Revisit Keynesian versus Wagner using Continuous Wavelet Analysis in China

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Abstract

We use government expenditure and GDP from China to revisit Keynesian versus Wagner hypothesis during the period of 1992Q2 to 2017Q2. Results from continuous wavelet tool demonstrate strong co-movements between government expenditure and GDP during 1992-1996, 2004-2007 and 2012-2017 time periods, support Keynesian view during 1997-2002 and Wagner view during 2008-2010 in 1-4 year frequency band (short-term). Our empirical results also find strong co-movements between government expenditure and GDP for most of the time during 1992-2017 in 4-8 year frequency band (long-run), except for 2005-2007 support Wagner view. In addition, for comparison purpose, we also apply time series VAR model to test the hypothesis. Empirical results from VAR model supporting Wagner hypothesis during the whole sample periods. Our empirical results have important policy implications in China to maintain its economic development.

Keywords: Keynesian; Wagner; Wavelet Analysis; VAR Model; Grange Causality Test

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1. Introduction

Over the past decades, owing to continuing increasing budget deficits have caused many studies devoted towards exploring the relationship between government expenditures and output (see, i.e., Chang, 2002; Chang *et al.,* 2004; Narayan *et al.,* 2008; Tang, 2008; Kesavarajah, 2012; Narayn *et al.,* 2012; Magazzino, 2012; Antonis *et al*., 2013; Mutascu, 2017; Chang and Chang, 2017 and Dai *et al.* 2017).

In previous literature there are two views and schools of thought regarding the relationship between government expenditures and output. Based on previous literature, the first one who becomes well-known in fiscal theory is Wagner law, which postulates that as the economic activity grows there is a tendency for government activities to increase. The second school of thought is Keynesian hypothesis. The Keynesian view (Keynes, 1936) hypothesized that the public expenditure is an exogenous factor that can be used as a policy variable, and which can impact upon growth and development in the short-run. Wagner's law and Keynesian hypothesis have been tested empirically for various countries using both time series and cross-sectional data sets. Empirical tests of this law have yielded results that differ considerably from country to country (Chang, 2002; Chang *et al.,* 2004; Chang and Chang, 2017 and Dai *et al.,* 2017).[1]

While previous studies largely focus on traditional Granger causality test to investigate its relationship in developing countries as well as the United States, there have been a few studies address the causal relationship between government expenditure and output in China. Though they did have some studies in Chinese case but compared to the number of studies of other developing countries it is still rare for

[1] Keynesian holds government activity stimulates growth while Wagner law holds the hypothesis that government expenditure increases more than proportionally with economic activity.

China. For example, Atasoy and Gur (2016) test Wagner hypothesis in China over the period 1982-2011 through static and dynamic analyses. Empirical results from this study indicate that Wagner hypothesis did hold in China over the period of 1982-2011. On the other hand, empirical results from Sinha (1998), Huang (2006), Zheng et al. (2010) and Wu and Lin (2012) did not support Wagner hypothesis in China.[2]

The aim of our study is to revisit the causal relationship that potentially exists between government expenditures and output in China over the period of 1992Q2-2017Q2, using continuous Wavelet analysis. Our study is done by highlighting how the relationship between variables varies across different frequencies over time. This analysis can generate short-, medium and long-run frameworks regarding Chinese fiscal policy. The use of the wavelet tool is superior to traditional tools because it allows us to determine how the series interact at different frequencies and how they evolve over time. The method allows us to identify both the causality and sign of correlation between government expenditure and GDP in China. We believe this is the first study using continuous Wavelet analysis to investigate causal link between GDP and government expenditure in China. We hope our study can bridge the gap of current literature.

China provides an interesting arena to research for several reasons. First China has some typical features of economic growth and has made remarkable economic progress over the last few decades with an annual average economic growth rate of 7-9% in the past two decades (1990 - 2015). Second, China's economy has become the second largest only next to the USA around the world since 2015. The overall economics in China in terms of total GDP will be sooner or later over pass that of the United States. Third, Mainland China has become the world's eleventh largest trading

[2] None of previous studies in this issue using Wavelet analysis. We hope that our study can make some contributions to the current literature.

country with a foreign exchange reserve estimated at US$ 3.12 trillion at the end of 2016. Fourth, Mainland China started its open policy in the late 1970s, thus sufficient data are available for researchers to evaluate the effect of economic liberalization on economic phenomena.

