New Approach to Analyzing Monetary Policy in China

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Abstract

Any attempt to model monetary policy in China has to take into account two 'specifics' of the Chinese monetary policy: the reliance on several operational instruments, both quantitative (open market operations, discount rate, reserve requirement) and qualitative (selective credit allowances, window guidance etc.), as well as the combined strategy pursued by the People's Bank of China, i.e. the two intermediate targets - the exchange rate and the money growth. In this paper we analyze monetary policy in China using a small, three-equation New Keynesian model, considering these issues as follows: first, the qualitative instruments are estimated by using the Kalman filter, as no data on them exist. Then, a monetary-policy index is created as a weighted average of the quantitative and the qualitative instruments, which is in turn included in the model instead of the interest rate. Finally, the two intermediate targets (monetary growth and exchange rate) are included in the monetary-policy rule. Our results suggest that monetary authorities in China consider stabilizing inflation and output gap when making their decisions. Intermediate targets, in particular the growth of the monetary aggregates, appear to be important determinants of the monetary-policy behaviour, implying that their omission might be a serious drawback of any analysis. We also find that omitting the qualitative instruments can lead to wrong conclusions about monetary-policy conduct.

Keywords: New Keynesian model, China, monetary policy

JEL classification: E12, E43, E52

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1. Introduction

As the importance of the People's Republic of China for the world economy has been growing, so has economists' interest in the Chinese economy. Particular issues that have attracted interest by researchers, to name a few, include the incredible growth of the Chinese economy and its sustainability, the high share of investments in the growth, the necessary change in the Chinese growth model – from external-led to domestic-led, the exchange rate of the renminbi, the role of China in the international trade, the reform of the Chinese financial system.

At the same time, monetary-policy conduct and transmission still remain enduring research issues in central banks. Recent years have seen the New Keynesian model becoming progressively popular for the analysis of these topics. Its adoption as the backbone of the medium-scale models currently developed by many central banks and policy institutions is a clear reflection of its success. Examples include Smets and Wouters (2003 and 2007), Christiano, Eichenbaum and Evans (2005) and many others.

The aim of this paper is to investigate whether a New Keynesian model can provide a reasonable description of the Chinese[1] economy. However, the attempt to model Chinese monetary policy must take into account two issues. The first refers to the specific monetary-policy strategy that People's Bank of China (PBC) pursues, which can be best described as a combination of monetary targeting and exchange-rate targeting. The second refers to the battery of *instruments* that PBC is using in order to achieve its goals, which are both 'standard', or quantitative, like the interest rate of the open market operations, the discount rate and the reserve requirement, and 'non-standard', or qualitative, like selective credits or 'window guidance' (i.e. advising commercial banks about what they should do). These two issues are incorporated in the New Keynesian model as follows. First, the qualitative instruments are estimated (as there are no data on them) using the Kalman filter. Then, a monetary-policy index is created as a weighted average of the quantitative and the qualitative instruments, and then this new variable is included in the model, instead of the interest rate. Finally, the two intermediate targets (monetary growth and exchange rate) are included in the monetary-policy rule.

The rest of the paper is structured as follows. Section 2 briefly reviews the characteristics of the Chinese monetary strategy and surveys the existing literature on

1 China in this paper refers to Mainland China.

Chinese monetary policy. Section 3 sets the New Keynesian model in an estimable form for China. Section 4 discusses the methodology and the data used in estimating the model. Section 5 presents the estimation results and offers some discussion. The last section concludes.

2. Monetary policy in China: characteristics and a literature review

2.1. Description of monetary policy in China

The objective of the monetary policy in China, set by the Law of People's Bank of China, is maintaining price stability and promoting economic growth. To achieve these objectives, PBC uses money growth as an intermediate target (Goodfriend and Prasad, 2006; Xie, 2004; Liu and Zhang, 2007). At the same time, the parity of the renminbi is heavily managed – until 2005 it was fixed to the US dollar (with several revaluations), and since then it has been fixed to a basket of currencies (Goodfriend and Prasad, 2006). Consequently, the best description of the Chinese monetary-policy strategy would be that it is a combination of an exchange-rate targeting and monetary targeting. At the operational level, policy instruments at disposal to PBC to achieve these policy objectives include: i) *primary (quantitative) instruments*: central bank base interest rate, reserve requirement ratio, discount rate; and ii) *secondary (mainly qualitative) instruments*: central-bank direct selective (instructive) lending, re-discount rate, and other administrative policy instruments (including "window" guidance), specified by the State Council (Liu and Zhang, 2007; Goodfriend and Prasad, 2006; Xie, 2004). The operational instruments are used to achieve intermediate targets (money target and the restraint of the exchange rate) and, in turn, to achieve final targets (Geiger, 2006).

Some studies justify this type of intermediate-target setup in China (e.g. Laurens and Maino, 2007) by the current phase of economic development and the still-underdeveloped financial system. In this endeavour, some of them (Gerlach and Kong, 2005; Laurens and Maino, 2007) find statistically significant long-run relationship between money and inflation, which supports the utilization of the money target. Another strand of studies (e.g. Goodfriend and Prasad, 2006) asserts that the fixed exchange rate (to the US dollar until 2005 and to a basket of currencies thereafter), considerably restrained PBC from conducting independent monetary policy. This might be at odds with the money target, but the existence of capital controls, although evaluated as being not entirely effective, implies some room for independent monetary policy. The peg itself has been also controversial, especially during episodes of strengthened capital inflows which were constantly making appreciating pressures (Prasad and Wei, 2005). Again, the interaction with the money target was reconciled by enlarged sterilized interventions and a build-up of official reserves.

Despite these considerations, any deeper judgements on the appropriateness of the current framework (in terms of intermediate targets) are out of the aim of this study. Instead, our objective is to analyse the current monetary policy, given its setup. The setup is, therefore, important in this study only to the extent needed for appropriate modelling of the monetary-policy conduct.

