

4.

THE COMOVEMENT BETWEEN MONEY AND ECONOMIC GROWTH IN 15 ASIA-PACIFIC COUNTRIES: WAVELET COHERENCY ANALYSIS IN TIME-FREQUENCY DOMAIN

Su-Ling TSAI¹
Tsangyao CHANG²

Abstract

The paper applies framework of the Wavelet-based measure of comovement from the Wavelet coherency analysis in Aguiar-Conraria and Soares (2011) to examine the comovement phenomenon and the causality of a lead-lag relationship between economic growth and money in 15 Asia-Pacific countries over about three decades. This is the first study to apply wavelet analysis in studying money and GDP lead-lag links in the Asia-Pacific countries. The main advantage of the wavelet approach is the ability to analyze transient dynamics between two time series across different frequencies or time scales. 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 our research variables. Therefore, through wavelet coherency and phase-difference analysis, this paper is the first study to identify certain period causality relationship of finance-growth, the lead-lag effect in 15 Asia-Pacific countries. In addition, our study has verified that monetary neutrality did support in some Asia-Pacific countries (i.e., Australia, Malaysia, Philippines, and South Korea). However, monetary policy did work in most of Asia-Pacific countries. The empirical results have important policy implications for these 15 Asia-Pacific countries conducting monetary policy to boot up its economy.

Keywords: money, economic growth, comovement, time domain, frequency domain, wavelet coherency analysis, phase difference

JEL Classification: F20, F40

¹ Department of International Trade, Shih Chien University at Kaohsiung, Taiwan. Email: t2746112@gmail.com.

² Corresponding author. Department of Finance, College of Finance, Feng Chia University, Taichung, Taiwan and CTBC Business School, Business Administration, Tainan, Taiwan. Email: tychang@mail.fcu.edu.tw.

1. Introduction

The relationship between financial development and economic growth is one of the core issues within the macroeconomic field. For a long time, several scholars have conducted deep and systematic theory research studies on this issue. Keynes (1936) proposed the thought of monetary non-neutrality, which states that currency supply influences both price and output through the interest rate and investment variables ($Y \leftarrow P \leftarrow I \leftarrow R \leftarrow M$). Based on wage stickiness and sticky price, the New-Keynes school's viewpoint of monetary non-neutrality in the short run, but neutrality in the long run, offers a micro-theory explanation for Keynes's macroeconomic theory. Compared with the Keynes's statement that monetary has a non-neutrality nature, the Chicago school of economics argues that monetary policy is invalid, and so the two viewpoints are in intense contrast.

Additionally, Freeman and Huffman (1991) and Freeman and Kydland (2000) pointed out that the positive correlation meant there was a monetary-multiplier effect of deposits, presenting the causality relationship in which money led output. And, Oi *et al.* (2004) used the structural VAR model to comprehensively investigate long-run monetary neutrality in Japan from the Period 1868-1912. The empirical results indicate little evidence against the long-run neutrality of money with respect to real GNP. Despite the great deal of academic research and discussion, the comovement between growth-money is not straightforward and empirical studies often produce contradictory findings. Traditionally, comovement has been assessed through the well-known correlation coefficient (Gruble and Fadner, 1971), and Johansen co-integration (Demetriades *et al.*, 1996). But Bollerslev *et al.* (1992) noted that if comovement involved change in time, then it was inappropriate to simply calculate the correlation coefficient, as it might omit the time-varying message in the conditional correlation coefficient. Besides, even with sweeping application in studies, the causal relationship between growth-money is also not explicitly, and empirical studies often produce inconsistent findings, no matter if using the Auto-regression VAR model (Eichenbaum and Singleton, 1986), the structural VAR (Oi *et al.*, 2004), the VECM approach (Masih *et al.*, 1996; Demetriades *et al.*, 1996), or frequency domain test (Croux *et al.*, 2001). For instance, Vymyatnina (2006) used the causality test proposed by Granger and Sims and provided an indirect inquiry on the transmission mechanism of monetary policy in Russia for the period of 1995-2004 by looking at the nature of money supply. The findings supported endogenous nature of money supply. Rousseau and Vuthipadadorn (2005) used multi-vector autoregressive models (multi-VAR) to investigate finance, investment, and growth from 10 Asian economies over the 1950-2000. The measure of financial development included M1, M2-M1, and credit allocated to the private sector. The results indicated that evidence of a role for financial factors in output was weaker. Masih *et al.* (1996) took Johansen's test for multiple co-integration analysis, vectors error-correction model (VECM), to capture the relationships between money-growth. They obtained the result that output predominantly led money supply during 1955-1991 for Indonesia. Abu-Bader and Abu-Qarn (2008) examined the causal relationship between M2/GDP ratio and economic growth in Egypt during the period 1960-2001 by using co-integration and vector error-correction method (VECM). Their finding showed an insignificant relationship between M2/GDP and economic growth.³

³ In fact, there are two hypothesis regarding the led-lag relationship between money/GDP (financial development) and GDP. Supply-leading hypothesis points out that financial development is a necessary condition for achieving a high rate of economic growth. The other hypothesis (demand-following hypothesis) is a distinctly opposite view. The demand-following

Additionally, the full-sample causality tests with assumptions of parameter constancy and a single causal relationship across the whole sample period are no longer reliable (Zeileis *et al.*, 2005). Balcilar *et al.* (2010) and Balcilar and Ozdemir (2013) pointed out the two time series may suffer from inaccurate results when the underlying full-sample time series have structure change.

Overall, in the above views, the obtained conclusions could not completely reflect the dynamic relationships between economic growth and money ([GDP, MONEY], hereafter). Therefore, to gain more insight, this literature applies the time-frequency wavelet-based measure of co-movement and wavelet coherency analysis to study the relationship of [GDP, MONEY] in 15 Asia-Pacific countries. The wavelet-based measure of comovement roots in Fourier analysis, but wavelets overcome the Fourier analysis restriction that cannot efficiently deal with non-stationary data and structural breaks problems. Therefore, wavelets systematically consider the comovement, the extent of correlation, and the long-run and short-run dynamic correlative paths under different time-frequency domains between money and economic growth.

