THE RIMINI CENTRE FOR ECONOMIC ANALYSIS

WP 34-07

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Identifying the Shocks Driving Inflation in China*

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Identifying the Shocks Driving Inflation in China*

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[This Draft: August 2007]

ABSTRACT

The time profile of inflation in China resembles the one experienced in major industrial countries. Given the uncertainty surrounding the sources of economic shocks, this paper compares results from three sets of alternative identification conditions, namely the standard Blanchard-Quah approach, the approach of Cover, Enders, and Hueng (2006), as well as the model considered by Bordo, Landon-Lane and Redish (2004). Our principal finding is that inflation in China has been primarily driven by monetary factors. While aggregate supply factors may have pushed inflation to cross the threshold leading to deflation, monetary policy is primarily responsible for Chinese inflationary outcomes.

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JEL Classification codes: E31, E32, C32, C52

1. Introduction

The time profile of inflation in China over the past 15 years resembles the one experienced in major industrial countries over a 40-year period. Figure 1 makes the point graphically by comparing the US inflation experience over the past 40 years against China's inflation since 1990. Negative aggregate supply shocks during the 1970s, combined with an inappropriate monetary policy response, are believed to explain the spike in inflation in the early 1980s in the US. In contrast, the low and stable inflation rates since the 1990s in the U.S. are the product of the emphasis on price stability, combined with good aggregate demand management (e.g., see Orphanides 2003). In China, the deregulation of prices in the early 1990s may well have contributed to the rapid rise of inflation together with an accommodative monetary policy. Some observers (e.g., Bernanke 2002, Cargill and Parker 2004) claim that the deflation in China, in particular, may have been driven primarily by aggregate supply factors, especially strong productivity growth. Others (e.g., Burdekin and Siklos 2007) are more skeptical. There is a subtle difference of opinion about whether the deflation in China was primarily driven by aggregate demand (AD) or supply (AS) factors.

Figure 1 about here

Whether inflation in China is explained by aggregate demand or supply factors have important broader implications for our understanding of the role of monetary policy. Moreover, if the disinflation and deflation are driven primarily by aggregate supply factors, this suggests that the recent Chinese macroeconomic experience stands in contrast with Japan's deflation induced slump.[i] Deflation is associated with economic contraction. An alternative view suggests that productivity and technological changes lead to an expansion of aggregate supply relative to aggregate demand thereby leading to lower prices while

economic activity expands. Bernanke (2002), then a governor of the US Federal Reserve, remarked: “I don't know of any unambiguous example of a supply-side deflation, although China in recent years is a possible case.” Generally, however, most observers associate deflation with negative economic outcomes (Burdekin and Siklos 2004, Bordo and Filardo 2004).

One way to explore the forces driving inflation in China is to examine the relative importance of aggregate demand versus aggregate supply factors via the estimation of small order vector autoregressions (VARs). However, this paper departs from the usual approach by comparing results from the application of three sets of alternative identification conditions, namely the standard Blanchard-Quah approach, an approach recently proposed by Cover, Enders, and Hueng (2006), as well as the set of identifying restrictions considered by Bordo, Landon-Lane and Redish (2004). The latter also use structural VARs to study economies from a longer run historical perspective. Our estimated models are bivariate, consisting of real GDP and inflation, or trivariate, consisting of real GDP, inflation, and money or credit growth. Money or credit growth are used to proxy the direct effects of monetary policy since institutional considerations imply that an interest rate instrument is unsuitable in China’s case.

Our principal finding is that inflation in China has been primarily driven by aggregate demand factors. Given that the People’s Bank of China (PBC) has a history of announcing monetary targets (generally in terms of an aggregate such as M2), our results are consistent with the view that monetary policy is central to understanding the behavior of inflation, disinflation, and deflation in China. While aggregate supply factors may have pushed inflation low enough to cross the threshold into deflation, monetary policy is

primarily responsible for Chinese macroeconomic outcomes. More importantly, one can only interpret China's deflation as being supply-driven if AS and AD disturbances are assumed to be uncorrelated, an assumption implicit in the oft-used Blanchard-Quah decomposition, but one that is unappealing in China's case.

Lately, monetary aggregates have taken a back seat to interest rates in models used to evaluate monetary policy. Estimation of a Taylor rule would not be sensible in China's case as the PBC does not have an interest rate target and several other key interest rates are largely administratively determined. Fatas, Mihov and Rose (2007) provide evidence suggesting that central banks with a monetary target generate, on average, lower inflation. China's experience adds additional evidence for the view that central banks which neglect monetary factors, in understanding the evolution of inflation do so at their own peril.

The paper is organized as follows. First, we provide an overview of economic performance and the role of monetary policy in China. The econometric techniques used in the paper are discussed in Section 3. Section 4 provides a description of the data together with model estimates and their interpretation. Section 5 concludes.

2. Inflation and Deflation in China: An Overview

Over the past decade or more, the Chinese economy has consistently maintained rapid economic growth. The results are reflected in the rather remarkable levels of growth in both real GDP and industrial production, shown in Figure 2. While there is controversy about the accuracy of Chinese macroeconomic data (e.g., see Rawski 2002, Prasad 2004) few would disagree that overall economic growth over the period in question has been impressive. Annual growth rates in real GDP are volatile. However, when the basis of

comparison is an emerging market economy, China's real GDP growth performance does not appear atypical.

Figure 2 about here

In the econometric analysis to follow, both output series were also converted into output gap type proxies, the usual practice in the relevant literature. A variety of filters, including cubic trends, HP filters and broken trends were examined. The series plotted in Figure 3 are representative of the various outcomes obtained. Broadly speaking, the type of filter does not seem to matter greatly except toward the end of the sample when the HP filter and cubic trends suggest that both real GDP and industrial production are below trend.[ii] When the output gap is measured in terms of industrial production, economic activity is above trend toward the end of the sample. During the disinflation and deflation portions of the sample (1995 to 2004), the output gap based on industrial production is typically positive whereas the real GDP version is closer to trend much of the time.

Figure 3 about here

As recent monetary policy and exchange rate developments in China have been ably described elsewhere (e.g., Frankel and Wei 2007, Cargill and Parker 2004, Dai 2002) we simply point out that, over the sample considered, the PBC relied primarily on the control of monetary aggregates, less so on an interest rate instrument, to send signals about its intentions.[iii] Figure 4 plots narrow and broad money growth measures and the benchmark interest rate level in China since 1991. There is considerably more variation in the monetary aggregates than in interest rates over the sample considered while the money growth proxies reveal somewhat different time profiles. The summary statistics in Table 1 suggest a clear demarcation in economic performance between the eras of inflation (1990-1994) and

disinflation or deflation (1995-2004).[iv] The data also suggest that economic growth slowed considerably during the second half of the sample considered. Interestingly, the average output gap based on industrial production is clearly positive during the inflation sample, and negative when only the disinflation and deflation data are considered. Almost two-thirds of the sample considered in this study consists of disinflation and deflation while over a third of the data cover a period of deflation, defined here as negative inflation.

Figure 4 about here

Table 1 about here

The disinflation/deflation experience in China differs from that of Japan in that low inflation is accompanied by increasing output. The stable or slightly falling prices, low nominal interest rates and high valuation of domestic assets are largely supported by China's strong long-term foreign direct investment inflows, abundant foreign currency liquidity and a favorable position of a net international creditor. However, large foreign capital inflows and the pegged exchange rate regime also feature potential high inflation, high local currency interest rates and lower asset prices in China. (see Icard 2003)

China has been maintaining tight capital controls with a fixed exchange rate regime for years and the increasing revaluation expectations of the Chinese currency have triggered large capital inflows. Whether these expectations are justified remains controversial (e.g, see Cheung, Chinn, and Fujii 2007). As Prasad and Wei (2005) point out the vast majority of this inflows are in the form of FDI fueled by tax and other government incentives as well as by the resort to domestic Chinese firms forming joint ventures with foreign firms to avoid domestic lending and other administrative restrictions. With limited scope for Renminbi (RMB) exchange rate fluctuations (e.g., see

Frankel and Wei 2007), interest rates to differ from the US dollar rate and the fixed exchange rate, the price level in China becomes the residual (Liang 2003). In order to restrain recent inflationary pressures stemming from capital inflows, the PBC has been sterilizing foreign exchange intervention by selling bonds to domestic banks, and thereby reducing the amount of available liquidity in the market. The massive interventions on the foreign exchange market required to maintain the peg between the RMB and the US dollar imply a huge money supply growth in China (Ouyang, Rajan, and Willett 2007).

In spite of the substantial sterilization of capital inflows, there is a sign that the PBC's capacity has reached its limit. Accordingly, the PBC has lately raised interest rates or used alternative administrative measures to slow the growth of liquidity in the economy so as to curb inflationary pressures as observed since 2006. The PBC thus faces a dilemma since a more restrictive monetary policy, mainly an interest rate hike, could trigger financial problems for some state-owned enterprises that already have to cope with relatively high debt burden. As a result, there could be an increase in the level of non-performing loans (NPL) in the already fragile state-owned banking sector.[v] The asset price inflation resulted from unchecked rapid credit growth further leads to deflationary pressure accompanied by more serious NPL problems in the banking sector and a possible reduction of economic growth.

Yu (1997) outlines the background of China's macroeconomic policy and assesses the effectiveness of monetary and fiscal policy control in particular. He examines the long-term relationship between a number of macroeconomic variables and economic activity from 1983:12-1994:05. Employing a variety of vector error-correction models (VECMs) that include variables such as money aggregates, bank credit, output and prices in the

empirical estimation, he argues that tight monetary management in the early transition period played an important role in influencing the economic cycle. However, monetary policy showed no significant impact on fixed-asset investment, retail sales to institutions and merchandise imports. The reasons are that the highly centralized bank-credit controlling system, the lack of independence of the central bank from government, showed up in the high deposit costs and huge non-performing loans that are on the books of the banking sector.[vi]

Woo (2003) provides an overview of the various signals of macroeconomic "overheating" and deflation experienced during the economic transition to a more market-driven economy. He argues that the roots of deflation pressure in China are the inadequate market-based macroeconomic reforms, and the continued unbalanced credit structure between the government or public sector vis-á-vis the domestic private sector. Consequently, existing savings are inefficiently intermediated through the monopoly state banks.

