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Money–output Granger causal dynamics in China ☆

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ABSTRACT

This paper attempts to investigate the time-varying causal dynamics between China's money and output by using a Markov switching causality approach. Unlike the pre-specified break points and rolling-window methods, the Markov switching causality approach can capture the time-varying causality patterns endogenously. Our empirical results show that there are bidirectional time-varying Granger causalities between China's money and output. On the one hand, the money supply Granger-causes output when the economy is overheated or during recession, whilst it has no significant effect on output when the economy grows moderately; the short term interest rate only has temporary effect on output, suggesting the ineffectiveness of the interest rate based monetary policy. On the other hand, output only affects the money supply in short periods, whilst the feedback of output on the short term interest rate has distinct regime switching features, which implies that the nonlinear Taylor rule targeting on the short term interest rate is more appropriate than the McCallum rule in describing China's monetary policy reaction function.

1. Introduction

Since the economic reform in the 1980s, China's economy has kept a rapid growth for more than thirty years and now is becoming one of the most important economies in the world. In particular, with the deepening of China's economic marketization, the People's Bank of China (PBC) tends to regulate the economic condition by economic policies rather than administrative means. As one of the most important economic policies, monetary policy plays a fundamental role in macroeconomic regulation. Since 2008, the PBC has frequently adjusted the benchmark deposit and lending interest rates as well as the growth rate of the money supply, expecting to stimulate recovery or curb overheating. However, there still exist some controversies on the effectiveness of monetary policy. Actually, since the publication of Keyes' writings named "The General Theory of Employment, Interest and Money", the relationship between money and output has attracted a phenomenal amount of interest over the years from macroeconomists and policy makers. This issue not only reflects the casual dynamics between nominal economic variables (e.g., money) and real economic variables (e.g. output), but also involves the important issue about whether monetary policy is neutral.

Since the 1970s, a stream of literature has empirically examined the money–output causal dynamics, see Sims (1972, 1980), Christiano and Ljungqvist (1988), Stock and Watson (1989), Friedman and Kuttner (1993), among others. However, the empirical results vary with sample intervals, indicating that the money–output causality appears to be unstable. To assess the instability of the money–output causality, Thoma (1994) and Swanson (1998) perform Granger's (1969) test based on the recursive and rolling methods. In the recursive scheme, the size of the sample used for Granger causality test grows iteratively, while in the rolling scheme, Granger causality tests are always carried out based on a sample of fixed window size when rolling through the sample. Both of them confirm the time-varying behavior of the Granger causality between money and output, and believe the instability reflects the existence of asymmetry[1]. In fact, there are also a few economic theories implying an asymmetric relationship between money and output. The sources of asymmetric effect may include asymmetric wage indexation and price adjustment (Kandil, 1995), asymmetric preference of central bank's monetary policy (Nobay and Peel, 2003;

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[1] The existing literature generally defines the nonlinearity in mean between the variables as "asymmetry".

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Ruge-Murcia, 2003; Surico, 2007a,b), nonlinearity of aggregate supply and demand curves (Dolado et al., 2005) as well as the existence of credit constraints (Bernanke and Gertler, 1995). Beyond that, such empirical studies as Weise (1999), Rothman et al. (2001), Lo and Piger (2005), Psaradakis et al. (2005), Christopoulos and León-Ledesma (2008) also provide fruitful evidences on the asymmetric effect of monetary policy using nonlinear models.

Taking into account the special nature of China's economy, the conclusions for developed economies may fail to apply to China's economy. Thus, it is necessary to reexamine the relationship between China's money and output. In fact, a lot of Chinese domestic scholars have made great effect on this issue. For example, Liu and Zhang (2003) divide the whole sample into several subsamples with pre-specified break points, and find significant asymmetric behavior of China's monetary policy. Similarly, by choosing Jan., 2003 as an economic recovery point in prior, Yan et al. (2009) show that the monetary policy is more effective in curbing overheating than stimulating recovery. Moreover, Zheng and Liu (2008) analyze the asymmetric effects between China's money and output during the period from 1989 to 2007 by employing a smooth transition vector autoregressive (STVAR) model and conclude that money has asymmetric effects on output. Wang et al. (2010) provide more evidence on the asymmetric effect of monetary policy in an open economy by introducing such variables as exchange rate to represent the degree of openness.