Related to this, Liu and Zhang (2007) argue that the sole use of the reference interest rate in China would appear inadequate, due to the functionality and effectiveness of the interest-rate channel. Namely, Chinese economy is still characterized by increased financial-market segmentation, institutional weaknesses, structural impediments and dominance of state-owned banks (Liu and Zhang, 2007; Podpiera, 2006; Peng, *et al.* 2006), which build significant obstacles to achieving the final target(s) by sole reliance on PBC interest rate. Additional argument is the huge difference between the rate of return to capital in the Chinese economy, which is estimated at around 20% (see Bai *et al.* 2006) and the PBC interest rate, which is, roughly, around 5%. As a consequence, the interest rate (or, broadly speaking, the quantitative operational instruments) of PBC might be inadequate in achieving the final target of price stability.

Given these characteristics of the Chinese monetary policy, a model that investigates monetary policy in China should embed, at least, two important facets: i) the usage of two intermediate targets (the money growth and the nominal exchange rate); and ii) reliance on both quantitative and qualitative operational instruments for affecting intermediate targets and in turn final targets.

2.2. Review of the existing literature on Chinese monetary policy

Monetary policy in China attracted researchers' interest, but only one study (Liu and Zhang, 2007), to our knowledge, applied the elsewhere-standard New Keynesian model (NKM) to analyse Chinese monetary policy. This study analyzes the period 1990-2005 by simultaneously specifying an interest-rate rule, based on the reference interest rate, and a money rule. While this may be justified by the role of credit in the monetary-policy window, this approach has *two drawbacks*: first, it implicitly assumes that the central bank can control the supply of money, which is questionable given the high capital inflows and; second, it may be at odds with the conventional persuasion of not including equations that separate the intermediate from the operational target(s). The study uses equation-by-equation Generalized Method of Moments (GMM) to estimate the NKM whereby both adaptive and rational behaviour is allowed. The results are plausible; however, *the parameters within the interest-rate rule are not estimated but preset*[2]. Since coefficients in the interest-rate rule are not estimated, this study actually does not investigate how monetary policy in China is conducted.

Similar approach to modelling the Chinese monetary policy has been followed by other researchers as well. Mehrotra and Sanchez-Fung (2010) estimate both a McCallum rule (McCallum, 1988) and a Taylor rule (Taylor, 1993) over 1994-2008. In the McCallum rule, they regress growth of the monetary base on the output gap, inflation and the exchange rate. Their results indicate that monetary base responds negatively to output growth, as expected, but positively on inflation, which is counter-intuitive. The exchange rate is found insignificant. In the Taylor rule, only inflation appears significant, though only at the 10% and with very small coefficient. Based on coefficients' significance, they conclude that the McCallum rule is more appropriate for modelling Chinese monetary policy. Fan et al. (2011), again, investigate Chinese monetary policy both through the Taylor and the McCallum rule, finding that Chinese monetary policy responds to movements in inflation, output gap and the real exchange rate, mainly with the money supply and less with the interest rate, though the strength of the reaction is much smaller than in the developed economies.

The latter two studies would imply that Chinese monetary policy is better described by the McCallum rule than the Taylor rule. Some other studies go even further, by modelling Chinese monetary policy only through the McCallum rule, leaving aside the interest rate. Burdekin and Siklos (2006), for instance, argue that money as a target is consistent with the monetary strategy pursued by PBC in this period and "avoids relying upon interest rates that are neither liberalized nor a reliable barometer of the stance of monetary policy" (p.8). This might be an acceptable justification for the period considered, albeit the lack of information in the model contained within interest rates might be questionable, particularly if these were more frequently used for the policy conduct. This study augments the basic McCallum's rule by taking M2, besides money base, as a dependent variable, and, as additional regressors: the

[2] In this regard, the interest rate is parameterized to be relatively mild in combating expected inflation (coefficient of 0.15), but more forceful in preventing economy's overheating (coefficient of 0.51 on the contemporaneous output).

real exchange rate and the official reserves. Surprisingly, monetary policy responds pro-cyclically to output movements; the direction of exchange-rate movements is expectedly negative, while reserves are expectedly positive, but insignificant. Similar approach is followed by Chen and Huo (2009), who estimate a McCallum-type rule (which they call 'modified Taylor rule') using advanced modelling techniques (Markov switching and time-varying parameters) with the purpose to analyse breaks in Chinese monetary policy and expectation formation by the PBC.

Nevertheless, the empirical investigation of Kong (2008) concludes that monetary-policy behaviour in China appears closer to a Taylor-type rule than to a McCallum-type rule. Also, Zhang (2009) investigates whether the quantity (McCallum) rule or the price (Taylor) rule is more effective in managing the Chinese economy, in a dynamic stochastic general equilibrium framework, concluding that it is the latter one which is likely to be more effective. Jinwen and Hui (2006) find that their Taylor-type rule mimics well the Chinese interest rate.

To summarize, existing literature does not provide clear indication about the factors to which Chinese monetary policy responds. Even more importantly, there is no consensus on the appropriate way of modelling monetary policy in China: some studies propose clear Taylor rules; other, clear McCallum rules; third, the usage of both. Although the first group considers the McCallum-type rule to be more appropriate for modelling Chinese monetary policy (due to the fact that PBC explicitly targets money growth, as well as due to the weak interest-rate channel of the monetary transmission), herein we argue that this might be at odds with the modern monetary-policy analysis, since money growth represents an intermediate target, and not an instrument of monetary policy, whereas appropriate modelling requires evaluating the factors that influence the instrument itself, and since money growth is not entirely controlled by the Chinese central bank. Moreover, although the second group of studies considers Taylor-type rule to be more appropriate (mainly because of the persuasion that Chinese monetary policy has acquired some characteristics of inflation targeting), herein we argue that the still-reliance on intermediate targets prevents us from a straightforward usage of the Taylor rule. Consequently, we propose a new approach to modelling monetary policy in China, nested within the New Keynesian model, to capture the two specifics mentioned above – the palette of instruments that the PBC uses and the intermediate monetary-policy targets.

