Climate Adaptation Funds on Agricultural GDP

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Abstract. There are no conclusions yet on the best adaptation policies affecting agricultural GDP. Based on the statistics and questionnaire survey for Yutian County and using a combination of vector cointegration the article aims to reveal the effects of three main external adaptation policies, including the improved varieties, water-saving irrigation and the grazing prohibition, on agricultural GDP growth in arid areas. The results are as follows. 1) Every 1% increase in adaptation investment of improved variety, water-saving irrigation and grazing prohibition will explain the agricultural GDP growth of 0.78%, 0.52%, and 0.27%, respectively. 2) The improved variety's influence on agricultural GDP keeps increasing and eventually reaches about 14%. 3) About 18% of agricultural GDP growth can be reported by the adaption investment in water-saving irrigation, which means that improving capacity of the water irrigation is still the most important and direct means to stimulating the GDP growth in Yutian County. Adaption investments in water-saving irrigation have greater influences on the variation of the improved variety, which means the latter passively adapt to the former. The recursive test results indicate that our conclusions are robust. Our research has showed that actively external policies help to improve the climate adaptation in the arid areas and increase the agricultural GDP.

Keywords: adaptation policies; agricultural GDP; DAG; VECM

1 Introduction

Historically, the agrarian economy and the nomadic economy in northwestern China extremely depended on the weather conditions, such as the rainfall and the temperature. So any marginal climate change would destroy the means of production, such as arable lands and livestocks, and thus undermine its fragile socio-economic foundation [2]. Once the farmers were forced to become destitute and homeless, which maybe provoke conflicts and even local war [3].

Unfortunately, previous researches are ambiguous on the nature of the causal relationship between the adaption funds and the agricultural GDP. Although most theoretical analyses and the empirical analyses maintain the adaption activities and funds can add considerably agricultural GDP in the long run. For example, Munang R et.al(2013)revealed that the adaption funds can prevent more peasant households from the negative effects by the climate change and have the chance to gain non-agricultural incomes, which could improve the income structure and enhance their ability to cope with climate change. Zhang Q (2014) showed that obvious

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changes are induced to the plant structure and household incomes by the changes in the adaption funds supply in the short time, particular in the areas for grain for green. Oluwatusin F M (2014) examined the issue that adaption funds invested in the agricultural fields could have a positive effect on agriculture and lift more people out of poverty no matter in short or long run. Generally, most of the previous studies have been applied by empirical analyses of historical time-series data. The existing empirical evidence on the relationship between adaption investments and the agricultural GDP, however, has been mixed and inconclusive.

Furthermore, the effectiveness of policy tools depends on the efficient policy conduct mechanism.

Particularly, under the different social-economic conditions and in some specific areas, the various adaption policies and the adaption initiatives have different impactions and the spatial heterogeneity on the agriculture and the household incomes. Hence, the purpose of this paper is to re-examine the dynamic relationship between agricultural GDP and adaption funds based on a relatively closed area, Yutian County, with an emphasis on improving on the specification of previous empirical models based on time-series techniques and the field research data. In our empirical analysis, we establish VECM to analyze the short and long-term effects of the adaption policies on the agricultural GDP. Secondly, it would build a contemporaneous correlation among variables with a directed acyclic graph (DAG) technique, and then draw some conclusions according to the outcomes above.

2 Data and Methodology

My empirical analysis relies on two major data sources that trace the adaption funds and the agricultural GDP across prefectures over time, and link the agricultural GDP to water-saving irrigation, the improved varieties and the grazing prohibition. This section describes each data source and provides their descriptive statistics.

2.1 Data Resources

Our time frame runs from 2001 to 2012.The data resources for this research are as follows: the first series uses quarterly data mainly from the China Statistical Yearbook, the Yutian Statistical Yearbook, and the related documents. The second ones are from the field research across 1999-2013a for Yutian County, which mainly applies a random sample survey on local farmers and adaptation policies for climate change. The survey uses the two-stage stratified random sampling method that follows these steps: First, Yutian County as the township is the first layer and within each layer there are random 2-3 administrative villages. Second, each village randomly selects 1~2 settlements in accordance with the size of the village. If any of the surveyed households do not match the study subjects or are unwilling to participate in the questionnaire, its neighbors may be chosen to replace them in the sample. The investigations are continuing in the last 15 years with selected 590 households. According to the survey data, more than 90% of respondents are Uighur and 92.9% are in the age range of 40-70 years. Those respondents under the junior middle school account for 72.8%.

