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The Effect of Agriculture on the Aggregate Economy in China

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Abstract: **China holds a huge rural population and large-scale agricultural production. Agriculture was a determinant of the economy for a long period. With the fast-expanding economy, the agricultural sector may still lead the national aggregate output. This article mainly aims to examine the role of agriculture in the aggregate economy in China, particularly its short-term dynamics and long-term impacts. Quarterly time series spanned 2002-2016. Data included agricultural output and aggregate GDP in nominal terms. The Phillips-Perron test, the augmented Dickey-Fuller test, the Dickey-Fuller generalised-squared method and the Elliott-Rothenberg-Stock point-optimal test suggested at least two unit roots. The Perron test suggested a unit root. Hence, cointegration rarely existed. GDP and agricultural output in nominal terms embrace a strong long memory. Conventional vector-autoregression and error-correction models could not be constructed. Instead, Toda-Yamamoto Granger causality tests suggest that agricultural output does not Granger cause aggregate GDP and *vice versa*. The empirical results are astonishing. Compared with the period before the 1990s, the role of agriculture in the economy in China has declined dramatically. Fast-expanding industry and real estate sectors might reduce the effect of the agricultural sector on the economy. The study suggests that short quarterly data in nominal terms may affect the results. More supports to the agricultural sector and rural population by the authority at various levels are needed.**

Keywords: **Agriculture, aggregate economy, dynamics, Granger causality, nominal output, quarterly series, unit root.**

I. INTRODUCTION

Agriculture had been China's leading economic forces for many years, particularly prior to 1980. Using annual data for 1949-1989, a research suggests that agriculture and the national economy in China influenced each other [1].

Quick migration of rural people to urban areas over the past two decades have reduced the percentage of population living in rural areas dramatically; however, a huge population still engaged in agriculture [2]. In 2000 and 2016, rural population in China were 808.37 million and 589.73 million, accounting for 60% and 40% of China's total population, respectively (TABLE I). The share of agricultural output in the aggregate economy was about 20% for 2000-2016. Net grain imports increased by 300% for 2000-2016. Agriculture had been a determinant of other sectors; however, non-agricultural sectors showed little impacts on agricultural growth [3]. Huge rural population and large-scale agricultural production may still drive the Chinese economy and vice versa. Statistics may distort the effects between agriculture and the aggregate economy [4]. This paper aims to examine the short-term dynamics and long-term equilibrium between agricultural output and the aggregate output. An understanding of the agricultural sector's role in the economy is implicative for macroeconomic forecasts and the better service offered to agriculture by the government at all levels.

TABLE I: DETAILS OF CHINA'S AGRICULTURE

Items	**2000**	**Share of China's total in 2000 (%)**	**2016**	**Share of China's total in 2016(%)**
Rural population (million)	808.37	60	589.73	40
China's total population (million)	1267.43		1382.71	
Agricultural output (RMB billion)	249.158	20	1120.9126	20
Aggregate GDP (RMB billion)	1002.801		7441.272	

Grain produced (10,000 tons)			61625.05	
Grain imports (10,000 tons)	315.00		2199.00	
Grain exports (10,000 tons)	1378.00		67.00	
Edible oil (10,000 tons)			3629.50	
Cotton (10,000 tons)			529.9452	
Sugar (10,000 tons)			12340.65	

Notes: Sources: National Bureau of Statistics of China [2].

II. METHODOLOGY

A traditional approach to the interaction between the agricultural output (*Agricultureoutput*) and aggregate GDP (*AggregateGDP*) could be formulated as follows:

$$\Delta \log(AggregateGDP_t) = \alpha \Delta \log(Agricultureoutput_t) + u_t \qquad (1)$$

Where variables are in first differences (denoted~Δ) and transformed into logarithms. u_t is the errer term. Using data in this study, OLS regression results are:

$$\Delta \log(AggregateGDP_t) = 1.76 \Delta \log(Agricultureoutput_t) - 0.03 \qquad (2)$$

Where F=216619, R^2=0.99. With a t-Statistic of 147, the estimated α is statistically significant. Agricultural output positively influences aggregate GDP. A 1% growth in agricultural output could result in a 1.76% growth in GDP. Nevertheless, spurious regressions are very likely to arise in Equation (2) because we do not know the integrated order of variables of interest and if they were cointegrated [5-9]. Therefore, procedures dealing with time series and construction of a linear model between these series comprise unit root and cointegration tests. Cointegration and Granger causality analyses could explore the interaction between variables.