Cargill and Parker (2004) is one of the few studies to have specifically examined China's deflation. They argue that the recent deflation in China may have been supply-led. They interpret the high rates of real GDP growth, loose monetary and fiscal policies, and ongoing structural changes in the economy as playing important roles in explaining the deflation. As a result, China's deflation was not harmful to the economy. They estimate a money demand function using quarterly data since 1960, and their empirical results show that the deflation had no measurable impact on money demand. Such a result is inconsistent with the People's Bank of China's (PBC) view that the recent aggressive monetary policy is

the key reason China has overcome the slowdown in the Asian economic zone, beginning with the Asian crisis of the late 1990s (also see Burdekin and Siklos 2007).

3. Identifying Aggregate Demand and Supply Shocks in China

The Blanchard-Quah (1989; BQ) approach has arguably been the most popular method used to examine the dynamic effects of economic innovations.[vii] In a recent survey, Fidrmuc and Korhonen (2004) identified 13 of 27 empirical studies of emerging markets that relied on this approach to study business cycle correlations in Europe. Applications to China and other Asian economies are also plentiful (e.g., Zhang 2005). Nevertheless, all such applications have focused on output developments while the primary focus of this paper is on the course of inflation in China since 1990. The technique consists in estimating a VAR system that includes at least two endogenous variables, imposes the necessary restrictions to identify two types of disturbances that are then interpreted as aggregate demand and aggregate supply shocks. By imposing different identification restrictions, the permanent or temporary effects of these two shocks and their economic interpretation can be estimated. Other research has extended BQ methodology to examine the contribution of either type of shock by employing a different set of restrictions.

The normalization restrictions in Cover, Enders and Hueng (2006) differ from BQ's methodology in important ways. They argue that it is not necessary to assume that the structural shocks are mutually uncorrelated. Instead, aggregate demand and supply are seen as moving together through time. The impact of supply shocks on output will then depend on the relationship between aggregate demand and supply shifts.

The bivariate approach is, arguably, a restrictive one. For example, Bordo and Redish (2004), using annual data, estimate aggregate supply, monetary policy and aggregate

demand shocks, and impose three different sets of restrictions to identify these. In this paper we adopt a similar methodology to theirs to explore the Chinese inflationary experience (also see Bordo, Landon-Lane and Redish 2004).

3.1 Identification methodology I: The Benchmark BQ model

Two types of disturbances affect output and inflation. Aggregate supply disturbances have a long run effect on either inflation and or output. Aggregate demand disturbances are assumed to have no long run effect on inflation, but may have a long run effect on output. Finally, these two disturbances are uncorrelated at all leads and lags. To derive the joint process, we let ΔP and ΔY, respectively, denote price and output level that have been differenced in the log levels once to achieve stationarity.[viii] The resulting bivariate VAR is written:

$$\begin{bmatrix} \Delta P_t \\ \Delta Y_t \end{bmatrix} = \begin{bmatrix} \Delta P_0 \\ \Delta Y_0 \end{bmatrix} + \begin{bmatrix} a_{11}(L) & a_{12}(L) \\ a_{21}(L) & a_{22}(L) \end{bmatrix} \begin{bmatrix} \Delta P_t \\ \Delta Y_t \end{bmatrix} + \begin{bmatrix} e_{pt} \\ e_{yt} \end{bmatrix} \tag{1}$$

where e_{pt} and e_{yt} are the random disturbances in the price and output level equations and they reflect a linear combination of the underlying structural shocks that are responsible for variations in P_t and Y_t. Following earlier studies, one of these structural shocks is assumed to be a supply shock, ε_s, while the other is demand shock, ε_d, so that residuals vector is defined as:

$$\begin{bmatrix} e_{pt} \\ e_{yt} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} e_d \\ e_s \end{bmatrix} \tag{2}$$

Following the BQ methodology, the first three restrictions are on the four elements of A (0), where for any matrix A (0) such that A (0) A (0)'= Ω. Since the two disturbances, e_{pt} and

e_{yt}, are assumed to be uncorrelated in the standard BQ model, the variance covariance matrix is diagonal and covariance matrix is identity. Therefore, we can write:

$$\begin{bmatrix} \text{var}(e_{yt}) & \text{cov}(e_{yt}\, e_{pt}) \\ \text{cov}(e_{yt}\, e_{pt}) & \text{var}(e_{pt}) \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} \sigma^2_{\varepsilon_s} & \sigma_{\varepsilon_s \varepsilon_d} \\ \sigma_{\varepsilon_s \varepsilon_d} & \sigma^2_{\varepsilon_d} \end{bmatrix} \begin{bmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \end{bmatrix} \tag{3}$$

According to the above description, the restriction $\sigma^2_{\varepsilon_s} = \sigma^2_{\varepsilon_d} = 1$ ensures that the variance of the demand and supply shocks are equal, while the condition $\sigma_{\varepsilon_s \varepsilon_d} = 0$ implies that the two types of shocks are uncorrelated. Finally, the restriction $\sum_{j=0}^{\infty} a_{12}(j) = 0$ means that demand shocks, ε_d, have no permanent effect on output.

3.2 Identification methodology II: Modified BQ Model

The assumption that demand and supply shocks are uncorrelated is implausible for the Chinese case because the monetary and fiscal authorities acted in tandem in setting national targets for economic growth. A methodology proposed by Cover, Enders and Hueng (2006) relaxes such restriction that AD and AS shocks are uncorrelated. Instead, they specify short-run restrictions implied by an aggregate demand and supply model which, when combined with the BQ restrictions, permits the structural shocks to be correlated.

These restrictions cannot be accommodated in the Benchmark BQ model. Therefore, the responses of output and the price level need to be re-estimated, allowing the disturbances to be correlated. Let Y_t and P_t denote the logarithm of output and the logarithm of price level respectively during period t, while ${}_{t-1}Y_t$ and ${}_{t-1}P_t$ represent the level of expected output and price level given the information at the end of period t. A simple AD-AS model can be written as:

$$
\begin{aligned}
Y_t^s &= {}_{t-1}Y_t + \alpha(P_t - {}_{t-1}P_t) + \varepsilon_s \\
(Y_t + P_t)^d &= {}_{t-1}(Y_t + P_t)^d + \varepsilon_d \\
Y_t^d &= Y_t^s
\end{aligned} \tag{4}
$$

As identified in the benchmark BQ model, ε_s is the aggregate supply shock and ε_d is the aggregate demand shock. However, the relationship between these shocks is no longer assumed to be uncorrelated. Therefore, $\sigma_{\varepsilon_s \varepsilon_d} \neq 0$ and there is one less restriction than in the BQ decomposition. Two alternatives for the short-run restrictions are possible. We can assume that an AS shock has an immediate impact on AD shocks in the following manner:

$$\varepsilon_d = \beta\varepsilon_s + \varepsilon_{d_0} \tag{5}$$

where ε_d is the linear combination of pure AD shocks ε_{d_0} and the induced change from the AS shocks is $\beta\varepsilon_s$; β is the weight of temporary AS shocks that can result in a contemporary change in aggregate demand. Covers, Enders, and Hueng (2006), show that the BQ decomposition amounts to assuming that a shift in AS leads to a shift in AD. A plausible scenario is one where the monetary authorities believe there has been an aggregate supply shock, and they react to it within the same quarter. Hence, AD shocks are seen to be a response to shocks that originate from the AS side of the economy. The reaction need not, of course, be such that $\beta = 1$. As noted earlier, some observers of the Chinese economy argue that short-run causality has effectively run from the AS to the AD side of the economy.

A second possibility is that the short-run link runs from AD shocks to AS shocks in which case the relationship is written:

$$\varepsilon_s = \gamma\varepsilon_d + \varepsilon_{s_0} \tag{6}$$

For example, the parameter γ can depend on the degree of price rigidity in the economy. Firms do not fully adjust price in response to some unexpected demands shock and continue

to oversupply the output demanded. There is a good case to be made that China's policies are consistent with this possibility as well. After all, China is not a full-fledged market economy, and there is substantial government involvement in the economy in the form of aggressive aggregate demand management. Consequently, any mistakes in the implementation of monetary policy in China could give rise to the relationship embodied in equation (6). Additionally, the well documented problems with the banking sector, dominated by state-owned banks and, consequently, strongly influenced by PBC policies, may also contribute to a short-run link going from AD to AS.

As in the BQ model, it is still assumed that structural demand and supply shocks are orthogonal in this bivariate VAR system. However, the variances of AD and AS shocks are no longer restricted to unity. Therefore, the estimation of the VAR yields the following variance-covariance representation:

$$\begin{bmatrix} \text{var}(e_{yt}) & \text{cov}(e_{yt}e_{pt}) \\ \text{cov}(e_{yt}e_{pt}) & \text{var}(e_{pt}) \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{bmatrix} \begin{bmatrix} \sigma^2_{\varepsilon_s} & \sigma_{sd} \\ \sigma_{sd} & \sigma^2_{\varepsilon_d} \end{bmatrix} \begin{bmatrix} c_{11} & c_{21} \\ c_{12} & c_{22} \end{bmatrix} = \begin{bmatrix} \frac{1}{1+\alpha} & \frac{\alpha}{1+\alpha} \\ \frac{-1}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \begin{bmatrix} \sigma^2_{\varepsilon_s} & \sigma_{sd} \\ \sigma_{sd} & \sigma^2_{\varepsilon_d} \end{bmatrix} \begin{bmatrix} \frac{1}{1+\alpha} & \frac{-1}{1+\alpha} \\ \frac{\alpha}{1+\alpha} & \frac{1}{1+\alpha} \end{bmatrix} \quad (7)$$

where $\sigma^2_{\varepsilon_s}$ is the variance of the structural supply shock and $\sigma_{\varepsilon_{d0}}^2$ is the variance of pure AD shocks, which is independent of AS shocks.

