# The Analysis on the Influence of Water Conservancy Investment on Agricultural Economic Growth: An Empirical Study Based on the Boom Period of Shandong Agriculture

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**Abstract** This paper uses econometric methods to carry out a Granger causality test on the construction of water conservancy infrastructure construction and agricultural economic growth in the boom period (1981 -2002) of Shandong agriculture. Empirical results indicate that there exists two-way Granger causality between Shandong water conservancy infrastructure construction and Shandong agricultural economic growth. Therefore, water conservancy infrastructure construction has a significant influence on agricultural economic growth in Shandong.

**Key words** Water conservancy, Agricultural economic growth, Granger causality

## 1 Introduction

Shandong Province is located in the lower reaches of the Yellow River. Its warm temperate monsoon climate zone features a windy spring, rainy summer, less rainy or snowy autumn and winter, and sudden shifts from warm to cool weather and heavy rains to drought. In the flood season, concentrated rainfall accounts for 70% to 80% of the province's total rainfall, with more than 50% of total rainfall in July and August. Flood control and disaster mitigation are always its water conservancy focus. This paper examines the relationship of water conservancy and agriculture economic growth in the boom period from 1981 to 2002. Using an econometric method, we made a quantitative analysis of their mutual relationship. Although lagging in time, the research reflects history and summarizes past experience and natural laws in a meaningful way.

## 2 An empirical analysis on water conservancy and agriculture economic growth

**2.1 Data sources** According to the studies' needs, the data were selected from the *Shandong Rural Statistical Yearbook*, 1981 to 2002. Data included Shandong Water conservancy investment in capital construction (*SI*) and agriculture economic growth (*AGDP*). *AGDP is the* Gross output value of agriculture' which refers to the total production of agriculture, forestry, animal husbandry and fishery in monetary form. It reflects the overall scale and achievement in a certain period. Meanwhile, in order to eliminate heteroscedasticity in the time sequence and the over - fluctuation of the data, in Table 1, we transformed the natural logarithm among variables which are presented by LN*AGDP* and LN*SI*, respectively.

**Table 1 The index of WCI and AEG from 1981 to 2002 in Shandong Province**

| Year | Gross output value of agriculture $10^8$ yuan | Water conservancy capital construction investment $10^8$ yuan | Water conservancy capital construction investment of agricultural capital construction investment // % |
|---|---|---|---|
| 1981 | 198.5 | 0.55 | 66.7 |
| 1982 | 218.51 | 0.5 | 53.5 |
| 1983 | 259.5 | 0.4 | 53.7 |
| 1984 | 310.11 | 0.91 | 74 |
| 1985 | 335.42 | 0.79 | 62.8 |
| 1986 | 361.19 | 0.89 | 57.4 |
| 1987 | 413.18 | 0.58 | 37.9 |
| 1988 | 494.53 | 0.77 | 41.4 |
| 1989 | 547.66 | 3.88 | 89.9 |
| 1990 | 645.75 | 1.53 | 70.9 |
| 1991 | 779.18 | 2 | 67.5 |
| 1992 | 815.62 | 4.39 | 80.4 |
| 1993 | 944.99 | 4.45 | 71.3 |
| 1994 | 1 282.25 | 8.08 | 78.7 |
| 1995 | 1 678.16 | 10.1 | 70.1 |
| 1996 | 1 962.12 | 13.75 | 78.3 |
| 1997 | 2 058.32 | 19.58 | 75.2 |
| 1998 | 2 174.54 | 15.14 | 73.9 |
| 1999 | 2 202.95 | 20.43 | 71.7 |
| 2000 | 2 294.35 | 31.05 | 80 |
| 2001 | 2 453.96 | 29.91 | 77.9 |
| 2002 | 2 526.05 | 30.38 | 77.4 |

Data Sources: *Shandong Rural Statistical Yearbook*. *WCI* = Water Conservancy Investment, *AEG* = Agriculture Economic Growth.

**2.2 Model establishment** The Granger causality test statistically tests the causal relationship between two variables. Its basic idea is that if $X$ causes the change in $Y$, then the change in $X$ should happen before the change of $Y$. If $X$ changes lead to $Y$ changes, then $X$ helps predict $Y$. Restated, if, after adding the independent lag variable $X$ to the lag variable $Y$ regression, the independent variable $X$ can significantly increase the capacity of the regression model to explain $Y$, then $X$ is the Granger causality of $Y$. If lag variable $X$ can't significantly increase the explaining capacity for the lag variable $Y$ regression, then $X$ is not the Granger

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causality of *Y*.

