A Test of the Relationship between Monetary Growth Uncertainty and Economic Growth in China: 1980-2008*

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1998   1998

2003

Monetary growth uncertainty in China can come from either monetary policy shocks or macroeconomic shocks. Our examination of the relationship between Chinese economic growth and monetary growth uncertainty indicates that monetary growth uncertainty results mainly from macroeconomic shocks. The pre-1998 period saw quite a high level of uncertainty, but this was markedly reduced after 1998. Monetary growth uncertainty caused by monetary policy shocks can be an effective stimulus for economic growth, implying the effectiveness of monetary policy regulation. From 2003 on, however, monetary growth uncertainty caused by macroeconomic shocks has inhibited economic growth, indicating the marked negative impact on China's steady growth of the economic shock represented by the international financial crisis. Active measures should be taken at the national level for early warning and prevention of economic risk.

Keywords: monetary growth uncertainty, economic growth, time-varying parameter, Markov regime switching

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I. Introduction

Within the category of nominal uncertainty, scholars have focused on the impact on macroeconomic activity of monetary growth uncertainty (hereinafter referred to as MGU) and inflation uncertainty. According to early theoretical research by Barro,[1] Friedman[2] and others, high nominal uncertainty not only interferes with economic agents' rational expectations of future economic activity, consequently undermining the timely making of economic decisions, but also lowers economic efficiency and intensifies macroeconomic fluctuations, eventually hindering steady and sustainable economic growth. Yet Caballero[3] stresses that the correlation found between nominal uncertainty and macroeconomic activity depends largely on what models we use. For example, Dixit and Pindyck[4] proved that the correlation is negative, while Abel's[5] research led to just the opposite result. In broad studies of the relationship between nominal uncertainty and macroeconomic activity, Coulson and Robins,[6] on the basis of the ARCH model, believed that the correlation is positive but not significant; but Lee and Ni,[7] adopting the state-dependent heteroscedasticity model, found it markedly negative. The findings of Bayoumi and Sgherri,[8] using the time-varying-parameter GARCH model, continued to show that high nominal uncertainty is always accompanied by drastic real output fluctuation, while Grier and Perry[9] pointed out that high nominal uncertainty significantly reduces the real output growth rate; at the same time Grier *et al.*[10] again confirmed that the correlation between nominal uncertainty and real output growth rate is significantly negative.

It should be noted that each of the empirical research studies above takes into account only one cause of nominal uncertainty. As Harrison and Stevens[11] put it, when using various economic models to study the features of the future uncertainty of economic entities, we should consider not only the impact of future stochastic disturbances within the model, but also the uncertainties embodied in some of the current parameters of economic variables, and should weigh the model's potential to link the present and the future. So Kim and

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1   R. Barro, "Rational Expectations and the Role of Monetary Policy," pp. 1-32.
2   M. Friedman, "Nobel Lecture: Inflation and Unemployment," pp. 451-472.
3   R. Caballero, "On the Sign of the Investment-uncertainty Relationship," pp. 279-288.
4   A. Dixit and R. Pindyck, *Investment under Uncertainty.*
5   A. Abel, "Optimal Investment under Uncertainty," pp. 228-233.
6   E. Coulson and R. Robins, "A Comment on the Testing of Functional Form in First Difference Models," pp. 710-712.
7   K. Lee and S. Ni, "Inflation Uncertainty and Real Economic Activities," pp. 460-462.
8   T. Bayoumi and S. Sgherri, "Monetary Magic? How the Fed Improved the Flexibility of the US Economy."
9   K. Grier and M. Perry, "The Effects of Real and Nominal Uncertainty on Inflation and Output Growth," pp. 45-58.
10   K. Grier *et al.*, "The Asymmetric Effects of Uncertainty on Inflation and Output Growth," pp. 551-565.
11   P. Harrison and C. Stevens, "Bayesian Forecasting," pp. 205-247.

Nelson[12] used a fixed-parameter model and a time-varying-parameter model separately to observe the US MGU, finding that though the time-varying-parameter model could measure the conditional variance of various time-varying parameters within the monetary growth equation so as to portray the hidden time-varying parameter features of each economic variable, it still failed to describe MGU in the monetary growth equation caused by shocks from future stochastic disturbances. In addition, Evans and Wachtel[13] proposed using the Markov-switching model to measure nominal uncertainty. Drawing on the above studies, Kim[14] distinguished among different sources of MGU and, using Markov regime switching heteroscedasticity, characterized the heteroscedastic features of disturbances within the monetary growth equation. On this basis, he further proposed a time-varying parameter Markov regime switching model (TVP-Markov) to examine the impact of US MGU on the macro economy and stated that inflation uncertainty from different sources had a time-varying effect on real GDP.

So far there have been just a few studies by Chinese scholars concerning nominal uncertainty and macroeconomic activity in China. One, by Jia Junxue *et al.*,[15] examined the impact of China's MGU on its macroeconomic fluctuations on the basis of the macro-level monthly statistics from 1994 to 2005. Our own research, based on China's quarterly statistics from the first quarter of 1980 to the third quarter of 2008, mainly follows Kim's method of model specification and uses the TVP-Markov model. We measure unexpected monetary growth with the help of errors in monetary growth forecasts and measure MGU with monetary forecast error conditional variance, and finally discuss the relationship between China's MGU and its economic development. Specifically, we divide the sources of China's MGU into the two categories of monetary policy shocks and macroeconomic shocks, and at the same time divide real GDP, which indicates China's macroeconomic situation, into a trend component and acyclical component. For the trend component of real GDP, two kinds of monetary uncertainty arising from monetary policy shocks and macroeconomic shocks respectively are considered so that their influence on China's economic growth can be tested. For the cyclical component, unexpected monetary growth can also be considered with a view to observing its impact on China's economic stability.

Since the second half of 2007, drastic fluctuations in world oil prices and the rapid expansion of the US subprime mortgage crisis eventually led to the eruption of the global financial crisis. This episode of financial crisis, whether considered in terms of its sources,

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12   C. Kim and C. Nelson, "The Time-varying-parameter Model for Modeling Changing Conditional Variance: The Case of the Lucas Hypothesis," pp. 433-440.

13   M. Evans and P. Wachtel, "Inflation Regimes and the Sources of Inflation Uncertainty," pp. 475-511.

14   C. Kim, "Sources of Monetary Growth Uncertainty and Economic Activity: The Time-varying-parameter Model with Heteroscedastic Disturbances," pp. 483-492.

