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### Smooth transition in China: New evidence in the cointegrating money demand relationship

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#### Abstract

Using linearity tests proposed by Choi and Saikkonen (2004), this paper finds evidence of a non-linear cointegrating money demand relationship in China during the 1987-2008 period and identifies potential explanations for this non-linearity.

# 1 Introduction

China has used money supply targeting as the basis for its monetary policy since 1983. However, standard monetary transmission mechanisms have not been effective and the central bank has resorted to administrative measures to achieve its targets (Laurens and Maino, 2007, Liu and Xie, 2006). In theory, money supply targeting is effective only if there is a strong and linear relationship between the goal of the policy, which in China is price stability, and the targeted monetary aggregate. However, there are various reasons for why the demand for money may be non-linear, particularly in countries undergoing transitions from planned economies to market-oriented economies (Mishkin, 2010). For example, a progressive increase in the elasticity between money and income may stem from a slowdown in money velocity due to the monetization process.

Despite a large literature on the demand for money in China since the seminal work of Chow (1987), only a few papers have investigated non-linear relationships. On the one hand, Austin, Ward and Dalziel (2007) examined non-linearities affecting the adjustment process to the equilibrium in a cointegrated framework. Their approach implies the existence of a linear and hence a single equilibrium relationship. However we find this hypothesis too restrictive as explained above. On the other hand, Lee and Chien (2008) tested for the presence of structural changes and identified one major structural breakpoint in 1993.

In this paper we start with examining the hypothesis of instability, i.e. the possibility of a structural break in the long-term relationship. Like Lee and Chien (2008), we find a structural break, which confirms that it is relevant to adopt a non-linear approach to model the demand for money in China. But a specification with structural breaks has some limits. First the use of a sharp transition model is not appropriate to China which has adopted a smooth economic transition process since 1978. Second a specification with structural break(s) implies changes without possible way-back. On the contrary, we assume that the relationship can transit from one regime to another in both directions. Last and not least, important policy implications may be drawn if we could interpret the reasons for non-linearity. These ideas clearly match the definition of a threshold regression model.

As a consequence, we test the null hypothesis of a linear cointegrating model against the alternative of a cointegrating STR model proposed by Choi and Saikkonen (2004). The STR model allows the long-run equilibrium relationship to change smoothly depending on the magnitude of a threshold variable, which subsequently allows us to interpret the economic causes for the non-linearity. In total, our methodology, new to China studies, en-

compasses the possibility of structural breaks while offering more exploitable information.

This methodology allows the threshold variables to be non-stationary, unlike the alternative test by Gonzalo and Pitarakis (2006). Relaxing this constraint enables us to test more probable reasons as a cause of the non-linearity. In the end, we find evidence of non-linearity in the money demand in China and identify potential explanations for this non-linearity.

The next Section reports stability tests of the linear cointegrating relationship. The following Section presents the non-linear specification as well as the test procedure and Section 4 presents the results from the tests.

## 2 Stability tests of a linear cointegrating relationship

As in most previous studies, we adopt a standard specification for the long-run money demand function in China. Our choice is motivated by the fact that our period of estimation starts almost a decade after the transition to the market economy has started, in 1987 (and ends in 2008). Since we are interested in the long-run equilibrium only and not in the adjustment process, we consider the univariate approach of Engle and Granger (1987). The general linear specification for the long-term demand for money is the following:

$$m_t - p_t = \beta_1' x_t + \sum_{j=-3}^3 \pi_j \delta x_{t-j} + u_t, \quad t = 1, \dots, T. \quad (1)$$

where  $(m_t - p_t)$  is the demand for real balances<sup>1</sup>,  $x_t$  is a vector including the real income and the opportunity cost of holding money and  $u_t$  is a zero-mean stationary error term. The opportunity cost is measured with the inflation rate and the domestic interest rate as in related studies. We follow Stock and Watson (1993) which corrects for regressor endogeneity by the inclusion of leads and lags of first differences of the regressors  $(\delta x_{t-j})$ , and for serially

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<sup>1</sup>All variables except the interest rate and the inflation rate are in logs. We use Chinese quarterly data from Datastream during the 1987-2008 period. They include M2, GDP both in real terms (deflated with the CPI), the inflation rate and the deposit interest rate. Official intermediate targets are M1 and M2. Estimations run using M1 yield similar results, available upon request. This study relies on the new GDP data that were revised upward by China's National Bureau of Statistics in 2005.

correlated errors by a GLS procedure ( $\pi_j$  is a vector of the coefficients related to  $\delta x_{t-j}$ ).