The remainder of this paper is organized as follows. Section 2 presents the data used. Section 3 describes the methodology used and the empirical findings and some policy implication are presented at Section 4. Finally, Section 5 concludes.

2. Data

We apply quarterly data covering the period from 1992Q1 to 2017Q2 for China. The variables used in this study include the Gross Domestic Product (*GDP*) and Government Expenditure (*GE)*. GDP and GE are retrieved from National Bureau of Statistics of China. We first take out the seasonal effect and then transform all data into natural logarithms before we conduct our test. We report the summary statistics for our data series in Table 1 and plot these two data series in Figure 1. From Table 1 and Figure 1 that we can see two data series show upward trending and Jarque-Bera also indicates that GDP and GE are non-normally distributed.

3. Methodology and Empirical Results

3.1. Results from the Unit Root Test

As we know that Wavelet analysis does not require the restrictive assumption that all series are $I(0)$ time series. Aguiar-Conraria *et al.,* (2008) also argue that the wavelet transformation is used 'to quantify the degree of linear relation between two non-stationary time series in the time–frequency domain'. Therefore, we need to first go for several conventional unit root tests such as the ADF, PP (Phillips and Perron, 1988), and KPSS (Kwiatkowski *et al,* 1992). Table 2 reports the results from several conventional unit root tests which all suggest that these two variables employed are all non-stationary in levels, while they turn stationary in first differences. Due to structural breaks occurred in our data series, we also incorporate Narayn and Popp (2010) Unit Root Test with Structural Breaks (2010) into our study. Results from Narayn and Popp (2010) Unit Root Test also demonstrate both GDP and GE are non-stationary after considering structural breaks. As a consequence, based on the wavelet tool requirements, the variables are considered to be non-stationary series.

3.2. Wavelet Analysis

This paper implements the continuous wavelet transform method to study the relationship between government expenditure and output in China[3]. We use a wavelet coherency to capture the correlation between the two series, and a phase difference to observe the causality between them.

First we define the wavelet power spectrum as $|W_x(\tau,s)|$ that measures the localized variance (volatility) of $x(t)$ through time and frequency. Because the wavelet is not completely localized in time, the continuous wavelet transform has edge artifacts. The cone of influence (COI) is an area where a discontinuity causes wavelet power drops at the edge (Tiwari *et al.*, 2015). The cross-wavelet power spectrum is given by:

$$\left|W_{xy}(\tau,s)\right|^2 = \left|W_x(\tau,s)\right|^2 \left|\bar{W}_y(\tau,s)\right|^2 \qquad (1)$$

where $W_x(\tau,s)$ and $W_y(\tau,s)$ are the wavelet transform of $x(t)$ and $y(t)$, respectively, $\bar{W}_y(\tau,s)$ indicates the complex conjugation.

3.3. Wavelet coherency and phase difference

Co-movement between two series over time and across frequencies can be measured using wavelet coherency of Torrence and Webster (1999) and the squared wavelet coherence coefficient is:

[3] Details about Wavelet transform interest readers please refer to Aguiar-Conraria *et al* (2008) and Qing and Chang (2017).

$$R_{xy}^2(\tau,s)=\frac{\left|S(s^{-1}W_{xy}(\tau,s)\right|^2}{S(s^{-1}\left|W_x(\tau,s)^2\right|\bullet S(s^{-1}\left|W_y(\tau,s)\right|^2} \quad (2)$$

with a smoothing operator S (Aguiar-Conraria *et al.*, 2008). In this way, wavelet coherence is between 0 and 1 in a time-frequency window. Zero coherency means no co-movement, while a higher coherency means stronger co-movement between series.