2.2 Quantitative Data Description

Using the quarterly data across 2001a to 2012a, we took into account the actual characteristics of agricultural production to examine the impact of the policies on the agricultural GDP. According to the agricultural adaptation measures indicated by the IPCC (2007),we found that seed subsidies, water-saving irrigation, and the grazing prohibition are the most important adaptation measures in these 12 years.

A review of the policy effect is hard to be quantified and often need to take proxy variables for analysis. Climate change is the public goods（IPCC,2007）,so financial capital is the key to address climate change in China(Zhang Q,2011). Therefore, we can use the public investment as a proxy variable to describe the appropriate adaptation measures. For example, the financial budget on the water-saving irrigation and improved varieties by the government are considered as the proxy variables of the corresponding adaptation policy, and the government subsidies as the policy variable of the grazing prohibition.

Overall, agricultural adaptation investments were always high accompanied by a rising trend over the past twelve years in Yutian showed by the figure 1. However, due to differences in environmental policies and economic development objectives, the capital flows on adaption projcets are also different during various stages of economic development. For example, from 2001a to 2005a, water-saving irrigation and the improved varieties accounted for the largest amount of adaption funds while the grazing prohibition only received fewer investments. From 2006a to 2010a, the investments on water-saving irrigation and the improved varieties were still growing, but growth rate became slowly. The investments on the grazing prohibition always increased rapidly. However, the investments on the three variables have been gradually declining (Tab.1) since 2011. Table 1 also illustrates that the growth trends about agricultural GDP are consistent with the adaptation funds. But the growth reasons in GDP and assessing what are the most effective adaption measures to prompt the GDP growth may require further analysis. Although the three main adaptive measures are experiencing decline in capital investments, the total adaptation investments are still growing. This may be related to the new agricultural adaptive initiatives in Yutian, but the investments are still more dispersed which can not have significant influence on the agricultural GDP growth in long periods. Further, all the variables are seasonally adjusted and converted into constant prices of 2000 to eliminate the fluctuations in the price and to get the actual value.

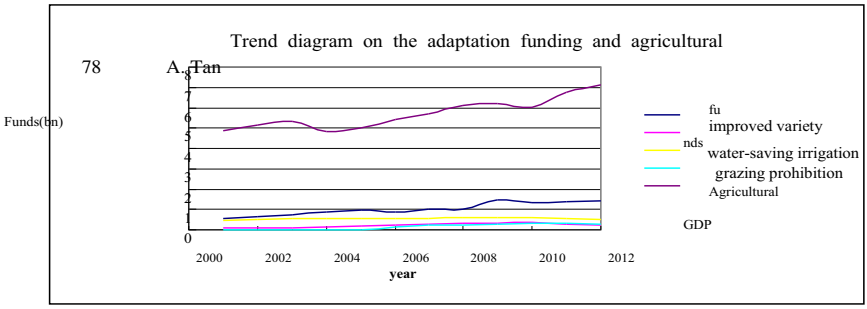

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Figure 1. Adaptation funds and agricultural GDP from 2001 to 2012

TABLE I . DESCRIPTION OF THE VARIABLES

Variable	2001-2005		2006-2010		2011-2012	
	Mean	Std.	Mean	Std.	Mean	Std.
Y:Agricultural GDP (bn Yuan)	4.95	6.21	5.82	6.30	6.93	7.22
The total adaptation funds (bn Yuan)	0.69	0.86	0.83	1.12	0.98	1.07
X1: improved varieties (bn Yuan)	0.11	0.23	0.15	0.34	0.14	0.29
X2:Water-saving irrigation (bn Yuan)	0.52	0.78	0.53	0.49	0.46	0.39
X3: Grazing proh. (bn Yuan)	0.01	0.02	0.11	0.17	0.15	0.22

2.3 Analytical Tools

In this study, VAR model (vector autoregressive model) is used for the empirical analysis as below:

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-1} + \upsilon + e_t \quad t=1,K,T \qquad (1)$$

where Y_t is an (n×1) column vector of p variables, υ is an (n×1) vector of constant terms, Γ and Π represent coefficient matrices, Δ is a difference operator, k denotes the lag length, and e_t is p-dimensional Gaussian error with mean zero and variance matrix (white noise disturbance term). The coefficient matrix Π is known as the impact matrix and contains information about the long-run relationships (Titus O. Awokuse, 2005).