Early studies on the frequency domain, using a wavelet transform to decompose the time series into a frequency base. Such as Ramsey and Lampart (1998) use monthly data during 1960-1994 in the U.S. to examine the relationship between money supply (M1) and income, they find that the causality relationship is income Granger causes money at the lowest time scale and money leads income at the highest time scale

Recently, a number of studies have employed a wavelet analysis to explore the comovement between two time series (see, for various applications of this methodology, Rua, 2010; Aguiar-Conraria *et al.*, 2011; Caraiani., 2012). For example, Caraiani (2012) used several tools based on the wavelet power transform and the wavelet coherence to analyze the relationship between money supply and output during 1960-2010 in the U.S., finding evidences of a weaker relationship within the Great Moderation and a stronger relationship during the Great Recession. These studies highlighted the importance of examining both the degrees of comovement and causality relationship between two time series in the time-frequency domain. This is precisely the goal of this paper.

Therefore, in the study we research the relationship of [GDP, MONEY] based on the wavelet measure of comovement provided by Aguiar-Conraria *et al.* (2011), which it is a powerful and advanced approach currently and not only catches structural breaks of the time domain, but also shows the short-term and long-term relationship of the frequency-domain space, no matter for stationary or non-stationary data. Hence, the wavelet coherency analysis constitutes a very promising tool as it represents a refinement in terms of analysis and can provide rich insights about several economic phenomena. We find that the wavelet strength fluctuates more severely in 1-4 years' frequency bands than in 5-8 years' frequency bands. For all 15 Asia-Pacific countries they present significantly positive comovement of [GDP, MONEY] in their individual period for the 1-4 years' frequency band at the 5% significant level. We also find that positive comovement and the causality relationship goes in both directions in the short-run, and this phenomenon is more significant in developed countries than in developing countries. And most of the developing countries show a consistent phenomenon that MONEY leads GDP in the short run. Additionally, in 4 out of 15 countries, money-finance relationships present a significantly positive comovement and money-growth present lead-lag effect in the long run (5-8 years' frequency). Hence, through wavelet

hypothesis argues for a reverse ordering from real economic growth (GDP) to financial development (money/GDP) (see Chang, 2002).

coherency and phase-difference analysis, this paper has verified that monetary neutrality could be not supported in Australia, Malaysia, Philippines and South Korea only and for the rest of 11 countries that we find money did lead output in either short- or long-run. Our evidence clearly underlines the importance of assessing the strength of comovement and causality relationship between variables using the time-frequency domain approach. The paper is organized as follows: in Section 2 methodology and model are presented and this includes wavelet coherency and phase difference; in Section 3 we present the empirical results while Section 4 wraps up our paper.

2. Research Model and Methodology

In the research context of wavelet analysis, this paper uses three tools: Continuous Wavelet Transformation (CWT), Wavelet Power Spectrum (WPS), and the phase-difference. We present the wavelet coherency and phase-difference as follows.

2.1 Continuous Wavelet Transformation (CWT)

The wavelet transformation, by composing the original series in dilation and scaling, gives us information simultaneously on time and frequency. The wavelet transform can be separated into Discrete Wavelet Transformation (DWT) and Continuous Wavelet Transformation (CWT). Most applied works have used the CWT in economics and finance (Aguar-Conraria *et al.*, 2008; Caraianni, 2012; Rua, 2010; Tiwari *et al.*, 2013), and we describe the key point of CWT methodology in the following paragraphs. For a time series $x(t)$, the CWT is represented as:

$$W_x(\tau, s) = \int_{-\infty}^{+\infty} x(t)\varphi_{(\tau, s)}^*(t)dt \quad (1)$$

Starting with a mother wavelet $\varphi(t)$, we obtain a family $\varphi_{(\tau, s)}(t)$ of “wavelet daughters” by simply scaling and translating, as shown in equation (2).

$$\varphi_{(\tau, s)}(t) = \frac{1}{\sqrt{s}}\varphi\left(\frac{t-\tau}{s}\right) \quad (2)$$

We note that s is a scaling or dilation parameter that controls the width of the wavelet, and τ is a location or translation parameter controlling the location of the wavelet. Scaling a wavelet simply means stretching it (if $|s|>1$) or compressing it (if $|s|<1$).

2.2 Wavelet Power Spectrum (WPS)

The wavelet theory defines WPS of the time-series $x(t)$ as $w_x(\tau, s)$:

$$WPS_x(\tau, s) = |W_x(\tau, s)|^2 \quad (3)$$

The Cross-Wavelet Transform (XWT) of two time series, $x(t)$ and $y(t)$, first introduced by Hudgins *et al.* (1993), is simply defined as $W_{xy}(\tau, s) = W_x(\tau, s)W_y(\tau, s)$. Following them, we then define the Cross-Wavelet Power Spectrum as:

$$XWP_{xy} = |W_{xy}(\tau, s)|^2 = |W_x(\tau, s)|^2 |W_y(\tau, s)|^2 \quad (4)$$

For the bivariate case, XWP_{xy} reflects the covariance between these two time series along both time scales and frequencies.

2.3 Wavelet Coherency Coefficient and Phase Difference

We are also very interested in deriving the wavelet coherence between money and output. The wavelet coherence is the ratio of cross-spectrum to the product of the spectrum of each individual series.

$$R_{xy}(\tau, s) = \frac{|S(W_{xy}(\tau, s))|}{[|S(W_x(\tau, s))|^2 |S(W_y(\tau, s))^2]^{1/2}} \quad (5)$$

Here, S denotes a smoothing operator in both time and frequency, when smoothing is necessary. The absolute value of the complex wavelet coherency is called the Wavelet Coherency and is denoted by $R_{xy}(\tau, s)$ with $0 \leq R_{xy}(\tau, s) \leq 1$

Aguiar-Conraria and Soares (2011a, b) argue that wavelet coherency should be preferred over the wavelet cross-spectrum since not only is it normalized by the power spectrum of the two time series, but that the wavelet cross spectrum also shows strong peaks even for independent processes.

$$\phi(\tau, s) = \tan^{-1} \left(\frac{\Im(W_{xy}(\tau, s))}{\Re(W_{xy}(\tau, s))} \right) \quad (6)$$

$\phi_{xy}(\tau, s) \in [-\pi, \pi]$. Aguiar-Conraria and Soares (2011b), Grinsted *et al.* (2004), and Tiwari *et al.* (2013) provide a few rules to interpret the phase difference as follows: First, when the phase difference is zero, $\phi(\tau, s) = 0$, we say that the two time series present highly comovement. This means that $x(t)$ and $y(t)$ show perfect positive correlation. Second, when the phase difference is π , $\phi(\tau, s) = \pi$, we say that $x(t)$ and $y(t)$ have an anti-phase relationship. This means that $x(t)$ and $y(t)$ show perfect negative correlation. Third, when the phase differences, both $\phi(\tau, s) \in [0, \pi/2]$ and $\phi(\tau, s) \in [-\pi/2, 0]$, respectively, represent a positive correlation between $x(t)$ and $y(t)$, the two time series move in phase, the former mean that x is leading y and the latter mean that y is leading x . Fourth, when the phase differences, both $\phi(\tau, s) \in [\pi/2, \pi]$ and $\phi(\tau, s) \in [-\pi, -\pi/2]$, respectively represent a negative correlation between $x(t)$ and $y(t)$, the two time series move out phase, the former means that y is leading x and the latter means that x is leading y .

