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What Determine China's Inflation?*

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What Determine China's Inflation?

Introduction

China's macroeconomic conditions experienced a rollercoaster ride at the wake of the global financial crisis in 2008-09. Affected by significant weakening of external demand, growth of real gross domestic product (GDP) moderated sharply from 10.6 percent year-on-year during the first quarter of 2008 to 6.1 percent during the first quarter of 2009. With the help of extraordinary stimulus measures, real GDP growth began to pick up, to 7.9 percent, in the second quarter of 2009 and accelerated further to 10.7 percent during the fourth quarter.

Equally striking was performance of consumer price index (CPI). Inflation was a major concern at the beginning of 2008, as CPI reached cyclical high of 8.7 percent in February. In order to contain inflation pressures, the People's Bank of China (PBOC) adopted various tightening measures, including hikes in interest rates, increases in reserve requirement, appreciation of the currency and even direct control of bank credit.

Entering the second half of 2008, however, CPI declined rapidly as global commodity prices fell and economic growth slowed. Price deflation re-emerged again at the end of 2008 and persisted during much of 2009. As a part of the expansionary package, new credit extension surged, amounting to CNY7.4 trillion during the first half of 2009 or equivalent to 150 percent of PBOC target for the whole year. This quickly gave rise to renewed concerns about potential inflation.

Intensifying the inflation worry, CPI returned to positive territory before the end of 2009 and recorded a surprising 1.9 percent in December. But economists' assessment of inflation outlook remains divided. Some argue that extraordinary loan growth in the preceding year implies much higher inflation. Others suggest that inflation pressures are likely to remain modest in the near future given existing overcapacity problems, pointing to 0.2 percent non-food CPI in December.

Should the central bank quickly rollback the expansionary monetary policies in order to maintain macroeconomic stability? This is a key question lies at the center of the policy debate in early 2010. Monetarists believe quantity of money is the single most important factor determining price levels in an economy. Structurists may argue that when productivity growth is strong and overcapacity problem widespread, monetary expansion may not always lead to high inflation immediately. Yet others worry about the spillovers from asset prices, such as housing and stock prices, to CPI.

In this study, we intend to address the key academic question relevant to the current policy debate: what determine inflation rates in China? We examine impacts of excess liquidity, output gap, housing prices, stock prices, real interest rate and real effective exchange rate on CPI inflation. The first two independent variables are conventional suspects of causes of inflation. And inclusion of interest and exchange rates should offer insights on these instruments' effectiveness in dealing with inflation problems in China.

In light of the debate about Greenspan's monetary policy, asset prices, CPI inflation and the subsequent financial crisis in the U.S., we also include housing prices and stock prices as potential determinants of inflation (Henderson and Hummel 2008, Greenspan 2009). Whether or not PBOC should take into account conditions of the asset markets has also become a subject of policy discussion in China. In order to better understand the behavior of asset prices, we take a step further to examine determinants of both housing and stock prices.

For the purpose of this study, we assemble a monthly time series data set for the period January 1998-July 2009. Most statistical data reported by the National Bureau of Statistics (NBS) are in year-on-year change terms. However, month-on-month data probably provide more accurate information about short-run momentum. We conduct detailed analyses for both sets of data.

Findings of this study are consistent with general expectations. Excess liquidity leads to inflation pressure and output gap also has positive impact on inflation. Asset prices have spillovers to CPI inflation, although the monthly impact trajectories are more complicated. Finally, there is no strong evidence that real interest rates and real effective exchange rates Granger cause lower inflation, although they do impact positively on asset prices. Most of the discovered effects occur within the first five months and disappear almost completely after 10-12 months.

This paper is organized as follows. The next section reviews existing studies on both international and Chinese cases and presents the central hypotheses of this study. The third section discusses the data set and outlines the methodology. The fourth reports empirical analyses applying the month-on-month change data. The fifth section summarizes findings of this study. And the final section discusses some possible ways of further improvement of the study and draws some useful policy implications.

The Hypotheses

Determinants of inflation are an ancient subject in economic literature. However, it was brought to new life in the twenty-first century as the global economy became awash with liquidity but CPI inflation remained generally stable. There has been a growing body of literature exploring this subject, especially the dynamic interactions among excess liquidity, asset prices and consumer prices. For the purpose of this study, here we provide a review of the literature on international experiences, with literature of the Chinese case incorporated in discussion of the hypotheses below.

Findings of the existing literature are mixed. For instance, through estimation of a global vector auto regression (VAR) model for 15 countries, Rüffer and Stracca (2006) confirmed that excess liquidity was a useful indicator of inflationary pressure at a global level. Baumeister et al (2008), applying a structured VAR framework, also discovered permanent impact of liquidity on price levels. Meanwhile, also using a global VAR model for developed countries, Belke and Orth (2007) found that significant increase in global money balances had not yet led to permanent rise in consumer prices.[1]

Results on correlation between asset prices and consumer prices are even more divided. Some suggest that asset prices had no impact on CPI inflation by pointing to the experiences of Japan in the 1980s and Britain in the 1990s. Based on both correlation and regression analyses, Cheick (2005) concluded that housing and stock prices could be useful indicators of future inflation, with six- to eight-quarter lags. At the same time, many studies using post-1953 American data revealed negative correlations between inflation and stock prices (Fama 1982).

Does excess liquidity always lead to asset boom? Bruggeman (2007) identified 40 periods of sustained excess liquidity between 1970 and 2005 and found that only about one-third of these periods were followed by an asset price boom. More interestingly, both Belke and Orth (2007), and Giese and Tuxen (2008) concluded that global excess liquidity had significant impact on housing prices, but not on stock prices.[2] Interestingly, while Belke and Orth found no direct effect of liquidity on CPI, they discovered spillovers from housing prices to consumer prices.

Based on the existing literature, we intend to take analysis of the Chinese case a step forward. First, we bring the data set more up-to-date. And currently our data series ends in July 2009. Second, most existing studies applied available data in year-on-year change terms. Our study provides detailed analyses of both year-on-year and month-on-month growth data as comparison. And finally, wherever possible, we include all potential determining variables of inflation in a single analytical framework, in addition to the usual causality tests.

Which factors determine China's inflation rates? This is the general research question we pose for this study. Specifically, we consider four sets of possible independent variables for explaining variations of China's inflation rates: excess liquidity, output gap, asset prices (housing prices and stock prices) and monetary policy instruments (interest rate and exchange rate). And we pose four specific hypotheses in this study:

- Large excess liquidity lifts inflation rate;
- Narrow output gap adds to inflation pressures;
- Strong asset markets push up inflation; and
- Interest rate hike and currency appreciation lower inflation.