15   Jia Junxue, Guo Qingwang and Cao Yonggang, "Monetary Growth Uncertainty and Its Effects on Macroeconomic Activity in China."

those affected, or its range and impact, went far beyond anything that had been expected, forcing us to reconsider and reassess the security of the modern financial system. It dragged the Chinese economy and even the global economy into a special period of adjustment, and gavethe world economic systema huge shock. Though global economic development has already moved into the post-financial crisis era, a thorough study of the basic features of Chinese MGU and its relationship to economic growth will still be of great benefit. It may help to analyze the transmission mechanism of fluctuations in China's monetary supply in the course of the formation, intensification and spread of this episode of the global financial crisis, and thence to discover and distinguish among China's capacities to resist and guard against them. It may also help policy makers to detect economic trends and changes, providing important reference evidence for advance warning of risks to the national economy and for risk management.

II. A Quantitative Econometric Model for Studying the Correlation Mechanism for MGU and the Business Cycle

We first introduce the quantitative model used and the processes of parameter estimation and testing of our empirical analysis.

1. TVP-Markov model

As the TVP-Markov model can accurately depict the interacting switching of MGU in different fluctuation regimes, we set out our monetary growth equation for measuring China's MGU on the basis of on the TVP-Markov state-space model put forward by Kim and Nelson:[16]

$$m_t = \alpha_{0t} + \alpha_{1t}g_{t-1} + \alpha_{2t}\pi_{t-1} + \alpha_{3t}m_{t-1} + \varepsilon_t \qquad (1)$$

where m_t stands for the monetary growth rate, ε_t for disturbance, and g_{t-1}, π_{t-1} and m_{t-1} for the real GDP growth rate, inflation rate and the monetary growth rate respectively in period $t-1$. We choose not to consider the influence of interest rates on the monetary growth rate simply because they are still not fully market-oriented in China and can reflect neither the actual market supply-demand relationship nor the market value or real value of monetary resources. Further, α_{it} ($i=0,...,3$) stands for time-varying parameters which contain intercepts and are independent from each other, delineating the extent to which various economic variables affect monetary growth. We assume that the time-varying parameter α_{it} follows the random walk process below:

$$\alpha_{it} = \alpha_{it-1} + e_{it}, \; i = 0, \ldots, 3 \qquad (2)$$

Here e_{it} represents the disturbance item. Disturbance ε_t of (1) and disturbance e_{it} of (2) are both subject to the normal distribution:

$$\varepsilon_t \sim i.i.d.N(0, \sigma_{D_t}^2), \; D_t = 1, 2$$

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16 C. Kim and C. Nelson, *State-space Models with Regime Switching: Classical and Gibbs-Sampling Approaches with Applications*.

$$e_{it} \sim i.i.d. N(0, \sigma_{ei}^2), \ i=0,1,...,3 \tag{3}$$

where σ_{Dt}^2 and σ_{ei}^2 are normal distribution variances. The unobservable regime state variable D_t follows first-order Markov process, and the regime switching can be defined as:

$$\Pr(D_t=1| D_{t-1}=1)=p_{11}, \ \Pr(D_t=2| D_{t-1}=1)=1-p_{11}$$
$$\Pr(D_t=2| D_{t-1}=2)=p_{22}, \ \Pr(D_t=1| D_{t-1}=2)=1-p_{22} \tag{4}$$

Let $\sigma_1^2<\sigma_2^2$, China's MGU is in a "low fluctuation regime" when $D_t=1$ and in a "high fluctuation regime" when $D_t=2$.

2. Regime state division and component decomposition of MGU

According to Kim's[17] approach to model specification, and combining respectively the Kalman filtering approach which estimates the state-space model and the Hamilton filtering approach which estimates the Markov regime switching model, we use the approximate filtering approach to estimate the TVP-Markov model that has been set up. Here we write the log-likelihood functions:

$$LL = \ln[f(m_T, m_{T-1},...|\psi_0)] = \sum_{t=1}^{T} \ln[f(m_t|\psi_{t-1})] \tag{5}$$

where ψ_{t-1} represents all the information sets up to period $t-1$. The marginal density of monetary growth rate m_t is defined by

$$f(m_t|\psi_{t-1}) = \sum_{i=1}^{2}\sum_{j=1}^{2} f(m_t, D_{t-1}=i, D_t=j|\psi_{t-1}) = \sum_{i=1}^{2}\sum_{j=1}^{2} \frac{1}{\sqrt{2\pi H_t^{(i,j)}}} \exp\left\{-\frac{(\eta_{t|t-1}^i)^2}{2H_t^{(i,j)}}\right\} \tag{6}$$

where $\eta_{t|t-1}^i$ is monetary growth forecasting error and $H_t^{(i,j)}$ stands for the conditional variance of $\eta_{t|t-1}^i$ when regime state variables $D_{t-1}=i$ and $D_t=j$, $(i,j=1,2)$ and the value of $H_t^{(i,j)}$ indicates the magnitude of MGU. In addition, we can describe the joint density of monetary growth rate m_t and variables $D_{t-1}=i$ and $D_t=j$ as:

$$f(m_t, D_t=j, D_{t-1}=i|\psi_{t-1})=f(m_t|D_t=j, D_{t-1}=i|\psi_{t-1})\times\Pr[D_t=j, D_{t-1}=i|\psi_{t-1}], \ i,j=1, 2 \tag{7}$$

From (6) and (7) we see the conditional density of D_t: $\Pr[D_t=j, D_{t-1}=i|\psi_t]$. Furthermore, when MGU is at state $D_t=1$ or $D_t=2$ when at time t, we can obtain the filtered probability $\Pr[D_t=i|\psi_t]$ based on ψ_t in period t, and smoothed probability $\Pr[D_t=i|\psi_t]$ based on the set of all sample information ψ_T, which synthesizes all earlier information.