3. The model

3.1. Brief overview of the New Keynesian Model

The New Keynesian model (NKM) assumes that the economy consists of households, firms and the government. The behaviour of the households and the firms is modelled in a representative-agent framework, i.e. it is assumed that the aggregate behaviour of all households/firms can be characterized by only one representative household/firm. Agents are rational and forward-looking, and maximize an objective function (households – utility; firms – profits), subject to some constraints. Since agents are rational and forward-looking, the model is immune to the Lucas critique, i.e. is policy-invariant. The market is monopolistically competitive - there is an infinite number of firms which produce differentiated goods. It is further assumed that firms cannot, or do not want to, change their prices every period, which results in a price stickiness. Consequently, output and prices depend on the interest rate (i.e. monetary policy is non-neutral). Deriving the first-order conditions for the maximization problems of the households and the firms, log-linearizing them around the steady state of the model and solving the model afterwards, results in the first two equations of NKM – the IS curve, which defines output gap; and the Phillips curve, which defines inflation. The model is closed by a representation of the behaviour of the central bank (the government), which is usually assumed to set interest rates following a Taylor-type rule, where the interest rate depends on the deviation of expected inflation from target and the expected output gap[3]. Thus, NKM consists of following three equations:

IS curve: $$y_t = \alpha_1 Ey_{t+1} - \alpha_2 (i_t - E\pi_{t+1}) \qquad (1)$$

Phillips curve: $$\pi_t = \alpha_3 E\pi_{t+1} + \alpha_4 y_t \qquad (2)$$

Interest-rate rule: $$\Delta i_t = \alpha_5 (E\pi_{t+1} - \pi^*) + \alpha_6 Ey_{t+1} \qquad (3)$$

The IS curve defines the output gap (y_t) as a positive function of the expected output gap (Ey_{t+1}) and negative of the real interest rate (i_t-$E\pi_{\tau+1}$). The Phillips curve states that inflation (π_τ) depends positively on expectations about inflation ($E\pi_{\tau+1}$) and on the current

[3] The optimal monetary policy in this simple model is actually one where the interest rate depends only on the inflation (see Gali, 2008, Chapter 4), but NKMs are usually arbitrarily closed with a Taylor-type rule, since it is widely believed that a Taylor-type rule is a much better description of the reality.

Also, we use a rule in which the interest rate reacts to *expected* inflation and output gap, although in the original Taylor rule inflation and output appear with the current values.

output gap (y_t). The interest-rate rule states that the change in the nominal interest rate (Δi_t) depends on the deviation of inflation (π_τ) from the target (π^*) and on the output gap (y_t).

However, NKM has been developed for the US economy and is not entirely appropriate for China. Therefore, this model must be modified to fit Chinese economy. Since the primary interest of this paper is to examine the conduct of monetary policy, the first two equations are of second-order importance, through assuming that output and price-formation processes in China are not largely different from those postulated by the model. This might not seem to be entirely appropriate, given the discussion from above about the weak interest rate transmission, but through the estimated coefficients of the IS curve we would obtain rough information of how strong the transmission is. Our attention is focused on the interest-rate rule. The rule is modified: *firstly, in terms of the definition of policy instruments; and secondly, in terms of the modelling of intermediate targets.* The two aspects are analysed in the following subsections, respectively.

3.2. Monetary-policy index: rationale and construction

Since PBC uses several instruments to conduct monetary policy, it would seem inappropriate to model Chinese monetary policy by solely including the reference interest rate, ignoring the other instruments - the discount rate and the reserve requirement (we consider only these three quantitative instruments, since Goodfriend and Prasad, 2006, argue that these are the primary quantitative instruments). In support to this, if the coefficient of variation of the open market operations rate, discount rate and reserve requirement rate is calculated, treating the frequency of change of one instrument as a proxy of its usage, we obtain 0.49, 0.52 and 0.70, which indicates that the reserve requirement has been used most frequently, whereas open market operations least frequently in regulating liquidity in the system. In addition, as already noted, monetary policy in China is not conducted only through *quantitative* instruments, but heavily relies on *qualitative* instruments - selective credits, window guidance etc. As an illustration, in the period which is analyzed (1999-2009), there have been only seven occasions when at least one of the three quantitative instruments was changed, i.e. there were only seven monetary-policy movements, judging by the quantitative instruments. Although doing nothing can be also an effective monetary policy, seven monetary-policy movements in 10 years seem certainly few[4]. Hence, if one considers

[4] For comparison, during the same period, the main interest rate of the European Central Bank (the rate on the main refinancing operations) has been changed 32 times.

quantitative instruments only, a large part of the money-supply changes will remain unexplained (i.e. will be considered a corollary of exogenous shocks, which, in essence, are endogenous, i.e. coming from the monetary-policy itself, but with the utilization of the other, qualitative instruments).

