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Monetary Dynamics of Inflation in China

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Abstract

This paper investigates both the short-run and the long-run relationships between monetary growth and inflation in China between 1980 and 2010. We construct multivariate dynamic models based on Friedman's quantity theory of money (but permitting money to be endogenous) and Meltzer's monetarist model. The empirical results provide robust evidence that there is a bilateral causal relationship between monetary growth and inflation as well as between monetary growth and output growth. An indirect and implicit causal relationship between monetary growth and inflation is found through the asset inflation channel. There are also long-run equilibrium relationships among money stock, price index, and other relevant variables. The present paper further provides a historical exploration of the mechanism of the monetary dynamics of inflation in China over the underlying period. We conclude that the monetary growth rule is likely to be the most promising policy orientation for China to manage its inflation.

JEL Classification: E31, E52, E58

Keywords: Inflation, Money, Monetary Policy, Cointegration

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1. Introduction

The idea that inflation is associated with the growth of money is one of the oldest and most established propositions in economics. Macroeconomists have repeatedly observed that prolonged increases in prices (and thereby inflation) are associated with increases in the nominal quantity of money. Friedman (1963) sums up the prevailing evidence and proposes that inflation is always and everywhere a monetary phenomenon. There is a vast amount of literature on the relation between monetary growth and inflation, mostly long-run relation analysis in nature[1]. Grauwe and Polan (2005) divide the literature into three groups based on the data frequency, countries, and sample periods involved in the relevant studies. A common finding in the articles surveyed by Grauwe and Polan (2005) is that monetary growth is positively correlated with inflation in the long-run. Representative studies are largely dominated by the experiences in the United States and other developed countries, presumably because this relationship originated from the United States and standard models often work less well in developing countries.

However, recent co-movement between inflation and monetary growth in China reminds researchers that inflation in China may also be a monetary phenomenon. Studies focusing on China's inflation dynamics, nonetheless, provide little consensus on this topic. For example, Chow (1987) and Blejer *et al.* (1991) suggest that China's inflationary process was a monetary phenomenon while Peebles (1992) argues that money is unlikely to be a significant driving force for inflation in China. To re-examine the relationship between money and inflation in China, Hasan (1999) constructs a "true price index" and finds a reliable long-run relationship between the "true price index" and the money stock, as well as between inflation and monetary growth. Although the "true price index" may be a useful proxy for the price index of China's economy in the pre-reform era (since it was developed for a highly centrally-planned economy), it is difficult to show the merits of using such a price index during post-reform China when the economy was greatly decentralized.

In this paper, we investigate the relationship between monetary growth and inflation in China by developing multivariate dynamic models based on conventional monetarist theories with officially published consumer price index (CPI) inflation data from 1980 to 2010. By so doing, the present research seeks to enrich the empirical branch of the literature that studies the relationship between money and inflation but that is largely long-run analysis in nature. In addition to the conventional quantity theory, we also investigate the topic through a monetarist model featuring dynamic interactions among money, real capital assets, and consumer price inflation. More importantly, most published articles use low frequency data (e.g. annual data), which substantially smooth out potential useful information that is embedded in higher frequency data; by contrast, we examine the money–inflation link using quarterly data throughout the empirical analysis. We also choose not to use annual data because with annual data most economic relationships (especially in short-run analysis) are likely

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[1] See Lucas (1980), Geweke (1986), Stock and Watson (1988), Hasan and Taghavi (1996), King and Watson (1997), Dwyer and Hafer (1999), Bachmeier and Swanson (2005), and Zhang and Pang (2008), to name a few.

to become simply contemporaneous owing to temporal aggregation.

As a result, this paper adds several useful contributions to the literature. First and foremost, we find that China's inflation, based on official data, is a monetary phenomenon in both the short-run and the long-run. Second, we find direct causal links between monetary growth and house price inflation, and between house price inflation and consumer price inflation. The causal relationship between monetary growth and consumer price inflation is indirect and implicit through the asset inflation channel proposed by Meltzer (1995). Third, unlike the existing literature (e.g. Hasan and Taghavi, 1996) that supports a one-way causality from broad money to real income, we find that there is also causality from real output to money, which depicts the important nature of monetary policy reaction function in China in the 1980–2010 period. The baseline findings are robust to various model specifications as well as to alternative measures for prices, real economic slumps, and monetary aggregates.

The remainder of the paper is organized as follows. The theoretical background of the study is discussed in section 2, very briefly, as it is familiar material which considers both Friedman's quantity theory of money (QTM) and Meltzer's (1995) monetarist model. Section 3 describes the data and shows the stylized facts of the correlations between monetary growth and inflation in China. Section 4 discusses and rationalizes the empirical results of the underlying models. Section 5 investigates the relationship between the long-run components of monetary growth and inflation and examines the interrelationship between money stock and price index using a co-integration methodology to delineate both long-run and short-run relationships. Section 6 discusses the mechanism of the monetary dynamics of the inflation process in China over the past three decades. Section 7 provides a summary and conclusion.

2. Theoretical Considerations
a. Friedman's Quantity Theory of Money

The view that inflation is essentially a monetary phenomenon began with Friedman's (1956) famous QTM, followed up later in Friedman (1970)[2]. Although a common interpretation of Friedman's QTM is that inflation is always and everywhere a monetary phenomenon over a sufficiently long period of time (e.g. Grauwe and Polan, 2005), the QTM is not necessarily confined to the long-run *per se*. At issue is how the theoretical model is interpreted when applied to empirical analysis. Therefore, the validity of both long-run equilibrium and short-run dynamics becomes an empirical issue.

In essence, the quantity theory identity in the rate of growth form at time period t can be written as

$$p_t + y_t = m_t + v_t \tag{1}$$

where p, y, m, and v are the proportionate rates of change in price level, real income, quantity of money, and money velocity, respectively. The best-known and simplest way of converting this identity into a theory is to assume that the velocity of money is

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[2] The idea that inflation is associated with money may be traced back to David Hume's 1752 essay "Of Money" which investigates the link between monetary growth and inflation (Dwyer and Hafer, 1999).

constant. The assumption of constant velocity provides approximation in many situations, and we follow this assumption in the present analysis[3].

Since money velocity is assumed to be constant, equation (1) can be written as

$$p_t = m_t - y_t \tag{2}$$

The foregoing identities indicate that in the long-run there is a proportional relation between inflation and monetary growth and that a permanent increase in the monetary growth leaves output (and velocity) unaffected. If there is a positive effect of monetary growth on output, it only holds in the short-run but not in the long-run, which is the well-known neutrality of money.

The theoretical specification of equation (2) is, of course, highly stylized. To specify an empirical model for the analysis of short-run dynamics with monthly or quarterly data, we need to consider the institutional length of price contracts in the real world. In addition, at a relatively high frequency, the contemporaneous timing of the annual equation (2) becomes less tenable given real-world recognition, processing, and adjusting lags. Taking into account the real world lags, equation (2) can be reformulated as:

$$p_t = \alpha(L)m_{t-1} - \beta(L)y_{t-1} \tag{3}$$

where $\alpha(L) = \alpha_1 + \alpha_2 L + \alpha_3 L^2 + \ldots + \alpha_n L^{n-1}$ is a polynomial in lag operator L with n as an optimal lag length which in practice can be specified by standard information criteria, and $\beta(L)$ is defined analogously.

Note that within the quantity theory framework it is conventional to treat output (and its detrended value) as exogenously determined by factors such as technological change, the characteristics of the labor force, and other variables that are largely independent of the quantity of money and prices. This assumption, especially since Friedman's statement of the natural rate hypothesis, is now regarded as a characteristic of the long-run when prices can be more realistically assumed to be fully flexible and expectations can be assumed to be correct. If this assumption is incorporated into the model, however, we are by implication developing a model that applies only to the analytic long-run and which we would therefore expect to be consistent with the long-run average rather than with short-run data.