Specifically, we may divide MGU measured by conditional variance (H_t) of monetary growth forecasting error into two categories: uncertainty arising from policy shocks and uncertainty arising from economic shocks. The first is caused by policy-makers' gradual improvement of monetary policy regulation and control mechanisms and timely changes to monetary policy. It is mainly reflected in the time-varying features of the variable parameters in the monetary growth equation. We measure it using H_{1t}, the conditional variance of time-varying parameters. H_{1t} is mainly dependent on regime state variable D_{t-1} in period $t-1$. The second MGU is caused by various macroeconomic shocks, especially outside shocks. It is mainly reflected in the heteroscedasticity feature of the conditional variance of the stochastic

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17   C. Kim, "Dynamic Linear Models with Markov-switching," pp. 1-22.

disturbance in the monetary growth equation. We measure it using the Markov regime switching heteroscedasticity (H_{2t}) of the disturbance. H_{2t} is mainly dependent on regime state variable D_t in period t.

Based on the time-varying parameter model which includes heteroscedastic disturbances and given that $D_{t-1}=i$, $D_t=j$, (i, j=1,2), we can obtain the conditional variance of monetary growth forecast error and its decomposition:

$$H_t=H_{1t}+H_{2t} \tag{8}$$

$$H_{1t} = X_{t-1}\left\{\sum_{i=1}^{2}\Pr[D_{t-1} = i \mid \psi_{t-1}][P_{t|t-1}^{i} + (\alpha_{t|t-1} - \alpha_{t|t-1}^{i})(\alpha_{t|t-1} - \alpha_{t|t-1}^{i})']\right\}X_{t-1}' \tag{9}$$

$$H_{2t} = \sum_{j=1}^{2}\{\Pr[D_t = j \mid \psi_{t-1}]\sigma_j^2\} \tag{10}$$

where X_{t-1} is the explanatory variable vector in period $t-1$, $P_{t|t-1}^{i}$ is the mean variance matrix of $\alpha_{t|t-1}^{i}$, $\alpha_{t|t-1}^{i}$ is the estimate of time-varying parameter α_{it} (i=0,...,3) in monetary growth equation (1) according to the information for period $t-1$ and $\alpha_{t|t-1} = \Sigma_{i=1}^{2}\Pr[D_{t-1} = i \mid \psi_{t-1}]\alpha_{t|t-1}^{i}$.

3. The component decomposition of Chinese real GDP

Drawing on Hamilton's[18] decomposition method, we divide Chinese real GDP into a trend component and a cyclical component:

$$G_t=G_t^T+G_t^C \tag{11}$$

where G_t refers to the natural logarithm of real GDP, and G_t^T and G_t^C represent the trend component and the cyclical component of G_t respectively. The unobserved components G_t^T and G_t^C are independent of each other. We suppose that G_t^T follows the first-order unit root process:

$$G_t^T= G_{t-1}^T+\gamma_{S_t}, S_t=1, 2 \tag{12}$$

where γ_{S_t} represents a drift term and we assume that $\gamma_1<\gamma_2$. In particular, when the regime state variable S_t=1, indicating the Chinese economy is in a "low-speed growth regime," γ_{S_t} suggests that the mean of the real GDP trend component growth rate is γ_1. When S_t=2, indicating the economy is in a "high-speed growth regime," γ_{S_t} suggests that the mean of the real GDP trend component growth rate is γ_2. Therefore we may further suppose that S_t follows the first-order Markov process and its regime switching probability can be written as:

$$\Pr(S_t=1\mid S_{t-1}=1)=q_{11}, \Pr(S_t=2\mid S_{t-1}=1)=1-q_{11}$$
$$\Pr(S_t=2\mid S_{t-1}=2)=q_{22}, \Pr(S_t=1\mid S_{t-1}=2)=1-q_{22} \tag{13}$$

Besides, we suppose G_t^C follows the first-order autoregressive process:

$$G_t^C = \phi_1 G_{t-1}^C + u_t, \ u_t \sim i.i.d. N(0,\sigma^2) \tag{14}$$

where ϕ_1 represents the autoregressive coefficient of the real GDP cyclical component in period $t-1$, and u_t represents the disturbance. Here we can use the maximum likelihood method to estimate the decomposition equation of Chinese real GDP.

4. MGU and economic growth in China

On the basis of the Chinese real GDP decomposition equation (11), we can further observe

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18   J. Hamilton, "A New Approach to the Economic Analysis of Nonstationary Time Series and the Business Cycle," pp. 357-384.

the impact of different components of China's MGU on Chinese economic growth. Suppose real GDP trend component G_t^T follows the first-order unit root process while being influenced by both categories of MGU; we can then rewrite equation (12) as:

$$G_t^T = G_{t-1}^T + \gamma_{S_t} + \rho_1 H_{1t} + \rho_2 H_{2t}, \; S_t = 1, \; 2 \qquad (15)$$

where H_{1t} and H_{2t} are the decomposition components of the two conditional variances defined by (9) and (10) respectively, and coefficients ρ_1 and ρ_2 measure the effectiveness of H_{1t} and H_{2t} on real GDP trend component respectively. γ_{S_t} remains the same as in equation (12). Regime state variable S_t still follows the first-order Markov process and its switching probability is defined as in (13).

At the same time, we suppose real GDP cyclical component G_t^C follows the first-order autoregressive process and is at the same time affected by unexpected monetary growth; equation (14) can then be written in the alternative form:

$$G_t^C = \phi_1 G_{t-1}^C + \delta \eta_{t|t-1} + u_t \qquad u_t \sim i.i.d. N(0, \sigma^2) \qquad (16)$$

where $\eta_{t|t-1} = \Sigma_{i=1}^2 \Pr[D_{t-1} = i \,|\, \psi_{t-1}] \eta_{t|t-1}^i$ represents the conditional forecasting error of monetary supply growth and measures unexpected monetary growth, and coefficient δ of $\eta_{t|t-1}$ measures the effect of unexpected monetary growth on the real GDP cyclical component. The autoregressive coefficient ϕ_1 and disturbance u_t are defined as in equation (14).

Here we can still employ the maximum likelihood method to estimate the monetary growth equation and the real GDP decomposition equation together. We suppose disturbance u_t from the real GDP decomposition equation and disturbance ε_t from the monetary growth equation to be independent of each other.

III. An Empirical Analysis of the Relationship between MGU and the Business Cycle in China

Given the above model structure and features, we choose the time series of the monetary supply rate, inflation rate and real GDP growth rate to provide a specific analysis of the characteristics of the interdependence between China's MGU and Chinese economic growth at different phases.