Following Cover, Enders and Hueng (2006), three independent restrictions are imposed. They are: $c_{11} = \alpha\, c_{12}$, $c_{11} = -c_{21}$ and $c_{11} = c_{22}$, as well as the long run neutrality restriction that AD shocks have no long run impact in output. The structural parameters obtained from such restrictions will be used to explain the slope of aggregate supply

curve, α; the effect of the structural AD shocks on output, $\frac{\alpha}{1+\alpha}$ and the effect of AS shocks on output, $\frac{1}{1+\alpha}$.

3.3 Identification methodology III: Separate Identification of Monetary Policy Shocks

A potential drawback with the methodologies discussed above is that they do not permit the separate identification of monetary policy shocks. Hence, we also consider the joint behavior of the price, output and money stock. Let ΔP again denote inflation, ΔY the growth of real GDP, and ΔM is growth in the money stock. Three stochastic disturbances are estimated, namely a money supply shock, ε_{ms}, an aggregate supply shock, ε_s and demand shock, ε_d. Next, we impose long-run restrictions on the impact of the shocks on prices and output. The resulting VAR consists of prices, output and money stock and is written as follows:

$$\Delta y_t = D_t\alpha + \sum_{j=1}^{p} B_j \Delta y_{t-j} + \varepsilon_t \tag{8}$$

where $y_t = (P_t, Y_t, M_t)'$ and D_t is a matrix of deterministic variables. Following the BQ approach, a set of structural innovations, u_t, that are orthogonal to each other can be obtained from this reduced VAR specification from:

$$\varepsilon_t = Cu_t \tag{9}$$

We identify C by imposing three alternative long-run restrictions on the structural impulse response functions implied by the reduced form VAR to examine the impact of each shock that drives the joint behavior of prices, output and the money stock.

A first set of restrictions assumes that an aggregate demand shock is the sum of money demand shocks and temporary spending shocks that have a zero long-run impact on output and prices. The money supply shock is defined to be non-neutral, implying that a positive monetary shock will increase output in the long run. Fluctuations in the price level are attributed to the change in money supply shocks but the temporary or permanent impact of these shocks on price, output, and the money stock, is not restricted. Aggregate supply shocks are expected to lower the price level and increase the output in the short run but a rise in aggregate demand will then raise the price level until it returns to its original level. Therefore, assuming the structural innovation vector is ordered as $u_t = (\varepsilon_{ms}, \varepsilon_s, \varepsilon_d)'$, the long run restriction can be written

$$\begin{bmatrix} \Delta P \\ \Delta Y \\ \Delta M \end{bmatrix} = \begin{bmatrix} c_{11}(1) & 0 & 0 \\ c_{21}(1) & c_{22}(1) & 0 \\ c_{31}(1) & c_{32}(1) & c_{33}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_{ms} \\ \varepsilon_s \\ \varepsilon_d \end{bmatrix} \tag{10}$$

Under this series of restrictions, aggregate supply shocks have no long-run impact on the price level. As previously discussed, this is not a view shared by most observers of Chinese economic developments during the 1990s. Since there are three zero restrictions the system is exactly identified.

Another long-run restriction consists in assuming that money is neutral, which implies that the long-run impact of a money supply shock on output is zero. In other words, AD shocks are neutral. Those who favor the view of a PBC that ‘did no harm’ to inflation would prefer this set of restrictions. Alternatively, if the PBC, and AD policies more generally, were important factors in China’s inflation rate then the following restrictions ought to be rejected by the data. The relevant restrictions are written:

$$\begin{bmatrix} \Delta P \\ \Delta Y \\ \Delta M \end{bmatrix} = \begin{bmatrix} c_{11}(1) & 0 & 0 \\ 0 & c_{22}(1) & 0 \\ c_{31}(1) & c_{32}(1) & c_{33}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_{ms} \\ \varepsilon_{s} \\ \varepsilon_{d} \end{bmatrix} \tag{11}$$

In this case there are four zero restrictions and this implies that the system is over identified. Consequently, we can test whether the hypothesis of monetary neutrality describes the Chinese experience.

Finally, we also consider the case where aggregate supply shocks are permitted to have a long-run impact on inflation while monetary neutrality is maintained. This is the case of a supply-side driven inflation. The relevant restrictions are written:

$$\begin{bmatrix} \Delta P \\ \Delta Y \\ \Delta M \end{bmatrix} = \begin{bmatrix} c_{11}(1) & c_{12}(1) & 0 \\ 0 & c_{22}(1) & 0 \\ c_{31}(1) & c_{32}(1) & c_{33}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_{ms} \\ \varepsilon_{s} \\ \varepsilon_{d} \end{bmatrix} \tag{12}$$

This system is also exactly identified.

If (11) is rejected then we are unable to formally discriminate between (10) and (12). In the case of (10) inflation would be interpreted as a monetary phenomenon, while in the case of (12) the results are consistent with a supply-side induced inflation. Therefore, in order to discriminate between the two hypotheses we also estimate the relevant VARs for a sub-sample beginning in 1995 when the behavior of inflation clearly changes (see Figure 1). If the results are similar across the two sub-samples then there is little evidence that the episodes of disinflation and deflation were driven by different shocks than ones explaining the period of rising inflation.

4. Empirical Results

4.1 Data

All models are estimated with quarterly data over the period 1990:1 to 2003:3. The data are collected from National Bureau of Statistics (NBS, formerly known as the State Statistics Bureau), the China Statistical Yearbook, the People's Bank of China website, and the International Financial Statistics CD-ROM. Because the statistical administration in China is still developing, only nominal GDP[ix] was available on a quarterly series while CPI did not become an official economic indicator until 2000. No CPI index is published. Only a measure of inflation, in percent at annual rates, is available. Therefore, real output was estimated by deriving a price index from published inflation figures and dividing nominal GDP by the resulting price index. The year 1989 was taken as the base year. [x] Additional seasonal adjustment is performed to remove seasonality in real GDP levels and price index.[xi] Next, the log first difference of the estimated quarterly real GDP figure is evaluated to obtain output growth. In addition, several proxies for the output gap, described earlier, are also considered. To investigate the sensitivity of our results, we repeat all our estimations using industrial production. The money stock is measured either as narrow money or Quasi-money, using the IMF definitions.

4.2 Estimates of Structural Shocks

Figures 5a and 5b plot the impulse response functions (IRFs) based on the standard BQ decomposition. Both full sample (top two figures; 1990-2003) and sub-sample (bottom two figures; 1995-2003) results are shown.[xii] In the case of inflation AS shocks elicit the largest response in the full sample while AD shocks produce larger responses in the disinflation/deflation sample. Turning to the impact of AD and AS shocks on output we find that whereas AD shocks temporarily reduce real GDP growth in either sample, AS shocks have a positive, albeit temporary impact on growth, again in both samples considered.

Clearly, the response of inflation is sensitive to the chosen sample while the impact of shocks on output growth is less sample sensitive. Figure 5b shows that the impact of AD and AS shocks is also sensitive to the choice of our measure of output. When a proxy for the gap in industrial production is used we now find that AD shocks generate a relatively larger inflationary response. However, in this case, the result is not sample sensitive. In the case of output responses to AD and AS shocks, both types of shocks produce positive, but only temporary, responses on industrial production with AS shocks producing the largest impulse responses of the two. While the results are clearly mixed there is considerable scope for interpreting China's inflation and output as possibly being primarily being driven by AD shocks.

Figure 5 about here

The IRFs in the case where short-run restrictions specified in equation (5) are imposed are shown in Figure 6. We note that the IRFs are no longer sensitive to the definition of output. In particular, AD shocks produce the biggest inflationary response in both samples and for both output definitions. In the case of IRFs for output, output responds positively, but temporarily, to AD and AS shocks. To the extent that consistency across output proxies makes for a more robust set of results, this suggests that inflation in China responds to AD shocks and not exclusively to AS shocks.

Figure 6 about here

Figure 7 provides IRFs for the trivariate VAR. Since the results for the 1995-2003 sub-sample are similar to ones obtained for the full sample (not shown), only the full sample estimates are presented. As discussed previously, the restriction that AD shocks have no long-run effects, produces an over-identified model (see (11)). The validity of this restriction

can therefore be tested. The likelihood ratio test statistic is found to be 27.93 (.00). Consequently, the null is soundly rejected. IRFs are shown in the middle portion of Figure 7 for completeness but are not discussed further. This leaves two alternatives, namely, either AS shocks are neutral (top portion of Figure 7), or monetary policy shocks are neutral (bottom portion of Figure 7) while AS shocks are unconstrained in the long run. When AS shocks have no long-run impact on inflation (top portion of the Figure) money supply shocks elicit a positive inflationary response while AD and AS shocks lead to a negative response. Moreover, money growth responds strongly to monetary policy shocks and to AD shocks but not to AS shocks. Finally, output growth responds positively to monetary policy shocks while AS shocks generate a temporary but positive response on real GDP growth.

The situation is rather different when AS shocks are not restricted in the long-run while money supply shocks are neutral in the long-run, as shown in the bottom portion of Figure 7. Inflation now elicits a positive response from AS shocks more so than from money supply shocks, while AD shocks lead to a negative response in inflation. Similarly, money supply shocks generate a temporary negative impact on output growth, as do AD shocks, while AS shocks generate a positive output growth response. Finally, monetary policy responds positively to all sources of shocks but especially to AS shocks.

Taken together the case depicted in the top portion of Figure 7, or the alternative identification strategy suggested by Cover, Enders and Hueng (see Figure 6) appear to be the most plausible candidates to explain the sources of shocks driving inflation in particular in China. Finally, as shown in Table 2, additional tests reveal that variables such as inflation in commodity prices are exogenous. Consequently, the addition of such variables did not affect the impulse responses shown in Figure 7. The same is generally true for export growth and

for the growth in the nominal effective exchange rates, although one is able to reject the null that the exchange rate is exogenous in the inflation equation. Yet, the IRFs (not shown) are largely unaffected.

