |
| 2013 | 441.87 | 24.33 | 307.34 | 151.90 | 6.09 | 3.19 | 5.73 | 5.02 |
| 2014 | 489.60 | 24.96 | 337.15 | 168.46 | 6.19 | 3.22 | 5.82 | 5.13 |

Table 3
The result of ADF test

| Variable | Type of Test (C,T,K) | ADF value | 5% Critical value | P value | Result of test |
|---|---|---|---|---|---|
| LNGDP | (C,T,2) | –1.4195 | –3.6450 | 0.8243 | non-stationary |
| DLNGDP | (C,T,1) | –7.4586 | –3.6450 | 0.0000 | stationary |
| LNG1 | (C,T,0) | –1.9575 | –3.6220 | 0.5926 | non-stationary |
| DLNG1 | (C,T,0) | –4.7796 | –3.6329 | 0.0050 | stationary |
| LNG2 | (C,T,2) | –1.1621 | –3.6450 | 0.8924 | non-stationary |
| DLNG2 | (C,T,1) | –6.2989 | –3.6450 | 0.0002 | stationary |
| LNG3 | (C,T,3) | –2.3081 | –3.6584 | 0.4112 | non-stationary |
| DLNG3 | (C,0,3) | –3.7775 | –3.0300 | 0.0112 | stationary |

Table 4
AIC value and SC value with different lag order from 0 to 3

| Lag | AIC | SC |
|---|---|---|
| 0 | –7.1727 | –6.9738 |
| 1 | –14.7315 | –13.1804 |
| 2 | –14.4358 | –12.6452 |
| 3 | –15.7669 | –13.7367 |

whether this relationship can constitute a causal relationship, so as to study the internal mechanism of interaction between these variables. The test result is shown as follow:

From Table 6, DLNG1 Granger causes DLNGDP, each of the DLNG1 and DLNG3 Granger causes the other, which means the differential of LNG1 Granger causes the differential of LNGDP, the differential of LNG1 and LNG3 Granger cause to each other, that is the rate of change of LNG1 Granger causes the rate of change of LNGDP, the rate of change of LNG1 and LNG3 Granger cause to each other.

Table 5
Johansen Cointegration test result

| $H_0$ | Eigen value | Trace statistic | 5% Critical value | P value | Max Eigen statistic | 5% Critical value | P value |
|---|---|---|---|---|---|---|---|
| r = 0 | 0.8748 | 90.6436 | 47.8561 | 0.0000 | 43.6339 | 27.5843 | 0.0002 |
| r ≤ 1 | 0.8333 | 47.0097 | 29.7971 | 0.0002 | 37.6209 | 21.1316 | 0.0001 |
| r ≤ 2 | 0.2976 | 9.3888 | 15.4947 | 0.3306 | 7.4196 | 14.2646 | 0.4408 |

Table 6
Granger Causality test result

| $H_0$ | F statistic | P value | Result |
|---|---|---|---|
| DLNG1 does not Granger Cause DLNGDP | 4.17494 | 0.0445 | DLNG1 Granger causes DLNGDP |
| DLNGDP does not Granger Cause DLNG1 | 2.62697 | 0.1201 | DLNGDP not Granger causes DLNG1 |
| DLNG2 does not Granger Cause DLNGDP | 0.35659 | 0.8630 | DLNG2 not Granger causes DLNGDP |
| DLNGDP does not Granger Cause DLNG2 | 0.42352 | 0.8193 | DLNGDP not Granger causes DLNG2 |
| DLNG3 does not Granger Cause DLNGDP | 1.33347 | 0.3511 | DLNG3 not Granger causes DLNGDP |
| DLNGDP does not Granger Cause DLNG3 | 2.03605 | 0.1900 | DLNGDP not Granger causes DLNG3 |
| DLNG2 does not Granger Cause DLNG1 | 1.38056 | 0.3362 | DLNG2 not Granger causes DLNG1 |
| DLNG1 does not Granger Cause DLNG2 | 1.10376 | 0.4358 | DLNG1 not Granger causes DLNG2 |
| DLNG3 does not Granger Cause DLNG1 | 4.80843 | 0.0317 | DLNG3 Granger causes DLNG1 |
| DLNG1 does not Granger Cause DLNG3 | 6.18542 | 0.0166 | DLNG1 Granger causes DLNG3 |
| DLNG3 does not Granger Cause DLNG2 | 2.62095 | 0.1207 | DLNG3 not Granger causes DLNG2 |
| DLNG2 does not Granger Cause DLNG3 | 0.90966 | 0.5249 | DLNG2 not Granger causes DLNG3 |

This result could be reasonable because of "DAN Comprehensive Treatment". The "DAN Comprehensive Treatment" by promoting green development has resulted in the growth and development of the expansion of the third industry. With the implementation of "DAN Comprehensive Treatment", the local ecological environment has been improved through the prevention and control of water pollution as well as water and soil conservation, which benefits the primary industry.