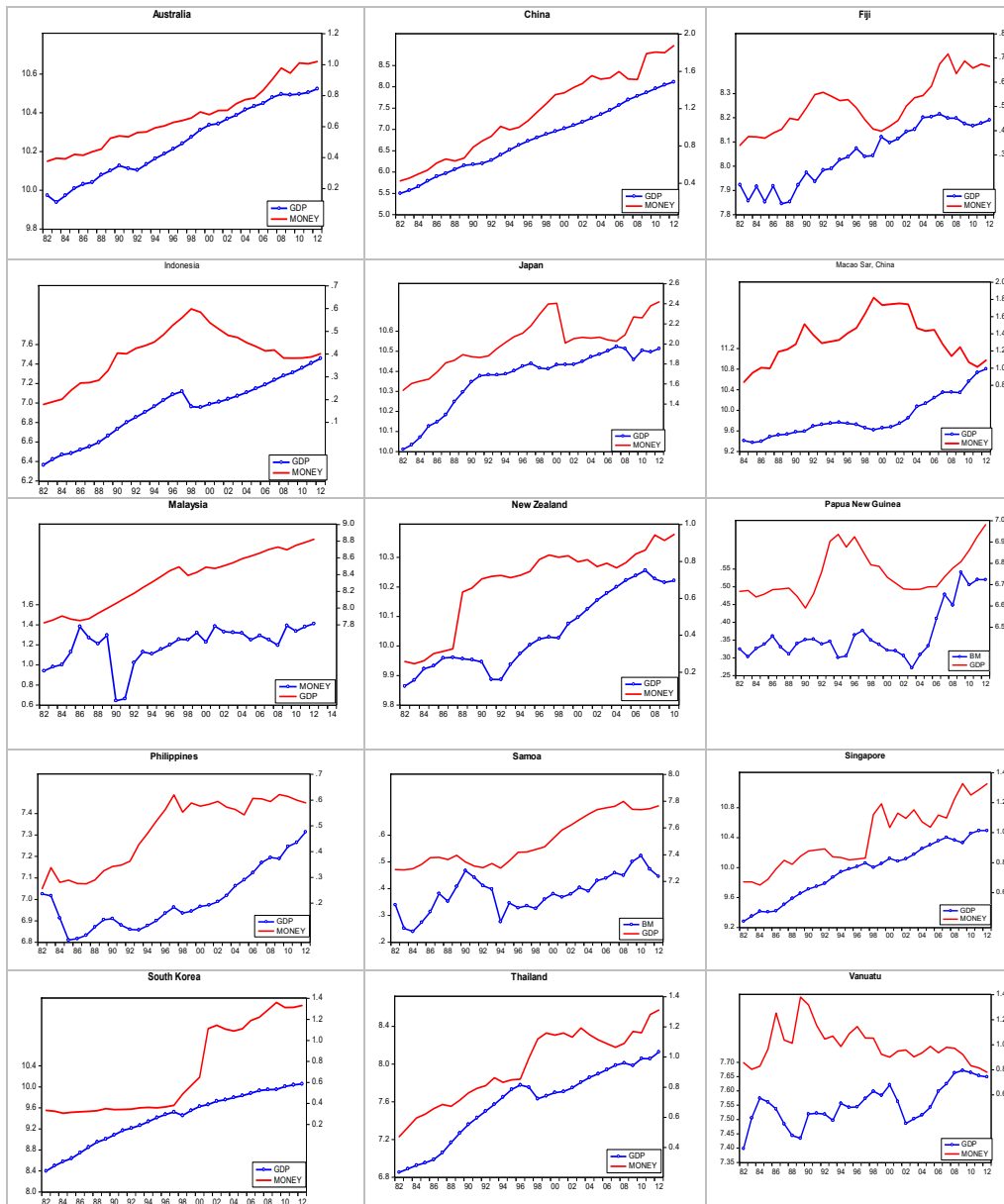
3. Empirical Results

The main annual data of MONEY and GDP is obtained from World Development Indicators for the sample of 15 Asia-Pacific countries in the period of 1982-2012, but in 1982-2010 for New Zealand and in 1984-2012 for Macao SAR, China. In this paper, GDP per capita (constant 2005 US\$), written as GDP, is transformed into natural logarithms. MONEY is the

broad money in percentage term of GDP. Time plots of the money to GDP ratio for 15 Asia-Pacific countries are presented below.

Figure 1

The Money/GDP and GDP for 15 Asia-Pacific Countries

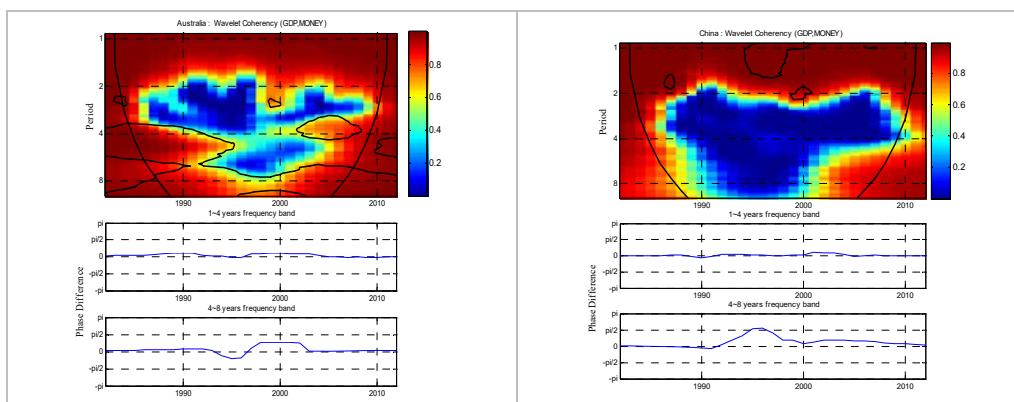


We implement wavelet coherency analysis of Aguiar-Conraria and Soares (2011a, b) and apply the strong function of Matlab software, mainly via Monte Carlo simulations with 5000 replications, where we examine the dynamic relationship and phase-difference among [GDP, MONEY] for all the 15 Asia-Pacific countries over the past three decades. We present the empirical results below.