First we test for the existence of a linear cointegrating relationship. All variables except the inflation rate are found nonstationary using ADF and PP tests<sup>2</sup>. The ADF and PP tests reject non-stationarity of the estimated residuals of equation (1) at 5%  $(-3, 32)$  and 1%  $(-9, 81)$  respectively (using Phillips-Ouliaris critical values), implying a cointegrating relationship, consistently with the related empirical studies.

Second, we carry out a White test for heteroscedasticity of the residuals. The test statistics is 2,75 (with a p-value equal to 0,00) providing evidence that there is heteroscedasticity. Based on this specification test, we follow MacKinnon and White (1985) and estimate equation (1) using the Newey-West covariance estimator that is consistent in the presence of both heteroskedasticity and autocorrelation of the residuals.

Last, we test whether the coefficients of this revised model have changed during the period. The year 1993 seems a good "candidate" for a structural break because a set of reforms was initiated with the double objective to turn the state-owned banks into independent commercial banks and make the People Bank of China independent (Cheng and Cheng, 1998). In equation (1), we introduce  $Du93$ , a dummy variable taking the value 0 from 1987 to 1992 and 1 afterwards. More precisely:

$$m_t - p_t = (\beta'_1 + \beta'_2 Du93)x_t + \sum_{j=-3}^3 \beta'_j \delta x_{t-j} + u_t, \quad t = 1, \dots, T. \quad (2)$$

To test the null hypothesis of constant coefficients, we carry out a Wald test with the restriction that all  $\beta'_2 = 0$  simultaneously. The test F-statistic of 9,41 (with the p-value equal to 0,00) indicates that we can decisively reject the null hypothesis of constant coefficients. This result is consistent with Lee and Chien (2008) who also found a structural break in 1993.

In total, we clearly reject the null hypothesis of a linear relationship, which should cast some doubt on the efficacy of monetary targeting in China. This result makes it relevant to adopt a non-linear approach to model the demand for money in China during its transition process. For the reasons explained in the introduction, we prefer the alternative specification of a cointegrating STR model proposed by Choi and Saikkonen (2004). The non-linear specification is presented in the next Section.

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<sup>2</sup>Tests values are available upon request.

### 3 Non-linear cointegrating relationship and test procedure

The non-linear specification is the following:

$$m_t - p_t = \beta_1' x_t + \beta_2' x_t g(q_t; \gamma, c) + \sum_{j=-K}^K \pi_j \delta x_{t-j} + u_t, \quad t = 1, \dots, T. \quad (3)$$

where  $g(\cdot)$  is a continuous logistic transition function bounded between 0 to 1,  $c$  denotes a location parameter, parameter  $\gamma$  determines the slope of the transition function and  $q_t$  the threshold variable (defined in the next Section). Finally,  $K$  lead and lag terms are added to the specification to resolve the serial and contemporaneous correlation between regressors and error terms.

The logistic function allows a smooth transition from an inferior regime to a superior one depending on the magnitude of a threshold variable. Its S-shape implies an infinite number of intermediate regimes (see Figure 1).

The statistical tests proposed by Choi and Saikkonen (2004) extend previous tests of linearity against STR models. Testing for linearity in a cointegrating STR model (equation (3)) can be done by testing  $H_0 : \gamma = 0$  or  $H_0 : \beta_2 = 0$  (for more details, see van Dijk *et al.*, 2000).

In both cases, the test is non-standard since the cointegrating STR model contains unidentified nuisance parameters under  $H_0$ . A possible solution is to replace the transition function,  $g(q_t; \gamma, c)$ , by its first-order Taylor expansion around  $\gamma = 0$  and to test an equivalent hypothesis in an auxiliary regression. We then obtain:

$$M_t = \theta_1' x_t + \theta_2' x_t q_t + \sum_{j=-K}^K \rho_j \delta x_{t-j} + \epsilon_t, \quad (4)$$

where  $\epsilon_t$  is the Taylor series approximation error. In these auxiliary regressions, parameter  $\theta_2$  is proportional to the slope parameter  $\gamma$  of the transition function. Thus, testing the linearity against the cointegration STR model simply consists of testing  $H_0 : \theta_2 = 0$  in (4) for a logistic function. To do so, Choi and Saikkonen (2004) proposed the following LM test:

$$T_1 = \hat{\theta}_2' [\tilde{\omega}_e^2(M^{-1})_{nn}]^{-1} \hat{\theta}_2 \quad (5)$$

where  $\hat{\theta}_2$  is the ordinary least squares estimator of  $\theta_2$  and  $M$  is the moment matrix in equation (4) and  $(M^{-1})_{nn}$  the block of the matrix  $M^{-1}$  corresponding to  $x_t q_t$ . Choi and Saikkonen (2004) showed that this test follows a standard chi square limiting distribution with  $p$  degrees of freedom where  $p$  is the number of explicative variables related to the transition function.

An alternative solution is to replace the transition function,  $g(q_t; \gamma, c)$ , by its third-order Taylor expansion around  $\gamma = 0$  in order to consider the case where non-linearity is due to the variation in the intercept only. The test procedure is similar and the results for both tests are reported in a single table in the Appendix and commented in the next Section.

## 4 Results and Conclusion

A major issue in the STR test is to identify the threshold variables to capture the model's non-linearity. We consider five candidates. The first group of threshold variables includes real GDP growth, inflation and the interest rate, to investigate whether the money demand remained linear over different business cycles. For example, agents may have been more sensitive to the inflation rate as an opportunity cost of holding money when it was high before 1995 than after it stabilized close to zero.

The second group of variables includes financial depth<sup>3</sup> and the level of income to capture the effect of the development process on money demand. For example, the deepening of financial markets broadens the choice of alternative assets to money, which is expected to make agents more sensitive to the interest rate when they demand money.

The LM linearity tests reported in Table 1 are performed for leads and lags,  $K = 1$  to 3. As in Choi and Saikkonen (2004), we reject the hypothesis of linearity if the LM test rejects the null for at least one value of  $K$ . Results in Table 1 indicate that linearity is rejected with some lags for all threshold variables tested, except for GDP growth.

The linearity tests allow us to make a quantitative comparison of the five threshold variables as potential explanations for the non-linearity in the money demand. Indeed, the "optimal" threshold variable is statistically the one that leads to the highest value of the linearity test (González *et al.*, 2005).

We find strongest evidence for financial depth as the optimal threshold variable. The liberalization and development of the Chinese financial market has been very progressive in comparison with the changes in the real economy (OECD, 2005). Therefore we interpret non-linearity of the money demand

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<sup>3</sup>Financial depth is  $\frac{M2-M1}{GDP}$ , lagged by one period to avoid simultaneity with M2.

triggered by our measure of the financial depth as follows: the discrepancy between financial and real development may have delayed the stabilization of money demand.

Second, the fact that inflation is a significant threshold variable suggests that the money demand changes over the different business cycles in China. More precisely, the money demand relationship changes along with the level of the inflation rate. This dynamic corresponds to the case considered in introduction, namely the relationship transits from one regime to another according to the level of the threshold variable. The estimation of the model will allow us to specify the inflation threshold triggering a regime change as well as to identify the different regimes.

In conclusion, for all transition variables tested, except one, linearity in money demand is rejected. This is novel result in studies on China. It provides a primary diagnosis for why it is difficult to implement an effective monetary policy, which is a common observation about China. An interesting extension would estimate the non-linear demand for money in China in a cointegrating STR model in order to provide more detailed recommendations.

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## Tables and figures

Table 1: Linearity test results for the Chinese money demand

Transition Variables	$T_1$			$T_2$		
	K=1	K=2	K=3	K=1	K=2	K=3
Financial depth	7.16*	7.96**	9.75**	7.92*	8.82*	11.46**
Inflation rate	5.37	6.61*	6.98*	5.67	7.04	7.89*
Real GDP	5.82	6.63*	7.44*	6.54	7.62	9.92**
Interest Rate	6.28	7.39*	8.40**	6.87	7.96*	9.95**
Real GDP growth	0.11	0.30	0.78	3.92	5.074	7.406

Notes: K denote the number of backward and forward lags in the auxiliary regression model. (\*): significant at the 10% level; (\*\*): significant at the 5% level.  $T_1$  (first-order Taylor expansion) and  $T_2$  (third-order) have the asymptotic chi-square distributions with three and four degrees of freedom, respectively.

Figure 1: Transition Function with  $c=0$ . Sensivity Analysis to the Slope Parameter  $\gamma$