The premise of Granger causality test is the stationary time sequence or non-stationary time sequence relationship. By applying Eviews software, this paper tests the stationary time sequence of LN*SI* and LN*AGDP*, respectively. Testing results are showed in Table 2.

**Table 2 ADF unit root test**

| Sequence | Checking form | ADF statistics | Prob | Results |
|---|---|---|---|---|
| LN*AGDP* | (C,T, K) | -6.120 070 | 0.004 3 | stationary * |
| LN*SI* | (C,T, K) | -6.120 070 | 0.000 9 | stationary * |

Note: The checking form (*C*, *T*, *K*) refers to the constant term, trend term and lag phase in unit root test equation; * means significantly different at the level of 5%.

The sequence of both LN*SI* and LN*AGDP* can reject the unit root null hypothesis at the 95% significant level which indicates that they are stationary. A further co-integration test also shows the co-integration relationship between LN*SI* and LN*AGDP* indicating that there is a long-term stable relationship between water conservancy infrastructure construction investment, effective irrigation area, and the total production of agriculture, forestry, animal husbandry, and fishery. The Granger causality test used Eviews software and the test results are shown in Table 3.

**Table 3 Granger causality test**

| Null Hypothesis: | F-statistic | Prob. | Results |
|---|---|---|---|
| LNSI does not Granger Cause LNAGDP | 3.58010 | 0.0468 | Reject the null hypothesis * |
| NAGDP does not Granger Cause LNSI | 3.22509 | 0.0611 | Reject the null hypothesis * |

The testing results indicate that there is a two-way inner-relationship between LN*SI* and LN*AGDP* at the 90% significance level. There exists long-run growth effect between the growth of water conservancy infrastructure construction investment and agriculture economic growth which can propel the development of the agricultural economy forward. What's more, the increase of the agricultural economy has raised new requirements for water conservancy infrastructure and has provided fund sources to further promote water conservancy investment.

Based on the above results of the Granger causality test, a further analysis was made on the relation between water conservancy infrastructure construction and agricultural economic growth. A Log linear regression model (see 1) was constructed as follows:

$$\ln(AGDP) = \beta_0 + \beta_1 \ln(SI) + \mu \quad (1)$$

In model (1), the explained variable *AGDP* represents the total production of agriculture, the explanatory variable *SI* represents water conservancy infrastructure construction investment, $\mu$ is random error, and $\beta_0$ and $\beta_1$ are estimated parameters. The elasticity coefficient, $\beta_1$, reflects the influence of water conservancy investment on agricultural economic growth.

**2.3 Parameter estimation** The parameter was estimated by using Eviews software and ordinary least squares (results are showed in Table 4) to obtain the regression equation (see 2).

$$\text{LN}AGDP = 0.551 \times \text{LN}SI\ 6.001 \quad (2)$$
$$18.187^{***} \qquad 100.170^{***}$$
$$R^2 = 0.942\ 980,\ D.W = 1.890\ 187,\ F = 330.754\ 1$$

The use of * * * means they passed the significant test at 1% level.

Regression equation (2) measured the impact of water conservancy infrastructure construction to the growth of Shandong agriculture economy. The overall significance of the equation and the *R*-squared are good, which indicates that water conservancy infrastructure construction has an overall explanative significance on the total production of agriculture. The constant term and the regression coefficient of *SI* have respectively passed the significance test at the 1% level which indicates that the influence of the two water conservancy infrastructure construction indexes on Shandong agriculture economic growth is very significant. Moreover, according to the regression coefficient, we found that a 1% increase in water conservancy infrastructure construction investment was associated with a 0.55% increase in the total production of agriculture. Results suggest that increasing water infrastructure construction has significant economic benefits to the sustainable and stable growth of Shandong's agricultural economy.