### 3.5. Impulsive response function

The orthogonal pulse response function of vector auto regression converges only when the vector is stationary, at the same time, VAR(p) needs to be stationary too, that is, the Eigenvalue of Eigen equation of VAR(p) must lie in unit circle [13]. DLNGDP, DLNG1, DLNG2, DLNG3 are stationary. Therefore, we only need to test the stationary of VAR(p).

From Fig. 1, no root lies outside the unit circle, VAR(p) satisfies the stationary condition. From Fig. 2, the response of DLNGDP to DLNGDP,DLNG1,DLNG2 and DLNG3 showed a strong short-term effect and a weak long-term one, which means, long term to see, the rate of change of LNGDP to the rate of change of LNG1, LNG2, LNG3, that is, the "DAN Comprehensive Treatment" has promoted the growth three industry so the GDP.

### 3.6. Variation decomposition analysis

From Fig. 3, the change of DLNGDP is influenced by DLNG1, which means the change of primary industry still plays an important role in promoting GDP.

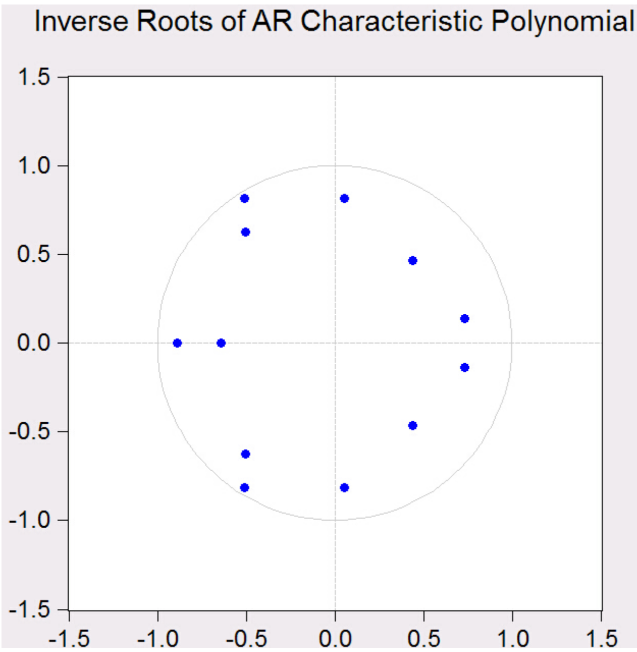


Fig. 1. The unit circle of the mode of reciprocal of the eigen values.

The "DAN Comprehensive Treatment" by promoting green development has resulted in the growth and development of the first industry strong. Based on the idea of ecological priority, through small watershed management and construction of ecological isolation zones around res-

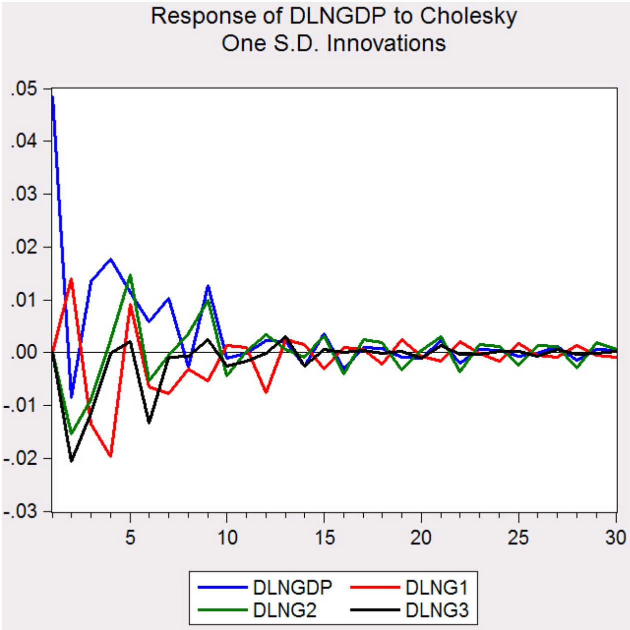


Fig. 2. The Response of DLNGDP to DLNGDP, DLNG1, DLNG2 and DLNG3.

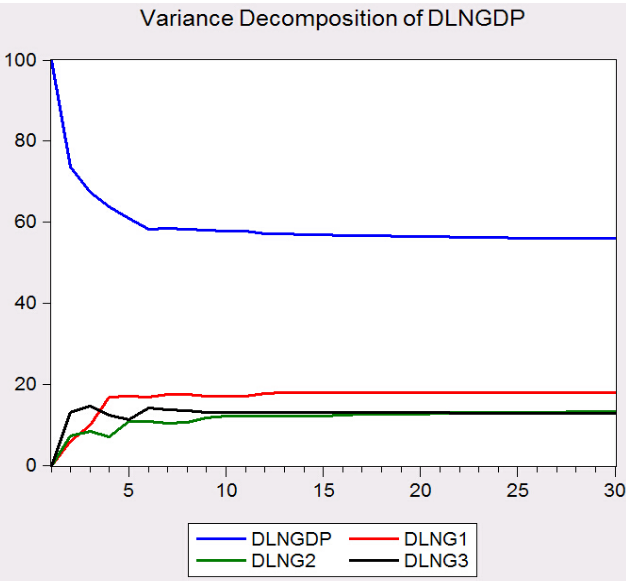


Fig. 3. Variation decomposition of DLNGDP.