If we do a survey of the policy debates on China's inflation, the above variables more or less provide an exhaustive list of the potential causes of inflation. The only exceptions are the so-called "imported inflation", i.e., inflation initially triggered by higher import prices for energy, food and other commodities.

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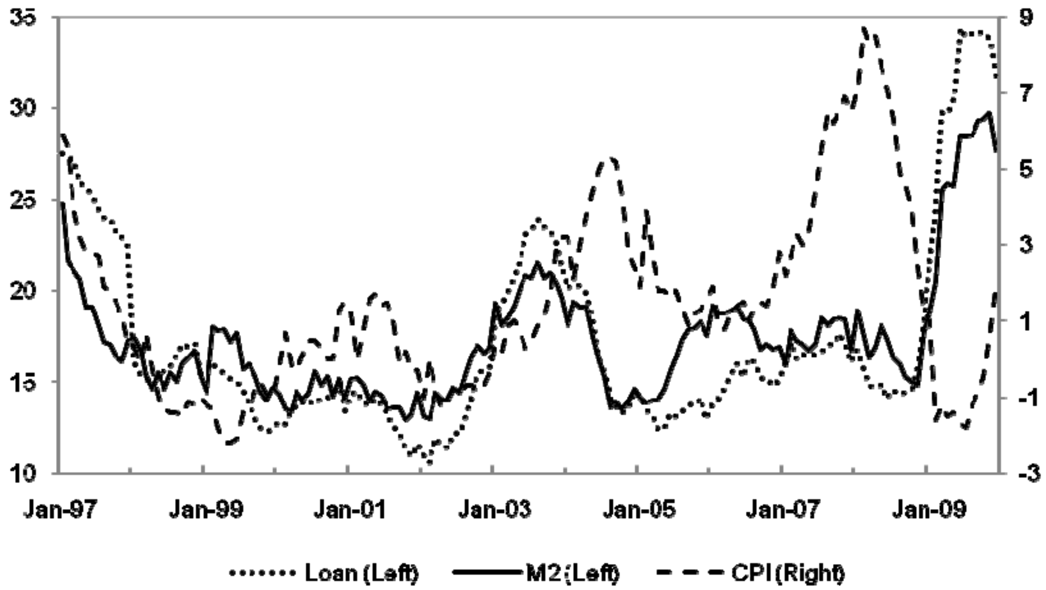
[1] The study by Belke and Orth (2007) applied the VAR framework by employing quarterly data for 18 industrial countries for the period 1984-2006.

[2] The study by Giese and Tuxen (2008) used quarterly data for 6 industrial countries for the period 1982-2006 for a VECM model.

We do not include these variables in this study for three reasons. One, we believe inflation rates are results of domestic economic variables. Imported inflation can only change relative prices if not accommodated by domestic macro variables. Two, higher international prices for food, energy and commodities in recent years were closely related to changing conditions of the Chinese economy. Although many call high international oil prices as "imported" into China, others view them as "exported" by China. And, three, distortions to domestic prices further complicate tasks of any quantitative exploration.

First, importance of excess liquidity for inflation is underscored by the "quantity theory of money" (Friedman 1987). The crudest form of the above theory states that price levels of an economy are determined by volume of money relative to volume of output.[3] This theory was behind recent repeated warnings by some prominent Chinese economists about potential inflation, given extraordinary growth of bank credit in 2009 (see, for instance, Zhou 2009). Indeed, causal observation of money supply, bank credit and inflation appears to suggest liquidity leading inflation in China (see Chart 1).

Chart 1. Growth of Money Supply (M2), Bank Loans and CPI in China, January 1997-December 2009 (% Year-on-Year)



Source: CEIC Data Company.

Some economists confirmed this causation using sophisticated quantitative frameworks. For instances, Zhang and Pang (2008), applying quarterly data between 1997 and 2007, concluded that excess liquidity had systematically imposed pressures on inflation. Likewise, Zhang (2009) showed that excess liquidity, ignited by dramatic capital inflows, was a significant driver for consumer price inflation in China during 1998-2007.

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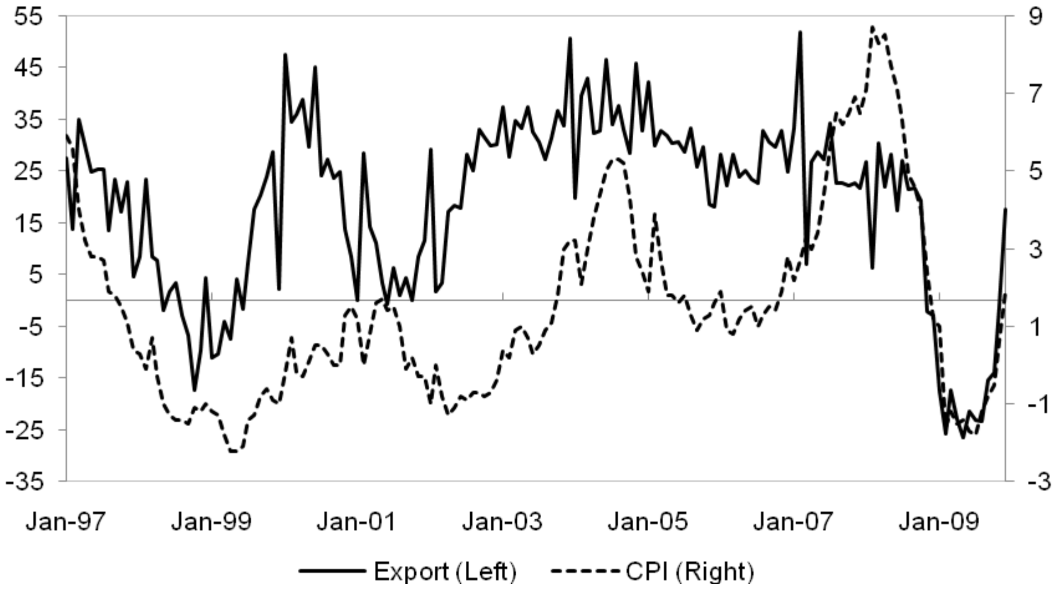
[3] The textbook formulae describing the quantity theory of money is: $M*V = P*Q$, where M is quality of money in circulation, V is velocity of money, P is price level and Q is real final expenditure.