More controversially, quantity theorists often treat the quantity of money as exogenous, mainly on the grounds that it is ultimately influenced by monetary authorities. This assumption is somewhat controversial because in some circumstances, notably when exchange rates are fixed and barriers to trade are stable (as in China), money supply could be an endogenous variable, and one would expect monetary growth to hover around an average, although there may be some room for independent monetary policy even in these circumstances. Even where these circumstances do not apply, for example, when exchange rates are flexible and as a result money supply can in principle be exogenously determined, the authorities may not so determine it.

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[3] Even if money velocity is not a constant, it may be squeezed into the disturbance term in empirical work. Therefore, this assumption presumably does not affect our empirical analysis.

Therefore, estimating equation (3) directly may induce biased estimates due to the potential endogeneity of the underlying variables in the model. In effect, these variables are more likely to be endogenously determined within a dynamic interaction system, especially in the short-run. For example, the growth rate of money supply may respond to the rate of inflation and the growth rate of the real economic slump, as articulated by Stock and Watson (2007). Likewise, the growth rate of real output in the short-run may also be affected by inflation rate and the growth rate of money supply.

Therefore, the empirical model for the QTM employs a vector autoregressive (VAR) system that is simple but can capture the dynamic interactions properly among the underlying variables. To be specific, the system can be written as

$$X_t = \Phi(L)X_{t-1} + \varepsilon_t, \tag{4}$$

where X_t is a vector time series incorporating the endogenous variables，$\Phi(L)$ denotes the vector polynomial of the lag operator with the optimal lag order determined by information criteria, and ε_t is a vector shock.

The empirical representation of Friedman's QTM above, together with variations appearing in the literature, also suggests some limitations to the stylized theory. First, the trivariate VAR model (4), based on the QTM, only comprises money, price, and output, which may not be able to fully capture the institutional features of a reforming transition economy such as China. It may be worth taking the effect of international prices and exchange rates on domestic inflation or domestic demand into account. Second, and perhaps more fundamentally, theory at this level gives no guidance as to the measurement of the quantity of money. Of course, it also gives no guidance as to the empirical definition of price level. These various issues will be addressed in the robustness analysis in section 4.

b. Meltzer's Monetarist Model

Another useful framework for examining the relation between monetary growth and inflation is Meltzer's (1995) monetarist model, which is essentially the asset inflation channel of monetary transmission. Although both Milton Friedman and Allan Meltzer are described as monetarists, the analytical frameworks of their respective theories remain distinct. Friedman's QTM features a direct link between monetary growth and aggregate price inflation in an economy, while Meltzer's (1995) monetarist theory underscores an indirect connection between monetary growth and inflation with real capital asset price being the intermediation.

The framework in Meltzer (1995) was originally used to analyze the monetary policy transmission process. The model highlights the interactions among three assets, namely money assets, securities assets, and real capital assets[4]. We note that the housing or real estate market has become an important real asset market as an intermediation that connects monetary growth and inflation in China since China's housing market reform in 1998.

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[4] The bonds market in Meltzer's framework covers securities traded in both open market operation of central banks and held by the public.

Therefore, we also utilize Meltzer's (1995) model to analyze the possible causal relationship between monetary growth and inflation in China over the particular period since 1998 when China commenced profound urban housing reforms. Meltzer's (1995) model contains the three assets: money, securities, and real capital (houses). Money is a nominally denominated asset that provides real services as a medium of exchange; securities are nominally denominated assets that yield the rate of interest, and real capital yields a real return. The model determines two relative prices to achieve asset market equilibrium for the economy. The movements in asset market equilibrium also disturb the output market, which depicts aggregate price changes in terms of aggregate demand and aggregate supply.

Meltzer's (1995) model highlights the important effects of monetary growth on the prices of equity and real estate. According to the theory of this asset inflation channel, expansionary monetary policy leads to higher equity prices, which make investment more attractive (through Tobin's q), thus raising aggregate demand. Higher equity prices also raise aggregate demand. In principle, the link between increased money supply and higher equity prices can be argued from either a monetarist or Keynesian perspective. In the former, an increase in money raises consumer wealth and asset prices, and hence spending on household and enterprise assets, whereas in the latter, the increase in money lowers interest rates and makes equity markets more attractive.

Overall, Meltzer's (1995) monetarist theory suggests that monetary growth may eventually lead to aggregate price inflation via real capital asset price or equity price changes. Accordingly, the implications for testing the theory are similar to Freidman's model by fitting VAR models with monetary growth, asset price inflation, and consumer price inflation.

3. The Data and Stylized Facts
a. Data Description

The data used in this paper are chosen to be in line with the respective models described in section 2. Here, we briefly describe our measures of the key variables, with supplementary details of the data description presented in the Appendix.

First, empirical investigations of Friedman's model involve series for monetary growth, aggregate price inflation, and a measure of real economic slumps. In the baseline analysis, monetary growth is computed as the growth rate of M2 and inflation is measured as the growth rate of CPI, both of which are calculated on a year-on-year basis[5]. For brevity, in what follows we use $\Delta M2$ to denote the year-on-year growth rate of M2, and all other variables in growth rate form are defined analogously. The real economic slumps in Friedman's model are measured by real GDP. Since no published data are available for China's real GDP series with a quarterly frequency, we use quarterly data on nominal GDP in levels and real GDP in growth rates (year-on-year) to construct a quarterly real GDP series with 1997 as the base year[6]. The estimated quarterly real GDP series based on this method appears to

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[5] Because in the long-run analysis the level of the CPI is also used, we recover the price index based on the published data (from the NBS) for CPI inflation series with the price index in October 1995 equal to 100 (seasonally adjusted).

[6] The year 1997 is chosen as the base year because the growth rates of nominal and real GDP for 1997 are roughly

match the officially published annual data quite convincingly.

Second, the empirical tests of Meltzer's model involve real estate price inflation in addition to the money and inflation series described above. We use the year-on-year growth rate in the property price index (building) to measure house price inflation (denoted ΔHPI). Furthermore, because Meltzer (1995) signified the role of equity price, we also consider the returns of the composite stock price index (CSPI) for China's A-share stock market as alternative asset price inflation to ΔHPI. This series of returns are calculated based on the value-weighted method and cash dividends are assumed to be reinvested into the security that paid them, as suggested by the standard literature (e.g. Blume and Friend, 1973; Fama and French, 1992). To further explore other real assets (commodities), we also consider the purchasing price index (PPI; in the form of year-on-year growth and denoted ΔPPI) for resource (raw) materials in China which covers the prices of fuels, power, and ferrous metal materials, among many other representative commodities.

In addition, to assess the robustness of the baseline results, M1 is used to assess the information content of an alternative monetary aggregate and the GDP deflator is used as an alternative measure for price index (denoted GDPIP). As a complementary hypothesis, we also check whether the expansion of domestic credit in China could be a legitimate cause of greater inflation. Quarterly data on domestic credit include credit issued by all banks in China (denoted CREDIT). Additionally, the possible effects of international prices and the exchange rate on inflation are also considered in our robustness analysis. To this end, import price index (denoted IMP) published by the Global Economic Monitor of the World Bank (available since 1990) and real effective exchange rate (denoted REER) for RMB from the IFS (available since 1980) are used in the corresponding assessments.

Furthermore, to examine the stationarity of the underlying variables, we perform the Augmented Dickey–Fuller (ADF) tests, which impose the null of non-stationarity, and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests, which impose the null of stationarity. Since our long-run analysis in section 5 also involves level data for money stock and price index, and the method applies to nonstatioanry series, the stationarity tests are performed on both level (in logarithm) and first difference data for all variables, except for ΔHPI and ΔPPI, which are only available (and applicable) in growth rate form.

The results of the two unit root tests are reported in Table 1, which show the *p*-values of the ADF tests and statistics of the KPSS tests. The unit root test regressions for all variables (except for real GDP) contain an intercept term but no time trend since a time trend in such regressions is insignificant. At the conventional levels of significance, the two different unit root test methods generally provide a uniform conclusion that most variables are I(1) in levels and I(0) after differencing. The results for ΔHPI and ΔPPI are somewhat conflicting, but it may be reasonable to assume that both of these price inflation series are I(0) given the well-known low

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power of the ADF test.