Figure 7 about here

Table 2 about here

While impulse responses are useful, variance decompositions (VD) can help us determine the relative importance of shocks. Tables 3a and 3b present VDs for the full sample case only rely on the BQ and Cover, Enders and Hueng methodologies. Table 3a is the case for the standard AD-AS model (with the direction of short-run causality running from AS to AD shocks), while Table 3b provides the case where the short-run restriction defined by equation (6) is imposed. In the BQ decomposition, output growth is largely explained by AS shocks, although AD shocks also play an important role. Turning to inflation, it is overwhelmingly explained by AS shocks.

Consider next the alternative specification proposed by Cover, Enders and Hueng. AD shocks now explain almost all of the variation in output growth. Under this scenario, independent AS shocks cannot explain Chinese output growth. In the case of inflation, AS shocks also explain much of the variation in inflation in the short-term. However, at longer horizons, AD shocks become increasingly important. The point estimates of the correlation between AD and AS shocks is 0.45, implying that both AD and AS shocks are indeed positively correlated, as hypothesized earlier.[xiii] Tables 4a and 4b show the VDs for the trivariate VARs.[xiv] Since we reject the case where AS shocks have no long-run impact on output or inflation, these VDs are not shown. Regardless whether AS shocks are restricted to have no long-run impact on inflation, money supply shocks overwhelmingly explain

inflation, as well as a large fraction of output growth. AS shocks, however, are important determinants of output growth in the case of either scenarios hypothesized in (10) or (12) but also play an relatively minor role in determining inflation.

Tables 3 and 4 about here

5. Conclusions

In light of the recent debate over the role of monetary policy and aggregate supply factors in explaining the recent Chinese inflationary experience, this paper asks whether the monetary transmission process of a highly centralized economy such as China's can adequately be described by estimating structural VARs. For this purpose, different models were estimated using Chinese data for the period from 1990 to 2004, together with a sub-sample running from 1995-2003. The structural shocks were identified by a mixture of long run and short-run restrictions, following the Blanchard-Quah decomposition methodology, and two variants of this approach.

Money supply shocks largely explain inflation while aggregate supply shocks play a secondary role. Therefore, our results do not support the "supply-driven" view of China's deflation in particular. One can only conclude that the Chinese deflation was driven by aggregate supply factors if it is assumed that AS and AD shocks are uncorrelated, and this appears highly unlikely in the Chinese case.

The results also reveal how China was able to escape deflation. An aggressive loosening of monetary policy permitted the end of deflation. However, the results also point to a role for AS factors. Nevertheless, since it is difficult to precisely identify the sources of AS shocks, the PBC should not automatically rely on future productivity improvements to

prevent an excessively loose monetary policy from producing once again excessively high inflation.

Table 1. Summary Statistics for the Chinese Economy, 1990-2003

	Full sample	Inflation only	Disinflation-Deflation only
Real GDP	8.86	11.34	7.74
Industrial Production	14.82	22.03	12.10
Inflation	5.68	10.34	3.02
Output Gap (Real GDP)	-	-0.004	0.002
Output Gap (Industrial Production)	-	0.82	-0.317

Note: See appendix and Figures 1 to 3 for additional details. The output gap figures are based on the HP filtered measures of the output gap. The disinflation-deflation sample consists of data for the 1995-2003 periods only.

Table 2. Tests of Exogeneity

Independent Variable	Test Statistic (p-value)			
	Commodity Price Inflation	Commodity Price Inflation Non Fuel	Export Growth	Nominal Effective Exchange Rate
Inflation	.75 (.86)	3.55 (.31)	2.74 (.43)	8.97 (.03)
Real GDP growth	.96 (.81)	4.40 (.22)	4.49 (.21)	3.42 (.33)
Money Supply growth	2.67 (.44)	1.35 (.72)	10.38 (.02)	5.90 (.18)

Note: Based on the three variable VAR described in the test estimated over the full sample. The test statistic is the χ^2 test for block exogeneity with p-values given in parenthesis.
.

Table 3. Variance Decompositions: Full Sample, Bivariate VAR

a. Standard or BQ Decomposition AD-AS Model (AS causes AD)

	Output Growth		**Inflation**	
Horizon	*Due to AS*	*Due to AD*	*Due to AS*	*Due to AD*
1.000	0.524	0.476	0.761	0.239
2.000	0.507	0.493	0.790	0.210
3.000	0.535	0.465	0.788	0.212
4.000	0.654	0.346	0.800	0.200
5.000	0.613	0.387	0.827	0.173
6.000	0.585	0.415	0.818	0.182
7.000	0.585	0.415	0.826	0.174
8.000	0.597	0.403	0.829	0.171
9.000	0.595	0.405	0.832	0.168
10.000	0.596	0.404	0.832	0.168
11.000	0.597	0.403	0.833	0.167

b. AD-AS Model (AD causes AS) or Cover, Enders, and Hueng Variation

Horizon	*Due to AS*	*Due to AD*	*Due to AS*	*Due to AD*
1.000	0.025	0.975	0.804	0.196
2.000	0.031	0.969	0.772	0.228
3.000	0.103	0.897	0.776	0.224
4.000	0.283	0.717	0.763	0.237
5.000	0.361	0.639	0.727	0.273
6.000	0.373	0.627	0.737	0.263
7.000	0.373	0.627	0.728	0.272
8.000	0.358	0.642	0.726	0.274
9.000	0.356	0.644	0.721	0.279
10.000	0.358	0.642	0.721	0.279
11.000	0.369	0.631	0.720	0.280

Notes: Output growth is the real GDP. Inflation is the rate of change in CPI. See Figures 1 and 2. Multiply by 100 to convert into percent.

Table 4a Variance Decompositions: Three-Variable VAR

Variance Decomposition of Inflation (%)

Period	S.E.	Money Supply	Aggregate Supply	Aggregate demand
			Source of Shocks	
1	0.938	100.0	0.000	0.000
2	1.431	97.70	1.135	1.162
3	1.913	98.62	0.709	0.666
4	2.285	98.95	0.522	0.529
5	2.496	98.84	0.714	0.444
6	2.658	98.53	1.045	0.425
7	2.747	98.01	1.593	0.401
8	2.816	97.37	2.228	0.399
9	2.859	97.14	2.455	0.400
10	2.891	96.95	2.639	0.411
11	2.919	96.91	2.679	0.415

Variance Decomposition of Real GDP Growth (%)

Period	S.E.	Money Supply	Aggregate Supply	Aggregate demand
			Source of Shocks	
1	5.734	4.427	95.57	0.000
2	5.850	4.270	95.43	0.300
3	6.471	21.74	78.02	0.246
4	7.002	30.88	68.46	0.661
5	7.107	30.18	67.32	2.500
6	7.189	30.64	65.80	3.560
7	7.253	31.28	65.20	3.520
8	7.262	31.22	65.11	3.673
9	7.318	32.02	64.11	3.868
10	7.322	32.00	64.08	3.923
11	7.333	32.04	64.05	3.912

Note: Restrictions imposed as in (10).

Table 4b Variance Decompositions: Three-Variable VAR

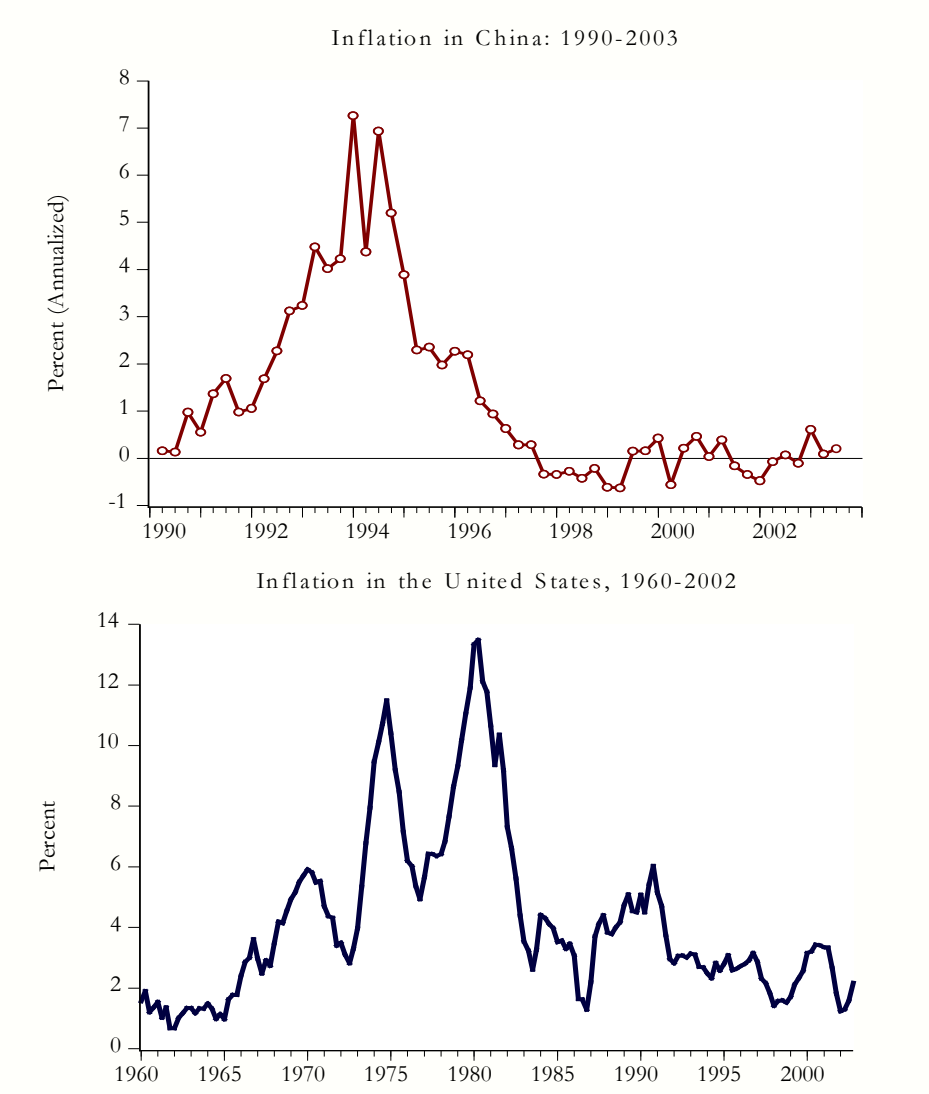
Variance Decomposition of Inflation (%)