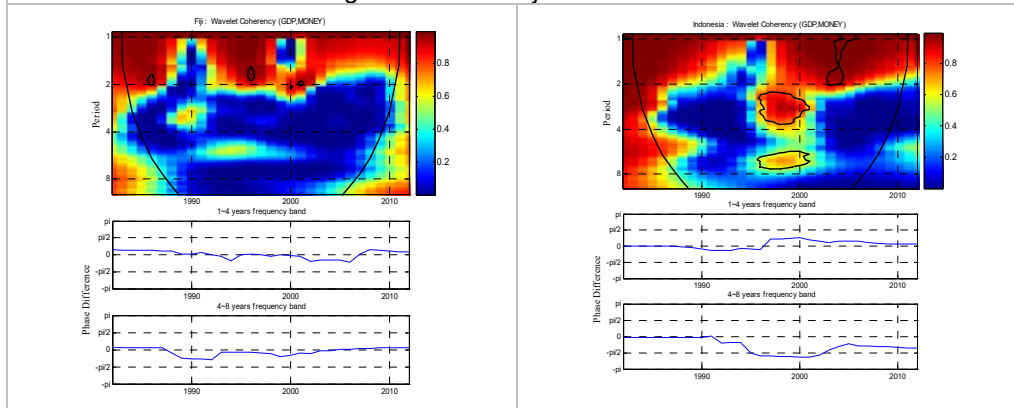
Figures 2 (a,b,...o, orderly) show our empirical results. The definitions of long-run and short-run in frequency-domain spaces, use a 5-8 years' frequency band to capture the long-run trend, which is a large time scale responding in a lower position of the frequency domain . In contrast, 1-4 years' frequency band is used to capture the short-run trend, which is a small time scale responding in a higher position of the frequency domain. We present the empirical results and analyses below. The followings are the descriptions, illustrations, and explanations of the results of 1-4 years' frequency and 5-8 year's frequency as Tables 1a, 1b, 2 and Figure 2.

Figure 2
Comovement between GDP and MONEY in 15 Asia-Pacific Countries:

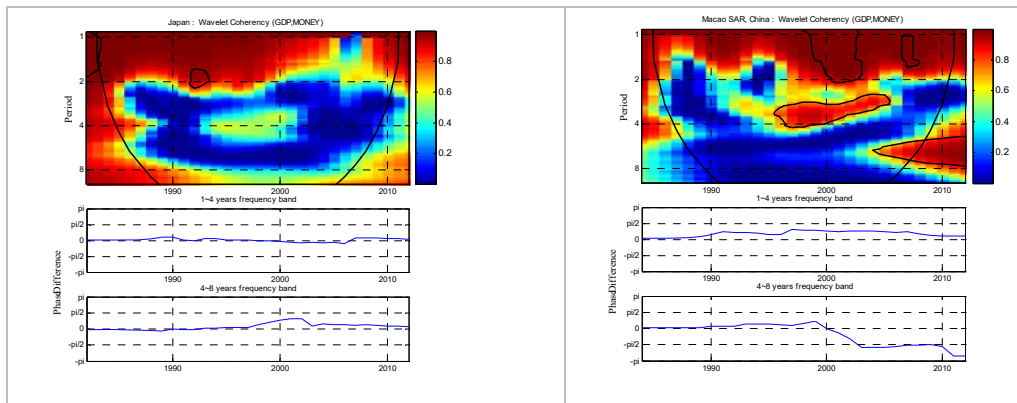
Figures a and b. Australia and China



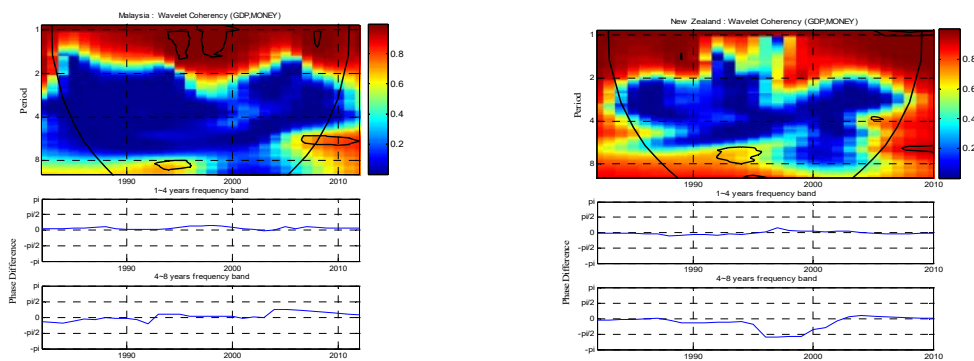
Figures c and d. Fiji and Indonesia



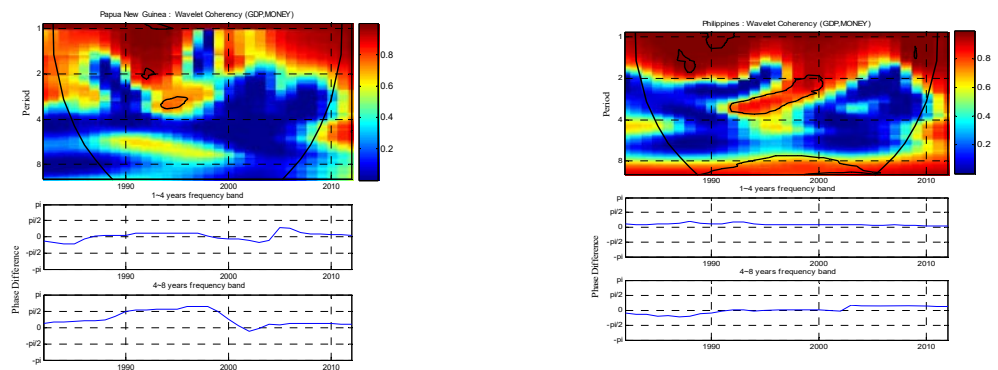
Figures e and f. Japan and Macao SAR,China