Table 1: Unit Root Tests Results for the Underlying Variables

Level data	ADF (p-value)	KPSS (statistic)	Growth rates	ADF (p-value)	KPSS (statistic)
CPI	0.579	1.228[***]	ΔCPI	0.044[**]	0.310
M2	0.234	1.326[***]	ΔM2	0.002[***]	0.419[*]
M1	0.748	1.333[***]	ΔM1	0.040[**]	0.211
GDPIP	0.731	1.287[***]	ΔGDPIP	0.071[*]	0.139
CREDIT	0.719	1.330[***]	ΔCREDIT	0.020[**]	0.253
IMP	0.501	0.830[***]	ΔIMP	0.000[***]	0.293
REER	0.078[*]	0.842[***]	ΔREER	0.000[***]	0.089
CSPI	0.350	1.063[***]	ΔCSPI	0.011[**]	0.105
GDP	0.935	1.333[***]	ΔGDP	0.036[**]	0.046
GDP^{trend}	0.014[**]	0.146[*]	ΔHPI	0.018[**]	0.535[**]
			ΔPPI	0.286	0.355[*]

Notes:

All level variables are defined in natural logarithms; the optimal lag order in ADF tests are specified by SIC with a maximum of 8 lags; The autocorrelation correction for the variance estimate in the KPSS test is based on the Newey-West procedure with the Bartlett kernel; Δ denotes first difference of the corresponding level data (i.e. $\ln(X_t)-\ln(X_{t-4})$); the unit root tests for all variables (except for GDP^{trend}) have an intercept term but no time trend; GDP^{trend} refers to the unit root tests for the real GDP with both an intercept and a time trend; [*], [**], and [***] indicate statistical significance at the 10, 5, and 1 per cent levels, respectively.

The unit root tests for real GDP deserve further discussion. Since a time trend is significant in the unit root tests for real GDP, the small *p*-value (0.014) of the ADF test indicates that China's real GDP may be trend stationary. Of course, if the true data-generating process is trend stationary; differencing would induce a non-invertible moving average while traditional HP detrending would also be inappropriate despite its widespread use in applied macro analysis. However, the trend stationary conclusion for the real GDP here seems to be sensitive to sample period changes and alternative unit root test methods. To ensure the robustness of the empirical analysis, therefore, we use the first difference of logged real GDP (i.e. the growth rate of the real GDP) in our baseline analysis and assess the sensitivity of the baseline results using a linearly detrended series (obtained via a regression on time trend and denoted LDGAP) as a measure of real economic slumps in the relevant models.

b. Stylized Facts

Figure 1 shows the full sample of observations on CPI inflation and growth rate of M2 in China between 1980 and 2010. To provide an intuitive illustration of the dynamic evolution of monetary growth and inflation, we use in our plot a dual axis

scaling with overlapping scales. The figure shows that the patterns of the evolution in monetary growth and inflation are remarkably similar. In particular, the peaks and troughs of CPI inflation are followed by corresponding rises and drops in monetary growth; furthermore, most of the time, monetary growth leads CPI inflation approximately one to two years.

Figure 1: China's Monetary Growth and CPI Inflation: 1980Q1-2010Q3
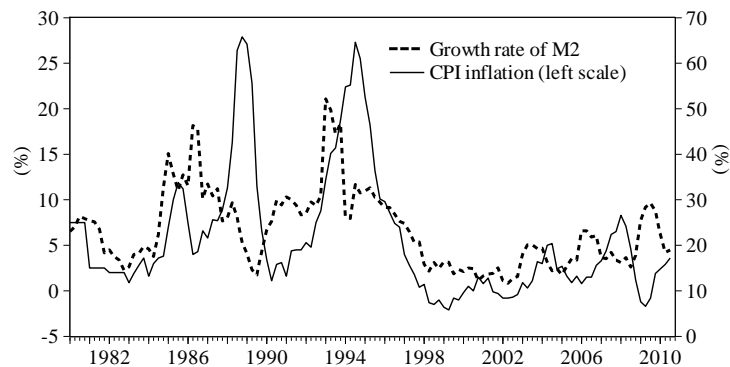
Data source: IFS, NBS of China, and the author's calculations.

From Figure 1 we can also observe that high fluctuations in inflation in the 1980s and 1990s are accompanied by large swings in monetary growth. Since the end of the 1990s, however, both inflation and monetary growth have witnessed marked decrease in their volatilities. A similar pattern but a clearer picture of the link between monetary growth and inflation can be observed in Figure 2, which plots three-year rolling averages of the two key variables of interest. The rolling averages smooth short-term fluctuations in the corresponding series and thereby provide a useful hint about the medium- to long-run relationship between money and inflation. As one can see from Figure 2, the smoothed series manifest a stronger pattern of co-movement over time than do the non-smoothed data. Additionally, the time leads from monetary growth to CPI inflation are more striking during the 1980s and 1990s than those thereafter. The observed reduction of time leads from monetary growth to inflation is consistent with the improvements in systematic monetary policy in China documented in Zhang and Clovis (2010).

Figure 2: Three-Year Rolling Averages of Monetary Growth and Inflation
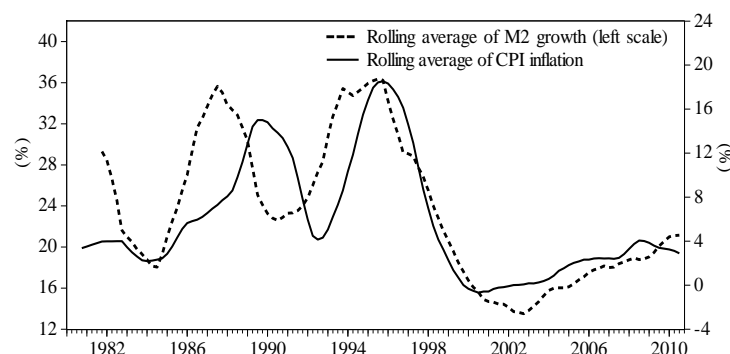
Data source: IFS, NBS of China, and the author's calculations.

If money matters for inflation, there should be a positive correlation between

monetary growth and inflation. It is also useful to compare correlations across different time horizons, using quarterly observations of each variable, to assess the link between monetary growth and inflation. Therefore, our analysis uses rolling averages of monetary growth and inflation over one-, three-, and five-year intervals. This approach effectively smoothes short-run fluctuations in the series that may mask the underlying long-term relationship. In addition to evaluating the static correlation between monetary growth and inflation, we also assess the dynamic correlations between the two variables using lags of ΔM2. The correlations are reported in Table 2.

Table 2: Correlation between Monetary Growth and CPI Inflation

Pair	Time Interval of Rolling Average		
	1-Year	3-Year	5-Year
ΔM2, ΔCPI	0.525	0.776	0.921
ΔM2(-1), ΔCPI	0.587	0.810	0.937
ΔM2(-2), ΔCPI	0.646	0.838	0.947
ΔM2(-3), ΔCPI	0.694	0.858	0.949
ΔM2(-4), ΔCPI	0.724	0.869	0.944
ΔM2(-5), ΔCPI	0.732	0.870	0.930
ΔM2(-6), ΔCPI	0.723	0.860	0.908
ΔM2(-7), Δ CPI	0.698	0.838	0.878
ΔM2(-8), ΔCPI	0.662	0.804	0.841

Notes:

Sample spans 1980Q1-2010Q3; ΔM2(-1) denotes the first lag of ΔM2 and ΔM2(-i) for i>1 are defined analogously.

The results in Table 2 indicate a wide range of correlation for the money–inflation link. The static correlation between ΔM2 and ΔCPI over one-, three-, and five-year intervals are 0.525, 0.776, and 0.921, respectively. This result generally suggests that there is a strong positive relationship between monetary growth and inflation, and that the link between monetary growth and inflation improves as the dynamic time horizon (lags of ΔM2) increases. Looking across dynamic correlations and taking the three-year rolling average as an example, the correlation grows from 0.810 for the first order lag in ΔM2 to 0.870 for the fifth order lag in ΔM2 and then decreases gradually as lag length grows. A similar rolling average pattern is observed for the other time intervals.