1. Data description

The data come from the *China Statistical Yearbook* and China Economic Information Network Statistical Database (http://db.cei.gov.cn) and the sample interval is from the 1st quarter of 1980 to the 3rd quarter of 2008. Due to the limited length of the M2 data, we have adopted the quarterly data on M1 to measure monetary supply and make seasonal adjustments accordingly. For real GDP data, we use the official GDP cumulative growth rate data to find out real GDP value at year 2000 constant prices through recalculation. In addition, to obtain quarterly data prior to 1994, we carry out quarterly decomposition and seasonal adjustment of real annual GDP data before 1994, drawing on the methods of

Abeysinghe and Gulasekaran.[19] The rate of change in the CPI is employed to measure inflation rate data. Based on quarter-on-quarter inflation rates after 2001 and the year-on-year quarterly inflation rates before 2001, the only official data available so far, we obtain the CPI with 2000 as the base year and conduct seasonal adjustments to get quarter-on-quarter inflation rate data which is stable enough for research.

2. Results of the estimation of state division and component decomposition of China's MGU

We first estimate the TVP-Markov model of China's MGU, with results listed in Table 1. It can be seen that when MGU is in a "low fluctuation regime," holding probability $p_{11}=0.9410$ and the average duration of the regime is about 17 quarters ($D(D_t)=(1-p_{ii})^{-1}=1/(1-0.9410)=16.9492$). When in a "high fluctuation regime," MGU's holding probability $p_{22}=0.9412$, and the regime's average duration is also about 17 quarters ($1/(1-0.9412)=17.0068$). This proves that China's MGU remains basically constant, whether in a "low fluctuation regime" ($D_t=1$) or a "high fluctuation regime" ($D_t=2$). In addition, we notice that in a "low fluctuation regime," MGU's variance $\sigma_1=1.0813$, while in a "high fluctuation regime," variance $\sigma_2=4.2479$, which is much higher. The estimates of the time-varying parameter variances $\sigma_{e0}=0.6320$, $\sigma_{e1}=0.1485$, $\sigma_{e2}=0.0000$ and $\sigma_{e3}=0.0501$. Their values and significance levels show that, comparatively, MGU caused by the intercept item and monetary growth rate in period $t-1$ is very significant while that caused by the real GDP growth rate in period $t-1$ is less significant and MGU caused by the inflation rate in period $t-1$ is not significant.

Table 1 TVP-Markov Model Estimation of China's MGU

Parameter	Estimate	Standard deviation	t-value
p_{11}	0.9410	0.0495	18.9995
p_{22}	0.9412	0.0640	14.7116
σ_1	1.0813	0.2461	4.3928
σ_2	4.2479	0.5678	7.4815
σ_{e0}	0.6320	0.2806	2.2524
σ_{e1}	0.1485	0.0940	1.5791
σ_{e2}	0.0000	0.0467	0.0000
σ_{e3}	0.0501	0.0298	1.6795

On the basis of parameter estimation of the TVP-Markov model, we can further deduce the smoothed probability of discrete values of the regime state variable D_t within the sample interval. Figure 1 and Figure 2 depict the smoothed probabilities of China's MGU in a "low fluctuation regime" ($D_t=1$) and a "high fluctuation regime" ($D_t=2$) respectively. The higher

19   T. Abeysinghe and R. Gulasekaran, "Quarterly Real GDP Estimates for China and ASEAN4 with a Forecast Evaluation," pp. 431-447.

the smoothed probability, the more possible it is that MGU lies in the corresponding regime. Given probability $\Pr[D_t=j|\psi_t]>0.5$, $j=1,2$, the economy can be held to be in j regime ($j=1,2$).

It is apparent from Figure 1 and Figure 2 that for a total of 43 quarters, including from the 1st quarter of 1981 to the 4th quarter of 1982 and from the 1st quarter of 1998 to the 3rd quarter of 2008, China's MGU was in a "low fluctuation regime," while for a total of 64 quarters, consisting of the 4 quarters of 1980 and from the 1st quarter of 1983 to the 4th quarter of 1997, it was in a "high fluctuation regime." The time-varying trajectory of the smoothed probability values shows that before 1998 the smoothed probability was quite unstable, while after 1998 it became very stable in a "low fluctuation regime."

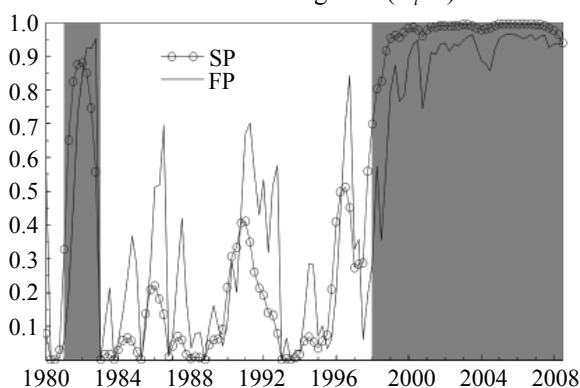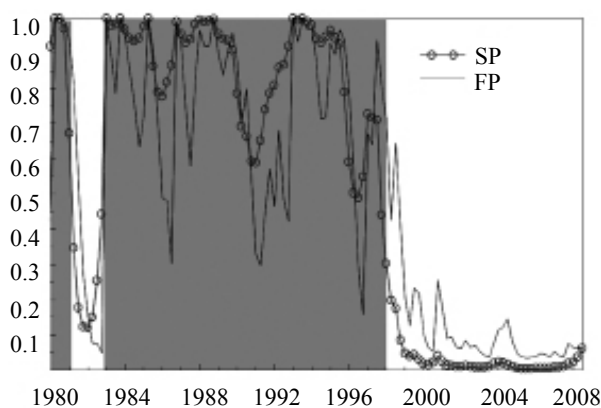Figure 1 China's MGU in a "Low Fluctuation Regime" (D_t=1)

Figure 2 China's MGU in a "High Fluctuation Regime" (D_t=2)


Note: In Figure 1 and Figure 2, SP: smoothed probability, FP: filtered probability

Figure 3 depicts China's MGU and its component decomposition results. It can be clearly seen that MGU was more severe during the period from the 1st quarter of 1980 to the 4th quarter of 1997 and reached its peak in the 2nd quarter of 1993. After 1998, MGU weakens significantly,

and especially since 2000 it has remained at a quite low level. These characteristics are in accordance with the conclusions we have drawn above. With regard to the structure of MGU, H_{2t} caused by macroeconomic shocks makes up a very large proportion with a mean value of 18.045 ($\sigma_2^2=4.248^2$, see Table 1) in a "high fluctuation regime" ($D_t=2$), and of 1.169 ($\sigma_1^2=1.081^2$, see Table 1) in a "low fluctuation regime" ($D_t=1$), whereas H_{1t} caused by monetary policy shocks constitutes quite a small proportion. It is only during the period from the 4th quarter of 1983 to the 2nd quarter of 1989 and from the 1st quarter of 1993 to the 1st quarter of 1994 that there was some degree of growth, which temporarily surpassed that of H_{2t} in the 2nd quarter of 1986 and the 2nd quarter of 1993. This shows that MGU in China results mainly from macroeconomic shocks; it is only for a very few, brief periods that monetary policy shocks have been the main source of MGU.