But academic findings have not been consistent and uniform. For example, Li and He (2007) pointed out that excess liquidity did not result in resurgence of consumer price inflation up to April 2007. Makin (2007) explained the relatively low inflation rate between 2000 and 2006 as a result of expanding real money demand generated by fast economic growth, which was able to accommodate high money and credit growth. American experiences before the 2008-09 financial crisis also cast doubt if correlation between liquidity and inflation is always significant and positive.

Second, the hypothesis on output gap and inflation is developed from observations of the Chinese economy during the past decade (Huang et al. 2009). China suffered from deflation three times, in 1998-99, 2002 and 2008-09. All these periods coincided with significant weakening of external demand, as a result of Asian financial crisis, U.S. mild recession, and global financial crisis, respectively. A common theme during those time periods was CPI declines following significant slowdown of exports and, possibly, worsening of overcapacity problems (see Chart 2).

Chart 2. Growth of Exports and CPI in China, January 1997-December 2009 (% Year-on-Year)



Source: CEIC Data Company.

Intuitively, it is easy to explain the correlation between output gap and inflation. When output gap, which is defined as actual output minus potential output, lowers, overcapacity problem escalates. Competition pressures rise and producers are forced to cut prices in order survive. Therefore, it is possible at times when overcapacity problems overrule excess liquidity in determining inflation.

Third, asset prices may affect inflation through many different channels, either changes in aggregate demand, i.e., consumption and investment, or changes in information content about expected inflation (Cheick 2005). But these effects may not always work in the same direction. For instance, an increase in housing prices signals an increase in life time wealth for those who own properties, and should lead to an increase in consumption expenditure. But the part of the population that does not possess houses would, instead, cut down on consumption (Vickers 2000).

Empirical findings of the Chinese case are mixed. Han et al (2008) demonstrated that the relationship between stock returns and inflation changed over time: negative during 1992-1999 but positive correlation during 2000-2007. Zhang and Zhang (2008) found that the rise of house prices led to inflation in Shanghai but not in Beijing. Yu (2008) revealed that the effects of housing prices on inflation were stronger than those of stock prices. And, finally, Zeng et al (2008) discovered positive response of housing prices to inflation and negative correlation between interest rate and housing prices.

Other economists pointed out that asset prices are inherently volatile and are highly susceptible to changes in investor sentiment, quite independent of any change in the fundamental factors (Bernanke and Gertler 2000). Hence there may be little information contained in the housing or stock prices for forecasting future inflation. Therefore, causations between asset prices and inflation remain an empirical question.

And, finally, we also include interest rate and exchange rate variables in the inflation equation. Interest rate and exchange rates are the most common policy instruments for managing inflation problems in market economies. Some economists also argued that the undervalued renminbi (RMB) was the key cause behind China's high inflation pressure (Yu 2008). Others, however, question the effectiveness of these instruments given China's quantitative controls over liquidity and nature of state-owned enterprises, which might not always respond sensitively to changes in interest rates and exchange rates.

Methodology and Data Set

We assemble a set of time series data from January 1998 to July 2009, including consumer prices (CPI), excess liquidity (LIQ), output gap (GAP), exports (EXP), housing prices (HSP), stock prices (STP), real interest rate (INR) and real effective exchange rate (REER). And analyses are conducted with both year-on-year and month-on-month growth data.

Given the nature of time series data, the first step of the analyses is to conduct unit root test. Interestingly, we find the year-on-year growth variables are non-stationary I(1) but the first order differences are stationary I(0). We therefore conduct the Johansen co-integration test to identify the long-run equilibrium relations between the key variables by applying the following model:

$$\Delta X_t = c + \sum_{j=1}^{p-1} \Gamma_j \Delta X_{t-j} + \beta \cdot \alpha' X_{t-1} + \upsilon_t$$

where X is a vector of variables, α is the co-integration vector, which implies the long run equilibrium relationship among the variables, and β is the matrix of adjusting coefficients which indicates the convergence speed of a variable to its equilibrium state when suffered from an outside shock.

The month-on-month change variables are stationary. However, since macroeconomic variables often influence each other, ordinary least square (OLS) regressions may suffer from endogeneity problem. In order to avoid this problem, we apply the structural vector auto-regression (SVAR) method in this study and the model can be specified as:

$$AZ_t = C + \Phi(L)Z_{t-1} + \varepsilon_t$$

where Z is vector of all variables, $\Phi(L) = \Phi_1 + \Phi_2 L + \cdots + \Phi_p L^{p-1}$ is the polynomials in lag operator of order p-1. $\varepsilon_{t_{n\times 1}}$ is the structural error term such that $E\{\varepsilon_t\} = 0, E\{\varepsilon_t \cdot \varepsilon_t'\} = (\sigma_i)_{n\times n}, i = 1,2,\cdots n$, which is a diagonal matrix. $E\{\varepsilon_t \cdot \varepsilon_s'\} = 0 \text{ if } t \neq s$.

By multiplying A^{-1} on both sides, we obtain the reduced form of SVAR:

$$Z_t = \Gamma_0 + \Gamma_1 Z_{t-1} + e_t$$

where $\Gamma_0 = A^{-1}C$, $\Gamma_1 = A^{-1}\Phi(L)$, $e_t = A^{-1}\varepsilon_t$. The variance-covariance matrix of e_t is

$$E\{e_t \cdot e_t'\} = \Sigma = (v_{ij})_{n\times n}$$

Following Amisano and Giannini (1997), the class of SVAR that MLE estimates can be written as:

$$Ae_t = \varepsilon_t = Bu_t$$

where u_t is the normalized unknown structural innovation such that $E\{u_t \cdot u_t'\} = I$. The assumption of orthonormal innovations u_t imposes the following identifying restrictions on A and B:

$$A\Sigma A' = BB'$$

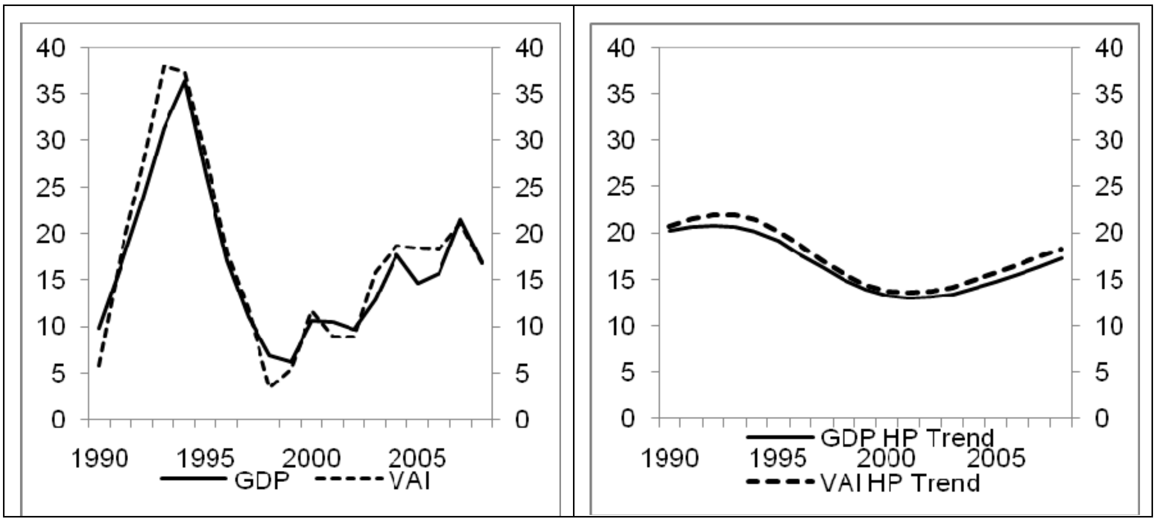
To obtain consistent estimations of the structural parameters, we first estimate the reduced form VAR, and then impose identification constrains to estimate SVAR parameters and structural impulse responds function.

And, finally, based on SVAR results, we calculate impulse response function to gauge the dynamic reactions among the variables.

NBS has most data for the variables needed for this study. CPI is consumer price index. STP is Shanghai A-share price index. HSP is the national average housing price index. And EXP is total national exports. With the exception of STP, all other indicators are normally reported in year-on-year growth terms. We first obtain additional information from the statistical system to calculate the levels of these variables. Then we apply seasonable adjustment to these series. And finally we calculate seasonally adjusted year-on-year or month-on-month growth rates.

Excess liquidity (LIQ), normally is measured by the ratio of M2/GDP (Zhang and Pang 2008). And LIQ's change rate may be calculated by subtracting nominal GDP growth rate from broad money supply (M2) growth rate. However, since we are using monthly data and there is no information on monthly GDP, we instead subtract nominal industrial growth from money supply growth. This approach may not be perfect, but a quick examination of GDP and industrial production suggest that the two variables show fairly synchronized movements (see Chart 3).[4]

Chart 3. GDP and Industrial Value Added: Growth Rates and Trends, 1990-2008 (%)



Source: CEIC Data Company.

Output gap (GAP) is defined as the percentage change of real industrial production relative to its HP trend. Thus, the higher the GAP, the less the overcapacity problem of production. Export (EXP) variable is also included, which may serve as a reasonable substitute for GAP but may also contain additional information in explaining behavior of CPI inflation.

There are several candidates for the interest rate variable: interbank rates, government bond yields or base lending rates. Each of them has its own advantages and disadvantages in terms of measuring the actual costs of capital in China. So far, however, both the interbank markets and government bond markets are not very liquid. And the base interest rates remain the most important interest rates in China. Therefore, we choose the one-year base lending rate as the representative interest rate in this study.

We adopt the real effective exchange rate index calculated by Citigroup as the representative variable for exchange rate. This is an average exchange rate index based on bilateral trade weights, adjusted for both domestic and overseas inflation rates.

Summaries of statistical descriptions of both year-on-year and month-on-month variables are reported in the Appendix (Appendix Tables A1 and A3).

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[4] Normal growth of industrial production is calculated as a product of real growth of industrial value-added and producer price index, both of which are directly available at the NBS data base.

Estimation Results Using Year-on-Year Growth Data

In this section we present results from empirical estimation using year-on-year growth data. We first employ ADF test to determine orders of the unit root in every variable. According to the ADF test, we then employ Johansen co-integration test to determine the number of co-integration vectors and identify the long run equilibrium relations among variables. Finally, based on Johansen Co-Integration test, we build vector error correction model (VECM) and examine the short run dynamic causal relationships between variables through VEC Granger Causality test.

Before building VECM model, we need determine the order(s) of the unit root in every variable. Only if all the variables are integrated of the same order, co-integration analysis is valid. ADF test results show that all the variables except output gap are integrated of order one, I(1), and the first order difference of every I(1) variable is stationary (see Table A2 in Appendix). Lag orders are determined based on minimizing Schwarz information criterion (SIC).

In order to identify long run determinants of inflation, we adopt HSP, STP, LIQ and EXP as explanatory variables for CPI.[5] To determine the lag orders, we first estimate level VAR which uses the original series (not the differenced series). Then the lag orders used in Johansen co-integration procedure are chosen by minimizing the information criterion, SIC as before. Co-integration test and the diagnostic check among CPI, HSP, STP, LIQ and EXP confirm that the model is well fitted (Table 1).[6]

Since there is only one co-integration relation, we normalize the coefficient of CPI to 1 and identify this relation as CPI equation. LIQ, HSP, STP and EXP are significant at 1% significant level (Table 2).[7] All the variables are consistent with our hypothesis. In the long run, large liquidity, rising asset prices and export lead to high inflation, defined by the following equation:

$$CPI_t = -0.073 + 0.223HSP_t + 0.041STP_t + 0.358LIQ_t + 0.132EXP_t + u_{c,t}$$

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[5] During our exercises initially we also included real exchange rates and real effective exchange rates as independent variables of CPI. However, both variables performed poorly in the CPI equation. Therefore, only report the results without these two explanatory variables.

[6] Both of the trace statistic and maximum eigenvalue statistic imply unique co-integration relation. LM test for serial autocorrelation shows that we cannot reject the null hypothesis that there is no serial correlation in residual matrix at 5% significant level. JB test for normality shows that residual vectors follow joint normal distribution at 5% significant level. Therefore, residual diagnostic check implies the model is fitted well.

[7] Note that since variables in co-integration equation are non-stationary, traditional t-test is invalid and we shall use Likelihood Ratio (LR) testing the co-integration vector. Significant test statistics about the adjustment coefficient follows standard distribution for co-integration equation as a whole is stationary.