The results tabulated in Table 2 reveal that monetary growth and inflation are strongly correlated in both the short-term and long-term, and that they seem to be related more closely in the long-run. The correlations are generally much higher than those found for many other countries in the literature (e.g. Hafer, 2001). In addition, the stylized facts also suggest that the dynamic correlation between monetary growth and inflation in China is higher than is its static counterpart and that it achieves its maximum value in approximately one year time. Taken as a whole, this correlation exercise indicates that monetary growth is strongly correlated with inflation in China. The correlation, of course, does not necessarily imply causation. The following

sections embark on investigating the causality between monetary growth and inflation from both the short-run and the long-run perspectives.

4. Empirical Results
a. Empirical Results of Friedman's Model

As discussed above, the aphorism "Inflation is always and everywhere a monetary phenomenon", coined by Milton Friedman, is essentially an empirical issue. To judge the usefulness of this theory and evaluate whether this claim applies to inflation in China between 1980 and 2010, we analyze the data on monetary growth and inflation in conjunction with the real economic slump and test whether such a hypothesis (inflation is a monetary phenomenon) is empirically true.

Specifically, we use the VAR model specified in section 2 to examine the nature and consistency of the conjuncture of the causal relationship between monetary growth and inflation. VAR modeling involves estimating a system of equations in which each variable is expressed as a linear combination of lagged values of itself and of all other variables in the system. Following the notations in section 3, we use ΔGDP, ΔCPI, and ΔM2 to denote the three variables in the system, namely the growth rate of real GDP, CPI, and the growth rate of M2, respectively.

In the present example, VARs are estimated from each variable for the other two variables using quarterly data from the first quarter of 1980 to the third quarter of 2010. To determine the appropriate lag length of the VAR model, the Schwartz Inflation Criterion (SIC) is implemented and the criterion suggests that a second-order VAR model is optimal. This VAR model is then used to conduct Granger causality tests. By definition, a variable x_{1t} is said to be Granger-caused by x_{2t} if x_{2t} helps in the prediction of x_{1t}, or equivalently if the coefficients of the lagged x_{2t}s are statistically significant.

Table 3 tabulates the results of the Granger causality tests for the three equations of the VAR system, which are VAR model tests of the joint statistical significance of the lagged values of each regressor in causing (predicting) the dependent variables. The results presented in Table 3 show that the p-value pertaining to the null hypothesis that ΔM2 does not Granger cause ΔCPI is 0.004, which indicates that CPI inflation in China can be explained by monetary growth occurring at earlier stages. Highlighting this result is the finding that, in the regression equation for ΔCPI, the coefficients of the lagged ΔM2 are jointly significant at the 1 per cent significance level.

Table 3: Results (p-values) of Granger Causality Tests for Friedman's QTM

	ΔCPI	ΔM2	ΔGDP
lag(ΔCPI)		0.044[**]	0.000[***]
lag(ΔM2)	0.004[***]		0.121
lag(ΔGDP)	0.170	0.041[**]	

Notes:

The p-values associated with the Wald statistics in Granger causality tests are reported; sample spans 1980Q1-2010Q3 prior to lag adjustment; the optimal lag length chosen by SIC is 2 (with a maximum of 8 lags); lag(ΔCPI) denotes all lagged items of ΔCPI on right hand side of each

regression, and lag(ΔM2) and lag(ΔGDP) are defined analogously.

An interesting finding is that monetary growth does not Granger cause the growth rate of real GDP. This result appears to indicate that even in the short-run money is "neutral" in the sense that monetary growth only predicts future inflation but has no significant prediction power on real economic growth. Another interesting result to note is the Granger causality tests for the equation with ΔM2 as a dependent variable. This result suggests that monetary growth responds significantly to both CPI inflation and the growth rate of real GDP.

The bilateral relationship between monetary growth and inflation corresponds to the endogenous view of money (e.g. Yun, 1996). Although this cannot be fully reflected in any monetarist type of argument, the explanation is straightforward. On one hand, expansionary monetary policy provides ample liquidity, which boosts demand above supply in the goods market and thereby causes consumer price inflation. On the other hand, a sudden surge in consumer price inflation may trigger a rise in the demand (and hence supply) for money because of higher transaction volumes on goods markets. Furthermore, as a response to higher inflation, the central bank will then adjust the growth rate of money supply, indicating a causal link from monetary growth to inflation.

The directional causality from output growth to monetary growth suggests that real GDP growth leads monetary growth. This may reflect the notion that the People's Bank of China (PBC) has been implementing (implicitly) a backward-looking monetary policy reaction function, which depicts the response of monetary growth to lagged (instead of future) output growth (Zhang and Clovis, 2010).

To provide further information about to what extent and in which direction that monetary growth has influenced consumer price inflation and how the underlying variables have been influenced by the associated shocks, we also compute the orthogonalized impulse response functions (IRFs) of each variable in the model to the underlying shocks. By definition, these orthogonalized IRFs produce the IRFs of structural shocks as implied by the reduced form shocks in VAR models. As in much of the literature on the effects of monetary policy using VARs, the underlying computations of the IRFs are then based on a standard Cholesky decomposition[7]. The results of the corresponding IRFs are reported in Figure 3.

The first two graphs in the upper panel of Figure 3 show the impulse responses of CPI inflation to a one-unit (standard deviation) shock in monetary growth and real GDP growth. The graphs suggest that ΔCPI positively responds to ΔM2 and ΔGDP. The IRFs of CPI inflation achieve maximum values after approximately six quarters. Additionally, the IRFs of ΔGDP (the last two graphs in the lower panel of Figure 3) suggest that a positive shock to ΔCPI and ΔM2 leads to a temporary increase in ΔGDP, with the impact of the inflation shock diminishing much faster than that of monetary growth. Another interesting result to note is that a random shock in ΔCPI induces a negative impact on ΔM2 (the first graph in the lower panel of Figure 3). This result

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[7] The ordering scheme in the VAR model follows ΔGDP-ΔCPI-ΔM2. Alternative orders provide very similar results.

implies that monetary policy will be tightened as a response to a positive shock to inflation, which seems to be consistent with the practical implementations of monetary policy.

Figure 3: Impulse Response Functions of CPI Inflation, M2 Growth, and Real GDP Growth
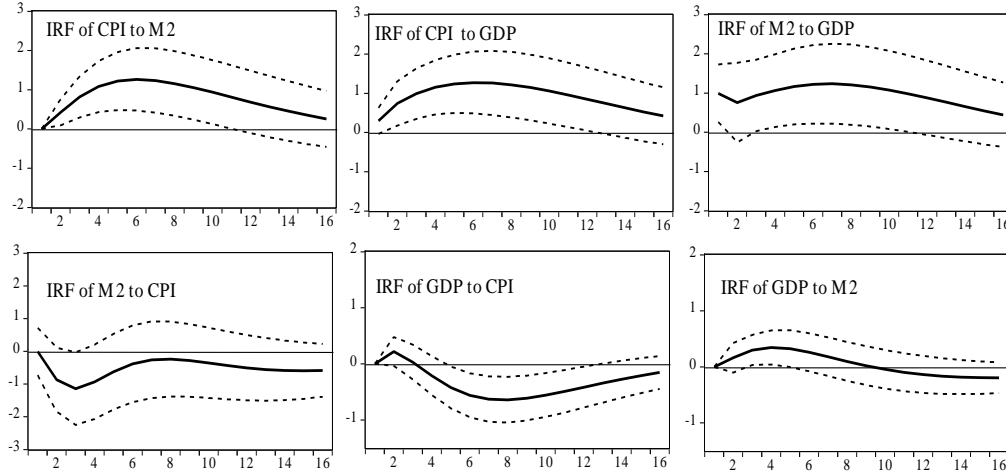
Notes:

The solid lines are the estimates of impulse responses and the dotted lines are their 95 per cent confidence bands; "IRF of CPI to M2" denotes the impulse response function of the CPI inflation to one standard deviation shock in the monetary growth and the other notations in the Figure are defined analogously.