Unit root tests used four alternative techniques: the augmented Dickey-Fuller (ADF) test [10, 11], the Dickey-Fuller GLS method [12-16], the Phillips-Perron test (PP) [17, 18] and the Elliott-Rothenberg-Stock (ERS) point-optimal test [14]. These tests each contains preferences and shortcomings [12, 19]. A structural break may provide new evidence for the variable integration [20-23]. We applied the Perron test (Model C) to detect the possible break point [21].

The order of variables decides the construction of either a vector-autoregression model (VAR) in first differences or an error-correction model (ECM). Variables should contain a unit root for these models. Cointegration means an ECM. We can use the Engle-Granger method [9] and the Johansen trace technique to test for cointegration [24-27].

Granger causality implies a leading or forecasting relationships between macroeconomic time-series variables [28-30]. Testing for the causality can be conducted in a VAR or an ECM [31]. However, if variables have un-identical unit roots and are not cointegrated, we cannot construct these models [7, 9]. Instead, an augmented VAR model (AVAR) is recommended. Testing for Granger causality could be done within an AVAR, which may not depend on the unit root and cointegrating properties of variables of interest [32].

III. DATA

GDP was measured in aggregate values onwards from the first quarter (*AggregateGDP*). GDP was at current prices. Data contained the total agricultural output (*Agricultureoutput*). Agricultural output was measured in aggregate values onwards from the first quarter. Data were quarterly time series and spanned 2002 to 2016. The quarterly agricultural output is not available before 2002, which implies the impossibility of examination for the before-2002 period. Data were collected from the National Bureau of Statistics of China [33]. Major details of the data were given in TABLE I. Fig. 1. Plotted the time series variables, which shows that two series were mean nonzero and may contain a trend.

TABLE II: DESCRIPTIVE STATISTICS

Description	Aggregate GDP (values accumulated from Quarter one onwards, RMB 100 million, at current prices)	Agricultural output (statistics accumulated from Quarter one onwards, RMB 100 million, at current prices)
Mean	12.19	9.63
Median	12.22	9.62
Maximum	13.03	10.38
Minimum	11.13	8.84

Std. Dev.	0.60	0.50
Skewness	-0.25	-0.11
Kurtosis	1.70	1.62
Jarque-Bera	4.84	4.85
Probability	0.09	0.09

Notes: Series were seasonally adjusted using the X13 (multiplicative). Data were transformed into logarithms.

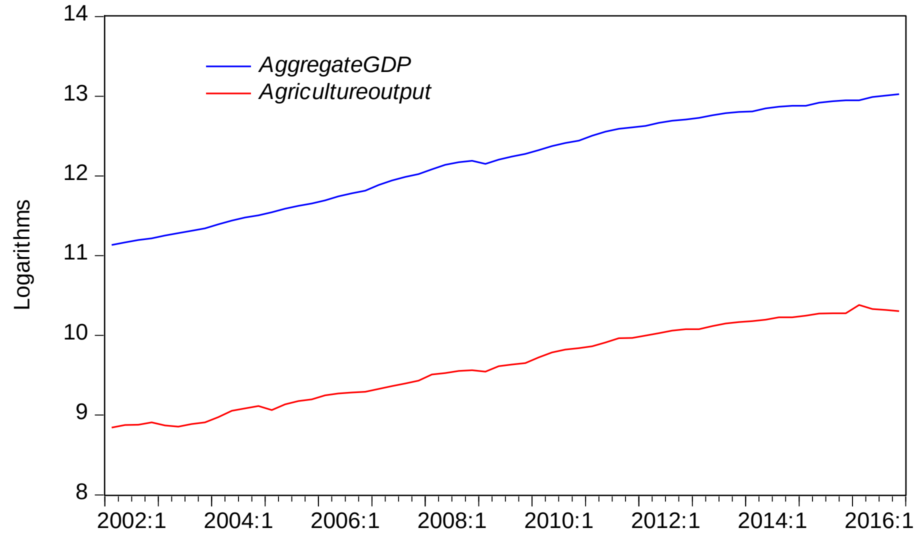

Fig.1: QUARTERLY CHANGES IN AGGREGATE GDP AND AGRICULTURAL OUTPUT IN CHINA

IV. EMPIRICAL RESULTS

For *Agricultureoutput*, the ADF and ERS tests indicated two unit roots (TABLE III); however, the PP test showed one unit root, and the DF-GLS suggested more than two unit roots. The Perron test showed a unit root (TABLE IV). Hence, tests suggest at least two unit roots.

For *AggregateGDP*, the ADF, DF-GLS and ERS tests indicated two unit roots (TABLE II); however, the PP test showed one. The Perron test showed a unit root (TABLE V). Hence, tests suggest that this variable may contain two unit roots.