Table 1. Johansen Cointegration Test and Diagnostic Check

H_0	λ_{trace} Statistic test			H_0	λ_{max} Statistic test		
	H_1	statistic	critical value		H_1	Statistic	critical value
r=0	r>0	92.12**	76.97	r=0	r=1	51.65**	34.81
r≤1	r>1	40.47	54.08	r=1	r=2	19.96	28.59
r≤2	r>2	20.5	35.19	r=2	r=3	13.03	22.3
r≤3	r>3	7.48	20.26	r=3	r=4	6.53	15.89
r≤4	r>4	0.95	9.16	r=4	r=5	0.95	9.16
Residual diagnostic check							
LM test for AR(1): P-value of Chi-square statistic=0.708							
JB test for Normality: P-value Chi-square statistic=0.527							

Note: "**" denotes significant at 5% significant level.
Source: Authors' estimation.

In other words, *cetris paribus*, a 1 percent increase in the growth of excess liquidity, house price, stock price and export would, respectively, increase CPI by 0.36 percent, 0.22 percent, 0.04 percent and 0.13 percent increase in CPI inflation. However, stock, excess liquidity and export are considered weak exogenous variables given that their adjustment coefficients are statistically insignificant (Table 2).

Table 2. Inflation Equation and Adjustment Coefficient estimation

CPI	HSP	STP	LIQ	EXP	C
Cointegration Equation					
1	-0.223***	-0.041***	-0.358***	-0.132***	0.073***
Ajustment Coefficinet					
-0.095***	0.291**	-0.723	0.244	0.327	
(-0.019)	(-0.120)	(-0.421)	(-0.136)	(-0.361)	

Note: "***", "**" and "*"denote significant at 1%, 5% and 10% significant levels, respectively.
Source: Authors' estimation.

Base on the co-integration analyses above, we build ECM model and then apply VEC Granger Causality test on differentiated variables to examine the short run dynamic causal relationships. The ECM model for CPI equation is as follows:

$$\begin{aligned}\Delta CPI_t = {} & -0.095CoEQ_t + 0.261\Delta CPI_{t-1} - 0.139\Delta CPI_{t-2} + 0.032\Delta CPI_{t-3} \\ & - 0.036\Delta HSP_{t-1} + 0.015\Delta HSP_{t-2} - 0.003\Delta HSP_{t-3} - 0.002\Delta STP_{t-1} \\ & - 0.008\Delta STP_{t-2} - 0.004\Delta STP_{t-3} - 0.109\Delta LIQ_{t-1} - 0.074\Delta LIQ_{t-2} \\ & - 0.026\Delta LIQ_{t-3} - 0.002\Delta EXP_{t-1} - 0.011\Delta EXP_{t-2} + 0.005\Delta EXP_{t-3} \\ & + e_{c,t}\end{aligned}$$

where COEQ is the co-integration equation part.

VEC Granger Causality Test results confirm that housing price, stock price, excess liquidity and export are Granger causes of CPI inflation (Table 3). This means that these factors are linearly informative in predicting CPI inflation. But the reversal causal relationship does not hold. Furthermore, variance decomposition shows that excess liquidity is the most important factor other than CPI itself to explain the variance of differenced CPI, which on average, accounts for 12.69% of CPI variance. Export, house price and stock price account for 6.4%, 1.73% and 0.15%, respectively.

Table 3. VEC Granger Causality Test

	△CPI	△HSP	△STP	△LIQ	△EXP
△CPI	—	0.253	0.149	0.184	0.145
△HSP	0.003***	—	0.652	0.536	0.372
△STP	0.012**	0.001***	—	0.605	0.129
△LIQ	0.000***	0.345	0.831	—	134
△EXP	0.025**	0.345	0.025**	0.173	—

Note: the null hypothesis is that variable in the column does not Granger cause the variable in the row. "***", "**" and "*"denote significant at 1%, 5% and 10% significant levels, respectively.

Estimation Results Applying Month-on-Month Growth Data

We now turn to analysis of the month-on-month growth data. The ADF test suggest that, with the exception of real interest rate (INT) and real effective exchange rate (REER), all month-on-month variables are stationary, I(0) (Table A4). For this reason, we use the first order difference of INT and REER in models to be constructed later in the paper.

To identify the structural parameters in the SVAR model, we first estimate the reduced form VAR. The lag orders are determined according to the information criteria, SIC. Since the aim is to estimate the structural parameters and the parameters in the reduced form do not have economic interpretation, for saving space, we do not report the VAR estimation results here.

Based on the VAR estimation, we can conduct Granger Causality test to check the short run dynamic relations among the variables (Table 6). In summary, output gap, exports, excess liquidity, housing prices, stock prices, and first-order differences of both interest rate and exchange rate all Granger cause CPI. Output gap, stock prices and interest rates Granger cause housing prices. But only exchange rate Granger causes stock prices.

In the estimation procedure of the Structural VAR, the key step is to set the identification constraints for the structural parameters. We do this by resorting to theoretical considerations. Our rationale is as follows: the monetary authority usually adjust the level of interest rate according to price levels; this change in interest rate will probably result in changes in saving, investment and real effective exchange rate through capital flow; as such, liquidity and export change; investment and export will lead to movement of output; furthermore, movement in real sector will influence asset prices; therefore, changes in real sector and asset prices lead to inflation movement.

Table 6. VAR Granger Causality Test Results/Block Exogeneity Wald test

	CPI	GAP	EXP	LIQ	HSP	STP	△reer	△r
CPI	—	0.00***	0.31	0.42	0.42	0.31	0.83	0.00***
GAP	0.00***	—	0.03**	0.95	0.07*	0.35	0.06*	0.00***
EXP	0.01**	0.64	—	0.37	0.06*	0.28	0.23	0.01***
LIQ	0.05***	0.38	0.53	—	0.56	0.88	0.55	0.66
HSP	0.85	0.94	0.16	0.59	—	0.89	0.86	0.93
STP	0.02**	0.54	0.14	0.31	0.07*	—	0.63	0.31
DREER	0.53	0.04	0.85	0.57	0.46	0.04**	—	0.40
DINT	0.10*	0.07*	0.05**	0.04**	0.06*	0.29	0.09*	—
All	0.00***	0.06*	0.02**	0.56	0.20	0.52	0.12	0.00***

Note: the null hypothesis is that variable in the column does not Granger cause the variable in the row. "***", "**" and "*"denote significant at 1%, 5% and 10% significant levels, respectively.
Source: Authors' estimation.

