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A Macroeconometric Model of the Chinese Economy

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Abstract

This paper describes a quarterly macroeconometric model of the Chinese economy. The model comprises household consumption, investment, government, trade, production, prices, money, and employment blocks. The equilibrium-correction form is used for all the behavioral equations and the general→simple dynamic specification approach is adopted. Great efforts have been made to achieve the best possible blend of standard long-run theories, country-specific institutional features and short-run dynamics in data. The tracking performance of the model is evaluated. Forecasting and empirical investigation of a number of topical macroeconomic issues utilizing model simulations have shown the model to be immensely useful.

JEL classifications: C51; E17

Keywords: Macroeconometric model; Chinese economy; forecasts; simulations

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1. Introduction

This paper outlines key features of the ADB China model, which is adapted and augmented from China_QEM, a quarterly macroeconomic model built by the Institute of World Economics and Politics (IWEP), Chinese Academy of Social Sciences (CASS).¹ First started in early 2004, model adaptation and augmentation has taken more than a year due primarily to the inherent difficulty in modeling such a highly vibrant economy as well as major revisions in China's historical data, in particular the revision on the GDP sectoral components in early 2005. To facilitate the need for forecasting and policy simulation, the modeling is guided by the main criteria that all behavioral equations should be economically meaningful, all parameter estimates relatively robust and time invariant, that dummy variables should be used as rarely as possible, and that variables representing policy instruments ought to have valid properties of exogeneity. The model has the following main characteristics:

1. Economic structure: The model reflects the essence of a transitional economy. This is achieved by extending economic theories purely for market economies to incorporate certain institutional factors pertaining to a mixed economy. Many equations are demand-oriented to reflect a high degree of marketization. It also contains a number of supply-side equations. In particular, the supply-side of GDP (Gross Domestic Product) plays a central role in the real-sector part of the model, a feature absent in most of the existing macro-econometric models in China.
2. Econometric methods: the Equilibrium/Error Correction Model (ECM) form is used for all behavioral equations to embed long-run economic theories into adequately specified dynamic equations following the dynamic specification approach (see Hendry 1995). To ensure within-sample coefficient constancy, we used recursive estimation methods and/or

¹ China_QEM was first built in 2002 and became relatively settled in 2004, see (He *et al* 2005).

parameter constancy tests extensively. We also minimized the use of dummy variables, except for seasonal dummies, as imposition of occasional dummies often indicates lack of super exogeneity and significantly reduces the policy simulation capacity of the model.

Section 2 sketches the Chinese macroeconomy, the data, and the literature on the existing models. Section 3 describes the main behavioral equations of the model. Section 4 summarizes the model performance results. Section 5 concludes.

2. The economy, data and existing models

2.1 The Chinese economy

The Chinese economy has experienced tremendous transformation and record-high growth during the last two decades since the start of economic reforms in 1978. The reforms progressed gradually from farming to commerce, to state-owned enterprises, and to government finance and banking. A so-called ‘socialist market economic system’ was established in the early to mid 1990s. For instance, over 80% of the agricultural products and most industrial products have been trading at market prices since 1993, see (Cai & Lin, 2004; Wang, 2002); the Law of the People’s Bank of China (PBC) and the Law of Commercial Banks of China were released in 1995, making PBC a central bank independent of commercial bank loans and fiscal controls, see (Shang, 2000); in 1994, the managed floating regime was adopted, and the foreign trade sector became self-managed.²

2.2 Data

In order to make the model useful for policy analysis, we choose quarterly frequency, as this is the highest frequency at which GDP is accounted, and because much of the short-run dynamic adjustments of an economy to policy shocks occur within one to a few quarters.

Collection of a quarterly data set with an adequate sample size is quite challenging,

especially for the GDP components. Experiments to convert the national accounting system from the material product system (MPS) under the old centrally planned regime to the system of national accounts (SNA) began in 1985. Although the SNA was formally adopted in 1993, published statistical series are few, short and low in frequency.³

Our data set has been collected by the IWEP in collaboration with the National Bureau of Statistics of China (NBSC). Most of the time series start from 1992, the year from which the NBSC released the quarterly GDP from the production side.⁴ Due to various constraints, these quarterly series are not seasonally adjusted and are often significantly re-adjusted after annual data is published to make them consistent with the annual accounts. When quarterly data are unavailable, annual series are interpolated into quarterly series.