Cointegration theory shows that these two variables are rarely cointegrated since they both contain at least two unit roots and may have un-identical unit roots. The cointegration tests supply evidence for this argument (TABLE VI, TABLE VII); the Engle-Granger test and the Johansen test consistently indicated no cointegration.

Therefore, we could not construct a conventional first-differenced VAR or an ECM. Instead, this study estimated an alternative augmented Toda-Yamamoto VAR, within which Granger causality tests were performed (TABLE VIII, TABLE IX). Chi-square statistics for no Granger causality were accepted at the 5% level.

TABLE III: ALTERNATIVE TESTS FOR VARIABLE INTEGRATION

Variable	**Method**	***k***	**Level**	***k***	**First difference**	***k***	**Second difference**
Agricultureoutput	ADF	0	-1.13	7	-2.60	6	-6.29***
	DF-GLS	8	-1.56	7	-2.22	10	-1.39
	PP	0	-1.13	2	-7.53***		
	ERS	0	15.42	10	276.4	0	4.35**
AggregateGDP	ADF	4	-0.37	3	-2.89	10	-5.06***
	DF-GLS	4	-1.29	3	-2.63	10	-3.41**
	PP	1	0.49	3	-6.19***		
	ERS	0	77.93	0	3.28	0	3.64**

Notes: For ADF and DF-GLS tests, lags *k* were decided by *t*-statistics. For ERS tests, *k* was selected using the modified AIC [12]. For PP tests, *k* was decided using the Newey-West technique [34]. Test equations contained the trend and intercept as Fig. 1. showed [35]. **, ***Rejection of a unit root at the 5% and 1% levels, respectively.

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TABLE IV: THE STRUCTURAL BREAK TEST FOR *AGRICULTUREOUTPUT* (PERRON MODEL C)

Log variable	**Parameter & variable**	**Coefficient**	**Std. Error**	***t*-Statistic**	***P*-value**
Agricultureoutput	θ	0.39	0.12	3.29	0.00
	β	0.02	0.01	2.13	0.04
	γ	-0.01	0.00	-3.53	0.00
	δ	-0.02	0.03	-0.58	0.57
	α	0.42	0.28	1.51	0.14
	Δ, t-1	0.03	0.25	0.14	0.89
	Δ, t-2	-0.06	0.22	-0.28	0.78
	Δ, t-3	-0.03	0.17	-0.18	0.85
	Δ, t-4	-0.20	0.18	-1.12	0.27
	Δ, t-5	-0.17	0.16	-1.09	0.28
	Δ, t-6	-0.28	0.15	-1.83	0.07
	Intercept	5.04	2.43	2.08	0.04
	R-squared	1.00	Mean dependent var	9.73	
	Adjusted *R*-squared	1.00	S.D. dependent var	0.44	
	S.E. of regression	0.02	Akaike info criterion	-4.35	
	Sum squared resid	0.03	Schwarz criterion	-3.90	
	Log likelihood	127.20	Hannan-Quinn criter.	-4.18	
	F-statistic	1482.18	Durbin-Watson stat	2.01	
	Prob(*F*-statistic)	0.00			

Notes: Parameters were the same as Perron [21]. Δ indicated the first difference. t-1, t-2, ..., t-*k* were lagged terms where *k* was set between 2 and 12 and selected using the method suggested by Ng and Perron [13]. Trimming fraction was 0.30.

TABLE V: THE STRUCTURAL BREAK TEST FOR *AGGREGATEGDP* (PERRON MODEL C)

Log variable	**Parameter & variable**	**Coefficient**	**Std. Error**	***t*-Statistic**	***P*-value**
AggregateGDP	θ	0.35	0.14	2.48	0.02
	β	0.02	0.01	2.49	0.02
	γ	-0.01	0.00	-2.60	0.01
	δ	-0.01	0.02	-0.62	0.54
	α	0.46	0.21	2.21	0.04
	Δ, t-1	0.38	0.22	1.73	0.10
	Δ, t-2	0.27	0.22	1.25	0.22
	Δ, t-3	0.15	0.21	0.70	0.49
	Δ, t-4	0.48	0.20	2.38	0.02
	Δ, t-5	0.18	0.21	0.86	0.40
	Δ, t-6	0.11	0.18	0.61	0.55
	Δ, t-7	0.10	0.18	0.56	0.58
	Δ, t-8	-0.06	0.17	-0.32	0.75
	Δ, t-9	0.13	0.17	0.75	0.46
	Δ, t-10	-0.03	0.16	-0.17	0.87
	Δ, t-11	0.01	0.17	0.08	0.93
	Δ, t-12	0.55	0.17	3.26	0.00
	Intercept	5.85	2.27	2.58	0.02
	R-squared	1.00	Mean dependent var		12.42
	Adjusted *R*-squared	1.00	S.D. dependent var		0.44
	S.E. of regression	0.02	Akaike info criterion		-5.19
	Sum squared resid	0.01	Schwarz criterion		-4.48
	Log likelihood	140.02	Hannan-Quinn criter.		-4.93
	F-statistic	2139.41	Durbin-Watson stat		2.08
	Prob(*F*-statistic)	0.00			