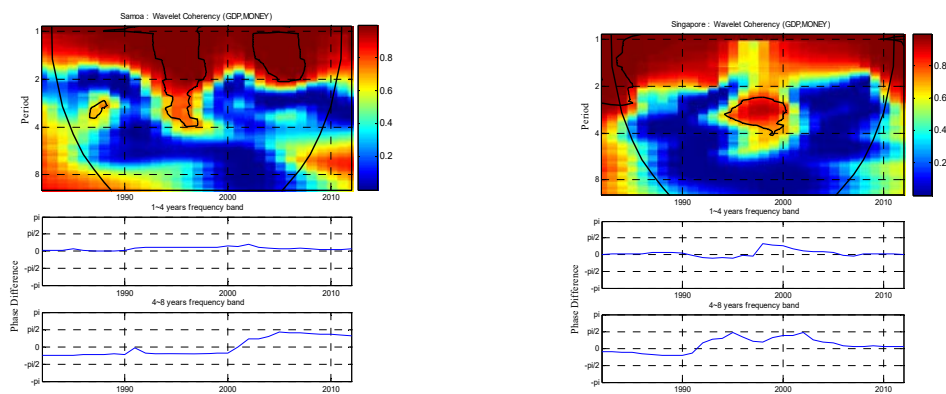
Figures g and h. Malaysia and New Zealand



Figures i and j. Papua New Guinea and Philippines



Figures k and l. Samoa and Singapore



Figures m and n. South Korea and Thailand

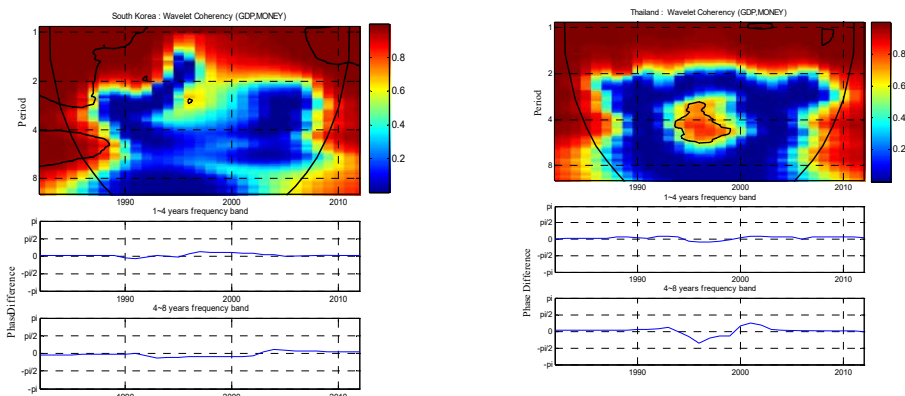
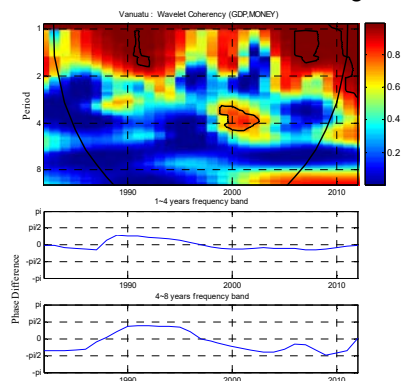


Figure o. Vanuatu



3.1 Comovement between GDP and MONEY in 1-4 Years' Frequency

All 15 Asia-Pacific countries present significantly positive comovement of [GDP, MONEY] in their individual period for the 1-4 years' frequency band at the 5% significant level. Simultaneously, the results show that the positive comovement of [GDP, MONEY] in short-run is more significant than the long-run.

In addition, most of the Asia-Pacific countries (in 8 out of 15) show a consistent phoneme that the causality relationships go in both directions in the short run seen in Figures a, b, c, e, h, k, l, m. Australia in 1982-1992 and 2002-2008, China in 1987-1988 and 1994-2001, Fiji in 1995-1996 and 2001-2002, 1992-1994 in Japan, New Zealand in 1989 and 2005-2008, Samoa in 1987-1988, Singapore in 1982-1983 and 1995-1997, South Korea in 1982-1991 and 2007-2011. Among these developing countries, China is worth mentioning, many important reforms were implemented to increase economic productivity since 1980s and successfully increased the country's wealth (Brandt *et al.*, 2008). In 1993, due to the huge impacts on monetary supplies caused by overheated economy, trade surplus, and increasing foreign exchange reserves, the central bank abandoned the direct loan plan, adopted an indirect control, using money supply as an intermediate target, and later in 1995, issued People's Bank Law and Commercial Bank Law, providing a sound environment for healthy development of monetary intermediate. That is, it would be better to use a series of macroeconomic policy to realize MONEY in short-run. Then, during Asian Financial Crisis (of 1997-98), the China government was in such an economic slump that they took macro-control and loose monetary oppositely, so that there exist highly comovement relationship between [MONEY, GDP]. Our empirical result from China shows the causality relationships go in both directions in the short run, particularly in 1987-1988 and 1994-2001 time periods. Next, there are some difference show that the wavelet coherency coefficients are positive in [GDP, MONEY] at the 5% significance level and the causality relationship shows MONEY leading GDP in 11 out of 15 Asia-Pacific countries, these countries as 1998-2000 in Australia, 1997-2000 in Singapore, Macao SAR of China in 1996-2005 and 2007-2008, Indonesia in 1996-2001 and 2003-2005, Malaysia in 1994-1996, 1997-1999 and 2007-2008, Philippines in 1986-1988, 1989-2001, and 2008-2009, Thailand in 2007-2008. Similarly, this phoneme that MONEY leads GDP in the short run, also appear in 1985-1986 for Fiji, Papua New Guinea in 1992-1997, Samoa in 1993-1998 and 2003-2007. Vanuatu in 1991-1993. These mean that the governments of the above countries had been aware that the monetary policy as an intermediate target is very important to economy. Hence, MONEY to promote GDP in the short-run, the influence of MONEY to GDP would be more direct, fast and effective. The meaning is that if facing an economy recession, the government would adopt a looser momentary policy to boost the economy in the short term. Apparently our empirical results demonstrate that money neutrality does not hold in those countries and this results is not consistent with that of views of the Chicago school of economics. That is, monetary neutrality is not supported in our study for most of the Asia-Pacific countries. Money did work in booming up the economy. Our empirical results support "Supply-leading hypothesis" that financial development is a necessary condition for achieving a high rate of economic growth in these Asia-Pacific countries.