2.3 Existing models

Macro-econometric research started in China in the early 1980s. Early models were built in close association with Project LINK. The models are commonly large in size and based on annual data series. As annual series have to span back to the pre-reform period for estimation purposes, many of the equations carry significant features of the old centrally planned regime. Models built using quarterly series and following the dynamic specification approach were first experimented by the Institute of Quantitative and Technical Economics of CASS. However, their models are currently out of maintenance. The PBC has recently developed a small quarterly model mainly for analyzing the interaction between the macroeconomy and monetary policy, see (Liu 2003). In terms of econometrics, these quarterly models have given greater attention to the time-series properties of data than those earlier annual models.⁵

² See (He *et al*, 2005, chapter 3) for a detailed review of the Chinese economic dynamics during the last two decades.

³ For a detailed description of the evolution of the Chinese national accounting systems, see (Xu, 2000).

⁴ The NBSC has recently published re-adjustment of the GDP annual series from the production side (January 2006), where the largest adjustment is the tertiary sector output in currently price. Our model has not incorporated this adjustment, as the NBSC has not yet published revised quarterly series, nor corresponding adjustment to the GDP expenditure side.

⁵ See (He *et al*, 2005, chapter 4) for a detailed review of the major existing macroeconomic models in China.

3. Basic Structure of the Model

The China model is roughly divided into the following blocks: income and consumption, labor and employment, investment, government, foreign trade, the three sectors of GDP, price and wage, and monetary. There are 73 endogenous variables and 16 exogenous variables. Specification and estimation of all the behavioral and linking equations is carried out using PcGive and PcGets, see (Doornik and Hendry 2001) and (Hendry and Krolzig 2001). Model forecasts and simulations are performed in WinSolve, see (Pierse 2001). Figure 1 depicts a simple flow chart of the model. The following briefly describes the key equation structure of each block.

Household income and consumption block

Household income and consumption are modeled separately for urban and rural areas. *Per capita income of urban households* is explained mainly by average earnings per urban employee. Unemployment rate also exerts a negative effect on per capita urban income. *Per capita cash income of rural household* is modeled via the total income of rural households, which depends on the output of the three sectors and unemployment rate in the long run. *Urban per capita consumption* is explained in the long run by urban household income and real interest rate while also affected by inflation in the short run. *Rural per capita consumption* is explained by rural household income in the long run while, in the short run, inflation exerts some effect. Aggregation of the two consumption series via population leads to the aggregate private consumption component in GDP.

Labor and employment block

Labor force depends mainly on population. Total *Employment* is explained by real GDP and urban wage rate. These two variables define *unemployment rate*. *Secondary sector employment* and *tertiary sector employment* are determined mainly by their sector real output

and urban wage rate respectively, whereas *primary sector employment* is derived from total employment net of the employment of the other two sectors.

Production block

A *long-run GDP* is specified as following a standard production function with constant returns to scale. This variable enables us to define a ‘GDP gap’ variable as the deviation of GDP from long-run GDP.

Real output of both the primary and tertiary sectors are demand driven, whereas the *secondary sector real output* follows a production function with constant returns to scale in the long run. The degree of openness is also found to affect the secondary sector real output.

Nominal output of the three sectors is modeled via their price deflators. These deflators are mainly linked with various price indices modeled in the price block.

Investment block

The total domestic investment in fixed assets is disaggregated into *government investment* and *business-sector investment*. *Government investment*, measured by fiscal expenditure on capital construction and innovation, serves mainly as a fiscal policy instrument targeted at reducing unemployment and smoothening the GDP gap (see the Production block). Changes in government investment are found to impact on business-sector investment, which otherwise follows a factor-demand equation with real GDP and real lending rate playing the key explanatory roles.⁶ *FDI* (Foreign Direct Investment) is modeled separately and determined primarily by GDP, relative factor prices and interest rate differentials.

Government block

Government expenditure comprises government investment and non-investment

⁶ A detailed description of an early version of these two equations is in (He and Qin, 2004). However, as the investment data series have been re-defined after the publication of that paper, the equation specification is now somewhat different. See also (Qin and Song, 2003), (Qin, Cagas, Quising and He, 2005) for more discussions of the investment issue.

expenditure, the latter being mainly explained by government revenue and linked to *government consumption* on the expenditure side of GDP. *Government revenue* is explained by *tax revenue*, which is composed of tariffs on trade, agricultural tax, and business tax mainly from the secondary and tertiary sectors.