Overall, the empirical results of the VAR system based on Friedman's QTM indicate that inflation has been a monetary phenomenon in China over the past three decades. The results also suggest a causal link from output growth to monetary growth. Whether this finding is robust to Meltzer's (1995) monetarist model is examined in the following subsection, which focuses on the short-run dynamics between monetary growth and inflation based on asset inflation channel.

b. Empirical Results of Meltzer's Model

To examine the indirect causal relationship between monetary growth and inflation in China through the asset inflation channel, we perform Granger causality tests based on three VAR systems. Each VAR model has the form of equation (4). The first VAR model contains all three variables (i.e. ΔM2, ΔHPI, and ΔCPI), the second VAR model includes ΔM2 and ΔHPI, and the third VAR model includes ΔHPI and ΔCPI. By estimating the first VAR model, we attempt to investigate the general relation and causal links among the three underlying variables. By estimating the second and third VAR models, we focus on the bilateral causal link between monetary growth and house price inflation, and house price inflation and consumer price inflation, respectively. The use of the second and third VAR models may also mitigate concerns regarding possible multicollinearity between ΔHPI and ΔCPI when they are simultaneously included (as in the first VAR model).

The specification and estimation procedures for the VAR models are similar to those in Table 3. Table 4 tabulates the results of the Granger causality tests for the three VAR models. For the first VAR model (which contains ΔM2, ΔHPI, and ΔCPI), we test for causal links between each pair of the three variables. The first null hypothesis in this VAR model tests for whether monetary growth Granger causes (predicts) house price inflation. The corresponding *p*-value (0.006) is smaller than 1 per cent, suggesting that the null hypothesis can be rejected, i.e. monetary growth does Granger cause house price inflation. Likewise, the *p*-value for the second test (0.045) suggests that ΔHPI also Granger cause ΔM2 at the 5 per cent level of significance. The *p*-values (0.191 and 0.911) associated with the Granger causality tests between ΔM2 and ΔCPI are insignificant at the conventional levels. This reflects the fact that the link between monetary growth and consumer price inflation is indeed indirect in the asset inflation model. In addition, the *p*-values (0.018 and 0.025) associated with the Granger causality tests between ΔHPI and ΔCPI suggest a significant feedback relationship between the house price inflation and consumer price inflation.

Table 4: Results (*p*-values) of Granger Causality Tests of Meltzer's Model

		ΔM2	ΔHPI	ΔCPI
VAR: [ΔM2, ΔHPI, ΔCPI]	lag(ΔM2)		0.006***	0.191
	lag(ΔHPI)	0.045**		0.018**
	lag(ΔCPI)	0.911	0.025**	
VAR: [ΔM2, ΔHPI]		ΔM2	ΔHPI	
	lag(ΔM2)		0.014**	
	lag(ΔHPI)	0.011**		
VAR: [ΔHPI, ΔCPI]		ΔHPI	ΔCPI	
	lag(ΔHPI)		0.004***	
	lag(ΔCPI)	0.061*		

Notes:
Sample spans 1998Q1-2010Q3 prior to lag adjustment; the optimal lag order is chosen by SIC (with a maximum of 8 lags).

For the second and third VAR models, which consider the bilateral links between ΔM2 and ΔHPI, and ΔHPI and ΔCPI, respectively, the Granger causality test results provide findings consistent with those of the first VAR model. Taken as a whole, the results presented in Table 4 suggest that there is a bilateral causal relationship between monetary growth and house price inflation and a bilateral causal link between house price inflation and consumer price inflation. These two bilateral relationships, however, imply an indirect pass-through from monetary growth to consumer price inflation via the asset inflation channel.

c. Robustness Analysis

The discussion so far suggests that monetary growth has a predictive power for CPI inflation in China, either directly through Friedman's model or indirectly via Meltzer's asset inflation channel. However, there are a number of issues deserving further assessment. In this subsection, we conduct seven robustness tests, with five sensitivity tests for Friedman's model and two further robustness tests for Meltzer's model. These tests incorporate various considerations of model specification and alternative measures for stationary real output, price index, monetary aggregate, and equity prices.

Specifically, for Friedman's model, we consider the following five sensitivity tests. First, we consider the possible pass-through effect of international prices and the exchange rate on domestic inflation, as articulated in Smets and Wouters (2002) and Slavov (2008), among many others. Second, since the nature of the stationarity of real GDP series seems to be sensitive to different unit root tests, as discussed in section 3, it is important to examine the sensitivity of the baseline finding using alternative stationary series for real output, namely linearly detrended real output (i.e. LDGAP). Third, to mitigate the possible measurement problem of price and inflation encountered in the empirical work in China, we also use GDP deflator (constructed in section 3) as an alternative price index to assess the robustness of the baseline finding. Fourth, to assess the information content of different monetary aggregates, we use M1 as an alternative monetary aggregate to M2. Fifth, the existing literature on monetary transmission mechanisms (e.g. Li, 2000) suggests that monetary expansion can generate a liquidity effect that increases bank lending and credit supply. Therefore, we also check whether the expansion of domestic credit in China (i.e. ΔCREDIT), which shows a very similar time series pattern to ΔM2, could be a legitimate cause of inflation. For Meltzer's model, we assess the sensitivity of the underlying results by considering the returns of the CSPI for China's A-share stock market as alternative asset price inflation to ΔHPI. Additionally, we also consider ΔPPI as an alternative real asset.

Table 5 summarizes the results of the robustness tests outlined above, with panels A to G corresponding to the respective sensitivity test results. The interpretation of the results is analogous to the previous subsection. For the robustness tests associated with Friedman's model, we find that monetary growth significantly Granger causes inflation in all cases (panels A to E) at the 5 per cent level. These findings support the Granger causality of monetary growth for inflation in a richer five-variable VAR framework (p-value=0.035), in models with alternative measures for stationary output (p-value=0.004), inflation series (p-value=0.002), monetary aggregate (p-value=0.000), and in the model with ΔCREDIT substituting ΔM2 (p-value=0.001).

In addition, the feedback relationship between monetary growth (or credit growth) and inflation remains significant in most of the sensitivity exercises in panels A to E. The causal link from real economic slumps to monetary growth, by contrast, is significant in three out of the five tests. Note that the two insignificant cases occur in panels B and D, which pertains to one model with LDGAP as the measure of the real economic slumps and another model with ΔM1 as a replacement for ΔM2. These two insignificant cases nonetheless, strengthen (rather than weaken) the important feature

of the PBC's monetary policy reaction function: in practice, the PBC looks at the growth rate of real GDP, rather than GDP gap, to adjust its broad (instead of narrow) money supply mechanism, as explicitly stated in the Central Bank Law of China enacted in 1995. Another interesting finding in the robustness exercises is that there also appears to be significant feedback from monetary growth to output growth, which is insignificant in the baseline analysis. The causality from money to real output may justify money as a good intermediate target variable in China (Hasan and Taghavi, 1996).

The two robustness tests for Meltzer's model seem to provide different results. The results in panel F make it clear that the baseline finding of Meltzer's model holds when ΔCSPI is used to measure equity price inflation, albeit the causality from ΔM2 to ΔCSPI is significant at the 10 per cent level. The results in Panel G, however, seem to suggest that the direct causal links from monetary growth to real asset price inflation and from real asset price inflation to consumer price inflation are insignificant even at the 10 per cent level. This inconsistent finding may be caused by the relatively high level of collinearity between ΔCPI and ΔPPI. Indeed, when the underlying variables are fitted in two separate VAR models, as practiced in the preceding subsection, the causality links from ΔM2 to ΔPPI and from ΔPPI to ΔCPI regain statistical significance.