Finally, there are two countries show positive coherency coefficients but different causality direction running from GDP to MONEY. Vanuatu in those periods of 1998-2003, 2006-2008, and 2009-2011, Thailand in 1995-1997. Apparently, the governments of these two countries can take GDP as a strategy to spur MONEY. We also could infer implemented an economic-boost model by export orientation and influx of funds, which in turn accumulated significant

foreign exchange reserves, contributing rapid growth in domestic money supplies. These results demonstrate that for both Vanuatu and Thailand support “Demand-following hypothesis” because we find a reverse ordering from real economic growth (GDP) to financial development (Money/GDP).

Table 1.a

**Relationship Analysis of the Wavelet-based Measure of Comovement
(1-4 Years' Frequency)**

Country	Wavelet Conherency		Phase Difference
Australia	+ correlation	1982-1992 1998-2000 2002-2008	<i>GDP ↔ MONEY</i> <i>GDP ← MONEY</i> <i>GDP ↔ MONEY</i>
China	+ correlation	1987-1988 1994-2001	<i>GDP ↔ MONEY</i> <i>GDP ↔ MONEY</i>
Fiji	+ correlation	1985-1986 1995-1996 2001-2002	<i>GDP ← MONEY</i> <i>GDP ↔ MONEY</i> <i>GDP ↔ MONEY</i>
Indonesia	+ correlation	1996-2001 2003-2005	<i>GDP ← MONEY</i> <i>GDP ← MONEY</i>
Japan	+ correlation	1992-1994	<i>GDP ↔ MONEY</i>
Macao SAR, China	+ correlation	1996-2005 2007-2008	<i>GDP ← MONEY</i> <i>GDP ← MONEY</i>
Malaysia	+ correlation	1994-1996 1997-1999 2007-2008	<i>GDP ← MONEY</i> <i>GDP ← MONEY</i> <i>GDP ← MONEY</i>
New Zealand	+ correlation	2005-2008 1989	<i>GDP ↔ MONEY</i> <i>GDP ↔ MONEY</i>
Papua New Guinea	+ correlation	1992-1997	<i>GDP ← MONEY</i>
Philippines	+ correlation	1986-1988 1989-2001 2008-2009	<i>GDP ← MONEY</i> <i>GDP ← MONEY</i> <i>GDP ← MONEY</i>
Samoa	+ correlation	1987-1988 1993-1998 2003-2007	<i>GDP ↔ MONEY</i> <i>GDP ← MONEY</i> <i>GDP ← MONEY</i>
Singapore	+ correlation	1982-1983 1995-1997 1997-2000	<i>GDP ↔ MONEY</i> <i>GDP ↔ MONEY</i> <i>GDP ← MONEY</i>

Table 1.b
Relationship Analysis of the Wavelet-based Measure of Comovement
(1-4 Years' Frequency)

Country	Wavelet Conherency		Phase Difference
South Korea	+ correlation	1982-1991 2007-2011	$GDP \leftrightarrow MONEY$ $GDP \leftrightarrow MONEY$
Thailand	+ correlation	1995-1997 2007-2008	$GDP \rightarrow MONEY$ $GDP \leftarrow MONEY$
Vanuatu	+ correlation	1991-1993 1998-2003 2006-2008 2009-2011	$GDP \leftarrow MONEY$ $GDP \rightarrow MONEY$ $GDP \rightarrow MONEY$ $GDP \rightarrow MONEY$

3.2 Comovement between GDP and MONEY in 5-8 Years' Frequency

Figures 4a, 4j, 4m, 4g of the 15 Asia-Pacific countries during their specific period in the wavelet model show a positive comovement and causality of MONEY leads GDP in the 5-8 years' frequency band during the periods of 1982-1994 and 2003-2008 in Australia, 1984-1988 in South Korea, 1991-2005 in Philippine, 1993-2008 in Malaysia. Hence, through wavelet coherency and phase-difference analysis, we have verified that the monetary policy by using money supply as an intermediate target in these countries have systematically improved in the past decades. This is, the long-run dynamic relationship of finance-growth, the lead-lag effect appears here. Money supply policies could boost economic growth. Additionally, the appearance of a significantly negative correlation and long-run causality relationship of finance-growth in two developing countries and lead-lag effect also show here. That is, Indonesia during the period 1996-2001, 2004-2007 in Macao SAR, China, this means that the faster the money supply, the lesser the economy grows is needed. Next, above in 4 out of 15 Asia-Pacific countries which are 1994-1999 in Thailand, and 1999-2003 in Vanuatu, 1994-1996 in Australia, and New Zealand in 1993-1995 have verified that the long-run dynamic relationship of growth-finance, the lead-lag effect appears here that economic growth policies could boost financial development. Therefore, if a nation had unstable problems both politically and economically, the authority adopted GDP policy to promote MONEY for the influences were effective. These results support "Demand-following hypothesis" in these four Asia-Pacific countries (*i.e.*, Thailand, Vanuatu, Australia and New Zealand) in the long-run.

Finally, for these six developing countries show non-significant correlations between [MONEY, GDP] in the 5-8 years frequency band, it revealed that MONEY was not the main component of GDP. Apart from China, Japan, Singapore, Fiji, Papua New Guinea and Samoa, it is strongly suggested that it is ideal to use other momentary intermediate targets to boost the economy, such as open market operation, instead of using money supply policies in these six developing countries.