Period	S.E.	Money Supply	Aggregate Supply	Aggregate Demand
			Source of Shocks	
1	0.938	95.57	4.427	0.000
2	1.431	96.67	2.168	1.162
3	1.913	96.85	2.486	0.666
4	2.285	96.74	2.731	0.529
5	2.496	95.44	4.121	0.444
6	2.658	94.15	5.430	0.425
7	2.747	92.90	6.699	0.401
8	2.816	91.66	7.944	0.399
9	2.859	91.13	8.468	0.400
10	2.891	90.71	8.877	0.411
11	2.919	90.54	9.041	0.415

Variance Decomposition of Real GDP Growth (%)

Period	S.E.	Money Supply	Aggregate Supply	Aggregate Demand
			Source of Shocks	
1	5.734	0.000	100.0	0.000
2	5.850	0.073	99.63	0.300
3	6.471	17.35	82.40	0.246
4	7.002	24.72	74.62	0.661
5	7.107	24.06	73.44	2.500
6	7.189	24.54	71.90	3.560
7	7.253	25.58	70.90	3.520
8	7.262	25.56	70.77	3.673
9	7.318	26.41	69.72	3.868
10	7.322	26.41	69.67	3.923
11	7.333	26.41	69.68	3.912

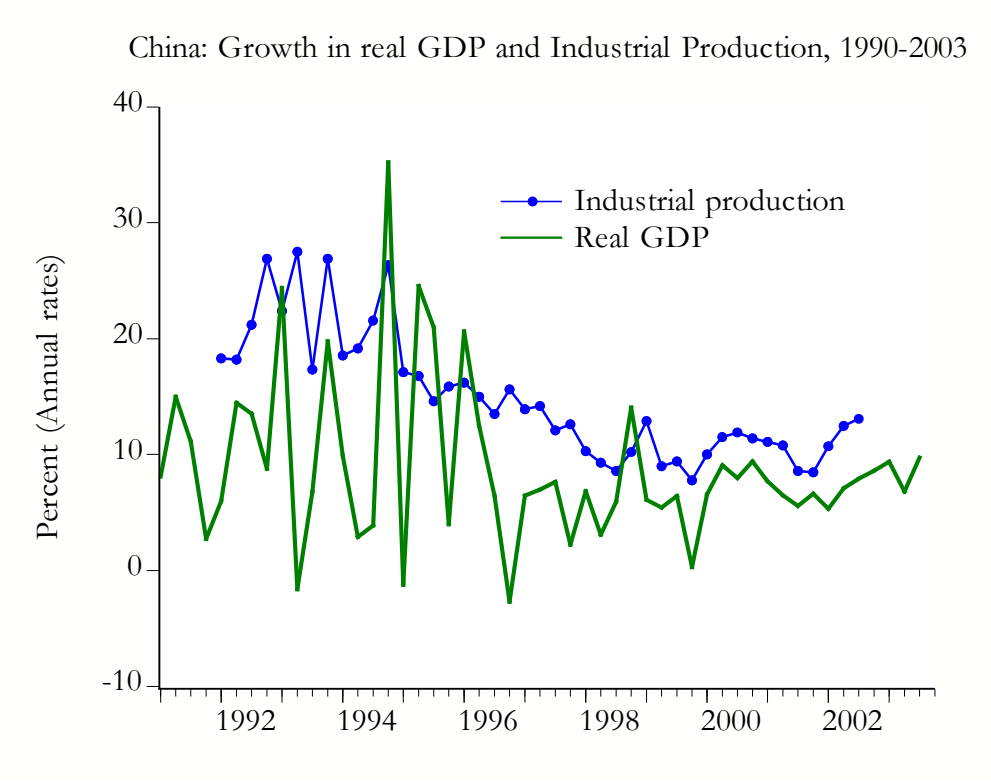
Note: Restrictions imposed as in (12).



Note: Inflation in China is the log change in the CPI. See the appendix. Inflation in the US is the annual rate of change (fourth order log difference) in the US CPI. Data from FRED II (research.stlouisfed.org/fred2/).

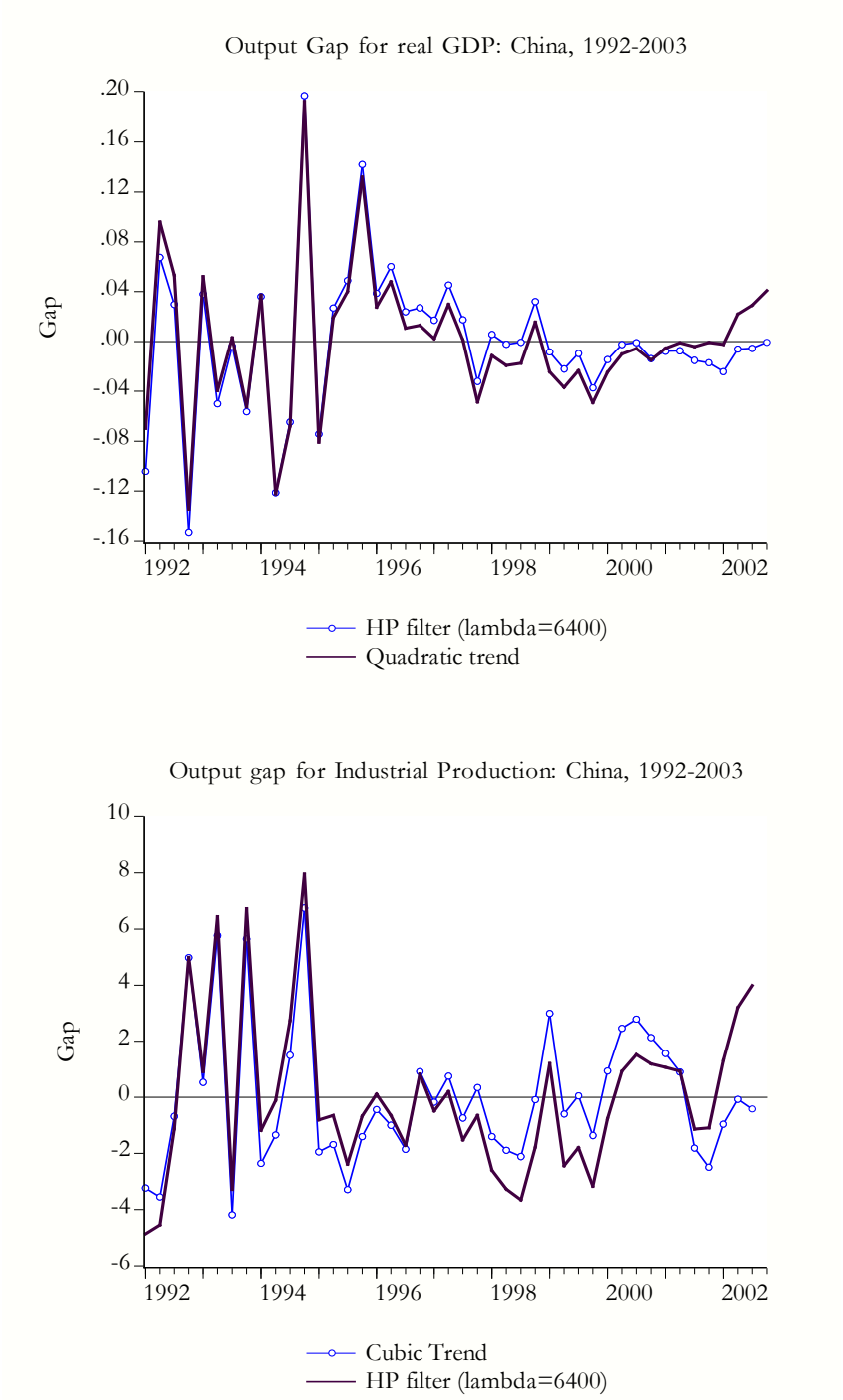
Figure 1 Comparing China's and the US's Inflation Rate

Figure 2 Alternative Estimates of Output Growth in China



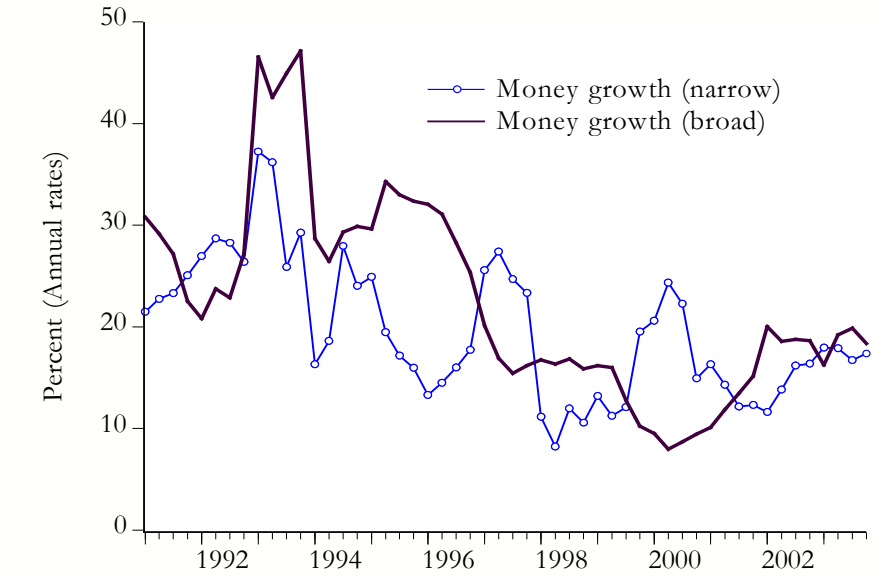
Note: Real GDP growth is the annual rate of change in the seasonally adjusted real GDP (fourth order log difference). Seasonal adjustment was obtained using X11 (additive method). Industrial production growth is from the IFS CD-ROM (IMF: Washington, D.C.).