Table 5: The Results (*p*-values) of Granger Causality Tests for the Robustness Analysis

Friedman's Model		ΔCPI	ΔM2	ΔGDP	ΔREER	ΔIMP
A.	lag(ΔCPI)		0.488	0.417	0.454	0.287
	lag(ΔM2)	0.035**		0.013**	0.226	0.870
	lag(ΔGDP)	0.008***	0.009***		0.319	0.056*
	lag(ΔREER)	0.003***	0.517	0.019**		0.012
	lag(ΔIMP)	0.276	0.069*	0.752	0.619	
B.		ΔCPI	ΔM2	LDGAP		
	lag(ΔCPI)		0.075*	0.041**		
	lag(ΔM2)	0.004***		0.016**		
	lag(LDGAP)	0.167	0.384			
C.		ΔGDPIP	ΔM2	ΔGDP		
	lag(ΔGDPIP)		0.052*	0.468		
	lag(ΔM2)	0.002***		0.474		
	lag(ΔGDP)	0.001***	0.098*			
D.		ΔCPI	ΔM1	ΔGDP		
	lag(ΔCPI)		0.026**	0.003***		

		ΔCPI	ΔM1	
	lag(ΔM1)	0.000^{***}		0.027^{**}
	lag(ΔGDP)	0.016^{**}	0.196	

	E.	ΔCPI	ΔCREDIT	ΔGDP
	lag(ΔCPI)		0.009^{***}	0.000^{***}
	lag(ΔGREDIT)	0.001^{***}		0.177
	lag(ΔGDP)	0.042^{**}	0.016^{**}	

Meltzer's Model				
	F.	ΔCPI	ΔM2	ΔCSPI
	lag(ΔCPI)		0.905	0.027^{**}
	lag(ΔM2)	0.071^{*}		0.076^{*}
	lag(ΔCSPI)	0.000^{***}	0.038^{**}	
	G.	ΔCPI	ΔM2	ΔPPI
	lag(ΔCPI)		0.856	0.005^{***}
	lag(ΔM2)	0.084^{*}		0.181
	lag(ΔPPI)	0.686	0.025^{**}	

Notes: See Table 3.

To summarise, the various robustness tests provide a uniform conclusion that there is a significant feedback relationship between monetary growth and inflation in China and that the causal relationship is valid implicitly through the asset inflation channel. All results highlight the monetary dynamics of inflation in China in the post-reform era.

5. Money and Inflation in the Long-run

The preceding analyses all focus on short-run inflation dynamics. Monetarist theories, however, are not confined to short-run analysis. In fact, the aphorism "Inflation is always and everywhere a monetary phenomenon", proposes that only money matters for inflation in the long-run. In this section, we carry out two sets of analyses, namely a naïve analysis on the relationship between long-run components in monetary growth and inflation and a co-integrating analysis for money stock and price index.

a. Naïve Analysis

In regards to the long-run relationship between monetary growth and inflation, a plethora of studies have shown that the fraction of inflation's long-run variation explained by long-run monetary growth has been very high and relatively stable in developed countries over the past two decades (Benati, 2009). However, the

proportionality between the long-run components of monetary growth and inflation may also vary over different time periods and in different countries. Therefore, it is intriguing to examine whether there exists a close link between the long-run components of monetary growth and inflation associated with the inflation performance in China.

To obtain the long-run components of the underlying series, we use the common detrending method, the Hodrick–Prescott (HP) filter. This filter is used to obtain a smoothed non-linear representation of a time series that is more sensitive to long-term than it is to short-term fluctuations. The adjustment of the sensitivity of the trend to short-term variations is achieved by a numerical penalty parameter (1600 for quarterly data). Figure 4 plots the trend components of monetary growth and CPI inflation in China based on the HP filter. The figure presents a remarkable co-movement between the trend in monetary growth (M2TREND) and the trend in inflation rate (CPITREND). For instance, the rising trends in monetary growth in the mid-1980s and early-1990s are followed by the rising trends in inflation in a similar pattern. When the trend in monetary growth drops drastically in the late-1990s, the trend in inflation rate also witnesses a marked decrease. Further comparison of the two series in Figure 4 also reveals that the long-run component of monetary growth leads the long-run component of CPI inflation in a few quarters time.

Figure 4: Long-run Components of Money Growth and Inflation in China
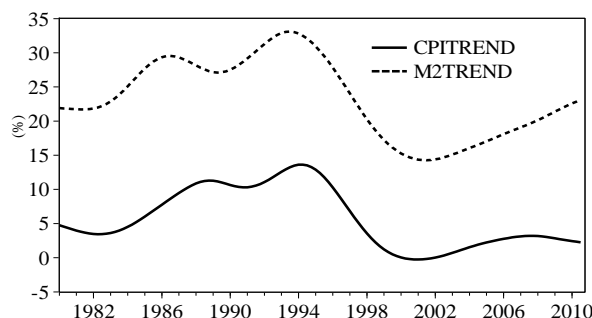
To provide further evidence of the correlation between M2TREND and CPITREND over different time periods, we also calculate rolling correlations (10-year backward rolling windows) between the two long-run components. The results (not reported here) provide three interesting and important results. First, the long-run components of monetary growth and CPI inflation are highly correlated in most periods with correlation coefficients being larger than 0.5 in all the rolling samples. Second, the highest rolling correlations (close to unity) are clustered between 1998 and 2007. With a 10-year rolling window, this second result implies the long-run components of monetary growth and inflation have been virtually perfectly correlated since the end of the 1980s. Third, the dynamic correlations are generally higher than are the static correlations prior to the mid-1990s, and the trend in monetary growth with more lags appear to be more correlated with inflation than it is with any other factor. This scenario reverses from the mid-1990s onwards, indicating that inflation trend tends to move more quickly with any change in monetary growth

trend in more recent periods than it did so before.

It is worth noting that in the short-run, supply shocks and other factors may push inflation above or below its long-run trend and the cyclical pattern of CPI inflation may not exactly mimic that of monetary growth at all times (recall Figure 1). The above results, however, demonstrate that the long-run trends in monetary growth and inflation are highly correlated over time. The high correlation, of course, provides little information about the causal relationship between the trends in monetary growth and inflation.

Obviously, the argument of causal relationship is much stronger and, therefore, entails further econometric investigations. In practice, we carried out a Granger causality test based on a bivariate VAR model with CPITREND and M2TREND. The p-value pertaining to the null hypothesis that "M2TREND does not Granger cause CPITREND" is 0.000, and the p-value corresponding to the null hypothesis that "CPITREND does not Granger cause M2TREND" is 0.048. These results suggest that there exists a bilateral causality between the long-run components of monetary growth and inflation.

b. Cointegration Analysis

In seeking to construct an improved model for the long-run relationship between money and price, we formulate a model that integrates long-run properties with short-run dynamics, based on the well-established theories of multivariate co-integrating and the vector error-correction (VEC) system developed by Johansen (1991, 1995). Johansen's method first tests for the number of the co-integrating relationships (or co-integrating vectors) based on a VAR model. A by-product of this test is the estimation of the co-integrating vectors, which is then used to formulate the VEC model.

The baseline VAR model in Johansen's approach can be formulated as:

$$\Phi^*(L)\Delta Y_t = C + \Pi Y_{t-1} + \varepsilon_t \tag{5}$$

where

$$\begin{cases} \Pi = -\Phi(1) = \sum_{i=1}^{p} \Phi_i - I_k \\ \Phi^*(L) = I_k - \sum_{i=1}^{p-1} (-\sum_{j=i}^{p} \Phi_j)L^i \end{cases} \tag{6}$$

In this setup, Y_t denotes a vector of the underlying variables, k denotes the number of variables in the VAR model, $\Phi(L)$ denotes the vector polynomial of the lag operator, and the optimal lag length p is determined by the lag exclusion test and serial correlation test with a maximum of eight lags.

Ideally, co-integrating analysis should incorporate all the relevant factors of aggregate demand and supply pertaining to inflation in China. Hasan (1999) provided an important analysis in this regard by including money stock, real output, wages, agricultural productivity (AP), and industrial productivity (IP). However, owing to the lack of quarterly data on wages, AP and IP, we confine our analysis to a five-variable

VAR model that contains I(1) series of GDP, CPI, M2, REER, and IMP (all variables are in natural logarithm), as defined in section 3.