TABLE VI: THE ENGLE-GRANGER COINTEGRATION TEST

Log dependent variable	***z****	***P*-value****
AggregateGDP	-16.06	0.12
Agricultureoutput	-15.24	0.14

Notes: *indicated the test statistic. Lags were chosen using the modified AIC. **MacKinnon's (1996) *P*-values [36]. Test equations included the constant and linear trend.

TABLE VII: THE JOHANSEN COINTEGRATION TEST

r	*k*	Eigenvalue	Trace	O-L*	C&L**	Reinsel-Ahn***
0	2	0.23	21.00	25.87	27.53	18.90
≤1		0.10	6.22	12.52	13.32	5.60
0	3	0.23	23.97	25.87	28.45	20.37
≤1		0.16	9.61	12.52	13.76	8.17
0	4	0.15	15.54	25.87	29.43	12.43
≤1		0.11	6.42	12.52	14.24	5.14
0	5	0.13	13.53	25.87	30.50	10.15
≤1		0.10	5.86	12.52	14.76	4.40
0	6	0.19	16.86	25.87	31.65	11.80
≤1		0.10	5.70	12.52	15.31	3.99

Notes: *Osterwald-Lenum 5% critical values [37]. **Cheung-Lai 5% finite-sample critical values 5% [38]. ***Reinsel-Ahn finite-sample trace corrections [39].

TABLE VIII: GRANGER CAUSALITY TESTS USING THE TODA-YAMAMOTO METHOD (1)

Log independent variable*	Coefficient	Std. Error	*t*-Statistic	*P*-value	Chi-square(df)**
$AggregateGDP_{t-1}$	0.09	0.09	0.91	0.37	
$AggregateGDP_{t-2}$	-0.16	0.11	-1.43	0.16	
$AggregateGDP_{t-3}$	0.11	0.12	0.94	0.35	
$AggregateGDP_{t-4}$	-0.15	0.10	-1.44	0.16	
$Agricultureoutput_{t-1}$	1.11	0.15	7.43	0.00	
$Agricultureoutput_{t-2}$	-0.24	0.22	-1.07	0.29	2.09(2)***
$Agricultureoutput_{t-3}$	0.08	0.22	0.39	0.70	
$Agricultureoutput_{t-4}$	0.10	0.17	0.63	0.53	
Trend	0.00	0.00	0.30	0.77	
intercept	0.32	0.54	0.58	0.56	
R-squared	1.00	Mean dependent var	12.26		
Adjusted *R*-squared	1.00	S.D. dependent var	0.56		
S.E. of regression	0.02	Akaike info criterion	-5.13		
Sum squared resid	0.01	Schwarz criterion	-4.77		
Log likelihood	153.70	Hannan-Quinn criter.	-4.99		
F-statistic	6408.78	Durbin-Watson stat	1.99		
Prob(*F*-statistic)	0.00				

Notes: *Dependent variable was *AggregateGDP*. Lags *k* (=2) of the augmented VAR (*k*+*d*) model were decided by AIC, where *d* was the possible order of variable integration, suggested by unit root tests. *k* were set between 2 and 12 following Ng and Perron [12]. This table tested for no Granger causality from *Agricultureoutput* to *AggregateGDP*. **df: degree of freedom. ***Chi-square was estimated for the hypothesis of lagged terms $Agricultureoutput_{t-1}$ and $Agricultureoutput_{t-2}$ equalled to zero at the same time.