ervoir as well as the relevant state support policies and funds, the farmers are guided and motivated to make adjustments in their planting practices. Under the banner of stationary grain production, the economic crops and ecological agriculture are actively developed, so as to optimize the structure of grain variety. The deep processing of agricultural products is promoted relying on scientific and technological progress. Shiyan authorities are actively encouraging new agricultural management systems, promoting large-scale agricultural production to intensive, development of big specialized households of crop and animal production, professional cooperative agency of farmers, agricultural enterprises and other agricultural management bodies. Treatment of sewage and recycling of human waste is conducted by intensive development of aquaculture industry. With the improvement of the mode of agricultural production and the promotion and utilization of clean energy, the agricultural non-point source pollution has been reduced, maintaining the ecological security in Danjiangkou reservoir and upstream areas. Combining the development of grain and the various economic crops, field planting and forestry, animal husbandry, side-production production and fishery, large-scale agriculture to innovate ecological circular agriculture mode, so as to form coupling symbiosis between ecological environment and economic development.

## 4. Conclusions

(1) At present, Shiyan's industrial structure is "231", where the third industry has not become the driving force of economic growth.

(2) According to the Granger Causity Test, DLNG1 Granger causes DLNGDP, each of the DLNG1 and DLNG3 Granger-causes the other, which means there is an interactive relationship between primary industry and tertiary industry.

(3) According to Impulsive Response Function analysis, the response of DLNGDP to DLNGDP,DLNG1,DLNG2 and DLNG3 showed a strong short-term effect and a weak long-term one. According to Variation Decomposition Analysis, the change of DLNGDP is influenced by DLNG1,which means the change of primary industry still plays an important role in promoting GDP.

## 5. Policy suggestions

According to the conclusion, at present, Shiyan's industrial structure is "231", where the third industry has not become the driving force of economic growth. In accordance with the Petty-Clark's law, along with the improvement of technological progress and labor productivity, the three industrial structures evolved from "123" to "213", then to "231", and then to "321" [14]. Therefore, speeding up the development of the third industry is the goal of reshaping the industrial structure in the future. Meanwhile, there is an interactive relationship between primary industry and tertiary industry. So the three industries should be developed in an integrated way.

The "DAN Comprehensive Treatment" by promoting green development has resulted in the growth and development of the expansion of the third industry. With the implementation of"DAN Comprehensive Treatment", the local ecological environment has been improved through the prevention and control of water pollution as well as water and soil conservation. The water surface has increased more than 20%.With the construction of ecological isolation zones around reservoirs, the construction of the greening riparian zone, as well as the grand view of the Danjiangkou dam, Shiyan has become more and more beautiful, which has promoted the vigorous development of tourism industry with a rapid growth of the number of tourists and tourism revenue. The annual number of tourists increased about 6.4 times from 5403 thousand people in 2004 to 34354 thousand people in 2014; the annual tourism revenue increased about 11.1 times from 2.19 billion RMB in 2004 to 24.27 billion RMB in 2014.The development of tourism has driven forward the development of traffic industry, communication industry and construction industry, and backward the development of hotel shop industry, food processing industry, tourism commodity production industry, commerce and trade, travel agencies and other manufacturing industries. That is to say, the development of tourism has stimulated the development of the third industry: the service industry. At the same time, the development of tourism has also promoted the protection of ecological environment in Shiyan, which has benefited local residents. The economic benefits of local residents depend on the protection of ecological environment. So the economic interests are the driving force for local residents to protect the ecological environment. The development of tourism has promoted the reshaping and optimization of the industrial structure and greatly improved the economic hematopoietic function. At the same time, the economic benefits also raise environmental consciousness and awareness, so that economic development and ecological protection form a virtuous cycle, ensuring that tourism contributes to sustainable development and becomes a pillar industry in Shiyan.

The implementation of "DAN Comprehensive Treatment" will gradually promote reshaping and optimization on the three industries from "231" to "321".

The reshaping and optimization of industrial structure is the fundamental path to escape from the dilemma between economic development and environmental protection. The implementation of "DAN Comprehensive Treatment" has not only contributed to the protection of water quality and the ecological environment, but it has also prompted the reshaping and optimization of three industrial structures. This has promoted the protection of the environment and stimulated local economic and social development and improved people's livelihood. In order to ensure sustainable development of Shiyan and the region, the water pollution prevention and control, as well as water and soil conservation in Danjiangkou reservoir and upstream areas must be prioritized. It has promoted a healthy relationship between the people and the living environment. The successful implementation of the "DAN Comprehensive Treatment" in the Shiyan City which is illustrated by the positive impact on the reshaping and optimization of its three industries provides valuable lessons and serves as an important model for implementation of similar projects in reservoir areas and water source areas.

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