Trade block

Imports is explained in the long run by domestic demand and exports whereas inflation in the investment price is also found to exert certain short-run impact. *Exports* is simply linked to a world import demand variable, which is computed from a trade matrix comprising of imports from China by 30 countries and regions that historically have accounted for over 90% of China's exports.

Price and wage block

Consumer price index is expressed simply as retail markup of industrial output price and import price indices in the long run. In addition, wage rate changes and the GDP gap are found to impact on inflation. The latter factor provides us with a useful macro measure of 'overheating'. *Industrial output price* is dependent mainly on import price index, investment price index and ratio of wage earnings per urban employee over per capita output from the secondary sector. *Fixed investment price index* is mainly explained by the secondary sector deflator, import price index and bank lending rate. *Import price index* follows the world price index and exchange rate while also being affected by export price dynamics. In fact export and import price indices are mutually dependent.⁷

Urban wage rate is explained by labor productivity in the secondary and tertiary sectors.

Monetary block

This block of the model follows the fundamental ideas of the Polak model (1957; 1997),

⁷ When endogenous variables are found to be mutually dependent, simultaneous-equation estimation is performed to check for

which is based on the key entries of two balance sheets: the balance sheet of the total banking sector and the balance sheet of the monetary authority, see (Qin, He, Liu and Quising 2005) for a detailed description of this block.

The total banking sector balance sheet is linked to the real economy via broad money, $M2$, and net foreign assets. $M2$ is explained via its two components: $M1$ and quasi-money. $M1$ follows a demand-driven equation with real GDP and real interest rate being the key long-run explanatory variables. Quasi-money is mainly explained by potential savings, i.e. household income less household consumption, and deposit interest rate. *Net foreign assets* is explained mainly by foreign trade balance and FDI.

The purpose of modeling the balance sheet of the monetary authority is to identify how monetary policies affect the economy. A key policy instrument identified is the imbalance between the monetary base and the base money supply, since the PBC has rarely adjusted interest rates on lending and deposits over the sample period. *Monetary base* comprises of *currency issue*¹⁴ and *reserve money*. *Currency issue* is explained by $M1$ and a gradual downward trend reflecting the impact of technological progress such as electronic transactions on cash demand. *Reserve money* is modeled via excess reserves in terms of the *excess reserve ratio*. This ratio depends mainly on the required reserves ratio, the ratio of money supply to the monetary base and the lending rate. Base money supply is modeled via the ratio of its excess supply to monetary base, which is found to be dependent on inflation.

4. Model performance

The model is evaluated for both within-sample and out-of-sample predictive performance. Empirical studies of a number of macroeconomic issues by means of model

simultaneity bias.

¹⁴ There is a small difference between the item of M0 issue on the balance sheet of the central bank and the item of M0 in circulation on the balance sheet of the banking survey. M0 issue is approximately 1.09 times of M0 in circulation.

simulations have also demonstrated the usefulness of the model.

Within-sample performance: Using historical data, static solutions of the model are generated. Figure 2 depicts the static simulations versus the actual values of four key macroeconomic variables in terms of their year-on-year growth rates: GDP, *MI*, inflation in terms of the consumer price index and unemployment. The fitted and actual values would be too close to be visually differentiable if they are plotted in levels. In addition, conventional statistics such as the root mean square percentage errors (RMSPE) and the mean percentage errors (MPE) are also calculated. Table 1 presents these statistics for a number of key variables. As seen from the table, the model tracks these major macro indicators reasonably well.

Out-of-sample performance: We evaluate out-of-sample performance through stochastic simulations. The McCarthy method is used here to generate random shocks from individual equation residuals for a specified sample period. Five hundred stochastic simulations are carried out and quantiles are computed to characterize the distribution of the simulated results. Figure 3 presents the stochastic forecasts of eight selected variables. Three curves are plotted for each variable: the simulated values at 2% quantile, 50% quantile, and 97% quantile. We regard the series at the 50% quantile as the approximate mean forecast, and the series at the 2% quantile and at the 97% quantile approximately as forming the 95% confidence interval.⁸

In addition to the above, the model has proved to be immensely useful in assisting in-depth analysis of topical macroeconomic issues. For example, Qin, He, Liu and Quising (2005) carry out various simulations to show how monetary policy impacts on the economy via different instruments; Qin, Cagas, Quising and He (2006) apply impulse analysis to investigate how much and in what ways investment and output affect each other; Qin, Cagas, Ducanes and He (2005) extend the household block of the model to incorporate income inequality indices into the

consumption equations to study the impact of increasing income inequality on growth.