Figure 3 China's MGU and Its Component Decomposition
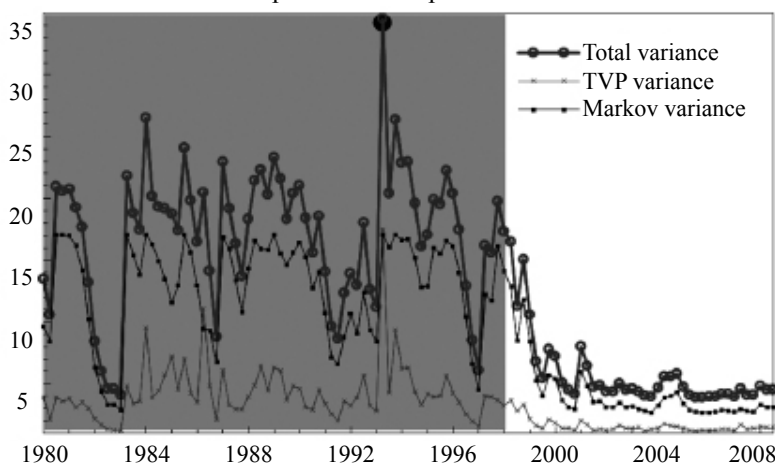
The above statistical results basically accord with the course of Chinese economic development. In 1980, the People's Bank of China initiated exchange rate reform. From 1985 to 1988, confronted with inflation caused by overinvestment and overconsumption, the Chinese government promptly adopted a tight monetary policy stressing "overall control and structural adjustment" and combining direct and indirect regulatory measures. This resulted in the tightening of monetary supply. From 1993, there was a real estate fever and excessive stock speculation. As the effects of the "bubble economy" became visible, and, around 1994, the economy was becoming relatively overheated, the government reacted by enforcing a moderately tight monetary policy and the base currency and credit total were tightened again. When the Asian financial crisis broke out in 1997, it caused a sharp currency devaluation in China's neighbors and turbulence in some national and regional financial markets. To meet actual domesticneeds and international requirements, China once again implemented a policy of stabilizing the RMB exchange rate. It was precisely because of these frequent changes

of monetary policy and the associated regulatory mechanisms and the severe fluctuations in the macro economy that China experienced frequent and comparatively intense MGU up to 1998. Since 1998, the Chinese central bank has set up and perfected an intermediate target system with base currency as the operating target and money supply as the effective target. Monetary policy in general became relatively stable. At the same time, the central government has greatly enhanced its ability to resist major external shocks, whether they be natural disasters such as flood, heavy snowfalls, drought, earthquakes and so on that damage material accumulation, or financial crises that undermine financial market efficiency. The Chinese economy has weathered these shocks safely with the "low uncertainty and robustness" of Chinese monetary growth ensured. Hence the major impact on Chinese MGU came from drastic fluctuations in the macro economy and from well-timed choices and appropriate changes of monetary policy.

3. The component decomposition of Chinese real GDP

Table 2 lists the estimation results of China's real GDP decomposition equation. It can be seen that the estimate and statistics of each parameter are both reasonable and significant. The fact that the autoregressive coefficient of real GDP cyclical component $\phi_1 = 0.9718$ shows that the real GDP cyclical component is strongly influenced by the earlier phase and ensures the stability of the autoregressive process. When the economy grows slowly (S_t=1), the drift mean of real GDP cyclical component γ_1=1.7900 and when the economy grows rapidly (S_t=2), the drift mean of real GDP cyclical component γ_2=2.7607. In addition, the holding probability q_{11}=0.9252 when Chinese real GDP is in a "low-speed growth regime" (S_t=1) and the holding probability q_{22}=0.9341 when real GDP is in a "high-speed growth regime" (S_t=2). Therefore it can be calculated that the average duration of "low-speed growth regimes" and "high-speed growth regimes" is 13.37 quarters (1/(1-0.9252)) and 15.18 quarters (1/(1-0.9341)) respectively, indicating that the duration of low-speed growth is slightly less than that of high-speed growth.

Table 2 Estimation of China's Real GDP Decomposition Equation

Parameter	Estimate	Standard deviation	t-value
q_{11}	0.9252	0.0504	18.3604
q_{22}	0.9341	0.0468	19.9416
γ_1	1.7900	0.1806	9.9097
γ_2	2.7607	0.1481	18.6390
ϕ_1	0.9718	0.0425	22.8396
σ	0.9031	0.0654	13.8186
T_0	815.98	0.9806	832.161

Note: Parameter T_0 represents the initial state value of the state space model trend component.

Figure 4 describes the time trajectories of Chinese real GDP and its trend component

and Figure 5 describes the time trajectory of the Chinese real GDP cyclical component. It is clear that two trajectories in Figure 4 nearly coincide while the trajectory in Figure 5 presents a position of significant cyclical changes. Especially in Figure 5, the expansionary phase is prolonged after 2000. A contraction phase begins in 2008 owing to the 2007 financial crisis.