Wavelet phase differences can capture negative and positive correlations and the lead-lag relationship between two series in the time-frequency domain. Torrence and Webster (1999) give the wavelet phase difference as follows:

$$\varphi_{xy}=\tan^{-1}\left(\frac{\Gamma\left\{S\left(s^{-1}W_{xy}(\tau,s)\right)\right\}}{R\left(S(s^{-1}W_{xy}(\tau,s))\right\}}\right), with \quad (3)$$
$$\varphi_{xy}\in\left[-\pi,\pi\right]$$

where Γ and R are the imaginary and real parts of the smoothed cross-wavelet transform, respectively. If φ_{xy} is zero, the two series move together, and if it is $\pi (or -\pi)$, they move in the opposite direction. If $\varphi_{xy}\in(0,\pi/2)$, they positively co-move and x leads y; if $\varphi_{xy}\in(\pi/2,\pi)$, they negatively co-move and y leads x; if $\varphi_{xy}\in(-\pi,-\pi/2)$, they negatively co-move and x leads y; if $\varphi_{xy}\in(-\pi/2,0)$, they positively co-move and y leads x.

3.4. Results from Wavelet Analysis

Figure 2 (a.1) shows wavelet coherency and (a.2)-(a.3) show phase differences between government expenditure (GE) and GDP. From the wavelet coherency plot, we observe positive and strong co-movement between these two series during 1992-1996, 2004-2007 and 2012-2017 (at 1-4 year frequency band). The co-movement varies at different frequencies and is quite stable during that sample periods. More specifically, during these sample periods, we observe the average coherency between the two series at the 1-4 year frequency band, which means they have strong co-movement, and the phase difference is between $-\pi/2$ and $\pi/2$, which indicates a positive relationship. After 1997, co-movements become lead-lag relationship from government expenditure to GDP at the 1-4 year frequency band during 1997-2002 and from GDP to government expenditure during 2008-2010, when the 1997 Asian financial crisis leads to economy instability, and government in China has to initiate expansionary policy to fight for this slump economy. During 1992-2005, we find a high coherency at the 4-8 year frequency band, implying that the two series have a significant and positive co-movement. However, during 2005-2007 that we find this relationship becomes led-lag relationship running from GDP to government expenditure across the 4-8 year frequency band. After 2007 again we see find a high coherency and a positive relationship at the 4-8 year frequency band, which means these two series have steady equilibrium in the long run after 2007. These findings prove the existence of a varying relationship between government expenditure and GDP in China. Figure 2 also shows causality between the two series. In the 1-4 year frequency band, phase differences are close to zero during 1997-2002 and 2004-2007, this means government expenditure and GDP move synchronously during these two time period in the short-run. However, in 4-8 year frequency band, phase differences are close to zero for most of the time period, which demonstrates government expenditure and GDP move quite synchronously in the long-run for most of the time. We summarize the lag-lead relationship between the two series, with and without the control variable, in Table 4. Our empirical results have important policy implications for the government in China to conduct fiscal policy to maintain its sustainable growth.

< Insert Figure 2 a(1), a(2), a(3) about here> and < Insert Table 4 about here>

3.5. Results from VAR Time Series Model

For comparison purpose, we also go for several time series analysis. Because we find both GDP and GE are I(1) processes (from Tables 2 and 3), therefore we go cointegration test. Based on Schwartz Criteria (SC) that we find the optimal lag length is 6 for our VAR model. Therefore cointegration test is based on VAR(6) and cointegration test results are reported in Table 4. From Table 4 that we find both trace and lamda (λ) tests reject cointegration between GDP and government expenditure during this time period. Therefore we go for traditional Granger causality based on VAR in difference model. Empirical results from VAR Granger causality test indicate one-way Granger causality running from GDP to government expenditure. This result indicates supporting Wagner hypothesis for China during 1992Q2-2017Q2. This result further confirms the finding of our Wavelet analysis. Apparently our empirical results from both Wavelet analysis and traditional VAR model are consistent with that fund in Atasoy and Gur (2016) support Wagner hypothesis in China but not consistent with those fund in Singh (1998), Huang (2006), Zheng et al. (2010), and Wu and Lin (2012), they don't support Wagner' law in China.