5. Conclusion

Although considerable changes have occurred in the Chinese economy over the last two decades, we are able to build a fairly robust econometric model to capture the main macro dynamics and to forecast major macro economic indicators of the economy. Real-time forecasts and empirical investigation of a number of topical macroeconomic issues have proved the model to be immensely useful. Further improvements of the model are expected with its continued application to the analysis of the Chinese macroeconomy.

⁸ For the detailed description of the stochastic simulations, see (Pierse 2001).

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Table 1. Prediction Statistics of the China Model, 1994 Q1 to 2005 Q2

Variable	RMSPE	MPE
Primary sector real output	0.0095	-0.0010
Secondary sector real output	0.0241	-0.0035
Tertiary sector real output	0.0094	-0.0017
Per capita income of urban households	0.0301	-0.0043
Per capita income of rural households	0.1047	0.0118
Per capita consumption of urban households	0.0321	0.0150
Per capita consumption of rural households	0.0497	-0.0073
Business sector real investment	0.1819	0.0077
Government real investment	0.1187	0.0177
Government expenditure	0.0897	0.0046
Government revenue	0.0141	0.0009
Narrow money (M1)	0.0180	0.0015
Broad money (M2)	0.0082	-0.0014
Consumer price index	0.0099	-0.0003
Producer price index	0.0104	0.0012
Investment price index	0.0157	0.0000

Note: The RMSPE and MPE are computed as follows:

$$\text{RMSPE} = \sqrt{\frac{1}{T} \sum_{t=1}^T \left(\frac{Y_t^s - Y_t^a}{Y_t^a} \right)^2}; \text{MPE} = \frac{1}{T} \sum_{t=1}^T \left(\frac{Y_t^s - Y_t^a}{Y_t^a} \right)$$

where Y^s and Y^a are the simulated and actual values of an endogenous variable, respectively and T is the number of simulation periods.