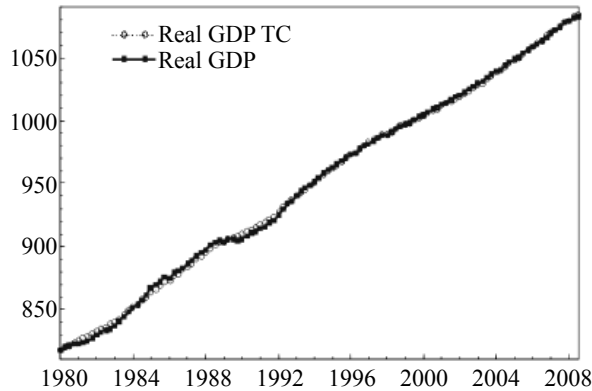Figure 4 China's Real GDP and Its Trend Component

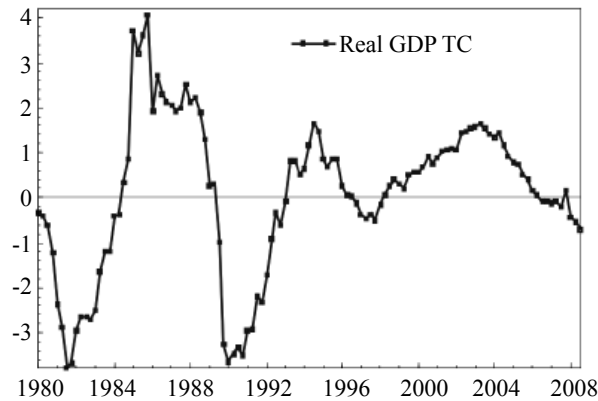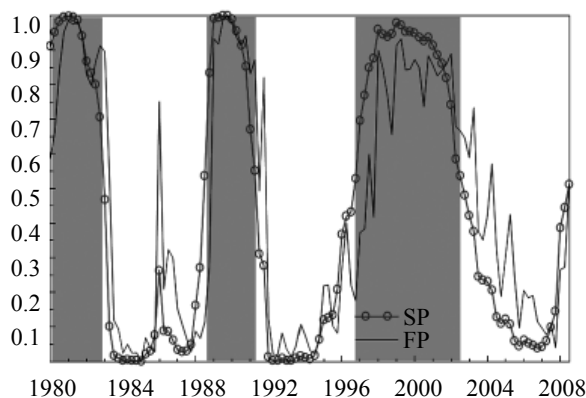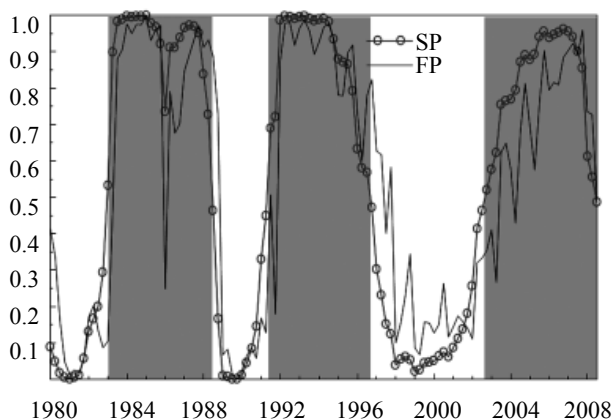Figure 5 China's Real GDP Cyclical Component

Figure 6 China's Real GDP in a "Low-speed Growth Regime" ($S_t=1$)

Figure7 China's Real GDP in a "High-speed Growth Regime" ($S_t=2$)

Note: In Figure 6 and Figure 7, SP: smoothed probability, FP: filtered probability

Based on the model parameter estimation, we can further get the smoothed probability of discrete values of regime state variable S_t in the sample interval. Figure 6 and Figure 7 depict the smoothed probabilities of Chinese real GDP in a "low-speed growth regime" ($S_t=1$) and a "high-speed growth regime" ($S_t=2$) respectively. We can see that in the three periods from the 1st quarter of 1980 to the 4th quarter of 1982, from the 3rd quarter of 1988 to the 1st quarter of 1991 and from the 4th quarter of 1996 to the 2nd quarter of 2002, the Chinese economy was in a "low-speed growth regime," while in the three periods from the 1st quarter of 1983 to the 2nd quarter of 1988, from the 2nd quarter of 1991 to the 3rd quarter of 1996 and from the 3rd quarter of 2002 till now, Chinese economy has been in a "high-speed growth regime." These results basically conform to the studies undertaken by Liu Heng and

Chen Shuyun,[20] Liu Jinquan and Liu Zhigang,[21] Liu Shucheng *et al.*[22] and other scholars. Thus it can be seen that our component decomposition of Chinese real GDP above provides a relatively good portrayal and measurement of the phases in the Chinese economic cycle and of trends in economic development.

4. A test of the relationship between MGU and economic growth in China

To test the influence of MGU on economic growth, we go on estimating the equations and list specific estimation results in Table 3, where estimates in column (a) are obtained after considering both time-varying parameters' conditional variance H_{1t} and Markov regime switching heteroscedasticity H_{2t}. Estimates in column (b) are obtained after considering H_{1t} only and estimates in column (c) are obtained after considering H_{2t} only.

The estimated values of autoregressive coefficient ϕ_1 in (a), (b) and (c) show that cyclical components of real GDP are significantly affected by the preceding phase, indicating the sustained character of real output. It is worth pointing out that though estimates of holding probability q_{11}, q_{22} and of drift mean γ_1, γ_2 are still significant here, they differ to a certain extent from those in Table 2 in terms of value. The lack of significance of the estimates of δ in (a) and (c) means that unexpected monetary policy shocks have a relatively weak effect on China's macroeconomic stability (measured by G_t^C), which indicates that regular elements still dominate monetary policy. The estimates of ρ_1 (the coefficient of H_{1t}) show that MGU caused by monetary policy shocks has a significantly stimulatory effect on China's economic growth (represented by G_t^T), while the estimates of ρ_2 (the coefficient of H_{2t}) show that MGU caused by macroeconomic shocks significantly retards China's economic growth. Since MGU caused by monetary policy shocks in China directly reflects monetary policy control mechanisms and changes, the improvement of these mechanisms and timely changes in monetary policy clearly benefit the sustainable and stable growth of the Chinese economy. But MGU caused by macroeconomic shocks, especially shocks from overseas, undoubtedly intensifies the uncertainty of economic agents' expectations for the future, thus retarding the stable and sustainable growth of the Chinese macro economy.