**Table 4 OLS parameter estimation results**

| Variable | Coefficient | Std. Error | t-statistic | Prob. |
|---|---|---|---|---|
| LN*SI* | 0.551 235 | 0.0303 10 | 18.186 65 | 0.000 0 |
| *C* | 6.001 484 | 0.0599 13 | 100.170 3 | 0.000 0 |
| *R*-squared | 0.942 980 | Mean dependent var | | 6.702 203 |
| Adjusted *R*-squared | 0.940 129 | S. D. dependent var | | 0.879 495 |
| S. E. of regression | 0.215 200 | Akaike info criterion | | -0.147 993 |
| Sum squared resid | 0.92 6218 | Schwarz criterion | | -0.048 807 |
| Log likelihood | 3.627 923 | Hannan - Quinn criter. | | -0.124 628 |
| *F*-statistic | 330.754 1 | Durbin - Watson stat | | 1.890 187 |
| Prob(*F*-statistic) | 0.000000 | | | |

## 2.4 Model Verification

**2.4.1** Economic significance evaluation. According to the regression equation (2), there is a positively correlated relationship between water conservancy infrastructure construction investment and agricultural economic growth. A 1% increase in water conservancy infrastructure construction investment was associated with a 0.55% increase in the total production of agriculture, forestry, animal husbandry and fishery.

**2.4.2** Statistical evaluation. Goodness of fit check: $R^2 = 0.943$, the overall significance of equation and the goodness of fit are excellent. T-test: the t-test value of LN*SI* is 18.187, the probability is near 0, it has passed the t-test and the significance is high. F-test: the f-test value is 330.75, the probability is near 0, it has passed the f-test and the significance is high.

**2.5 Model Analysis** Based on Shandong Rural Statistical Yearbook, this study selected data from 1981 to 2002 to analyze the influence of Shandong water conservancy infrastructure investment on the total production of agriculture, forestry, animal husbandry and fishery. In order to eliminate heteroscedasticity exist-

ing in the time sequence and data over-fluctuation, the variables were transformed using natural logarithms which are presented by LN*AGDP* and LN*SI* respectively. Afterwards, an ADF stationary test was conducted to ensure the stationarity of the time sequence which satisfied the premise of the Granger causality test. The Granger causality test indicates that there is a two-way inner-relationship between LN*SI* and LN*AGDP* at the 90% significant level. To ensure that there exists a long-run growth effect between the growth of water conservancy infrastructure construction investment and agriculture economic growth, the role of water conservancy infrastructure construction investment on agriculture economic growth was analyzed. A ordinary least squares regression model was used to estimate parameters as follows:

$$\mathrm{LN}AGDP = 0.551 \times \mathrm{LN}SI + 6.001.$$

## 3 Policy recommendations

**3.1 Coordinating departments to build strong leadership mechanism** Water and finance departments at all levels should establish a platform to construct small-scale irrigation and water conservancy systems, set up leadership groups, strengthen coordination and cooperation between departments, clarify the functions and division of work, fulfill duties and responsibilities, and use regulations and mechanisms to guarantee small-scale irrigation systems in rural areas. Under leadership groups, we should establish province-wide construction planning for small-scale irrigation and water conservancy systems and guide the relevant departments to realize jointly connected, input matching, project co-constructing and resources sharing. We should try to enrich regulatory power and strengthen internal supervision. We should try to give full play to discipline inspection, attorney, auditing, and intermediary organization to make joint efforts in inspection and management. Thus, we should provide strong organization to guarantee funds for supporting agriculture and benefiting farmers. We should prepare for capital integration to ensure that rural water conservancy construction funds can be employed with optimum efficiency.

**3.2 Promulgating Rural Water Conservancy Development Fund Law as soon as possible** Two features characterize the presently published policies that concern the construction of irrigation and water conservancy projects. One is that most of the policies are not in the form of law. Thus, some beneficial policies have not been well implemented because there is no clear plan or government commitment. The other is that the policies do not fully reflect the general welfare policy of granting 'the same national treatment' or 'the same peasants' treatment'. Such defects lead to unfairness where some villages and peasants receive policy support but others do not – even if the latter does all the same things. To make up for these deficiencies, we should provide legislative and financial guarantees. It is essential to promulgate Rural Water Conservancy Development Fund Law and to fund the special provisions of that law.

**3.3 Setting up diversified financing mechanism, innovating investment model** We recommend continuously improving the water conservancy investment system based on public input to achieve a long-term, steadily rising mechanism. During times when government at all levels enjoys increasing fiscal revenues, we encourage government policies that facilitate prosperity at all levels and in all sectors of society. To make the fullest use of market mechanisms, we recommend speeding up irrigation and water conservancy construction by auctioning managerial rights to increase the scale of water conservancy investments and to enhance their efficiency. We also recommend continuing to implement the policy of 'substituting subsidies with rewards'. For example, if key projects at a township level can pass the acceptance tests organized by the water conservancy, finance, and audit departments, then they should receive appropriate rewards in proportion to their government investment.