Figure 1. A flow chart of the China model

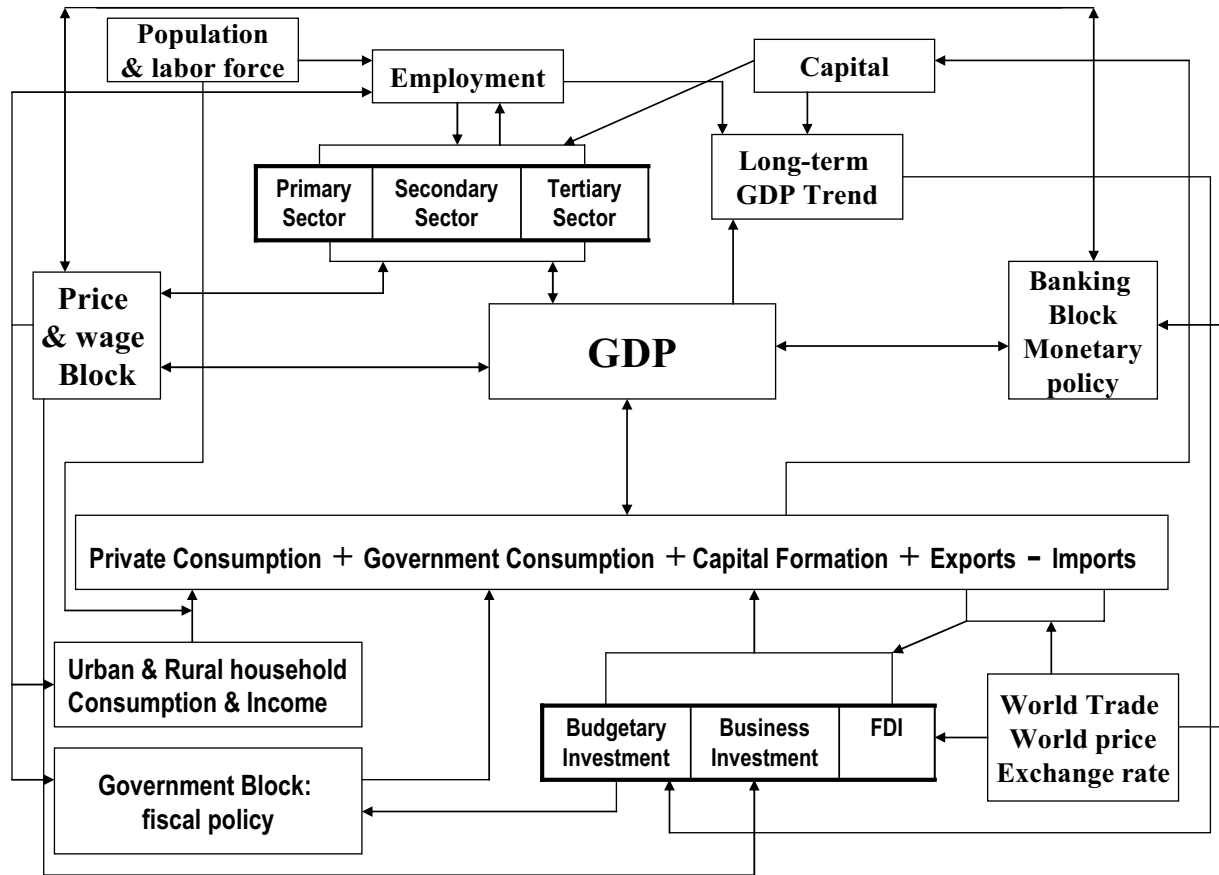
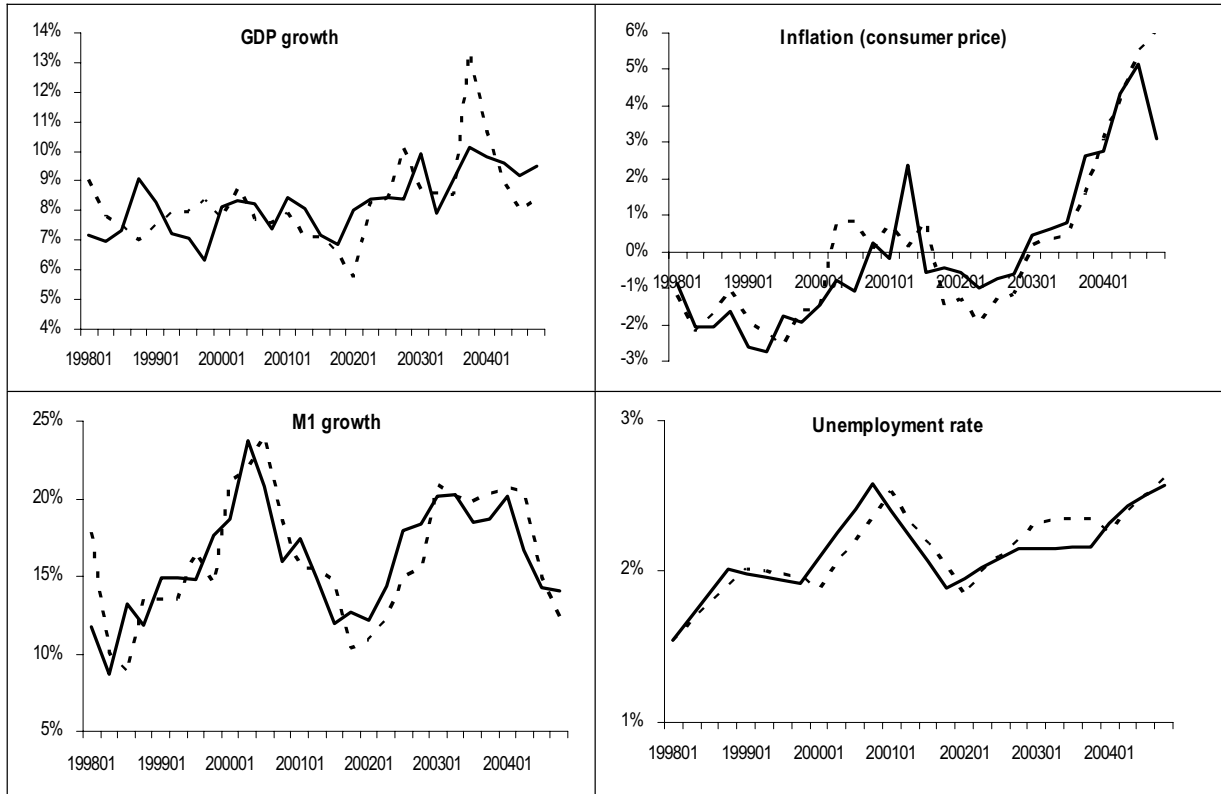