Table 3 China's MGU and Estimation of the Real GDP Decomposition Equation

Parameters	(a) Decomposition equation of H_{1t} and H_{2t} simultaneously			(b) Equation of H_{1t} only			(c) Equation of H_{2t} only		
	Estimate	Standard deviation	t-value	Estimate	Standard deviation	t-value	Estimate	Standard deviation	t-value
q_{11}	0.9623	0.0221	43.602	0.8040	0.1283	6.2669	0.9630	0.0217	44.340

20   Liu Heng and Chen Shuyun, "The New Situation of Chinese Economic Cycle Fluctuation."
21   Liu Jinquan and Liu Zhigang, "The Dynamic Model and Cause Analysis of Real Output Volatility in Chinese Economic Cycle Fluctuation."
22   Liu Shucheng, Zhang Xiaojing and Zhang Ping, "Realization of Smoothing Economic Cycle Fluctuation at an Appropriate Height."

q_{22}	0.8958	0.0542	16.520	0.9680	0.0197	49.128	0.8969	0.0538	16.681
γ_1	2.4804	0.0947	26.195	0.0312	0.3335	0.0934	2.5987	0.0819	31.713
γ_2	4.1671	0.2542	16.395	2.0266	0.1302	15.566	4.4350	0.2365	18.752
ϕ_1	0.8970	0.0567	15.811	0.9908	0.0147	67.375	0.8729	0.0587	14.866
σ	0.7381	0.0513	14.400	0.7946	0.0599	13.276	0.7655	0.0529	14.477
ρ_1	0.1678	0.0532	3.155	0.1624	0.0366	4.4308	——	——	——
ρ_2	-0.1261	0.0176	-7.156	——	——	——	-0.0851	0.0125	-6.8116
δ	0.0200	0.0205	0.973	0.0437	0.0234	1.8686	0.0169	0.0210	0.8022
T_0	816.04	0.7180	1136.6	817.22	1.0084	810.43	815.98	0.7133	1143.9

Note: Parameter T_0 represents the initial state value of the state-space model trend component.

After the two main sources of China's MGU are introduced, Figure 8 and Figure 9 describe the time trajectories of the trend component and the cyclical component of China's real GDP respectively. As with the results of Figure 4, the time trajectories of the trend component and real GDP in Figure 8 basically coincide. Compared with Figure 5, Figure 9 presents a clearer picture of the cyclical component with sharper cycle boundaries, revealing signs of an economic contraction after 2008. The function of MGU as an auxiliary tool of business cycle decomposition indicates that monetary policy operation plays an important role in the process of business cycle formation and there is an interaction between the "monetary cycle" and "the economic cycle" in Chinese economic activity.

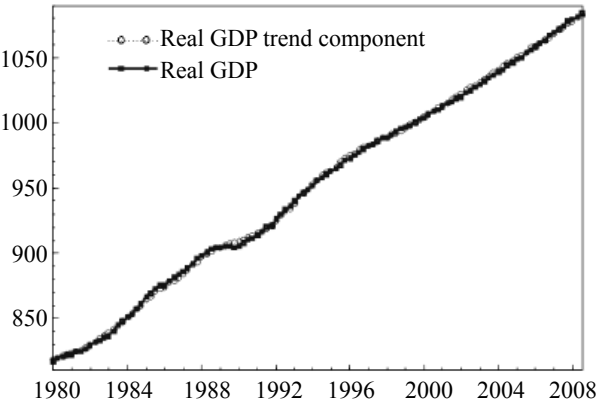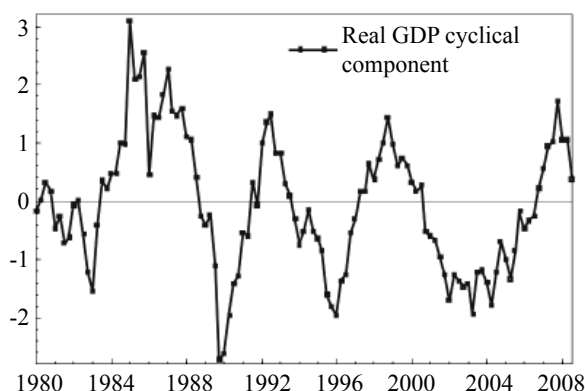Figure 8 China's Real GDP and Its Trend Component

Figure 9 China's Real GDP Cyclical Component

    On the basis of the observation of the two sources of MGU, we keep on estimating the decomposition equation of real GDP and obtainthe smoothed probability of regime state variable S_t within the sample interval. Figures 10 and 11 describe the smoothed probabilities of China's real GDP within a "low-speed growth regime" (S_t=1) and a "high-speed growth regime" (S_t=2) respectively. It can be seen that in four periods, from the 1st quarter of 1980 to the 4th quarter of 1982; in the first three quarters of 1986; from the 2nd quarter of 1988 to the 3rd quarter of 1991; and from the 1st quarter of 1996 till now, the Chinese economy has beenin a "low-speed growth regime," while in three periods, from the 1st quarter of 1983 to the 4th quarter of 1985; from the 4th quarter of 1986 to the 1st quarter of 1988; and from the 4th quarter of 1991 to the 4th quarter of 1995, the economy was in a "high-speed growth regime." Compared with Figure 6 and Figure 7, Figure 10 and Figure 11 show that, after the effect of MGU is introduced, marked changes appear in the division of Chinese business cycles. Specifically, the smoothed probability time trajectory is roughly the same as before 2000, indicating that MGU produced little effect during that period. Since 2003, China's real GDP has changed from the "high-speed growth regime" of Figure 7 to the "low-speed growth regime" of Figure 10. But this does not change the fact that Chinese economy has been growing rapidly during this period, it simply explains from the empirical point of view the unique role and "long-term effects" that MGU has had in the course of economic cycle component decomposition. It is clear that MGU caused by macroeconomic shocks can markedly impede economic growth and the selective monetary policy adopted in response during such periods to smooth business cycle fluctuations and fight financial crises can have a negative effect on economic development in the long run.