TABLE IX: GRANGER CAUSALITY TESTS USING THE TODA-YAMAMOTO METHOD (2)

Log independent variable*	Coefficient	Std. Error	*t*-Statistic	*P*-value	Chi-square(df)**
$Agricultureoutput_{t-1}$	0.49	0.26	1.90	0.08	
$Agricultureoutput_{t-2}$	-0.33	0.25	-1.33	0.20	
$Agricultureoutput_{t-3}$	0.01	0.23	0.04	0.97	
$Agricultureoutput_{t-4}$	0.22	0.31	0.71	0.49	
$Agricultureoutput_{t-5}$	0.18	0.34	0.53	0.60	
$Agricultureoutput_{t-6}$	-0.18	0.29	-0.62	0.54	
$Agricultureoutput_{t-7}$	0.34	0.30	1.14	0.27	
$Agricultureoutput_{t-8}$	0.03	0.30	0.10	0.92	
$Agricultureoutput_{t-9}$	-0.04	0.30	-0.12	0.90	
$Agricultureoutput_{t-10}$	-0.07	0.29	-0.24	0.82	

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$Agricultureoutput_{t-11}$	0.09	0.27	0.33	0.74	
$Agricultureoutput_{t-12}$	-0.68	0.28	-2.45	0.03	
$Agricultureoutput_{t-13}$	0.51	0.32	1.60	0.13	
$Agricultureoutput_{t-14}$	-0.19	0.28	-0.69	0.50	
$AggregateGDP_{t-1}$	0.25	0.33	0.75	0.46	
$AggregateGDP_{t-2}$	-0.11	0.42	-0.26	0.80	
$AggregateGDP_{t-3}$	0.68	0.39	1.73	0.10	
$AggregateGDP_{t-4}$	-0.82	0.48	-1.72	0.10	
$AggregateGDP_{t-5}$	0.28	0.57	0.49	0.63	
$AggregateGDP_{t-6}$	-0.11	0.48	-0.22	0.83	
$AggregateGDP_{t-7}$	-0.17	0.45	-0.37	0.71	
$AggregateGDP_{t-8}$	-0.11	0.45	-0.24	0.81	
$AggregateGDP_{t-9}$	0.64	0.45	1.43	0.17	
$AggregateGDP_{t-10}$	-0.78	0.46	-1.69	0.11	
$AggregateGDP_{t-11}$	0.83	0.48	1.74	0.10	
$AggregateGDP_{t-12}$	0.13	0.48	0.28	0.78	18.31(12)***
$AggregateGDP_{t-13}$	-0.31	0.48	-0.65	0.53	
$AggregateGDP_{t-14}$	0.22	0.36	0.60	0.55	
Trend	-0.01	0.01	-0.63	0.54	
intercept	-1.61	2.54	-0.63	0.54	
R-squared	1.00	Mean dependent var	9.83		
Adjusted *R*-squared	1.00	S.D. dependent var	0.38		
S.E. of regression	0.02	Akaike info criterion	-4.37		
Sum squared resid	0.01	Schwarz criterion	-3.18		
Log likelihood	130.53	Hannan-Quinn criter.	-3.92		
F-statistic	380.65	Durbin-Watson stat	2.02		
Prob(*F*-statistic)	0.00				

Notes: *Dependent variable was *Agricultureoutput*. Lags k (=12) of the augmented VAR (k+d) model were decided by AIC, where d was the possible order of variable integration, suggested by unit root tests. k were set between 2 and 12 following Ng and Perron [12]. This table tested for no Granger causality from *AggregateGDP* to *Agricultureoutput*. **df: degree of freedom. ***Chi-square was estimated for the hypothesis of lagged terms $AggregateGDP_{t-1}$, $AggregateGDP_{t-2}$,..., $AggregateGDP_{t-12}$ equalled to zero at the same time.

V. CONCLUSION

Rural population is still huge. Agriculture contributes about 20 percent to the aggregate GDP in China. Correlation between quarterly agricultural output and aggregate GDP in China was high. Past studies that used annual data indicated the positive effect of agricultural production on the economy or other sectors. However, over the past two decades, China's industrial and real estate sectors have expanded quickly. Shares of these sectors' output in GDP have increased substantially. Previous evidence supports a rising effect between industry, real estate and the economy [40, 41]. In addition, analyses on quarterly data were rare. It is worthwhile that we further examine the effects between agriculture and the economy.

This study used quarterly data for the period from 2002 to 2016. Cumulative agricultural output and aggregate GDP were in nominal terms. Four alternative unit root tests (the ADF, DF-GLS, PP and ERS tests) were performed. Also, the Perron break-date test was conducted. We suggest at least two unit roots in the variables. Hence, the variables have hardly moved together in the long term. We could not construct a vector-autoregression or error-correction model between the time series variables.

Granger causality was applied to examining the short-term effect. The study constructed an augmented Toda-Yamamoto VAR model, within which Granger causality tests were conducted. Major findings are that agricultural output and aggregate GDP during 2002-2016 did not influence each other either in the long run or in the short run. These findings are a little astonishing. I propose that agriculture provides a solid foundation for other sectors (e.g. [3]) that are driving the economy. Short quarterly data and statistical problems possibly existing in GDP and the composition of GDP [4] might affect the analysis.

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