Given this, we propose creating a *monetary-policy index*, as an approximation of the operational instrument of the monetary policy of China, consisting of both quantitative and qualitative instruments. However, the task to construct an index of this type is not easy, given that no data exist on the qualitative instruments in China. Thus, the qualitative instruments need to be empirically approximated. In this paper, they are obtained by the Kalman filter; this represents one contribution of the present research. The Kalman filter is an iterative algorithm, which can be used to estimate unobservable-components models. They consist of a measurement equation, which relates observable series to unobservable series, and a transition equation, which defines the dynamics of the unobservable series. In our model, the unobservable series is the qualitative instruments, and the transition equation defines them as an AR(1) process; whereas the measurement equation relates *the monthly rate of growth* of M2 (broad money) to the three quantitative instruments (open market operations rate, discount rate, reserve requirement) and the qualitative instruments. M2 and not M0 (monetary base) is chosen because qualitative instruments are likely to be reflected onto broad money, and not onto the base money, since with the qualitative instruments the central bank 'advises' commercial banks to undertake certain steps, without itself taking any significant action. Thus, the two equations are as follows:

measurement equation: $$m2=\beta_1+ \beta_2*omor+ \beta_3*dr+ \beta_4*rr+ \beta_5*qual+\varepsilon_1 \qquad (4)$$

transition equation: $$qual= \beta_6*qual(-1)+\varepsilon_2 \qquad (5)$$

whereby *m2* stands for the monthly percentage growth of the broad money, *omor* for the open market operations rate, *dr* for the discount rate, *rr* for the reserve requirement, *qual* for the qualitative instruments, and ε_1 and ε_2 for the two white-noise error terms.

This set-up assumes that the only variable affecting the monthly growth rate of M2 that can have AR(1) structure is qualitative instruments, and treats all other factors as shocks (i.e. white-noise). This could be problematic if some other factors that affect M2 could have AR(1) structure, too. The only important factor that might be characterized as such process is the GDP. Still, it is the level of GDP that might resemble AR(1) process, not the first-difference, and if GDP appears in our specification, it should appear with its first difference (since our dependent variable is the growth of M2). Therefore, it is likely that our AR(1) variable extracted by the Kalman filter could be treated as the qualitative instruments.

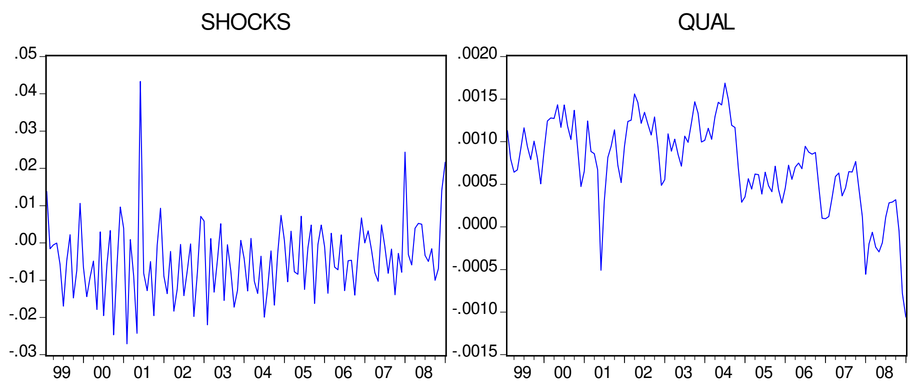
The results of the above model are:

$$m2=0.04 - 0.004*omor - 0.004*dr + 0.001*rr - 0.36*qual \tag{6}$$

$$qual= 0.57*qual(-1) \tag{7}$$

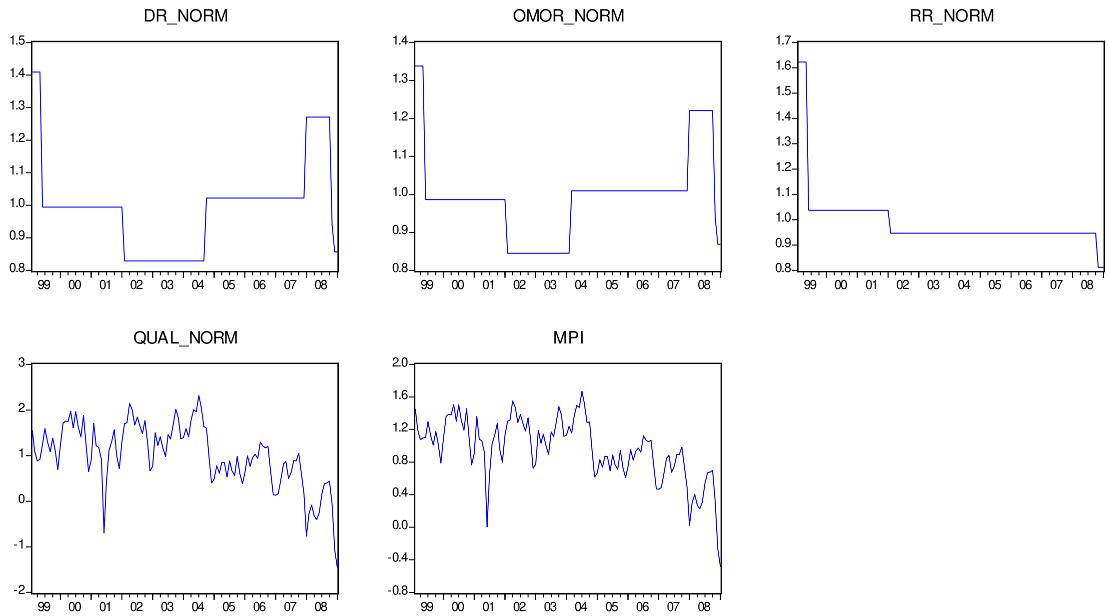
Quantitative instruments are insignificant and with very small coefficients, likely suggesting that they have exerted limited role in controlling money supply in China. This opposes the strand of the literature that solely relies on estimating or calibrating a simple interest rate rule for China. On the other hand, the coefficient on the qualitative instruments is fairly strong (0.36), implying that they exerted significant and stronge effect on the broad money growth. Qualitative instruments appear with a negative coefficient in the measurement equation, suggesting that an upward movement in the obtained series would imply monetary restriction. The autoregressive coefficient of the qualitative instruments in the transition equation is 0.57, signifying a moderate persistence. This is, plausible, since sudden changes in the quantitative instruments are not expected. Potential issue with the unobservable-component model might be the insignificance of all the coefficients. The reason might be the small sample size and the small variation in the variables. The qualitative instruments and the monetary-policy shocks (the residuals from the measurement equation) are shown below. They seem to be well-behaved: the shocks appear to be white noise, and the qualitative instruments in the second half of the sample point to a gradual easing in the monetary policy.