Figure 10 Chinese Real GDP in a "Low-speed Growth Regime" (S_t=1)
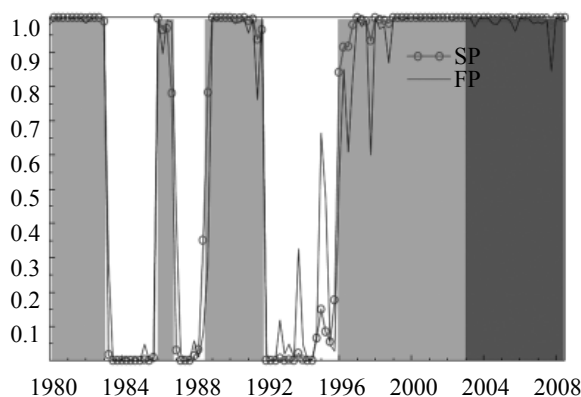
Figure 11 Chinese Real GDP in a "High-speed Growth Regime" (S_t=2)
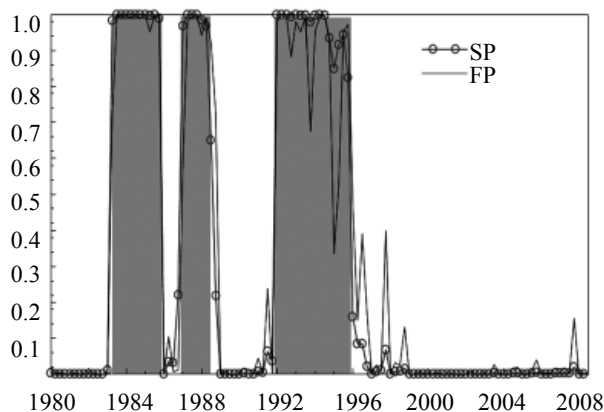
Note: In Figure 10 and Figure 11, SP: smoothed probability, FP: filtered probability

The above empirical findings remind us that we need to give a high degree of attention to monetary supply fluctuations arising from the latest round of the financial crisis and falling under the scope of macroeconomic shocks. The financial crisis has resulted in severe external shocks to the endogenous growth trend of the Chinese economy, leading to dramatic changes in the trajectory of the Chinese economy. Therefore, while adopting the necessary monetary policies to deal with the financial crisis, we should seriously consider that too much policy interference may cause macroeconomic shocks which will inhibit economic growth in the long run. We should treat monetary supply fluctuation and instability as crucial targets of national risk warning and risk management and set up organicconnections between economic cycleand money market fluctuations. In the post-financial crisis era, we should reduce the discretionary element in monetary policy as much as possible and restore rational expectations of the economic growth rate, inflation rate, monetary supply growth rate and

other major economic indicators as quickly as possible. We should keep the current trend of steady economic recovery and promote stable long-term economic growth by building up the inherent harmonization of economic norms and activity in the macroeconomic regulatory system, the policy transmission mechanism, structural adjustment in the national economy, coordinated development of both financial and product markets, cross-country economic regulation and control, and so on.

IV. Basic Conclusions and Implications for Economic Policy

By distinguishing the sources of China's MGU and separating the trend component and the cyclical component of real output, we have measured and tested the effects of MGU on Chinese economic cycle fluctuation and drawn the following significant conclusions.

Firstly, we believe that 1998 was the watershed for the state of China's MGU, since MGU was quite severe before 1998 while after 1998 it lessened significantly. Especially since 2000, MGU has been maintained at a relatively low level; this not only reflects the two-fold increase in the sustainability and stability of Chinese economic growth during this period but also indicates that the Chinese economy has a solid basis and potential strength that safeguard its stable and sustainable development. This shows that appropriate macroeconomic regulatory measures, regular monetary policy and effective supply management all played important roles in ensuring the smooth development of the Chinese economy from 1998 to 2007.

Secondly, we found that China's MGU came mainly from macroeconomic shocks and only occasionally from Central Bank initiatives. This shows that the formulation and operation of monetary policy in China already has a certain endogenous character and that the Central Bank has been cautious in choosing and manipulating monetary policy tools according to economic development trends. In recent years, the increase in factors leading to uncertainty in the international economic environment has led to drastic external shocks in China. With the deepening of economic opening and financial globalization has come a marked increase in the possibility of transfer of international financial risks, attacks from financial speculation and the infection from financial crises. In addition to financial crises, major external shocks, such as sharp fluctuations in oil prices and bulk commodity prices, the frequent and sudden occurrence of massive natural disasters, etc., have made the formulation and implementation of Chinese economic policy difficult. This is another important reason for the current intensification of China's MGU.

Thirdly, we found that "unexpected monetary policy" shocks have little impact on Chinese macroeconomic stability but have an inhibiting effect on economic growth, while "regular monetary policy" shocks have a markedly stimulatory effect on growth. Generally, "unexpected monetary policy" is a short-term strategy adopted to deal with macroeconomic shocks whereas "regular monetary policy" is monetary policy operation aimed at long-term growth goals. Since 2003, MGU caused by macroeconomic shocks has increased sharply,

leading to numerous "unforeseen monetary policy" shocks which did well in fighting the financial crisis over a short period but which will have a negative influence on stable economic growth in the long run. This requires that the operation of our monetary policy should break away from the vicious cycle of contraction and expansion and that monetary policy should return to sustainability and stability as quickly as possible.

It should be noted that though the global economy has entered the post-financial crisis era, there are still many unstable factors in the Chinese economic environment. Fluctuations in the product market, the real estate market, the labor market, the money market and the stock market have intensified, inflationary expectations have increased, and industry structural adjustment, coordinated regional economic development and other macroeconomic management tasks remain extremely demanding. While the "total demand shocks" triggered by the financial crisis have not yet subsided, the "total supply shocks" originating from severe fluctuations in oil prices and bulk commodity prices and from earthquakes and other natural disasters are still strong. This means that current economic activity faces a double shock and disruption from supply and demand, a situation which was rare in the past. We therefore need to adopt a two-fold management policy of giving equal weight to "total demand management" and "total supply management." On the one hand, we should not only foster effective supply of investment sources but also integrate supply management goals into industry and market structural adjustment; on the other, we should encourage upgrading from "stimulating demand" and "fostering demand" to "demand management." On the premise of attending to both supply management and demand management, coordinating industry structural balance with regional economic development, and reconciling price stability and output stability, we should formulate macroeconomic regulatory mechanisms which tally with the process of constructing a market economy, suit the current character of the Chinese market, and are unified with international financial risk management under the conditions of an open economy. Only in this way can we successfully carry out a regular and prudent monetary policy, effectively reduce the negative impact of "unexpected monetary shocks" on economic growth, lessen the economic fluctuations caused by MGU, boost the sound and rapid development of the Chinese economy in the post-financial crisis era and lay down favorable conditions and a good foundation for the formulation and implementation of the 12th Five-year Plan.

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