Table 2

Relationship Analysis of the Wavelet-based Measure of Comovement (5-8 Years' Frequency)

Country	Wavelet Coherency	Phase Difference
Australia	+ correlation 1982-1994 1994-1996 1996-2003 2003-2008	$GDP \leftrightarrow MONEY$ $GDP \rightarrow MONEY$ $GDP \leftarrow MONEY$ $GDP \leftrightarrow MONEY$
China	Insignificant	Insignificant
Fiji	Insignificant	Insignificant
Indonesia	-correlation 1996-2001	$GDP \leftarrow MONEY$
Japan	Insignificant	Insignificant
Macao SAR, China	- correlation 2004-2007	$GDP \leftarrow MONEY$
Malaysia	+ correlation 1993-1996 2007-2008	$GDP \leftarrow MONEY$ $GDP \leftarrow MONEY$
New Zealand	+ correlation 1993-1995	$GDP \rightarrow MONEY$
Papua New Guinea	Insignificant	Insignificant
Philippines	+ correlation 1988-1991 1991-2002 2002-2005	$GDP \rightarrow MONEY$ $GDP \leftrightarrow MONEY$ $GDP \leftarrow MONEY$
Samoa	Insignificant	Insignificant
Singapore	Insignificant	Insignificant
South Korea	+ correlation 1984-1988	$GDP \leftrightarrow MONEY$
Thailand	+ correlation 1994-1999	$GDP \rightarrow MONEY$
Vanuatu	+ correlation 1999-2003	$GDP \rightarrow MONEY$

4. Conclusions

This paper examines the comovement between [GDP, MONEY] for 15 Asia-Pacific countries by adopting the wavelet coherency analysis of Aguiar-Conraria and Soares (2011a, b) to investigate the dynamic relationship between [GDP, MONEY]. The main contribution of this paper takes this new analysis to identify certain periods wherein either the growth-finance or finance-growth relationship can be observed. Besides, our study has verified that monetary neutrality is found in some Asia-Pacific countries. Our results are obtained from this new econometric technique – wavelet analysis.

Firstly, the wavelet strength fluctuates more severely in 1-4 years' frequency bands than in 5-8 years' frequency bands. That is, after wavelet transformation, 1-4 years' frequency (short run) behaves more highly synchronized and strong comovement than the 5-8 years' frequency (long run), relatively. As for the strong positive correlations demonstrated above, the economical meaning is that if facing an economy recession, the government would adopt a looser momentary policy to boost the economy in the short run.

Secondly, in 11 out of 15 Asia-Pacific countries show a consistent phoneme that MONEY leads GDP in the short run. Obviously, loose money supply policy is promoted through the establishment of economic growth strategy in the short run and the influence of MONEY to GDP would be more direct, fast and effective.

Thirdly, in 4 out of 15 Asia-Pacific countries (Australia, South Korea, Philippines and Malaysia), money-growth relationships present a significantly positive comovement and money-growth present lead-lag effect in the long run (5-8 years' frequency). Therefore, through wavelet coherency and phase-difference analysis, this paper has verified that views of the Chicago school of economics could be wrong. That is, monetary neutrality is not supported. Apparently, all these empirical results support "Supply-leading hypothesis." in most of Asia-Pacific countries.

Finally, 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 our research variables. Therefore, through wavelet coherency and phase-difference analysis, our paper is the first study to identify certain period causality relationship of finance-growth and the lead-lag effect. The empirical results have important policy implications for these 15 Asia-Pacific countries conducting monetary policy to boot up its economy. Of course our study still has some limitations such as omitted variable bias (like interest rate might affect the relationship between money supply and economic growth). We might want to add interest rate into our model as a control variable (in fact, money supply did affect interest rate, see Appendix). Future study will be in this direction.

References

- Abu-Bader, S. and Abu-Qarn, A., 2008). Financial development and economic growth: The Egyptian experience. *Journal of Policy Modeling*, 30(5), pp. 887-898.
- Aguiar-Conraria, L. and Soares, M., 2011a). Business cycle synchronization and the Euro: a wavelet analysis. *Journal of Macroeconomics*, 33(3), pp. 477-489.
- Aguiar-Conraria, L. and Soares, M., 2011b. Oil and the macroeconomy: using wavelets to analyze old issues. *Empirical Economics*, 40(3), pp. 645-655.
- Aguiar-Conraria, L. Azevedo, N. and Soares, M., 2008. Using wavelets to decompose the time-frequency effects of monetary policy. *Physica A: Statistical Mechanics and Its Applications*, 387(12), pp. 2863-2878.
- Ang, J. and McKibbin, W., 2007. Financial liberalization, financial sector development and growth: evidence from Malaysia. *Journal of development Economics*, 84(1), pp. 215-233.
- Bollerslev, T. Chou, Y. and Kroner, K., 1992. ARCH modeling in finance: A review of the theory and empirical evidence. *Journal of Econometrics*, 52(1), pp. 5-59.
- Balcilar, M. Ozdemir, A. and Arslanturk Y., 2010. Economic growth and energy consumption causal nexus viewed through a bootstrap rolling window. *Energy Economics*, 32(6), pp. 181-189.
- Balcilar, M. and Ozdemir, A., 2013. The export-output growth nexus in Japan : A bootstrap rolling window approach. *Empirical Economics*, 44, pp. 639-660.
- Caraiani, P., 2012. Money and output: New evidence based on wavelet coherence. *Economics Letters*, 116(3), pp. 547-550.
- Chang, T., 2002. Financial development and economic growth in Mainland China: a note on testing demand-following or supply-leading hypothesis. *Applied Economics Letters*, 9, pp. 869-873.