Figure 1: Qualitative instruments and monetary-policy shocks



Having obtained the qualitative instruments, the monetary policy index is created as follows: 1) the four instruments are normalized, i.e. divided by their sample mean to avoid units of measurements affecting results; 2) the coefficient of variation of the four instruments is calculated and their sum normalized to unity; 3) the monetary-policy index is calculated as a weighted average of the four instruments, using the normalized coefficients of variation as weights. The monetary-policy index (MPI) is shown below, alongside the four instruments. The normalized weights of the instruments in the monetary-policy index are: 0.115 for the open market operations rate; 0.141 for the discount rate; 0.140 for the reserve requirement rate; and 0.605 for the qualitative instruments, still confirming that qualitative instruments play an important role in the monetary-policy conduct.

Figure 2: Instruments of the monetary policy and the monetary policy index



The largest drawback of the use of a monetary-policy index for analysing monetary-policy conduct lies in its interpretation. While no doubts pertain to the qualitative relationship between the index and the other variables, the quantitative aspects of the relation might be more problematic. Namely, it is clear that the upward movement of the index would imply monetary tightening, but it is not clear how big tightening one index-point increase would imply. To gain insight about the magnitudes of the coefficients in the monetary-policy rule, these will be interpreted in terms of the standard deviations of the variables, i.e. how many standard deviations the dependent variable increases when the independent variable increases by one standard deviation (the descriptive statistics of the variables are shown in Table A-1, in the Appendix).

3.3. Estimable model

The second specificity that needs to be addressed when evaluating monetary policy in China is related to the intermediate targets. Given that China pursues a strategy of a *restrained exchange rate* and limited capital mobility, and *targets monetary growth* with the ultimate aim of low inflation and favourable economic growth, the interest-rate rule should include not only the inflation and the output gap. As argued in Section 2, the reliance on intermediate targets in China is still heavy. Hence, the interest-rate rule will be completed once the two intermediate targets (exchange rate and money growth), besides final targets (inflation and output), enter the equation.

Regarding this, there is no clear conclusion in the general economic literature about which variables should be included in the monetary policy rule. While many studies explicitly include the exchange rate, in one form or another, to account mainly for the usage of the exchange rate as an implicit or explicit target of monetary policy, the inclusion of any money target is greatly absent. The latter might be due to the progressive abandoning of money as a target at all, since its link with inflation has considerably weakened over time (see, for instance, Mishkin, 2002; Mishkin and Savastano, 2002). However, Taylor (2001) and Edwards (2006) express their scepticism on the merits of adding the exchange rate into the policy-rule function (and, by analogy, of adding money), because of the indirect role of the exchange rate (and, by analogy, of money) on inflation and output, and since its addition could add volatility to monetary policy (refer to further discussion in Mishkin and Schmidt-Hebbel, 2001). On the other hand, Mohanty and Klau (2004) estimate modified Taylor rules for 13 emerging and transition economies, complementing inflation, the output gap and lagged interest rates with current and lagged real exchange-rate changes. They find that the coefficients on the real exchange rate are statistically significant in ten countries, and that the policy response to exchange-rate changes is frequently larger than the response to inflation and output gap. Aizenman *et al.* (2008) also use a variant of a Taylor rule to test whether the interest rate responds to real-exchange-rate developments in emerging markets. They find that the exchange rate plays crucial role in the monetary framework of developing economies. Hence, in general and despite the warning of Taylor (2001) and Edwards (2006), these studies confirm that the exchange rate has a strong role to play in developing economies at least. Yet, no strong argument is available for money growth, but we believe that, given the specific setup of the Chinese monetary policy, its inclusion is critical.

Hence, following the discussion in Section 3.1, the construction of the MPI in Section 3.2 and the consideration of intermediate targets in this section, an "augmented" New Keynesian model will be estimated for China, as follows.

$$y_t = \alpha_0 + \alpha_1 y_{t+1} - \alpha_2 mpi_t + \varepsilon_t \tag{8}$$

$$inf_t = \beta_0 + \beta_1 inf_{t+1} + \beta_2 y_t + \eta_t \tag{9}$$

$$mpi_t = \gamma_0 + \gamma_1 inf_{t+1} + \gamma_2 y_{t+1} + \gamma_3 m2_{t+1} + \gamma_4 neer_{t+1} + \nu_t \tag{10}$$

whereby the same notations are used as before; *mpi* stands for the monetary-policy index constructed in Section 3.2; *m2* is the monetary aggregate M2; and *neer* is the nominal effective exchange rate of the remnibi. One should note that in the estimable model we assume perfect foresight, i.e. future values of the variables are used for the expectations. This is a common assumption in the literature.

One possible criticism to this specification of the monetary policy rule is that one would clearly expect to find a significant coefficient on the monetary aggregate, since the qualitative instruments were obtained exactly from the monetary aggregate, as a result of what they are likely to be correlated. While this might be a problem, we believe that it is not something that would invalidate our results. Interest rates (or monetary policy instruments in general) are always correlated with monetary aggregates, but still, this has not prevented researchers from including the money in interest rate rules (see Leeper and Roush, 2003, for a discussion on this).