< Insert Tables 5 and 6 about here>

4. Economic and Policy Implications

In sum our empirical findings support feedback hypothesis between government expenditure and GDP during 1992-1996, 2004-2007 and 2012-2017 three time periods, support Keynesian view during 1997-2002 and Wagner view during 2008-2010 in 1-4 year frequency band (short-term). Our empirical findings also show evidence in support feedback hypothesis for most of the time during 1992-2017 in 4-8 year frequency band (long-run), except for 2005-2007 support Wagner view. Apparently that our empirical findings show the relationship between government expenditure and GDP is more Wagnerian (2005-2007 at 4-8 year frequency band and 2008-2010 at 1-4 year frequency band) than Keynesian (1997-2002 at 1-4 year frequency band) While most of the time either in 1-4 year frequency band or 4-8 year frequency band we find strong co-movement between government expenditure and GDP. Results from time series VAR model further confirm this finding – support Wagner hypothesis in China. If we observe economic growth in China over the past two decades we can find this successful economic growth was being accompanied by a growth in the role of government activity, our empirical results seems to be consistent with this observation in China. The detection of Wagner's hypothesis from our study could be justified by the increased needs of a newly formed State to build the necessary mechanisms (institutions) in order to control and organize effectively its functions. The same needs, someone may argue, are still present and have to be considered in the restructuring of the Chinese government to overcome from the current slow growth conditions.

5. Conclusion

We use government expenditure and GDP from China to revisit Keynesian versus Wagner hypothesis during the period of 1992Q2 to 2017Q2. Results from our continuous Wavelet tools demonstrate strong co-movements between government expenditure and GDP during 1992-1996, 2004-2007 and 2012-2017 time periods, support Keynesian view during 1997-2002 and Wagner view during 2008-2010 in 1-4 year frequency band (short-term). Our empirical results also find strong co-movements between government expenditure and GDP for most of the time during 1992-2017 in 4-8 year frequency band (long-run), except for 2005-2007 support Wagner view. On the other hand, results from time series VAR model further confirm this finding – support Wagner hypothesis in China Our empirical results have important policy implications in China to maintain its economic development.

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Table 1: Data Description (1992Q1-2017Q2)

Variable	Mean	Median	Maximum	Minimum	Skewness	Kurtosis	Jarque-Bera (P-value)
GDP	68376.45	41154.75	211281.3	5262.8	0.84367	2.3544	13.871**
GE	14875.38	7250.39	57566.27	568.45	1.1053	2.9616	20.777**

***** ,**and * indicate significance at the 1% ,5%, 10% levels, respectively.**

Table 2: Univariate Unit Root Tests.

	Level			First differences		
	ADF	**PP**	**KPSS**	**ADF**	**PP**	**KPSS**
GDP	-0.9414 [5]	-2.4714(9)	1.2386(8)***	-2.5108[5]	-9.945***(9)	0.345(9)
GE	-1.7679[4]	-0.7738(11)	1.2396(8)***	-8.7436 [3] ***	-28.063(10) ***	0.1087(11)

Notes: *, ** and * indicate the null hypothesis is rejected at the 1%, 5% and 10% levels, respectively. The number in brackets indicates the lag order selected based on Schwarz information criterion. The number in the parenthesis indicates the truncation for the Bartlett Kernel, as suggested by the Newey-West test (1987).**

Table 3. Narayn and Popp (2010) Unit Root Test with two Structural Breaks

Countries					
	K	TB1	TB2	Test	Statistics
GE	4	1999Q4	2007Q3	I(1)	-2.019
GDP	4	2007Q1	2008Q2	I(1)	-2.334

Note:
1. The sample period is from 1992Q2 to 2017Q2.
2. We set a maximum lag 8 and the optimum k is selected based on SBC.
3 * indicates significance at the 0.1 level.

Table 4. Summary of lead-lag relationship between GDP and Government Expenditure

	Period and lead-leg relationship between GDP and GE			
Short run (1-4 year)	1992-1996 Synchronously	1997-2002 Keynesian	2004-2007 Synchronously	2008-2010 Wagner after 2012-2017
Long run (4-8 year)	1992-2005 Synchronously	2005-2007 Wagner	2007-2017 Synchronously	Synchronously

Note: GDP and GE represent the GDP and Government expenditure, respectively.