Our logic is supported by the results of Granger causality test shown (Table 6). We set the order of the variables in SVAR as DINT, DREER, LIQ, EXP, GAP, STP, HSP and CPI. In order to identify the structural parameters, we need to set certain constraints. Granger causality test sheds some light on this. Consider house price(HSP) and stock price(STP), real effective exchange rate(REER) and output gap(GAP) do not Granger change HSP and STP in the sense of predictive information. Therefore, we set the coefficients of REER and GAP to zero in the equations of HSP and STP, respectively. Then we set the identification constraints as:

$$A=\begin{bmatrix} a_{11} & 0 & 0 & 0 & 0 & 0 & 0 & a_{18} \\ a_{21} & a_{22} & 0 & 0 & 0 & 0 & 0 & 0 \\ a_{31} & a_{32} & a_{33} & 0 & 0 & 0 & 0 & 0 \\ a_{41} & a_{41} & a_{43} & a_{44} & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & a_{55} & 0 & 0 & 0 \\ a_{61} & 0 & a_{63} & a_{64} & 0 & a_{66} & 0 & 0 \\ a_{71} & 0 & a_{73} & a_{74} & 0 & a_{76} & a_{77} & 0 \\ a_{81} & a_{82} & a_{83} & a_{84} & a_{85} & a_{86} & a_{87} & a_{88} \end{bmatrix}, \quad B=\begin{bmatrix} b_1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & b_2 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & b_3 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & b_4 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & b_5 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & b_6 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & b_7 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & b_8 \end{bmatrix}$$

After setting the identification constraints, we use Maximum Likelihood Estimation (MLE) to estimate A and B, then we can identify the following structural equations:

$$\begin{aligned} CPI_t = & -0.0005 - 0.003HSP_t + 0.001STP_t + 0.01GAP_t + 0.001EXP_t + 0.011LIQ_t \\ & - 0.013DREER_t - 0.935DINT_t + 1.064CPI_{t-1} + 0.005HSP_{t-1} + 0.003STP_{t-1} \\ & + 0.004GAP_{t-1} + 0.0006EXP_{t-1} + 0.007LIQ_{t-1} - 0.002DREER_{t-1} \\ & + 0.061DINT_{t-1} + \varepsilon_{8,t} \end{aligned}$$

$$\begin{aligned} HSP_t = & \, 0.002 + 0.032STP_t + 0.01EXP_t + 0.101LIQ_t - 0.468DINT_t + 0.359CPI_{t-1} \\ & + 0.145HSP_{t-1} + 0.021STP_{t-1} + 0.065GAP_{t-1} - 0.052EXP_{t-1} + 0.121LIQ_{t-1} \\ & - 0.145DREER_{t-1} - 0.217DINT_{t-1} + \varepsilon_{7,t} \end{aligned}$$

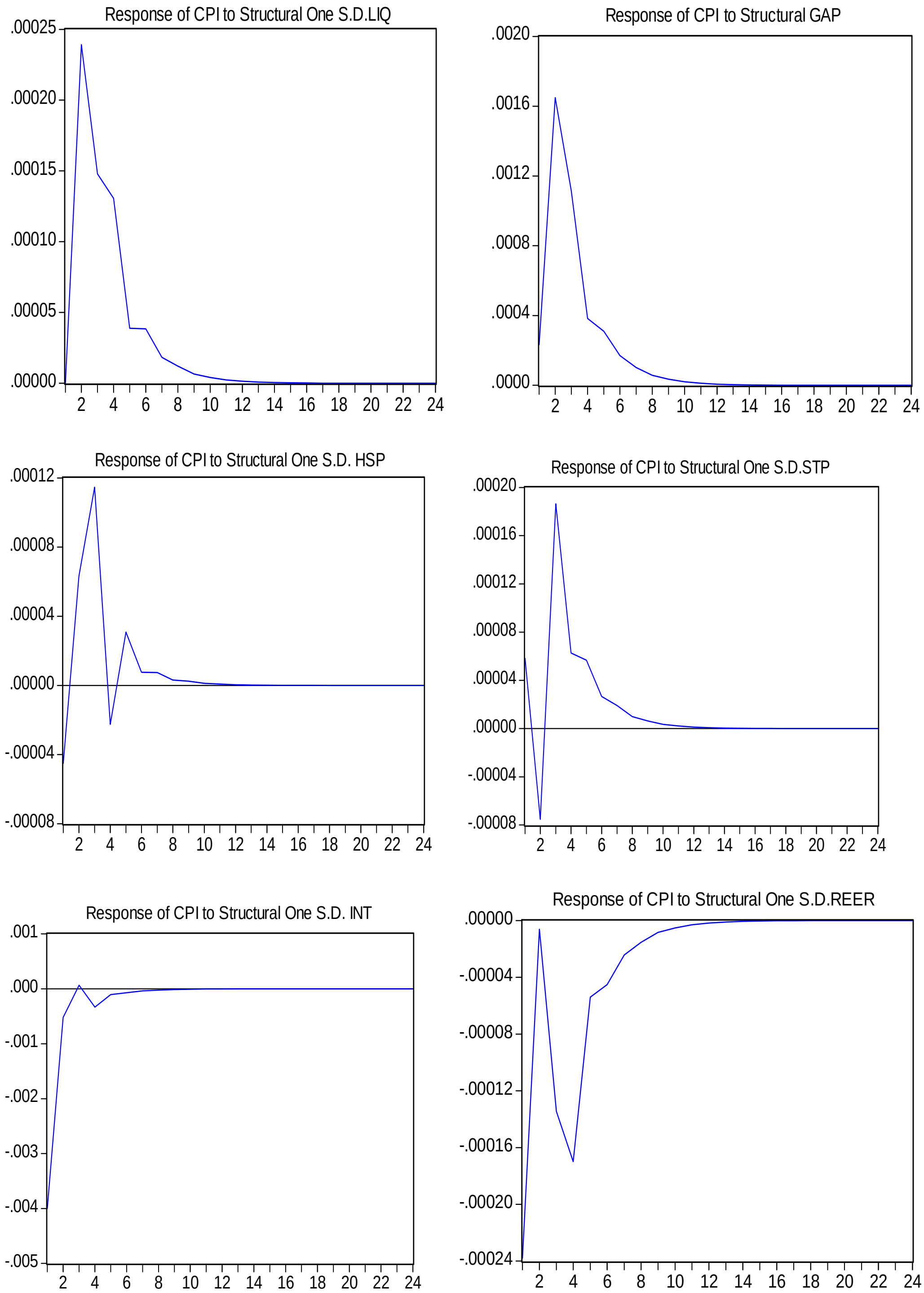
$$\begin{aligned}STP_t = &-0.002 - 0.12EXP_t + 0.254LIQ_t - 3.644DINT_t + 5.70CPI_{t-1} + 0.219HSP_{t-1} \\ &+ 0.129STP_{t-1} - 0.374GAP_{t-1} - 0.097EXP_{t-1} + 0.21LIQ_{t-1} \\ &- 0.781DREER_{t-1} + 2.791DINT_{t-1} + \varepsilon_{6,t}\end{aligned}$$

Based on the SVAR model estimated above, we generate CPI impulse responses to one standard deviation in LIQ, EXP, GAP, STP, HSP, DINT, and DREER, respectively (Chart 4). Most of the impact of the various shocks on CPI occurs within the first 5 months, and after 10 months both accumulated and marginal impulse responses are very small and almost unchanged.