By adding the break points exogenously or endogenously, the above studies all confirm the asymmetric relationship between China's money and output, which largely enriches the study on this issue. However, the pre-specified break point method used by Liu and Zhang (2003) and Yan et al. (2009) relies on the prior information about both the number and the location of break points. In practice, there is no exact information on the economic situation, especially recent economic situation. As a result, the specification of the break points is usually arbitrary and suffers from model misspecification problem. An alternative approach is the rolling-window approach adopted by Swanson (1998) and Balcilar and Ozdemir (2013). This method fixes the length of the window and rolls through the sample to test the Granger causality using observations in the window only. The rolling-window method avoids the arbitrary specification of break points, but introduces the selection of window size. Actually, the selection of window size involves a tradeoff between the robustness of the result and the preciseness in describing the time-varying behavior. More precisely, if the window size is small, the observations used for testing will be relatively few, failing to obtain the robust test results. If the window size is large, the subsample will cover the samples with (or high) and without (or low) Granger causalities, decreasing the sensitivity of the test results. Beyond that, the STVAR model used by Zheng and Liu (2008) and Wang et al. (2010) involves the selection of threshold variable and the results usually vary with threshold variables.

In contrast to most existing studies on China's money and output that rely on the pre-specified break points or rolling-window size, this paper attempts to address the time-varying causal dynamics between China's money and output endogenously by employing the Markov switching causality (MSC) approach developed in Psaradakis et al. (2005). As the changes in causal links are usually unknown in advance, this method assumes the state variable, which reflects possible structural changes, to be endogenously governed by a first order hidden Markov chain with stationary but unknown transition probabilities, and thus avoids the arbitrary pre-specification of break points and rolling-window size. The MSC approach is quite convenient to model the time-varying causality between variables in practice. For example, Balcilar and Ozdemir (2013) confirm the time-varying casual links between inflation and inflation uncertainty by using this method. In our paper, by using the year-on-year growth rate of M1 and M2, as well as the short term interest rate as proxy variables for the monetary policy, we document the existence of time-varying bidirectional casual relationship between China's money and output. As a result, the MSC approach applied here could capture not only the asymmetric effect of monetary policy, which has received widespread attention in the literature, but also the feedback of output on money. In fact, the latter has become a key reference in determining monetary policy rules (McCallum, 1984; Taylor, 1993).

The rest of this paper is organized as follows. Section 2 briefly reviews the MSC approach. Section 3 describes the data. In Section 4, we examine China's time-varying money–output causal dynamics using the rolling-window approach and MSC approach respectively. Section 5 concludes.

2. Econometric methods

Traditionally, the causal analysis of money and output is based on the Granger causality test (Granger, 1969). Consider a time series $X_t = (X_{1,t}, X_{2,t})$, a simple bivariate VAR(p) model is defined as follows:

$$\begin{pmatrix} X_{1,t} \\ X_{2,t} \end{pmatrix} = \begin{pmatrix} \mu_{10} \\ \mu_{20} \end{pmatrix} + \sum_{k=1}^{p} \begin{pmatrix} \phi_1^{(k)} & \psi_1^{(k)} \\ \psi_2^{(k)} & \phi_2^{(k)} \end{pmatrix} \begin{pmatrix} X_{1,t-k} \\ X_{2,t-k} \end{pmatrix} + \sum_{k=1}^{q} \begin{pmatrix} \varphi_1^{(k)} \\ \varphi_2^{(k)} \end{pmatrix} Z_{t-k} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix},$$
$$\begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix} \sim \text{i.i.d. } N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix} \right) \tag{1}$$

where $t = 1, \cdots T$, Z_t is an exogenous random variable. $X_{2,t}$ causes $X_{1,t}$ provided some $\psi_1^{(k)}$, $k = 1, \cdots, p$ is not zero. Similarly $X_{1,t}$ causes $X_{2,t}$ if some $\psi_2^{(k)}$, $k = 1, 2, \cdots, p$ is not zero. If both of these events occur, there is said to be a feedback relationship between $X_{1,t}$ and $X_{2,t}$.