In effect, this model is a non-stationary counterpart to the one used in panel A of Table 5 in section 4. The structural interpretation of such a model can be found in Smets and Wouters (2002). The key difference between our model and Smets and Wouters' framework is that money stock, rather than interest rate, is used as the baseline monetary policy indicator. This modification, of course, is consistent with China's monetary policy implementation and is also necessary for the current analysis of the monetary dynamics of inflation in China.

By construction, Johansen's approach is a sequential procedure, starting from the overall null hypothesis that rank(Π)=0 (implying all variables are non-stationary and that there is no co-integrating), and working progressively towards the case of a stationary system where rank(Π)=k. Johansen developed two related test statistics to implement this procedure, namely the trace statistic and maximal eigenvalue statistic. Although both these statistics are used to test the number of co-integrating vectors, more weight is typically placed on the trace statistic because it has the advantage of being effectively a joint test rather than considering a single estimated eigenvalue as in the maximal eigenvalue test.

Table 6 reports the results of Johansen's co-integrating tests. The trace test suggests that there exist four co-integrating relationships in the five-variable VAR system at the 5 per cent level of significance. The maximum eigenvalue test, by contrast, indicates that there are three co-integrating vectors in the model. Based on either of the two statistics, however, we can conclude that there exist long-run equilibrium relationships among money stock, price index, and other variables in the model. The finding of co-integrating among the underlying variables also indicates that the monetary dynamics of inflation in China contains valid error-correction representations with co-integrating constraints embedded in them (Hasan, 1999).

Table 6: Results of Johansen Co-integrating Tests

Hypothesized No. of CE(s)	Trace statistic (*p-value*)	Max-Eigen statistic (*p-value*)
None	0.000[***]	0.000[***]
At most 1	0.000[***]	0.000[***]
At most 2	0.000[***]	0.000[***]
At most 3	0.015[**]	0.054[*]
At most 4	0.096	0.096[*]

Notes：

The table reports MacKinnon-Haug-Michelis (1999) *p*-values; co-integration equations include both intercepts and time trends; lag length of the VAR model is determined by lag exclusion test and LM serial correlation test with a maximum of 8 lags.

With co-integrating, there are $r<k$ co-integrating relationships between the k elements of Y_t in Equation (5). For convenience, define the $k \times r$ matrix B, where the

columns of B contain the r distinct, linearly independent, co-integrating vectors. Therefore, the r elements of Z_t, defined by $Z_t=B'Y_t$, are all I(0) variables[8]. As such, the VEC model can be formulated by rewriting model (5) as:

$$\Phi(L)\Delta Y_t=C+AB'Y_{t-1}+\varepsilon_t=C+AZ_{t-1}+\varepsilon_t \tag{7}$$

where C is a vector of constants, B denotes the co-integration vector, and A is the adjustment coefficient matrix. The VEC model (7) provides a behavioral interpretation to co-integration. Each co-integrating relationship represents a long-run equilibrium relationship among the non-stationary variables in Y_t. Therefore, Z_t captures r distinct long-run relationships. These hold in equilibrium, so that in steady state $Z_t=0$. For each specific time period t, $Z_t=B'Y_t$ is the extent of disequilibrium in these relationships. The adjustment coefficient A then shows how each of the variables adjusts to achieve these long-run equilibrium relationships.

Of course, given the four co-integrating relationships here, the scale of matrix A (and B) is relatively large (5×4), and it provides little information as to the issue of our interest to present all the estimates for A and B in the VEC system. However, model (7) can be further used to carry out Granger causality tests for the stationary variables of ΔY_t. Under the current setup, Granger causality tests based on the VEC model (7) can effectively provide information about the causality relationships among monetary growth, CPI inflation, and the growth rates of real output, effective exchange rate, and the import price index. Therefore, model (7) is employed as a further examination of the relationship between monetary growth and inflation, among other issues of interest.

The results of the Granger causality tests are reported in Table 7. Judged by the p-values associated with them, monetary growth and output growth significantly Granger cause CPI inflation (with the former significant at the 10 per cent level). There are also significant causal links from CPI inflation to monetary growth and output growth. These results are generally consistent with the short-run analysis in the preceding section, which highlights the feedback relationship between monetary growth and inflation. The results also suggest bilateral causality between monetary growth and real output growth.

Table 7: The Results (p-values) of Granger Causality Tests for the VEC Model

	ΔCPI	ΔM2	ΔGDP	ΔREER	ΔIMP
lag(ΔCPI)		0.017^{**}	0.001^{***}	0.432	0.003^{***}
lag(ΔM2)	0.095^{*}		0.000^{***}	0.000^{***}	0.670
lag(ΔGDP)	0.047^{**}	0.017^{**}		0.530	0.572

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lag(ΔREER)	0.112	0.293	0.024[**]		0.088[*]
lag(ΔIMP)	0.100	0.000[***]	0.013[**]	0.920	

Notes:

The results are based on the VEC model (7) of Table 6; other notations follow those of Table 3 and Table 5.

To summarize the long-run analysis in this section, we find that there exists a feedback relationship between the long-run components of monetary growth and inflation. We also find long-run equilibrium relationships among money stock, price index, and other relevant variables. The Granger causality tests based on the VEC system also suggest a feedback relationship between monetary growth and inflation and a feedback relationship between monetary growth and real output growth.

6. Further Discussion

Prior to the economic reforms in 1978, rigid controls kept the consumer prices of many goods virtually unchanged for decades, and thereby inflation was not a major concern for China. In the post-reform era, however, China had to confront historical upward spikes in inflation in the early 1980s, 1988–1989, and 1994–1995, as well as recent rises in inflation in 2007 and 2010. China also experienced notable deflation between 1998 and 2002. The evolution of inflation over the past three decades reflects the corresponding historical changes in the mechanism of price formation in China. From a historical perspective, changes in pricing mechanisms and in turn, inflation processes are accompanied and mainly caused (predicted) by changes in the money supply mechanism, albeit other factors also seem relevant to inflation behavior in China. In what follows, we will explore this argument on a decade-by-decade basis from 1980.

a. Money and Inflation in the 1980s

From 1978, government-set prices were gradually liberalized. In particular, the central government of China officially initiated a so-called "adjustment and reform" policy in 1979 to promote robust growth in the industrial and agricultural sectors. In 1979, consumer prices began to increase, and this increase became substantial and widespread in 1980. Although there was a slowdown in the growth of prices between 1981 and 1983, inflation continued to represent a latent threat to China's economic development during the entire 1980s.

Although the institutional change in the price control system may cause changes in relative prices and, in turn, aggregate consumer prices (Zhang and Clovis, 2010), the price liberalization alone cannot change the overall pricing mechanism without monetary boost (the price liberalization may be viewed as a "fuse igniter" rather than the underlying cause of the inflation in the 1980s). Indeed, there were serial shifts in the money supply mechanism during the late 1970s and early 1980s, and these shifts ultimately dominated inflation during the 1980s. Specifically, China began to decentralize its bank lending system in 1979 by changing its old "credit quota system". Under the new bank lending system (implemented in 1980), commercial banks' credit

lending was not constrained by the earmarked quota from the Central Bank of China. The new system allowed banks to expand their credit as their deposits increase, instead of remitting the deposits to higher levels of the banking system, as long as the borrow–lend spread was in line with the central bank's requirement. Because commercial banks in the 1980s (especially after 1984) maintained a sizable amount of public deposits, the new bank lending system effectively expanded overall credit and money supply in the economy.