4. Data issues and methodology

4.1. Data

Monthly data for the period 1999-M01 - 2009-M01 are employed, to obtain as many observations as possible. The dataset consists of five variables: industrial-production's year-on-year growth rate (*y*), year-on-year inflation (*inf*), nominal effective exchange rate (*NEER*), money (*M2*) growth and the monetary policy index (*MPI*), constructed as explained in section 3.2. All data, including those used in the construction of the monetary-policy index (the open market operations rate, the discount rate, the reserve requirement and the monetary base) are from the CEIC database, which in turn, draws the series from the International Monetary Fund and the People's Bank of China. The descriptive statistics for the data is given in Table A-1, in the Appendix.

Since the technique used, GMM (see Section 4.2), usually requires stationary data[5], at the outset, integration characteristics of the series are inspected in Table 1. Unit-root tests suggest that all variables, except the industrial production, are likely integrated of order 1. Therefore, these are differenced and as such included in the regressions. The plots of the variables, shown on Figure 3, are shown as a support of our decision.

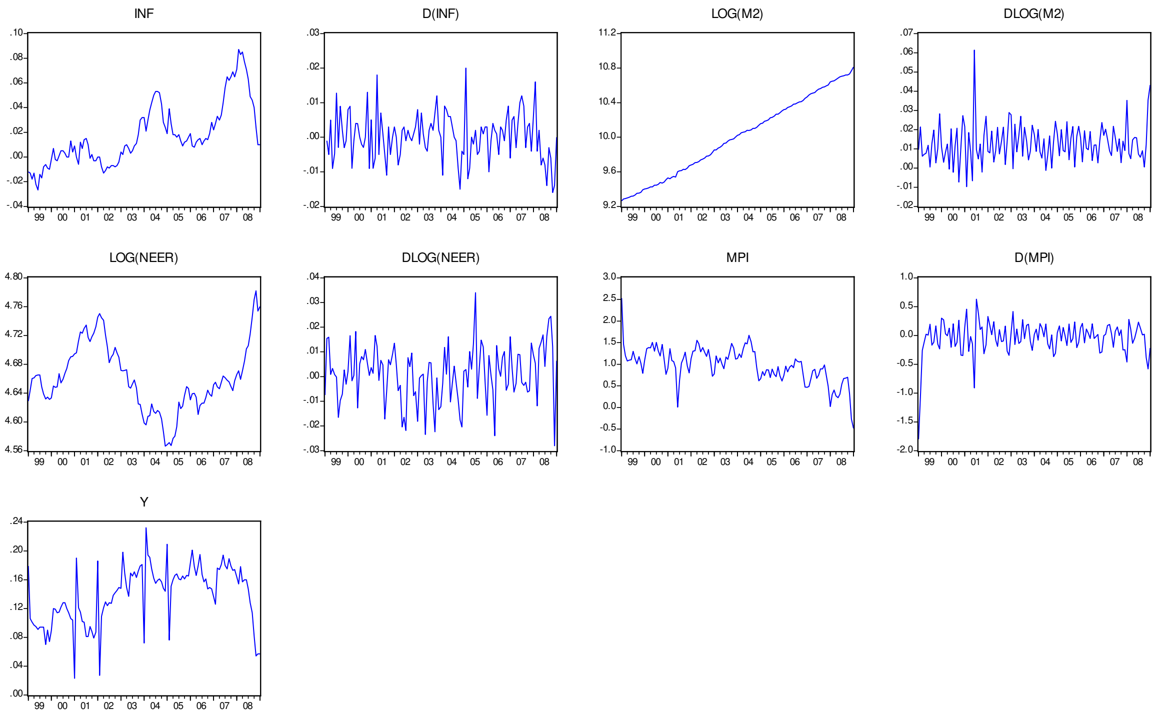
Table 1: Unit root tests of the variables used

Variable	ADF test	DF-GLS test	PP test	NG-Peron test
Y	-2.06	-1.70*	-6.75***	-6.40*
Inf	-1.69	-1.13	-1.86	-2.51
d(inf)	-9.96***	-9.82***	-9.93***	-69.03***
log(M2)	-3.6**	-1.25	-3.28*	-2.47
dlog(M2)	-6.92***	-10.14***	-13.43***	-112.00***
log(NEER)	-1.04	-0.95	-0.99	-3.09
dlog(NEER)	-8.54***	-3.23***	-8.54***	-13.34**
MPI	-1.7	0.79	-7.09***	-1.06
d(MPI)	-7.7***	-0.37	-16.4***	-0.3

*, ** and *** indicate rejecting the null of unit root at 10, 5 and 1% level, respectively.

[5] Technically speaking, GMM can be used even with non-stationary data. See Hamilton (1994, p. 424) for this.

Figure 3: Plots of the variables



4.2. Methodology

Given that three equations are estimated, whereby at least three variables are endogenously determined, we need an estimation method that takes into account the potential endogeneity, which causes inconsistency of the usual OLS estimates. The model is estimated using the Generalized Method of Moments (GMM), developed by Hansen (1982). Note that the model is estimated as a system of three equations, instead of estimating it equation by equation. This is done since the system estimation exploits cross-equation dependencies, and is expected to result in more efficient estimators, i.e. estimators with lower standard errors. The risk associated with a system estimator is that a misspecification of one equation translates into a misspecification of all the equations in the system. Thus, the modelling is cautious and the results of each of the equations are carefully examined.

A note on the instrumentation. As usual in the literature on NKMs and interest-rate rules, the set of instruments consists of lagged values of the regressors. This is justified as long as the error term in the equations is not correlated with the past values of regressors (which could cause weak identification). Whereas this seems plausible enough in the case of inflation and output gap, in the case of the interest-rate rule, this assumption implies that *monetary-policy decisions are rational*, i.e. that central-bank decisions incorporate all information that is available at the time when decisions are made, as a result of what forecast errors are uncorrelated with the available information (Boivin, 2006; Clarida *et al.* 2000). This is a standard assumption in the literature. Seven lags of the regressors are included as instruments, as in Clarida et al. (1998), and their validity is checked by computing the J test[6]. In the robustness section, these results are compared with the results when less or more instruments are used.