Granger (1969) proposes an F test for Granger causality in the above linear regression setup, which is widely used in empirical studies (e.g., Calderon and Liu, 2003; Granger et al., 2000). However, the Granger's (1969) F test and the linear VAR model are only powerful in capturing the linear Granger causality. As mentioned in the Introduction, considerable empirical studies document the time-varying behavior of the Granger causalities between money and output, and believe that the time-varying behavior is a reflection of nonlinear relationship. As a result, Granger's (1969) F test or the linear VAR model is inappropriate in measuring the nonlinear relationship between money and output.

In this paper, we adopt the Markov switching causality (MSC) method proposed by Psaradakis et al. (2005), which is based on the following bivariate VAR model with Markov switching:

$$\begin{pmatrix} X_{1,t} \\ X_{2,t} \end{pmatrix} = \begin{pmatrix} \mu_{10} + \mu_{11}S_{1,t} \\ \mu_{20} + \mu_{21}S_{2,t} \end{pmatrix} + \sum_{k=1}^{p} \begin{pmatrix} \phi_{10}^{(k)} + \phi_{11}^{(k)}S_{1,t} & \psi_1^{(k)}S_{1,t} \\ \psi_2^{(k)}S_{2,t} & \phi_{20}^{(k)} + \phi_{21}^{(k)}S_{2,t} \end{pmatrix} \begin{pmatrix} X_{1,t-k} \\ X_{2,t-k} \end{pmatrix}$$
$$+ \sum_{k=1}^{q} \begin{pmatrix} \varphi_{10}^{(k)} + \varphi_{11}^{(k)}S_{1,t} \\ \varphi_{20}^{(k)} + \varphi_{21}^{(k)}S_{2,t} \end{pmatrix} Z_{t-k} + \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix} \cdot \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \end{pmatrix}$$
$$\sim \text{i.i.d.}\, N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2_{1,S_{1,t},S_{2,t}} & \rho_{S_{1,t},S_{2,t}}\sigma_{1,S_{1,t},S_{2,t}}\sigma_{2,S_{1,t},S_{2,t}} \\ \rho_{S_{1,t},S_{2,t}}\sigma_{1,S_{1,t},S_{2,t}}\sigma_{2,S_{1,t},S_{2,t}} & \sigma^2_{2,S_{1,t},S_{2,t}} \end{pmatrix} \right) \tag{2}$$

In Eq. (2), the two discrete variables $S_{1,t}$ and $S_{2,t}$ are mutually independent state variables taking values 0 or 1. Different combinations of $S_{1,t}$ and $S_{2,t}$ allow for four alternative states of nature, which may be conveniently indexed by using the following four-regime state variable S_t:

$$S_t = \begin{cases} 1, & \text{if } S_{1,t} = 1,\ S_{2,t} = 1 \\ 2, & \text{if } S_{1,t} = 0,\ S_{2,t} = 1 \\ 3, & \text{if } S_{1,t} = 1,\ S_{2,t} = 0 \\ 4, & \text{if } S_{1,t} = 0,\ S_{2,t} = 0 \end{cases}. \tag{3}$$

It is evident that $S_{1,t}$ and $S_{2,t}$ (and hence S_t) determine the causal links in the model. In particular, $S_{1,t}$ determines whether $X_{2,t}$ is Granger-causal for $X_{1,t}$, while $S_{2,t}$ dictates whether $X_{1,t}$ is Granger-