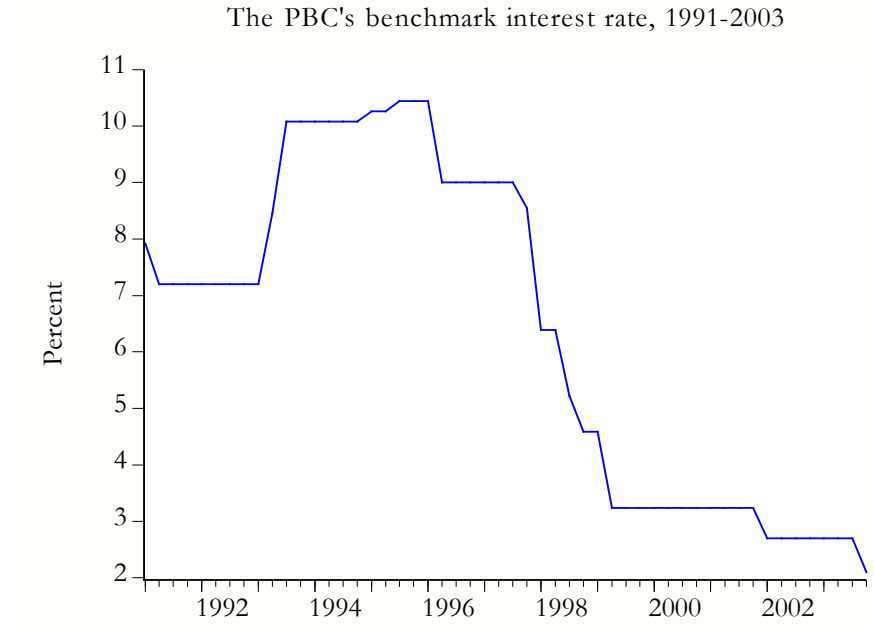
Figure 3 Proxies for the Output Gap



Note: The output gap is log of real GDP or Industrial Production less the HP filtered value (with smoothing parameter shown above) or from the fitted values of either a quadratic or a cubic trend fitted to the log levels of either series.

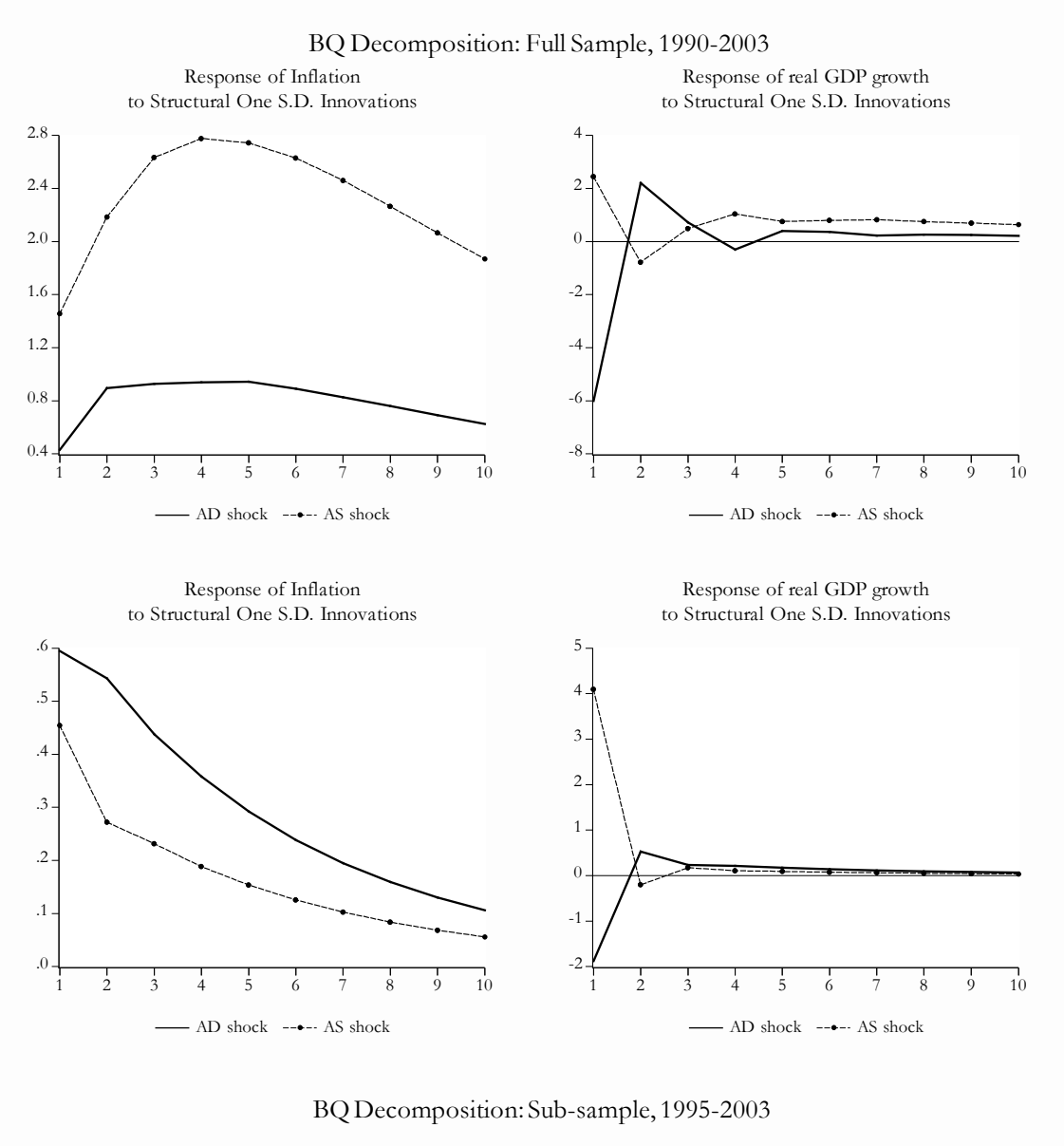
Figure 4 Monetary Variables for China





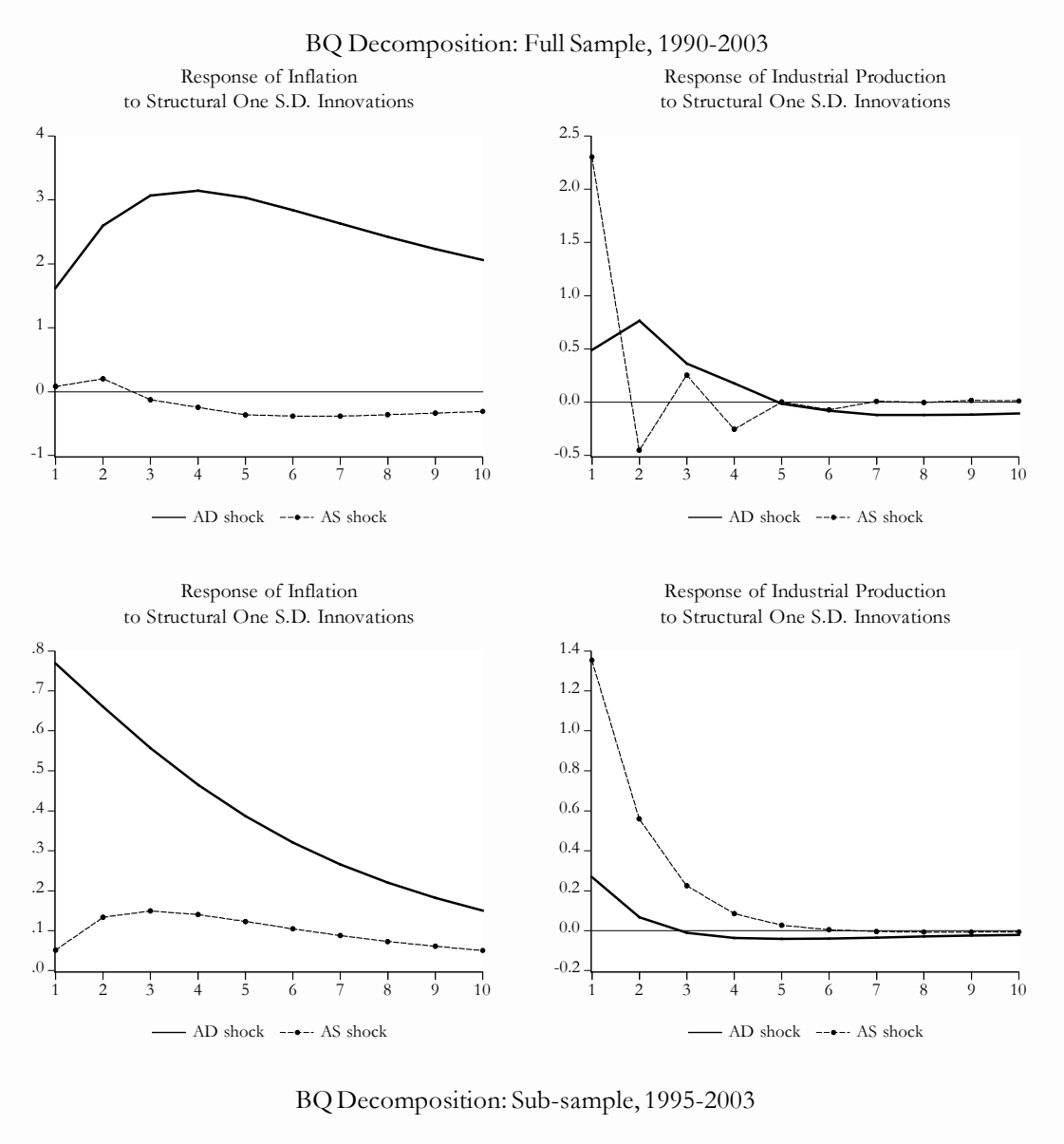
Note: For data sources, see the appendix. Annual growth rates for narrow and broad money are plotted.