5. Empirical findings and discussion

At the outset, the specification given by equations (8)-(10), in which the monetary policy rule is entirely forward-looking, i.e. all the variables in it appear with a lead, is estimated. Results are shown in Table 2. Inflation and M2 appear with the wrong sign, while output gap and NEER have the correct sign but are insignificant. Because of this, this specification is discarded and both forward- and backward-looking behaviour of the monetary-policy rule is allowed in the next specification (Table 3).

Table 2: Results of the purely forward-looking specification for the monetary policy rule

IS curve			**Phillips curve**			**Monetary policy rule**		
y			**d(inf)**			**d(mpi)**		
Constant	0.015	***	constant	-0.003	***	constant	0.04	
Y	0.89	**	d(inf)	0.92	***	d(mpi(-1))	0.19	***
d(mpi)	-0.014	***	y	0.02	***	d(inf(+1))	-4.43	
						y(+1)	0.12	
						dlog(m2(+1))	-4.86	***
						dlog(neer(+1))	-0.86	
J test p value			0.93					
H_0: instruments are valid								

* indicates significance at 10%, ** significance at 5%, *** significance at 1%
the dependent variable in each equation is given in the heading row

[6] The null hypothesis in the J test is that the overidentifying restrictions for the instruments hold, i.e. often informally interpreted as a sign that the instruments are valid. When the p-value of the J-statistics is higher than 0.1, this is taken as evidence that the instruments are valid.

This mixed specification allows seeing if PBC responded to the movements in the past, current or expected values of the targeted variables. If the lag of, say, the inflation is significant, whereas the current value and the lead are not, this can be taken as evidence that the central bank has been backward-looking in terms of the inflation. Turning to the results in Table 3, the lagged inflation is significant, in contrast to the current value and the lead, as a result of what we decide to keep only the lags. Regarding the output gap, only the lag appears with the expected sign, because of what we discard the current value and the lead. The same is the case with the M2, while none of the NEER terms has the expected sign. Therefore, in the next specification, we include only lags of the variables in the monetary-policy rule (Table 4).

Table 3: Results of the specification with both forward- and backward-looking behaviour in the monetary policy rule

IS curve			**Phillips curve**			**Interest rate rule**		
y			**d(inf)**			**d(mpi)**		
constant	0.01	**	constant	0.00	**	constant	-0.09	***
y	0.94	***	d(inf)	0.93	***	d(mpi(-1))	0.62	***
d(mpi)	-0.02	***	y	0.02	***	d(inf(-1))	2.71	***
						d(inf)	0.09	
						d(inf(+1))	1.20	
						y(-1)	0.01	
						y	-0.16	*
						y(+1)	-0.29	
						dlog(m2(-1))	23.18	***
						dlog(m2)	-7.63	***
						dlog(m2(+1))	-3.62	***
						dlog(neer(-1))	0.43	
						dlog(neer)	0.73	
						dlog(neer(+1))	0.32	
J test p value			0.95					
H_0: instruments are valid								

* indicates significance at 10%, ** significance at 5%, *** significance at 1%
the dependent variable in each equation is given in the heading row

Table 4: Results of the backward-looking specification for the monetary-policy rule

IS curve			Phillips curve			Monetary policy rule		
y			**d(inf)**			**d(mpi)**		
constant	0.01	***	constant	0.00	**	constant	-0.50	***
y	0.92	***	d(inf)	0.87	*	d(mpi(-1))	0.95	***
d(mpi)	-0.01		y	0.02	**	d(inf(-1))	3.19	*
						y(-1)	0.53	*
						dlog(m2(-1))	32.25	***
						dlog(neer(-1))	-0.90	
J test p value			0.94					
H_0: instruments are valid								

* indicates significance at 10%, ** significance at 5%, *** significance at 1%
the dependent variable in each equation is given in the heading row

In this backward-looking specification, all variables have the a-priori signs and interpretation is focused on these results. The output gap coefficient in the ***IS curve*** is highly significant suggesting that economic agents in China are forward-looking, i.e. increase output when expectations are optimistic. The monetary-policy index coefficient in the IS curve is significant, too, but implies rather small dependence of the output on monetary policy – one standard deviation increase in MPI results in 0.08 standard deviations decline in the output. Both the future-inflation and the output gap coefficients in the ***Phillips curve*** are highly significant and with the expected signs; only the magnitude of the latter seems to be rather low.

In the ***monetary-policy rule***, the lagged MPI is significant, with a very high coefficient (0.95), which suggests strong monetary-policy smoothing. This might be a little surprising, given the low level of development of the financial market in China (see, e.g. Goodfriend and Prasad, 2006). Since all target variables appear with lags in the monetary-policy rule, the monetary-policy conduct has been likely backward-looking. The inflation coefficient is significant, in accordance with the existing literature (Jinwen and Hui, 2006; Kong, 2008; Chen and Huo, 2009), which in general finds that PBC considers inflation in its decisions. Still, its magnitude (3.2) implies only a weak monetary-policy response to inflation - one standard deviation increase of inflation leads to approximately 0.1 standard-deviations increase in MPI. Similarly, the output gap is significant, and when it increases by one standard deviation, monetary policy tightens by one-tenth of a standard deviation. This finding is in contrast with most of the existing studies, which, in general, find that monetary policy acts pro-cyclically (Burdekin and Siklos, 2005; Jinwen and Hui, 2006; Chen and Huo, 2009), but is certainly not implausible. Regarding the two intermediate targets, the M2, as expected, is highly significant, and with a magnitude that implies a rather strong reaction – one standard deviation increase in M2 growth leads to a 1.3 standard-deviation increase in MPI. This confirms that PBC indeed closely monitors monetary aggregates when deciding on the monetary policy. The NEER, on the other hand, is significant, but with a very small magnitude (one-standard-deviation appreciation of NEER results in only a 0.04 standard-deviation decrease in MPI), and in line with Mehrotra and Sanchez-Fung (2010).