Table 5. Johansen cointegration test with unrestricted intercepts and no trends

Series	Null Hypothesis	Alternative Hypothesis	Trace Test	95% critical value	90% critical value
LGDP and LGE	$r = 0$	$r \geq 1$	11.461	15.494	13.75
	$r \leq 1$	$r = 2$	1.424	3.8414	2.918
	Null Hypothesis	Alternative Hypothesis	Maximum Eigen Value test	95% critical value	90% critical Value
	$r = 0$	$r = 1$	10.037	14.265	12.98
	$r \leq 1$	$r = 2$	1.424	3.8414	2.918

Note: Both the maximum and trace eigenvalue statistics strongly reject the null hypothesis that there is no cointegration between LGDP and LGE (r=0), do not reject the hypothesis that there is one cointegration relation between these variables (r=1). ** indicates significance at 5% level. Based on SC, the lag length for our VAR model is 6.

Table 6. Full-Sample Granger Causality Tests

	H0: ΔLGDP does not Granger cause ΔLGE		H0: ΔLGE does not Granger cause ΔLGDP	
	Statistics	P value	Statistics	P value

	2.6912**	0.0262	0.1291	0.9854

Note: ** indicates significance at the 5% level.

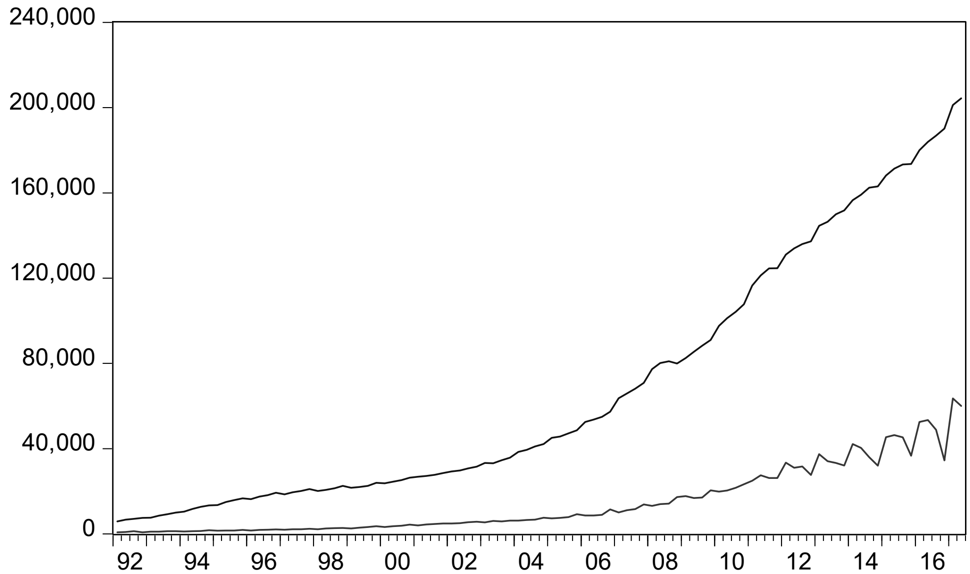

Figure 1. Plot Government Expenditure and GDP in China

GDPSA GESA

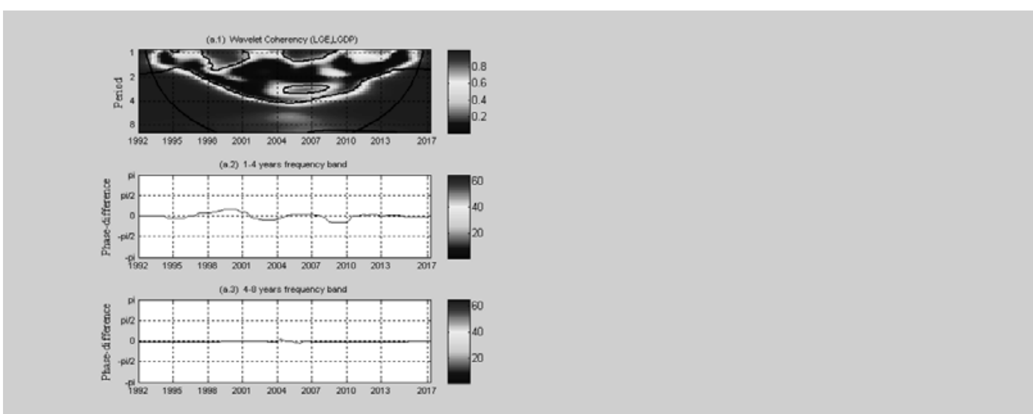

Figure 2. Wavelet Analysis for GDP and Government Expenditure in China