- Croux, C. Forni, M. and Reichlin, L., 2001. A measure of comovement for economic variables: theory and empirics. *Review of Economics and Statistics*, 83(2), pp. 232-241.
- Demetriades, P. and Hussein, K., 1996. Does financial development cause economic growth? Time-series evidence from 16 countries. *Journal of development Economics*, 51(2), pp. 387-411.
- Eichenbaum, M. and Singleton, K., 1986. Do equilibrium real business cycle theories explain postwar US business cycles? *NBER Macroeconomics*, 1, pp. 91-146.
- Frankel, A. and Rose, K., 1998. The endogeneity of the optimum currency area criteria. *Economic Journal*, 108(449), pp. 1009-1025.
- Freeman, S. and Huffman, G., 1991. Inside money, output, and causality. *International Economic Review*, 32(3), pp. 645-667.
- Freeman, S. and Kydland, F., 2000. Monetary aggregates and output. *American Economic Review*, 90(5), pp. 1125-1135.
- Gençay, R. Selçuk, F. and Whitcher, B., 2001a. Differentiating intraday seasonalities through wavelet multi-scaling. *Physica A: Statistical Mechanics and Its Applications*, 289(3), pp. 543-556.
- Gençay, R. Selçuk, F. and Whitcher, B., 2001b. Scaling properties of foreign exchange volatility. *Physica A: Statistical Mechanics and Its Applications*, 289(1), pp. 249-266.
- Goffe, W., 1994. *Computational Techniques for Econometrics and Economic Analysis*. Springer Netherlands. pp. 137-149.
- Grubel, G. and Fadner, K., 1971. The interdependence of international equity markets. *The Journal of Finance*, 26(1), pp. 89-94.
- Hudgins L. Friehe A. and Mayer. E., 1993. Wavelet transforms and atmospheric turbulence. *Physical Review Letters*, 71(20): 3279.
- Imbs, J., 2004. Trade, finance, specialization, and synchronization. *Review of Economics and Statistics*, 86(3), pp. 723-734.
- King, R. and Levine, R., 1993a. Finance and growth: Schumpeter might be right. *The Quarterly Journal of Economics*, 108(3), pp. 717-737.
- King, R. and Plosser C., 1984. The behavior of money, credit, and prices in a real business cycle. *The American Economic Review*, 74(3), pp. 363-380.
- Kose, A. and Yi, M (2006). Can the standard international business cycle model explain the relation between trade and comovement? *Journal of International Economics*, 68(2), pp. 267-295.
- Liu, W. and Hsu, C., 2006. The role of financial development in economic growth: The experiences of Taiwan, Korea, and Japan. *Journal of Asian Economic*, 17(4), pp. 667-690.
- Masih, R. and Masih, A., 1996. Macroeconomic activity dynamics and Granger causality: New evidence from a small developing economy based on a vector error-correction modelling analysis. *Economic Modelling*, 13(3), pp. 407-426.
- Oi, H. Shiratsuka, S. and Shirota, T., 2004. *On Long-Run Monetary Neutrality in Japan*, Institute for Monetary and Economic Studies, Bank of Japan.
- Prasad, S., 1999. International Trade and Business Cycle. *Econometric Journal*, 109(458), pp. 588-606.
- Ramsey, J. and Lampart, C., 1998. Decomposition of economic relationships by timescale using wavelets, *Macroeconomic Dynamics*, 2(1), pp. 49-71.

- Rousseau, P. and Vuthipadadorn, D., 2005. Finance, investment, and growth: Time series evidence from 10 Asian economies. *Journal of Macroeconomics*, 27(1), pp. 87-106.
- Rua, A., 2010. Measuring comovement in the time–frequency space. *Journal of Macroeconomics*, 32(2), pp. 685-691.
- Sinai, A. and Stokes, H., 1972. Real money balances: An omitted variable from the production function? *The Review of Economics and Statistics*, 54(3), pp. 290-296.
- Tiwari, A. Mutascu, M. and Andries, A., 2013. Decomposing time-frequency relationship between producer price and consumer price indices in Romania through wavelet analysis. *Economic Modelling*, 31(19), pp. 151-159.
- Vymyatnina, Y., 2006. How much control does Bank of Russia have over money supply? *Research in International Business and Finance*, 20(2), pp. 131-144.
- Zeileis, A. Leisch, F. Hornik, K. and Kleiber C., 2005. Monitoring structural change in dynamic econometric models. *Journal of Applied Econometrics*, 20, pp. 99-121.

Appendix

Figure p. M2 and Interest Rate in China -1996.1-2016.12 and in Japan - 1990.1-2016.12

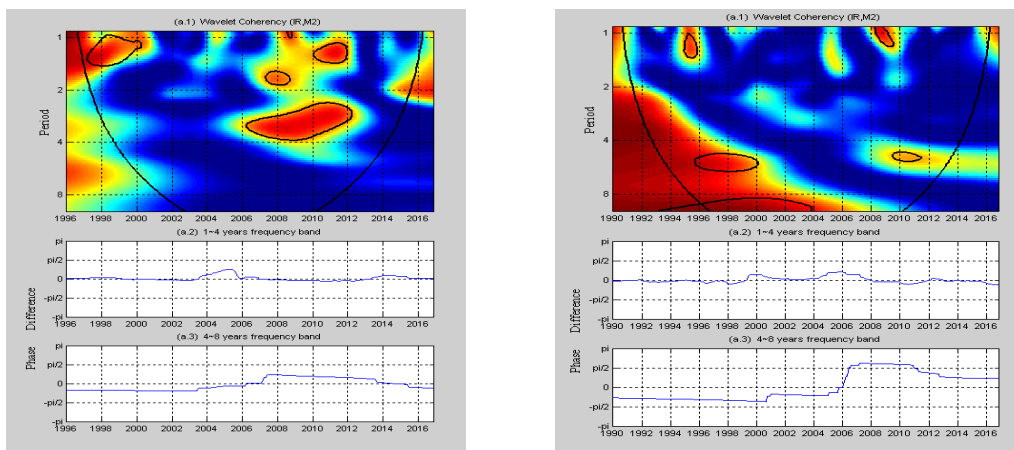
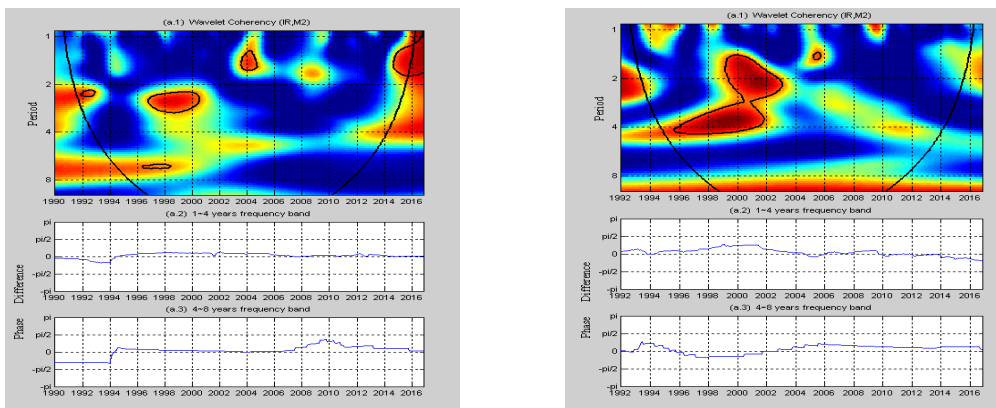


Figure q. M2 and Interest Rate in Korea -1990.1-2016.12 and in Singapore - 1992.1-2016.12



Note: Due to space constraints, that we only report China, Japan, South Korea and Singapore. From Figures p and q that we find money and interest rates have only short-term relationship in China, Korea and Singapore. However for Japan we find both short-term and long-term relationship between money and interest rates (money leads interest rates in the long-run). Also from Figures p and q that we find interest rates and money demonstrate strong co-movement in the short-run and interest rates lead money in the short-run only in Singapore.