To determine the effectiveness of policy transmission, we usually use the Granger's (1969) definition of causality. However, the Granger causality test emphasizes a chronological order and causality of events, which is sensitive to the lagged variable and the different lag intervals for endogenous which could lead to different conclusions. More importantly, the Granger causality test prefers to the causality of economic variables than the economically significant（Abdullah and Rangazas,1988）.The variance methodology mostly uses Cholesky decomposition to illustrate the relationship between structures in contemporaneous time (Enders&Walter, 2004). But the results are still dependent on variable ordering. Because of a priori judgments by the VAR model, it is inevitable that some results are subjective (Spirtes, et.al, 2004). So this article used the DAG to avoid the uncertainty caused by the selection of the lagged variable in VAR model (Pearl, 1995, 2000), which can analyze the causal relationships among the variables independent of time.

A DAG can be defined as a graph using arrows and vertices to describe the causal relationship in contemporaneous time. In the graph, the vertices can represent random variables. The line segments connecting vertices (directed edges or arrows) among a set of variables representing the causal relationship between them by calculating the conditionally statistical dependence or independence among variables (ceteris paribus). If the two vertices are connected, which means there exists causality between the variables in contemporaneous time and the variables also are independent each other. In a detailed analysis, in order to terrify whether the estimated sample correlations and conditional correlations coefficient is 0 or not, we use a Fisher's z statistical tests. The formula is showed as below:

$$z\left[\rho(i,j|k)n\right] = 1/2(n-|k|-3)^{1/2} \times \ln\left\{\left[1+\rho(i,j|k)\right] \times \left[1-\rho(i,j|k)\right]^{-1}\right\} \qquad (2)$$

Where n is the observed value of the estimated correlation coefficient. $\rho(i,j|k)$ expresses that k is the conditional variable, and the variables i and j are the partial correlation coefficient. Further, $|k|$ is the number of condition variables in k. If the variable i, j and k are normal distribution, and the $r(i,j|k)n$ is the sample conditional correlation of i and j given that k, $z\left[\rho(i,j|k)n\right] - z\left[r(i,j|k)n\right]$ also would obey the standard normal distribution.

3 Results

3.1 Long-term Equilibrium Relations

According to the quarterly data of 2001a to 2012a, we use the De-trending unit root tests (DF- GLS) to examine the four variables (table 2). Results showed in Table 2 suggest that the test results all reject the null hypothesis at the 5 percent levels of significance for each time-series level value. According to the first-order difference test, the results could be significantly rejected the null hypothesis of the "existed unit root". Thus, results prove that the four variables (X1, X2, X3, Y) are non-stationary (I) process by the unit root test.

TABLE II TESTS FOR UNIT ROOT

Var.	MZ_a^{GLS}	MZ_t^{GLS}	MSB^{GLS}	MR_T^{GLS}	P_T^{GLS}
Y	-11.32	-2.06	0.33	4.76	9.52
X1	-6.35	-1.23	0.17	10.04	11.44
X2	-7.88	-1.58	0.180	5.34	6.05
X3	-5.46	-1.00	0.24	9.12	8.63
Sig. 5%	-16.67	-2.73	0.26	3.67	3.67
ΔY	-11.2**	-2.32**	0.26**	2.13**	2.76**
ΔX1	-14.1***	-2.91***	0.20***	1.16***	3.61***
ΔX2	-9.20**	-1.85**	0.14**	1.90**	2.011
ΔX3	-16.01*	-3.01*	0.18**	1.22*	1.44*
Sig. 5%	-10.16	-1.41	0.30	2.77	2.77

Note:*** p<0.01, ** p<0.05, * p<0.1 ; Level variables use the trend term plus constant term ; differential variable tests only used the constant term; " Δ " means the first-order differences.

It is estimated the long-term equilibrium relationship between the agricultural GDP and the adaptation funds by the least square method. The estimated results are as follows (figures in brackets are the standard deviation):

$$Y = -0.736 + 0.538X1 + 0.712X2 + 0.336X3$$
$$(0.243) \quad (0.301) \quad (0.216)$$
$$R^2 = 0.82 \qquad DW=1.97 \tag{3}$$

The residual being used to test the unit root of the above OLS equation, the results indicate the hypothesis on the "existed unit root" is be rejected, that is, the residual is stable. All that proves that there is a long-term and stable co-integrative relation among the four variables.