Next, the results of the final specification (Table 4) are compared with the results obtained by including a monetary-policy index consisted solely of the three quantitative instruments[7] (Table 5).

Table 5: Results of the specification with only the quantitative instruments

IS curve			**Phillips curve**			**Monetary policy rule**		
Y			**d(inf)**			**d(mpi_quant)**		
Constant	0.01	***	constant	0.00	*	Constant	-0.01	***
y	0.91	***	d(inf)	0.81	***	d(mpi_quant(-1))	0.50	***
d(mpi_quant)	0.01	***	y	0.01	*	d(inf)	0.03	
						y	0.04	***
						dlog(m2)	0.37	***
						dlog(neer)	-0.45	***
J test p value			0.92					
H_0: instruments are valid								

* indicates significance at 10%, ** significance at 5%, *** significance at 1%
the dependent variable in each equation is given in the heading row

There are several important differences between results in Table 4 and 5. When quantitative instruments are used only, inflation is insignificant. Hence, if the analysis had not considered qualitative instruments, we would have wrongly concluded that PBC does not respond to inflation. The second difference in this specification (Table 5) vis-a-vis the one including the qualitative instruments (Table 4) is that NEER is highly significant, implying

[7] This index is constructed in the same way as the qualitative instrument, with weights equal to 0.29, 0.36 and 0.35 for the OMOR, DR and RR, respectively.

that abstracting from the qualitative instruments, one could easily conclude that PBC responds to movements in the exchange rate. Finally, in the specification with only the quantitative instruments (Table 5), reactions to inflation, the output gap and M2 are much smaller than in Table 4 – for illustration, one standard deviation increase in inflation, the gap and M2 imply 0.00, 0.03 and 0.07 standard-deviation increase in MPI, respectively, as compared to 0.1, 0.1 and 1.3 in Table 43, respectively. Needless to say, if we had not included the qualitative instruments in the monetary-policy index, findings would have been strikingly different and likely wrong.

Finally, to give further support to the results, a series of robustness checks are performed, given that the obtained results might be reflecting a combined effect of the specific method of estimation, the chosen variables, sample length etc. Only the interest-rate rule estimates are reported.

Table 6: Results of the robustness checks

	-1-		-2-		-3-		-4-		-5-	
	Results of the final model (Table 4)		**Shorter sample (without first and last year)**		**9 lags as instruments**		**5 lags as instruments**		**equation estimate**	
constant	-0.50	***	-0.37	***	-0.40	***	-0.45	***	-0.45	***
d(mpi)(-1)	0.95	***	0.81	***	0.87	***	0.83	***	0.92	***
d(inf)	3.19	*	0.18		4.00	***	2.44		-1.63	
Y	0.53	*	-0.28	*	0.01		0.31		0.20	
dlog(m2)	32.25	***	31.63	***	31.02	***	31.30	***	32.78	***
dlog(neer)	-0.90		1.07		-0.27		-0.31		0.07	
J test p value	0.94		0.93		0.96		0.97		0.96	
H_0: instruments are valid										

In the *sample-length exercise,* results of the final specification (Table 4) are compared with the results obtained with a shorter sample, i.e. when the first and the last years are excluded (Table 6, column 1). In the *number of instruments exercise,* nine and five lags are used as instruments to estimate the model (columns 3 and 4, respectively); recall, in the final specification, 7 lags of the variables were used. In the final robustness exercise, we investigate whether results differ when the policy rule is estimated *as a single equation, not as a system* (Table 6, column 5). The robustness exercises, in general, support previously discussed findings. However, note that inflation lost significance twice, and the output gap appeared insignificant in three checks (though it had a plausible magnitude in two of these three cases). All the other variables proved very robust.

6. Conclusion

The objective of this study is to investigate Chinese monetary policy through the basic three-equation New Keynesian model, explicitly accounting for the battery of instruments that the PBC uses and for the two intermediate targets of the Chinese monetary policy. Consequently, the monetary-policy rule in the estimable model included as the dependent variable a monetary-policy index that incorporates selective credits, "window" guidance and other qualitative instruments used to achieve the final targets, besides the interest rates. On the right-hand side, besides the final targets, the rule included M2 growth and NEER changes, as a reflection of the intermediate targets considered in the policy conduct in China.

Two important findings, largely absent from the empirical literature, emerge from the quantitative analysis. Firstly, two "construction" characteristics of the Chinese monetary policy are found essential: i) both quantitative and qualitative set of instruments of the monetary policy are estimated to be crucial for the conduct of monetary policy, with special emphasis on the power of the qualitative instruments in China; and ii) the inclusion of both intermediate targets (exchange-rate target and money-growth target) is essential in understanding the channel through which monetary policy operates. In addition, this characterization of the monetary-policy setup in China leads to the conclusion that PBC cares about stabilizing output and inflation. Moreover, the policy conduct is more dependent on money growth than on the exchange rate in attaining the final targets. These two essential findings regarding PBC policy were usually neglected within the literature and, hence, represent the main contributions to knowledge this paper makes.

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Appendix

Table A-1: Descriptive statistics of the variables

	D(INF)	DLOG(M2)	DLOG(NEER)	D(MPI)	Y
Mean	0.0002	0.0129	0.0011	-0.0251	0.1386
Median	0.0000	0.0120	0.0017	-0.0043	0.1480
Maximum	0.0200	0.0613	0.0340	0.6292	0.2320
Minimum	-0.0160	-0.0097	-0.0280	-1.0759	0.0230
Std. Dev.	0.0068	0.0101	0.0112	0.2424	0.0407