During these bank lending reforms, the cash flow supply of state-owned enterprises (SOEs) also changed from fiscal appropriation to full bank credit supply. In the mid-1980s, commercial banks in China (mostly state-owned) gained a lending appetite and showed growing confidence in approving loans to SOEs. Banks even urged enterprises to take advantage of this loose lending policy. The reform of the cash flow supply to SOEs, therefore, reinforced monetary expansion in the mid-1980s.

b. Money and Inflation in the 1990s

Due to the lack of an efficient and consistent monetary transmission mechanism in the 1980s and 1990s, however, monetary growth regained a rapid rise (29 per cent) in 1991 and 1992. In the spring of 1992, a speech on the subject of "promoting Chinese economic development with all efforts" by the Chinese leader Deng Xiaoping (known as the "South China Tour Speech") marked a new round of fast economic development in China. To encourage investment, the central government aggressively loosened credit control and the growth rate of aggregate money supply reached a record high of 48 per cent in 1993.

This proactive monetary policy led to an increase in Chinese inflation in 1992 and it reached a peak of 24 per cent in 1994. To curtail this unprecedented high inflation, the Central Bank of China increased benchmark interest rates by 218 basis points in May 1993. Moreover, in July 1993, the monetary authority of China decided to cut loans to on-going building projects and cease loans to new projects. Some building projects were even suspended, leaving thousands of incomplete buildings across the nation. These incomplete projects also led to a large amount of non-performing loans in commercial banks of China.

Following these policy measures, monetary growth dropped to 15 per cent in 1998 and 1999. Consequently, inflation started to decelerate in 1995 and dropped to below zero in 1998 and 1999. It may be noted that the Asian financial crisis in 1997–1998 also brought negative supply shocks to the Chinese economy, which helped subdue inflation in China at the end of the 1990s.

c. Money and Inflation in the 2000s

At the end of the 1990s, considerable improvements were implemented in China's monetary policy. As a result, the PBC adjusted its intermediate target for monetary growth by issuing central bank bills and using repurchase agreements to offer collateralized loans to primary dealers (about 50 selected commercial banks). In January 1999, the Central Bank of China abolished its branches at provincial and

municipal levels and set up nine regional branches to promote policy efficiency, protect the PBC from local government interference, and to prevent potential moral hazards in the financial sectors. From the end of the 1990s, the PBC has used a composite measure of quantity-based and price-based tools to implement its policies, with the quantity-based tool being the predominant policy instrument.

These reforms have enhanced the PBC's capability of managing and accomplishing its intermediate and final goals in the new century. The average rate of monetary growth was much lower between 2000 and 2008 than it was prior to 2000. Accompanied by this strained monetary growth, the rate of inflation has also been low and stable over the period. As the econometric results shown in sections 3 and 4 of this paper, a causal link is embedded in these co-movements between monetary growth and inflation.

It should also be noted that inflation in 2004, 2007, 2008, and 2010 was high (above 3 per cent) relative to other periods in the 2000s. The rises in inflation in 2004, 2007, and 2008 were mainly caused by real estate market booms in China, which reflects flow from monetary growth to real capital asset price changes and eventually to general price inflation, as articulated in Meltzer's (1995) monetarist theory.

The most recent rise in inflation in 2010 was another example of money-driven inflation. To counteract the negative disturbances of the new global financial crisis in 2007–2008, China implemented a 4 trillion Yuan economic stimulus package to reinvigorate the economy and the PBC also reduced benchmark interest rates on deposits and loans five times and reserve ratio rate four times over four months from September 2008. In late 2008, the central bank also abolished the constraints on the credit lending of commercial banks. As a result, money supply grew 28 per cent in 2009, leading to a notable rise in inflation in 2010.

7. Conclusions

This paper examines the interrelationship between monetary growth and inflation in China using quarterly data between 1980 and 2010. We construct multivariate dynamic models based on Friedman's QTM and Meltzer's monetarist framework, with both short-run dynamics and long-run equilibrium relationships investigated. The empirical results suggest that inflation in China is Granger caused by monetary growth in both the short- and the long-run. An indirect and implicit causal relationship between monetary growth and inflation is found through the asset inflation channel. Our results also suggest that the causal relationship between monetary growth and inflation is bilateral, reflecting the endogenous view of money. Another interesting finding is that there exists a feedback relationship between monetary growth and output growth. This finding not only justifies money as a good intermediate target variable in China, but also depicts the gist of monetary policy reaction function in China.

The paper also provides a comprehensive discussion of the mechanism of money-driven inflation in China over the past three decades. Since monetary growth is the dominant driving (predictive) force of inflation, our results indicate that the monetary growth rule is likely to be the most promising policy orientation for China

to manage and control its inflation in an effective manner. Overall, the article presents firm evidence of a stable dynamic relationship between monetary growth and inflation, which implies that the deviation of real money growth from its long-run average is a good indicator of future inflation acceleration or deceleration. In this regard, our results imply that there may be room to consider more general versions of the New Keynesian model that allow for a more prominent role for money, at least in models analyzing developing economies such as that in China.

The analysis in this paper is not intended to be exhaustive. Other factors may also influence inflation, and some of these may provide other possible explanations for the recent change in Chinese inflation dynamics. For example, increased globalization and competition may have lowered the sensitivity of domestic inflation to alternative shocks. Other factors that possibly influence inflation in China include wages, agricultural productivity, and industrial productivity, as suggested by Hasan (1999). Net trade (as a percentage of GDP) may also be a relevant factor for inflation (Smets and Wouters, 2002). Therefore, it could be fruitful for future research to adopt a more structural framework incorporating, when tractability allows, all relevant factors pertaining to inflation in China. Studies in this direction may provide more compelling results that may complement the present research. One caveat to note is that when more variables are adopted, it could be more difficult to obtain accurate empirical results because of the potential multicollinearity problem given possible overlapping information embedded in the underlying time series. Researchers may then have to balance between model completeness and parsimony.

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Appendix

This appendix provides a detailed description of our data sources, data manipulations and statistical methods. It also tabulates the supplemental data used in the robustness analysis of the paper. The raw data were collected from various sources (as listed below) and transformed prior to empirical work. Monthly available data were transformed into quarterly frequency using end-of-quarter observations as the corresponding quarter values to avoid inducing serial correlation in the final dataset. The stationary variables used in the empirical analysis are plotted in Figure A1 through Figure A5.

In addition, the quarterly data for real GDP is constructed based on quarterly data of nominal GDP in levels and real GDP in growth rates (year-on-year) which are available from the NBS since 1992, with 1997 as the base year. Prior to 1992, however, China's GDP data (both levels and growth rates) are mostly available only on an annual basis. To address the problem of low frequency, we first convert the annual data of the nominal GDP over 1980–1991 (published by the NBS) into quarterly data by averaging annual figures, and then employ estimation results from Abeysinghe and Gulasekaran (2004) for quarterly growth rates of real GDP (year-on-year) over the same period to derive the corresponding quarterly real GDP series.

Data description

Name	Trans. code	Description	Data sources	Sample availability
CPI	2/3	Consumer price index	NBS	1980-2010 (M)
M2	2/3	M2 money stock	IFS	1980-2010 (Q)
M1	2/3	M1 money stock	IFS	1980-2010 (Q)
GDPIP	2/3	GDP deflator, calculated as the ratio of nominal GDP to real GDP	NBS	1980-2010 (Q)
CREDIT	3	Domestic credit,	IFS	1980-2010 (Q)
IMP	3	Import price index	GEM	1990-2010 (M)
REER	3	Real effective exchange rate	IFS	1980-2010 (Q)
CSPI	3	Composite stock price index of China's A-share stock market	CSMAR	1991-2010 (M)

GDP	2/3/4	Real Gross Domestic Product	NBS	1980-2010 (Q)
ΔHPI	1	Year-on-year growth rate of house price index	NBS	1998-2010 (Q)
ΔPPI	1	Year-on-year growth rate of purchasing price index for resource materials	NBS	1997-2010 (M)

Notes: The following abbreviations are used: M=monthly available; Q=quarterly available. Data sources are: NBS=National Bureau of Statistics; IFS=International Financial Statistics; GEM=Global Economic Monitor of the World Bank; CSMAR= China Securities Market Research Database. Data transformation codes are: 1. level of the series; 2. series in natural logarithm; 3. first difference (year-one-year) of the logged series; 4. linearly detrended series.