3.2 Error Correction Model and Factor Decomposition

1)Error correction model (ECM)

. According to results by the cointegration tests based on equation (3), we can use the autoregressive distributed lag model (ADL) to gain more accurate characterization of the long-term equilibrium relationship between the four variables, and then to set the error correction model (ECM). The estimation results are as follows:

$$Y=-0.244Y_{t-1}+0.038Y_{t-2}+0.457X1_{t}+0.521X1_{t-1}+0.544X1_{t-2}+0.848X2_{t}-0.842X2_{t-1}+0.829X2_{t-2}+0.337X3_{t}-0.429X3_{t-1}+0.386X3_{t-2}$$

$$R^2=0.86 \qquad DW=2.13 \qquad (4)$$

the long-term equilibrium relation is bellow as equation (5) according to equation (4):

$$Y=0.521X1+0.783X2+0.275X3 \qquad (5)$$

Thus the unbalanced error is as below: $e_t=Y-0.521X1-0.783X2-0.275X3$

Where the unit root test of e_t can also confirm the long-term relationship between the four variables. Using non-equilibrium error and eliminating the insignificant variables, we will finally get the following amended error model as equation (6) (standard deviations in brackets):

$$Y=-0.017+0.294X_1+0.091X_3-0.997e_{t-1}$$
$$(0.128) \quad (0.064) \quad (0.233)$$
$$R^2=0.79 \qquad DW=1.87 \qquad (6)$$

Parameter estimations of the variables all use their natural logarithm. Equations (4) ,(5)and (6) show that adaptation investments on the water-saving irrigation have the greatest effect on the GDP growth at 0.783.The other two variables have effects on the GDP growth at 0.521 and 0.275, respectively. All that proves water resources always are the critical factor to increasing agricultural GDP in Yutian.Further, populations in rural area of Yutian are growing quickly in recent years. Compared with the increasing demands, the Tarim River has difficulty to fortify the water supply. Thus the capacity of water-saving irrigation contributing the GDP growth is very limited. Due to the grazing prohibition, more young adults can work outside the pasture, which are conducive to the improvement of the Yutan's industrial structure in the long run while it brings some short-term pressure on natural resources. Comprehensive analysis can be found that three variables give the reasonable explanations about the effect on the GDP growth.

2) The factor decomposition

In order to analyze the adaption investments how to impact the GDP growth, Table 3 approximately calculate the contribution rate of the different variables according to equation (5).

TABLE III THE FACTOR DECOMPOSITION (%)

Year	Y1	X1	X2	X3	Other resources
2001	2.2	0.2	0.8	0.0	0.5
2002	1.7	0.1	0.9	0.0	0.4

2003	1.9	0.3	0.9	0.0	0.4
2004	-0.8	0.7	-1.2	0.0	-0.3
2005	1.3	0.3	0.7	0.0	0.3
2001-2005	1.3	0.3	0.4	0.0	0.3
2006	2.9	0.5	1.2	0.1	0.6
2007	3.1	0.6	1.4	0.3	0.2
2008	3.3	0.9	1.5	0.4	0.2
2009	3.1	0.8	1.8	0.5	0.2
2010	2.2	0.8	1.0	0.2	0.1
2006-2010	2.9	0.7	1.4	0.3	0.3
2011	3.9	1.2	1.6	0.3	0.4
2012	4.2	1.3	1.4	0.2	0.4
2001-2012	3.1	0.9	1.2	0.2	0.4

Overall, the annual average growth rate was 3.1% in Yutian from 2001 to 2012. One of the adaption funds to finance the improved varieties contributing to the GDP growth rate about 0.7%, the funds on the water–saving irrigation and the grazing prohibition contributing to the growth rate about 1.2% and 0.2%, respectively.

Table 3 shows that from 2001 to 2005, under the influence of returning farmland into forest and grass projects, there was an obvious fall in the amount of the arable land. During this period, adjustment of the industrial structure through promoting improved varieties had not yet play a role, and the water-saving irrigation facilities in irrigated area are still under construction which can't effectively improve the environment of agricultural production of the Yutian.So the contribution rates of the two variables were very small, well below the average. The catastrophic wind damage and the dry damage in 2004 produced the negative GDP growth, but the contribution rate of the improved varieties is positive, which means the adaption investments on the improved varieties with the characteristics of water saving and drought resistance has been working effectively.