Figure 2. Static simulation results: growth rates of key variables

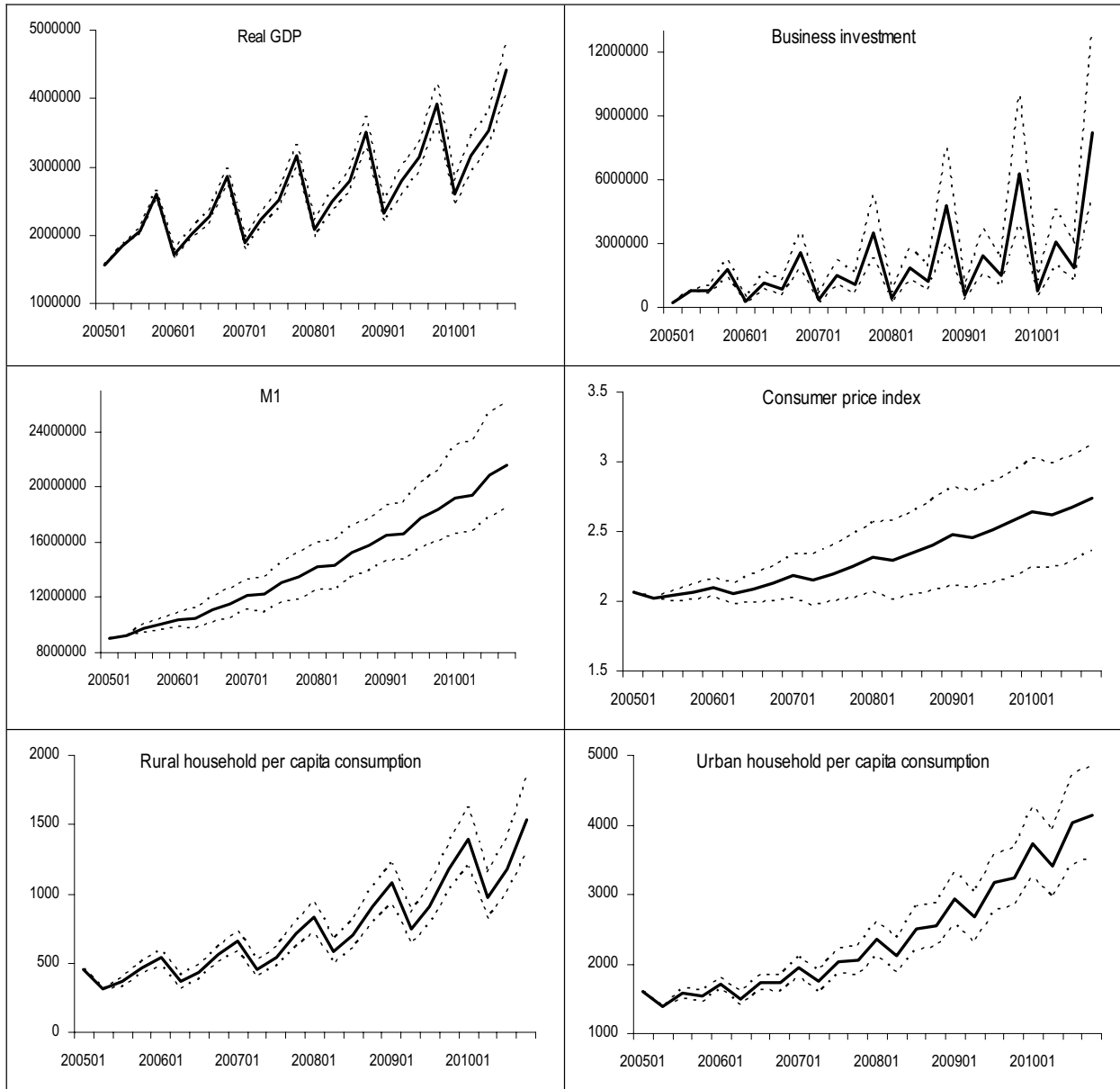
Solid line: actual values; dotted line: fitted values



Note: The simulated GDP is calculated as the sum of the simulated real output of the three sectors; the simulated unemployment is derived from the simulated labor force and total employment.

Figure 3. Stochastic forecasting: a few key variables

Solid line: forecasts (at 50% quantile); dotted line: confidence interval (at 2% and 97% quantiles)



Note: The simulated GDP is calculated as the sum of the simulated real output of the three sectors.

**This working paper has been produced by
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