It is found that impulse of excess liquidity and output gap has similar impact on CPI growth. The impact gets to its peak after one period and then decline sharply. Initially CPI growth corresponds to a shock in stock price positively but the marginal responses turn to be negative in the second month and positive again in the third month. But house price growth impact CPI growth negatively initially, and then marginal effects turn to be positive in the second month and peak at the third month. In addition, real interest rate and real effective interest rate have negative effects on CPI.

Moreover, structural variance decomposition shows that excess liquidity and output gap are the two most important factors to explain the variance of CPI inflation, which on average, account for 22.24% and 33.17% of CPI variance. However, housing price and stock price, on average, account for 0.06% and 1.38% of CPI variance.

Chart 4. Impulse Responses of CPI to External Shocks



Source: Authors' estimation.

Summary of the Findings

Inflation has been a constant macroeconomic risk for China since economic reforms began in the late 1970s. High inflation in 1988 contributed at least in part to political instability in early 1989. In 1994, 2004 and 2007, inflation also risked destabilizing macroeconomic conditions. And, again in early 2010, even though the global economy barely started to recover, inflation is already the subject of contentious policy debate in China.

In this study, we took a step back from the heated policy discussion by asking a more fundamental question: which factors determine China's inflation? Through careful quantitative exploration of the Chinese data, we hope to gain better understanding about factors influencing inflation trajectory. Such understanding should help improve our abilities in predicting future inflation and recommending sensible policies.

We include four sets of explanatory variables for inflation in China: excess liquidity, output gap, asset prices (housing and stock prices), and policy instruments (interest rate and exchange rate). Liquidity is probably the single most important determinant of inflation, according to economic theory. Past experiences, however, suggest that structural factors such as overcapacity may also play an important role.

Correlations between asset prices and inflation and their implications for monetary policy are a new hot topic for discussion, especially after onset of the U.S. financial crisis in 2008-09. Critical questions have been raised about the need for PBOC to pay attention to asset prices when making monetary policy decisions. Finally, we also include interest rate and exchange rate variables to see if these instruments are effective measures managing inflation problems in China.

We gathered a set of monthly data from January 1998 to July 2009. We first calculate the levels of economic indicators and then compute both year-on-year and month-on-month growth data, having conducted seasonal adjustment. NBS conventionally reports year-on-year growth data for most economic indicators, although month-on-month data probably offer more information about current momentum. We analyze the two sets of data in this paper to provide comparison.

According to ADF test, the year-on-year growth variables are non-stationary I(1), but the first order differences are stationary I(0). Therefore we apply the Johansen cointegration approach to identify the long-run equilibrium relations between inflation rate and other variables. We then build ECM model and apply the Granger Causality test to examine short-run dynamic causal relations.

The month-on-month growth variables are stationary, with the exception of interest rate and exchange rate. Therefore we first estimate the reduced form of VAR, based on which we conduct Granger Causality test to check the short-run dynamic relations. And then we identify parameters of the structural VAR, based on which we generate impulse responses of CPI to one standard deviation of the explanatory variables.

Findings from two sets of examinations are generally consistent with each other. According to the estimated long-run equilibrium relation based on year-on-year data, a 1 percent increase in excess liquidity, housing price, stock prices and exports would, respectively, lead to increase in CPI by 0.35 percent, 0.22 percent, 0.04 percent and 0.13 percent. Statistical tests also confirm excess liquidity, exports, housing prices and stock prices Granger causing inflation in the short-run dynamics.

Again, statistical tests, based on VAR estimation employing month-on-month growth data, also confirm excess liquidity, output gap, exports, and stock prices Granger causing inflation in the short-run dynamics.

The direct effects of real interest rates and real effective exchange rates on inflation are complicated. These two policy instruments in general do not Granger cause inflation, although real interest rate was found causing inflation at 10 percent significance level, in the case of month-on-month data. Surprisingly, evidences of CPI Granger causing changes in real interest rates were much stronger statistically.

Such results should be interpreted with caution. Since the authorities still pay a lot of attention to the quantity variables of monetary policy (such as bank loan and money supply), the price variables (such as interest rates and exchange rates) could become non-binding. Therefore, it is possible that liquidity measures are often still more effective in controlling inflation in China. But we shouldn't assume that interest rates and exchange rates are not effective. At least interest rates and exchange rates do affect housing prices and interest rates affect stock prices. Both asset prices have important spillovers on inflation. But the findings also suggest that further reforms of the monetary policy system is necessary.

The impulse response analyses find that shocks to excess liquidity, output gap, exports, housing prices and stock prices have positive accumulated impacts on CPI. Interestingly, most responses occur within the first five months and gradually disappear after 10 months. While both housing prices and stock prices have generally positive impacts on inflation, the monthly trajectories are more complicated with negative effects in some months. Overall, according to structural variance decomposition, output gap and excess liquidity have the largest effects on inflation while housing prices have the smallest effect.

Concluding Remarks

Before drawing any policy implications, we should be aware of the shortcomings of the analyses in this study. One methodological problem is with the Granger causality test. The test only identifies time sequence of different events. To be certain about the actual causal relations, we need to conduct large number of experiment. That, however, is beyond the scope of this study.

A more fundamental drawback is quality of data, especially price data. During the past decade, NBS made important efforts to improve quality of statistical data. But there are still evidences about biases of the official data, particularly the GDP data. CPI inflation is widely believed to be under-reported. One possible cause is that the computed rental equivalent only accounts for a little over 10 percent of the CPI basket, while the actual spending is much higher. Distortions to housing price index are, perhaps, even greater.

In this study, we employ official data for the analyses as we do not have the resources to correct the possible distortions. Therefore, one possible improvement on this study is to gather more reliable information, including through collection of survey data, to adjust the official data. Another possible progress is to explore the dynamic interactions among inflation, excess liquidity and asset prices. We plan to deal with that in a separate paper.