Figure 5a Impulse Response Functions: BQ Decomposition



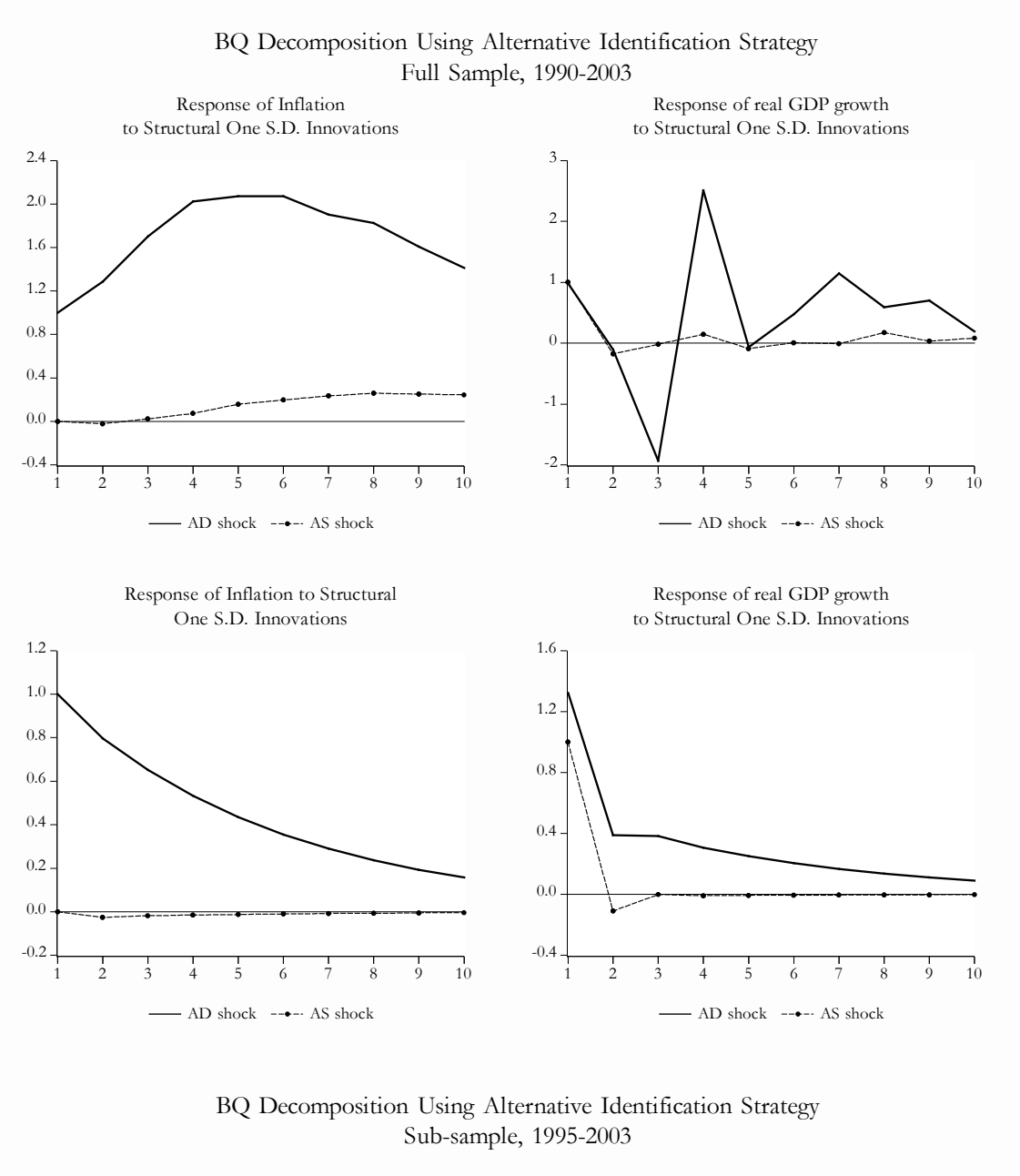
Note: For estimation details, see text.

Figure 5b Impulse Response Functions: BQ Decomposition



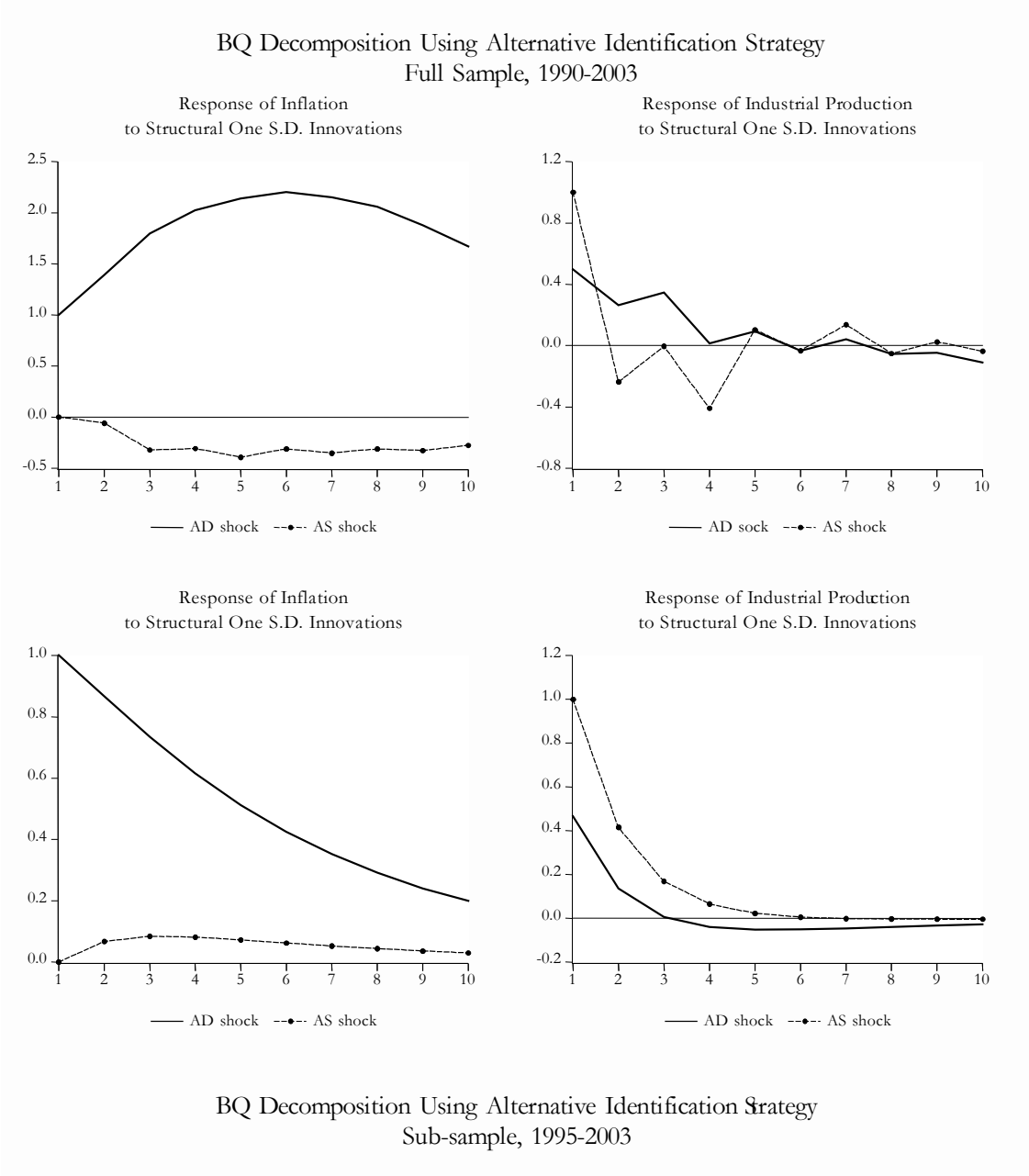
Note: For estimation details see text.

