

Trends and Cycles in China's Macroeconomy: A Multivariate Approach¹

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¹The views expressed herein are those of the authors and do not necessarily reflect the views of the Federal Reserve Bank of Atlanta or the Federal Reserve System or the National Bureau of Economic Research.

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- ▶ In particular there has been little empirical study on
 - ▶ the basic facts on trends, cycles, and volatilities of China's economy,
 - ▶ and how various monetary instruments interact with the real variables.

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 - ▶ the basic facts on trends, cycles, and volatilities of China's economy,
 - ▶ and how various monetary instruments interact with the real variables.
- ▶ This paper is to fill this important vacuum by providing some empirical facts on China's macroeconomy.

What does this paper do?

The first challenging task is to construct a set of core macroeconomic time series for China to be as consistent with the NIPA as possible, **all in level on quarterly frequency** from 1991Q1 to present (2013Q2):

- ▶ nominal and real GDP (fixed-weight – the 1993 UN standards), implicit GDP deflator;
- ▶ CPI, nominal retail consumption (no data available for some services);
- ▶ nominal investment, prices of investment goods;
- ▶ nominal exports and imports of goods (these data are collected by customs, so no data available for services);
- ▶ nominal exchange rate for the RMB and the USD;
- ▶ nominal government spendings;
- ▶ M2, monetary base;
- ▶ Required reserve ratio;
- ▶ Deposit rates.

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Sources of the data

- ▶ Our quarterly macroeconomic series are constructed based on the CEIC (China Economic Information Center, now belonging to Euromoney Institutional Investor Company) Database—one of the most comprehensive macroeconomic data sources for China.
- ▶ Two major sources of the CEIC Database are the National Bureau of Statistics (NBS) and the People's Bank of China (PBOC).
- ▶ During the past one and a half years, we have been assembling the macroeconomic time series and are still in the process of improving our data quality.

Challenge

The difficulty of constructing a standard set of quarterly time series lies in several dimensions.

- ▶ The NBS—the most authoritative source of economic data—reports only percentage changes of certain key macroeconomic variables such as real GDP.
- ▶ Many variables, such as investment and consumption, do not have quarterly data. Annual books published by the NBS, using the expenditure approach, have only annual data with continual revisions of the data from 2000 on.
- ▶ For quarterly or monthly frequencies, there are data published by the NBS, using the value-added approach (Brandt and Zhu 2010), for only subcomponents or variables with definitions different from those with the NIPA expenditure approach.
- ▶ Many series on quarterly frequencies are not available for the period of the early 1990s. For that period, we extrapolate the series that are likely to be unreliable.
- ▶ Few seasonally adjusted data are provided by the NBS or by the PBOC.

Illustration: Construction of Real GDP in Level

- ▶ The NBS publishes y/y changes of real GDP in two forms (let t be the first quarter of the base year):
 - ▶ year-to-date (YTD) y/y changes: $\frac{y_t}{y_{t-4}}$ (Q1), $\frac{y_{t+1}+y_t}{y_{t-3}+y_{t-4}}$ (Q2), $\frac{y_{t+2}+y_{t+1}+y_t}{y_{t-2}+y_{t-3}+y_{t-4}}$ (Q3), $\frac{y_{t+3}+y_{t+2}+y_{t+1}+y_t}{y_{t-1}+y_{t-2}+y_{t-3}+y_{t-4}}$ (Q4);
 - ▶ non-YTD y/y changes: $\frac{y_t}{y_{t-4}}$ (Q1), $\frac{y_{t+1}}{y_{t-3}}$ (Q2), $\frac{y_{t+2}}{y_{t-2}}$ (Q3), $\frac{y_{t+3}}{y_{t-1}}$ (Q4).
- ▶ What is published: the data on non-YTD y/y changes go back to only 1999Q4, while the series of YTD y/y changes begins from 1991Q4 on.
- ▶ Given y_t , we obtain y_{t+4} from

$$y_{t+4} = a_{t+4}y_t = b_{t+4}y_t,$$

where a represents YTD y/y changes and b represents non-YTD y/y changes.

- ▶ We then obtain y_{t+1} and y_{t+5} by solving the following two equations

$$\frac{y_{t+5} + y_{t+4}}{y_{t+1} + y_t} = a_{t+5},$$
$$\frac{y_{t+5}}{y_{t+1}} = b_{t+5}.$$

Illustration: Construction of real GDP in level

- ▶ Now given $y_t, y_{t+1}, y_{t+4}, y_{t+5}$, we obtain y_{t+2} and y_{t+6} by solving the two equations

$$\frac{y_{t+6} + y_{t+5} + y_{t+4}}{y_{t+2} + y_{t+1} + y_t} = a_{t+6},$$
$$\frac{y_{t+6}}{y_{t+2}} = b_{t+6}.$$