From 2006 to 2010, various adaption investments came into effect and agricultural GDP has 2.9% increasing ratio per year during these years. Contribution rates of improved varieties and water-saving irrigation are 0.7% and 1.4%, respectively. Contribution rate of grazing prohibition is 0.3%, higher than the average. Although there was an extreme drought in 2010, improved varieties and water-saving irrigation still contributed 0.8% and 1.0% to GDP growth, respectively. This fully justifies the adaptation investments having positive impact on GDP growth.

In 2011 and 2012, reduction for labor supply and increase for the breeding expenses have caused contribution rates of improved varieties to run low. The adapta-

tion funds on the improved varieties and water-saving irrigation helped the output values to remain high. Other factor's contribution rate also gradually grew during this period as shown in Table 1.

3.3 VECM, DAG analysis and svar recognition

VECM

Because variables X1, X2, X3, and Y are (I) series, they are applicable to the prerequisites by the cointegration test. According to the unit root test (Tab.2), we determine the appropriate lag length of the VAR model based on the MAIC criterion to do the trace test, which can ascertain whether there are the cointegration relationship between all Non - stationary time series or not（Tab.4）.

TABLE IV JOHANSEN COINTEGRATION TEST

Co -equation	Eig.v	trace test		Corr.trace sample		C (5%)
		T	A. v	Cor.T	A. v	
0	0.72	69.3	0.01	64.06	0.02	47.93
r≦1	0.52	22.4	0.04	20.38	0. 07	29.29
r≦ 2	0.33	8.76	0.12	6.29	0. 13	15.36
r≦3	0.04	0.14	0.47	0.11	0.52	5.22

The test results of the traditional trace test and small-sample correction trace test all show that there exists a cointegration relationship between the four variables at the 5 percent levels of significance. According to results of the equation (5) and the table 4, we can estimate the VECM on the basis of economic theory and analysis of the data (standard deviation in brackets).

$$\begin{vmatrix} \Delta Yt \\ \Delta X1_t \\ \Delta X2_t \\ \Delta X3_t \end{vmatrix} = \begin{vmatrix} -0.394(0.262) & -0.238(0.379) & 0.606(0.433) & -0.105(0.022) \\ -0.257(0.114) & 0.347(0.406) & 0.995(0.320) & -0.213(0.075) \\ 0.563(0.421) & -0.723(0.315) & 3.648(2.479) & 0.842(0.613) \\ 0.374(0.167) & -0.539(0.224) & 2.115(1.306) & -0.536(0.172) \end{vmatrix} \begin{vmatrix} \Delta Y_{t-1} \\ \Delta X1_{t-1} \\ \Delta X2_{t-1} \\ \Delta X3_{t-1} \end{vmatrix}$$

$$+ \begin{vmatrix} -0.777(0.426) \\ -0.103(0.025) \\ -0.836(0.741) \\ -0.095(0.134) \end{vmatrix} vecm_{t-1} + \begin{vmatrix} 0.004(0.002) \\ 0.007(0.031) \\ 0.003(0.217) \\ 0.001(0.121) \end{vmatrix}$$

$$VECM_t = Y - 0.521\ X1 - 0.783\ X2 - 0.275X3 \quad (7)$$

4 Summary and Conclusions

This study is in introducing an alternative method to identifying contemporaneous correlation structure in VAR-type time-series models of the adaption investments. Directed acyclic graph theory is proposed as an alternative modeling approach to supplement current methods of analyzing the effect of adaption policy on agricultural

GDP. The estimated three-variable vector error correction model are based on Yutian data over the period 2001 to 2012 for adaption investments in water-saving irrigation,the grazing prohibition and improved varieties and the agricultural GDP.

The study has also shown that significantly increases the coverage areas of the water-saving irrigation by more sprinkling irrigation and drip irrigation facilities are more directly and efficiently to increase the agricultural GDP. Furthermore, the grazing prohibition can improve the ecological environment which expands meadow stock rising not only, also be agriculturally ecological barrier in Yutan's the grazing prohibition has also been reported as the main contributon factor to the agricultural GDP.

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