Figure 6a Impulse Response Functions: Alternative Identification Assumption



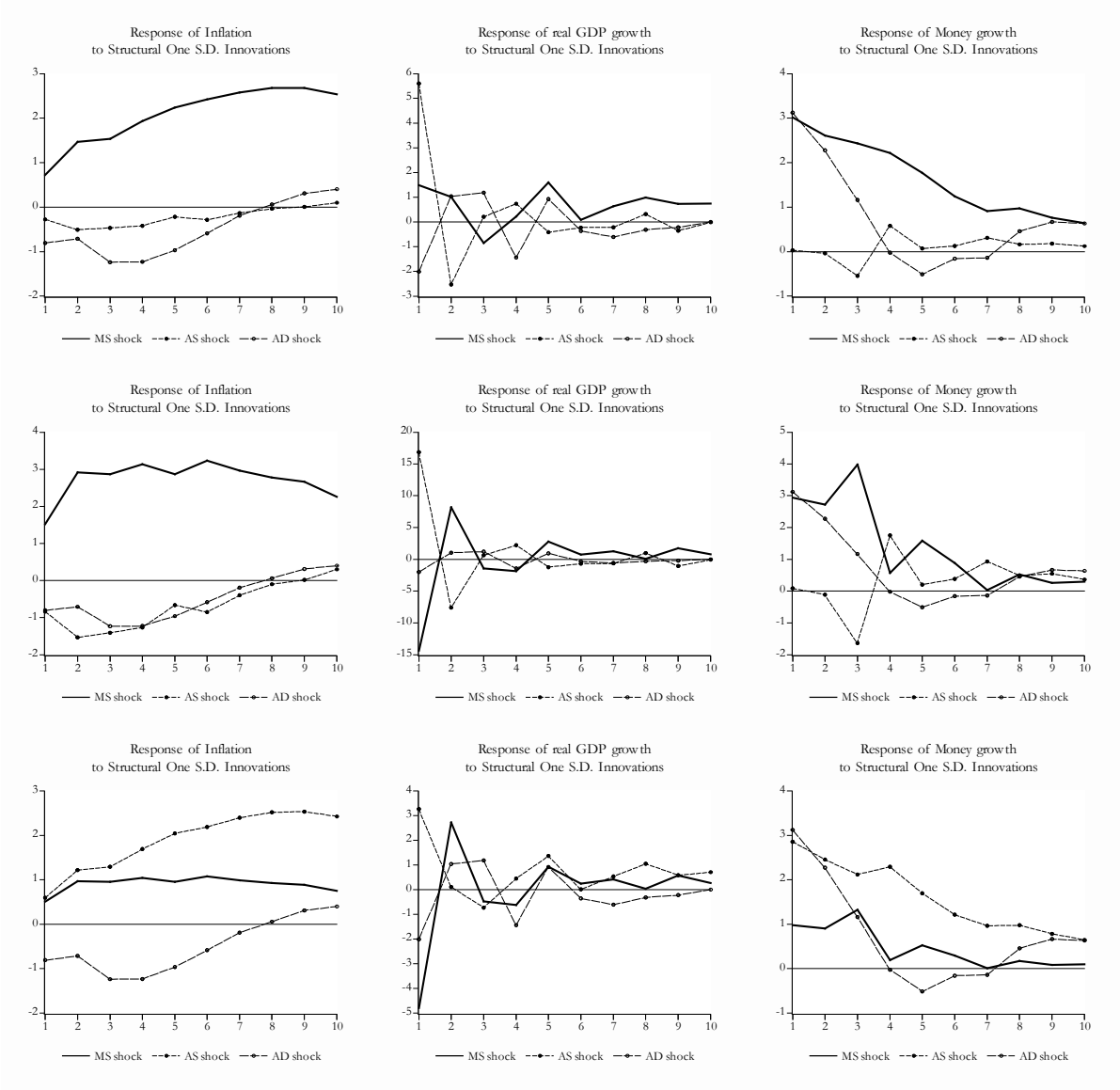
Note: For estimation details, see text.

Figure 6b Impulse Response Functions: Alternative Identification Assumption



Note: For estimation details, see text.

Figure 7 Impulse Response Functions: Trivariate VAR with Alternative Policy Restrictions, 1990-2003



Note: For estimation details, see text. The top portion of the Figure imposes the restrictions found in (10), the middle figure relies on the restrictions in (11), while the restrictions in (11) are used to generate the results in the bottom portion of the figure.

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Appendix

CPI calculation: Before 2000, there was no economic indicator of Consumer Price Index in China and the available official index for price level measure from 1985 to 2000 is annual or monthly change of consumer price. Year 2000 was made as the base period of the first round of compile fix-based monthly price index (Year 2000=100).

(1) Grouping of CPI. The consumer price index in China consists of 8 major categories: food, alcoholic beverages and tobacco products, clothing, household equipment and service, health and personal care, transportation and communication, entertainment, education and culture, shelter, etc.

(2) Selection of representative items. In the previous series, 289 kinds of goods and 36 kings of services have been selected for China's CPI. The current CPI is based on a basket comprised of 500-600 goods and services, which are aggregated into 282 subgroup, then into 80 groups and finally into 8 sections. Those goods and services were guided by certain criteria and based on the accounting material of about 30,000 urban households and 60,000 rural households.

(3) Selection of surveying area and outlets. There are about citied and countries used for China CPI survey up to now. In each area, shops (including country fairs and service sites)are selected based on their sales volume and abundance of goods, and they must be representative of price trends. There are nearly 10000 outlets included in China CPI.

(4) Price collection. Prices are collected directly by professional staff at certain time and outlets, which are: (a) Those actually paid by purchasers rather than the amounts listed in the counter. (b) Items have close relation to people's life and their prices change frequently are priced at least every five days; Others are collected 2-3 times each month; where prices are controlled by government or price movement are relatively stable, information is collected monthly or quarterly.

(5) Source of the weights. The weights of CPI are calculated according to the expenditure structure in household survey annually, while weights for fresh vegetables and foods are adjusted monthly.

(6) Release of the Index. Index is released through monthly economic reports of NBS on 12^{th} of following month and quarterly news release conference of NBS.

GDP calculation: GDP in China is the sum of the gross value added by all resident producers in the economy plus any taxes and minus any subsidies not included in the value of the products. It

is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Transfer payments are excluded from the calculation of GDP. Value added is the net output of an industry after adding up all outputs and subtracting intermediate inputs. The industrial origin of value added is determined by the International Standard Industrial Classification (ISIC) revision.

Data source description: NBS is the abbreviation of National Bureau of Statistics of China. Its responsibility include: Drafting and implementing statistics and regulations; Overseeing statistical and national accounting activities of local governments and ministries. Improving the systems of national accounts and statistical indicators; formulating the national statistical standards; Collecting national statistics and conducting statistical analysis of economic, social, and technological development; Improving the automated statistical information system and the national statistical database.

It was set up in 1952 and until March 1999 the NBS launched the China Statistical Information Network (**www.stats.gov.cn**), an online resource that makes information from NBS databases available to a wider audience, including detailed statistics on economic and social development, information from various censuses and the NBS's monthly statistics on national economic performance. The statistical data before 1999 is only available from the annual publication of NBS, the China Statistical Yearbook.

China Statistical Yearbook: It is an annual statistics publication, which covers very comprehensive data in every year and some selected data series in historically important years and the most recent twenty years at national level and local levels of province, autonomous region, and municipalities directly under control of the central government and therefore, reflects various aspects of China's social and economic development.

* Earlier versions were presented at an invited session of the Hong Kong Economic Association/Western Economic Association International Conference, Hong Kong, the Bank of Finland, the WEAI conference in San Diego, and the Hong Kong Institute of Monetary Research. Comments on a previous draft by King Banaian, Andy Filardo, Elliott Parker and the Editor, are gratefully acknowledged, as is the GAUSS program from Walt Enders used in Cover, Enders and Hueng (2006)

[i] There is, of course, a vast literature on the Japanese experience with deflation. A partial list would include, for example, Hutchison (2004), Kuttner and Posen (2004), Okina and Shiratsuka (2004), Hetzel (1999), and Krugman (1998).

[ii] A well-known problem with the HP filter is its sensitivity to the end-points of the sample. See, for example, Dupasquier, Guay and St.-Amant (1999).

[iii] See, for example, www.pbc.gov.cn/english/huobizhengce/instruments.asp, and People's Bank of China (2003, 2004).

[iv] Negative inflation rates were actually recorded in 1998-99 and 2001-02. However, even when positive inflation rates were recorded in 2000 and 2001, these were well below 1% (except in 2001Q2 when the inflation rate was 1.10%). Hence, it is not inaccurate to state that China experienced deflation during the 1998-2002 period.

[v] Chinese state-owned banks are the most important player of the Chinese financial system. In 2004, bank loans represented 83 percent of the funds raised by the non-financial sector, while stocks were only 5 percent and bonds 12 percent (11 percent for government bonds and 1 percent corporate ones). As the main financier of non-profitable state-owned enterprises (SOEs), state-owned banks' performance have a direct impact on

SOEs and systemic consequences on the economy. See, for example, García-Herrero, Gavilá and Santabárbara (2006).

[vi] Reforms of the Chinese banking sector has not brought sizeable benefits so far except for improving asset quality, and doubts remain about a possible build-up of new NPLs by low profitable state-owned banks given the fast credit growth and overheating in real estate recently.

[vii] See, for example, a simulated out-of-sample forecasting study for Finnish CPI inflation by Billmeier (2004). Cheung and Yuen (2004) also use BQ approach to assess the level of integration of the three Greater China economies (China, Hong Kong and Taiwan) and examines the suitability of a Greater China currency union. A variant of the BQ technique is also applied on evaluating the high-yield spread as a predictor of real economic activity in supportive of the financial accelerator mechanism for the U.S. See Mody and Taylor (2003).

[viii] In the case of output an alternative that is often preferred is to use a proxy for the output gap. This approach is also followed below.

[ix] Estimates of GDP are made independently from the production side (sum of value added) and the expenditure side (sum of final expenditures). Different estimates are obtained by the two methods. The NBS considers that its estimates from the production side are more reliable and the statistical discrepancy is therefore shown in the estimates of GDP from the expenditure side. The quarterly estimates of GDP from the production side distinguish 13 separate activities for the tertiary sector, but there is no breakdown of the primary sector (agriculture, animal husbandry, forestry and fishing) and the secondary sector is broken down into only "industry" and "construction". The discrepancies are not

large and are about 1% of GDP on average. Quarterly GDP data are provided in Press Releases issued at regular press conferences held in April, July, October and January (Chinese). Source: IMF, general data dissemination system site, data category and indicators of China, from http://dsbb.imf.org/Applications/web/gdds/gddscountrycategorydcreport/?strcode=CHN&strcat=NGDP0.

[x] The official year-to-year change of consumer price is available from 1990 only.

[xi] The ARIMA X-12 (additive) procedure was used to obtain seasonally adjusted estimates.

[xii] It has been suggested to us that splitting the sample around 1997, to account for the Asian crisis, might be preferable. Doing so, however, would leave too few usable observations to perform the kind of econometrc testing envisaged here. Nevertheless, as our full and sub-sample estimates both confirm the central role played by monetary factors we can only presume that this result would also hold for a sub-sample since the Asian crisis (also see Burdekin and Siklos 2007).

[xiii] The estimate is slightly lower than the point estimate of 0.64 reported in Cover, Enders and Hueng (2006). Given the short span of the sample, one cannot claim that these point estimates are precisely estimated.

[xiv] To conserve space, the VDs for money growth are not shown but are available on request.