Nevertheless, findings of this study should help enhance our understanding about the inflation picture in China. The empirical analyses provide unambiguous confirmation about excess liquidity, output gap, housing prices and stock prices causing inflation. So long as the central bank is concerned about potential inflation, it should not sit idle when excess liquidity surges. According to findings of this paper, largest response of inflation to liquidity occurs within 2-3 months.

Practical experiences, however, suggest that CPI may not always follow liquidity sensitively. This may be because overcapacity is capping prices, like what happened in 1998-98 and 2008-09 in China. We find output gap variable has greater impact on inflation than most other variables.

Therefore, the fact that high inflation did not materialize in 2009 following surge of liquidity should not be taken as evidence that "quantity theory of money" doesn't work in China. It's simply because effects of excess liquidity and effects of overcapacity offset each other. In fact, we can confidently predict that as overcapacity problems begin to ease following recovery of exports, inflation pressures are likely to mount rapidly.

More importantly, when CPI is capped by overcapacity, large liquidity may fuel asset bubbles. In the U.S. before the current financial crisis, cheap and abundant liquidities boosted housing prices, while CPI remained stable. In China in 2009, extraordinary credit expansion also pushed up housing prices across the country, but CPI continued to decline due to widespread overcapacity. According to traditional macroeconomic theory, the central bank should do nothing as long as CPI is stable.

But asset bubbles could eventually destabilize macroeconomic conditions. This study confirms positive spillovers from asset prices to CPI. So it's only a matter of time. The recent American experiences also indicate that eventual collapse of asset bubbles could have major adverse effects on consumption, investment and prices. Therefore, PBOC should at least monitor and possibly intervene in the asset markets, when necessary, in order to maintain macroeconomic stability.

Finally, limited effectiveness of interest rates and exchange rates suggest that, at least for now, PBOC should probably focus more on liquidity conditions in controlling inflation. Interest rates and exchange rates are still useful instruments, possibly through their influences on asset prices. More importantly, PBOC should accelerate reform of the monetary policy system, transitioning from over-reliance on quantity control to interest rate- and exchange rate-centered policy system. But this requires market-based interest rates and exchange rates.

Appendix: The Data Set and Test Results

This Appendix describes the data set assembled for this study and reports the ADF test results. The variables are defined as follows:

CPI: Consumer price index change;

GAP: Difference between actual real industrial production and its HP trend;

EXP: Export growth;

LIQ: Difference between money supply (M2) growth and nominal production growth;

HSP: Change in national housing price index;

STP: Change in Shanghai A-share price index;

INT: One-year base lending rate adjusted for CPI; and

REER: Change in real effective exchange rate index of renminbi.

With the exception of STP, INT and REER, all variables are reported in year-on-year percentage change forms. Therefore, we first obtain additional information to calculate level readings of individual variables and conduct seasonal adjustment. Finally we calculate two separate sets of data: one year-on-year change and the other on month-on-month change. The following tables provide summaries of statistical descriptions and ADF test results.

Table A1. Summary of Statistical Description of the Year-on-Year Variables

	Obs	Mean	Median	Max	Min	S.D.
CPI	139	0.0142	0.0100	0.0870	-0.0220	0.0254
GAP	139	-0.0006	-0.0051	0.0680	-0.1083	0.0259
EXP	139	0.1938	0.2390	0.5170	-0.2640	0.1714
LIQ	139	0.0348	0.0208	0.2223	-0.0931	0.0510
HSP	139	0.0656	0.0611	0.2055	-0.1805	0.0747
STP	139	0.1581	0.0078	2.2371	-0.7095	0.5434
INT	139	0.0461	0.0470	0.0920	-0.0120	0.0240
REER	139	0.9959	0.9940	1.1430	0.8870	0.0596

Source: Authors' calculation based on data assembled for this study.

Table A2. ADF Test of the Year-on-Year Variables

	Type	Lag orders	ADF statistic	Critical value
CPI	c,0	3	-1.9167	-2.8828
△CPI	0,0	2	-5.5989	-1.9422
LIQ	c,0	3	-0.6083	-2.8828
△LIQ	0,0	1	-10.9805	-1.9422
STP	c,0	2	-2.6767	-2.8827
△STP	0,0	1	-5.9737	-1.9422
HSP	0,0	3	-1.7158	-1.9422
△HSP	0,0	2	-8.0482	-1.9422
EXP	c,0	2	-1.0199	-2.8828
△EXP	0,0	1	-12.5713	-1.9422
INT	c,0	3	-1.8789	-2.8828
△INT	0,0	2	-6.8013	-1.9422
REER	c,0	3	-1.4866	-2.8828
△REER	0,0	2	-6.653	-1.9422
GAP	c,0	3	-5.5729	-2.8828

Note: c denotes the intercept term, t the linear trend, and 0 no such term.
Source: Authors' estimation.

Table A3. Summary of Statistical Description of the Month-on-Month Variables

	Obs	Mean	Median	Max	Min	S.D.
CPI	139	0.0012	0.0007	0.0190	-0.0104	0.0049
GAP	139	-0.0006	-0.0051	0.0680	-0.1083	0.0259
EXP	139	0.0156	0.0047	0.2682	-0.2816	0.0753
LIQ	139	0.0128	0.0124	0.0472	-0.0528	0.0113
HSP	139	0.0062	0.0062	0.1057	-0.0548	0.0226
STP	139	0.0106	0.0091	0.3241	-0.2248	0.0832
INT	139	0.0591	0.0571	0.0890	0.0395	0.0091
REER	139	0.9959	0.9940	1.1430	0.8870	0.0596

Source: Authors' calculation based on data assembled for this study.

Table A4. ADF Test of the Month-on-Month Variables

	Type	lag orders	ADF statistic	critical value
CPI	c,0	1	-7.2466	-2.8825
LIQ	c,0	1	-8.5252	-2.8825
STP	c,0	1	-5.6369	-2.8825
HSP	0,0	1	-8.7126	-2.8825
EXP	c,0	1	-12.1354	-2.8825
INT	c,t	4	-3.0099	-3.4437
△INT	c,0	2	-9.0086	-2.883
REER	c,0	1	-1.5364	-2.8825
△REER	0,0	0	-11.6538	-1.9422
GAP	c,0	3	-5.5729	-2.8828

Note: c denotes the intercept term, t the linear trend, and 0 no such term.
Source: Authors' estimation.

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