**3.4 Supervisory and evaluation mechanisms to promote rational use of water conservancy public finances** While promoting water conservancy reform, attention should also be paid to 'rent-seeking', 'broken window economics', and 'for uncultivated land' auction contracts that occur in the water rights transfer process. Water resources have a public finance feature which sometimes enables rent-seeking behavior by vested interests (including local government, interest groups. enterprises, individuals, etc.). The government should watch the 'window' and select the 'craftsman' carefully. Comprehensive and multi-level supervisory mechanisms for the small-scale irrigation and water conservancy construction should be established. Emphasis should be on the transformation from post-supervision to whole-process supervision. Law should make fund supervision run through the process of approval summation, fund allocation, implementation, and performance evaluation. The surveillance function including inspection, supervision, auditing and discipline departments should be unfettered. Social forces should participate in regulation and engage in supervision to ensure safe compliance and effective utilization of irrigation and water conservancy construction funds.

**3.5 Improving the utilization efficiency of water conservancy public funding** Management is the theme of economic activity. We recommend to change the phenomenon of "value construction, ignore management", to avoid the formalism of only competing for projects and investment but ignoring management and profit afterwards. We recommend serious considerations on water conservancy project fixed assets as the economic fundamentals to manage. We recommend constructing dynamic water tariffs and billing structures to ensure normal operation and sustained development of water conservancy project. We also recommend establishing benign management mechanism of the basic industry which regards economic benefits as its center and fixed assets management as its tool.

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term but positive in the long term.

Thirdly, the reverse flow of rural financial resources is obvious in Hubei Province. The deposits absorbed by Postal Savings Bank and rural credit cooperatives mostly flow out to economically developed regions. This results in the shortage of capital for supporting agriculture in Hubei Province and low allocation efficiency of rural financial resources.

### 3.2 Recommendations

**3.2.1** Improving the main function of rural finance and playing the role of financial institutions in supporting agriculture. It is necessary to establish the long-term agriculture-supporting mechanism of Agricultural Bank to make it provide services for "agriculture, farmers and countryside" and county economy; expand the agriculture-supporting service scope of Agricultural Development Bank to strengthen its policy banking functions; give full play to the role of the main force of rural credit cooperatives to enhance the level of financial services for the county's economic development; build the capital backflow mechanism of Postal Savings Bank, set up the rural consumption and rural microfinance business to nurture the county's economic development and give full play to its role in supporting the new rural construction.

**3.2.2** Guiding and regulating the private finance to expand financing channels. In rural areas, taking into account the risk prevention and the pursuit of profit, the formal finance is unwilling to provide loans to farmers, and the private finance can transfer and spread the bank's credit risk to provide another financing path for the rural businesses and farmers, and effectively fill the gaps in rural financial needs.

It is necessary to guide and regulate the private lending, open the rural private financial markets, and actively explore the "sunshine" mode of private financial financing, to promote the rural economic development and optimize the rural social credit environment.

**3.2.3** Accelerating the rural financial service innovation. It is necessary to innovate upon the derivative products of financial support for agriculture, especially agricultural insurance, agricultural credit insurance, agricultural futures and options, to effectively disperse and avoid all kinds of agricultural credit risk; expand the rural credit service field of financial institutions, and increase variety of businesses, to meet farmers and rural enterprises' diversified needs for financial services.

**3.2.4** Improving the rural financial system and optimizing the allocation of financial resources. It is necessary to promote the formation and development of diversified pattern of rural financial institutions, and make the financial institutions actively carry out rational and orderly full competition.

Meanwhile, the local governments should vigorously promote the building of rural credit system, and implement the farmer credit information sharing, to achieve the connection between rural credit assessment work and credit system, and ease the rural information asymmetry.

**3.2.5** Striving to improve and optimize the rural financial ecological environment. The key to new rural construction is to establish the long-term funding gathering mechanism, and its core is to optimize the rural financial ecological environment. Favorable financial ecological environment is conducive to improving the allocation efficiency of financial resources, rationalizing the operational mechanism of rural funds, guiding the backflow of capital, guarding against the financial risks, and improving the investment environment in rural areas, to truly form the "depression" effect of capital accumulation.

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