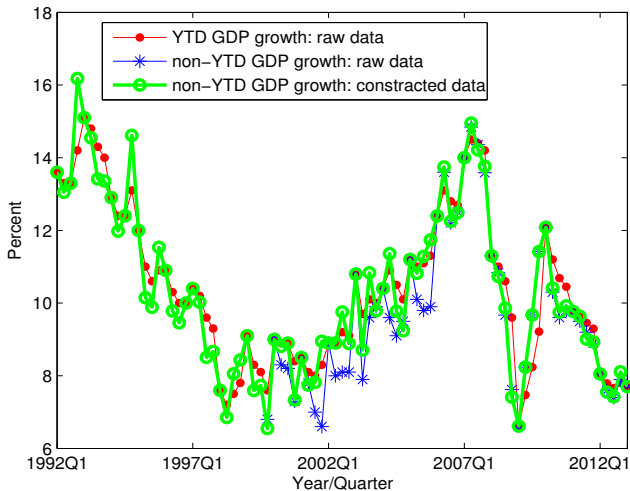
- ▶ Then, we obtain y_{t+3} and y_{t+7} by solving

$$\frac{y_{t+7} + y_{t+6} + y_{t+5} + y_{t+4}}{y_{t+3} + y_{t+2} + y_{t+1} + y_t} = a_{t+7},$$
$$\frac{y_{t+7}}{y_{t+3}} = b_{t+7}.$$

- ▶ Given $y_t, y_{t+1}, y_{t+2}, y_{t+3}, y_{t+4}, y_{t+5}, y_{t+6}, y_{t+7}$, we use the YTD y/y changes to calculate out all the series of real GDP in level.

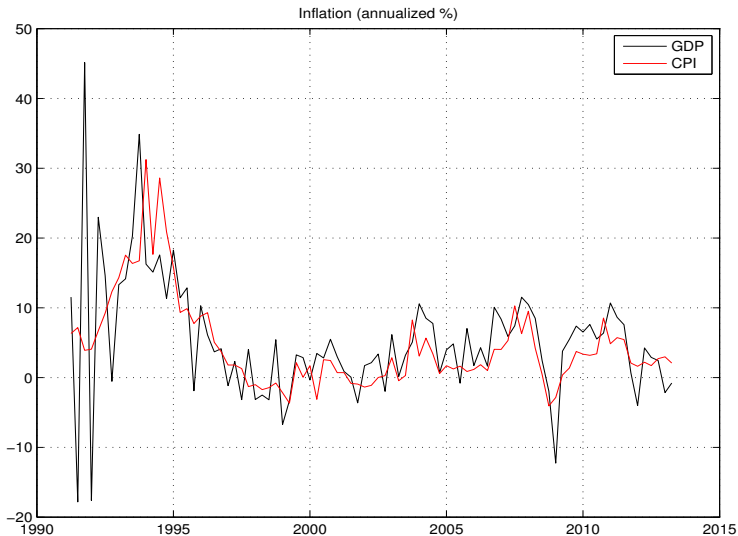
Quality of constructed data

We choose the base year (2008Q1) to minimize the differences between the non-YTD y/y changes implied by our constructed level series and those from the NBS.

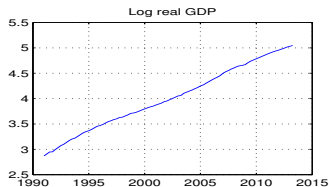
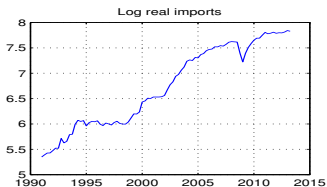
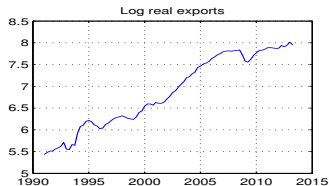
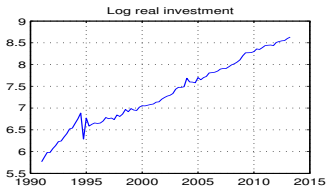
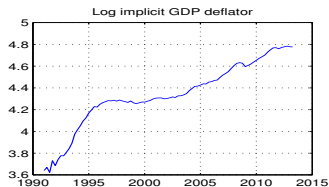
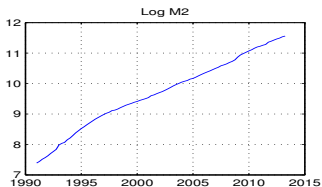


Inflation data

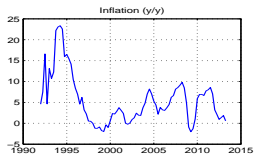
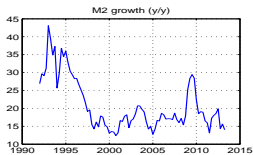
The implicit GDP deflator is more volatile than the CPI (consistent with Nakamura, Steinsson, and Liu (2013)).



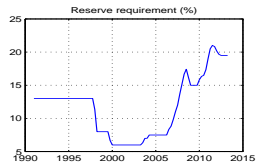
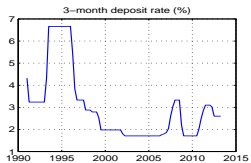
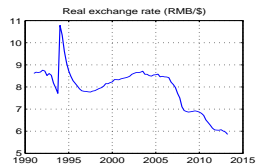
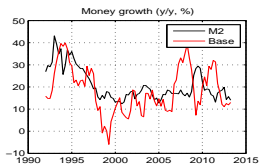
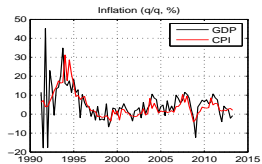
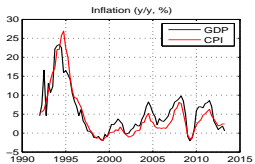
Constructed quarterly core data for estimation



Growth rates (y/y, %)



Further data analysis



Further data analysis

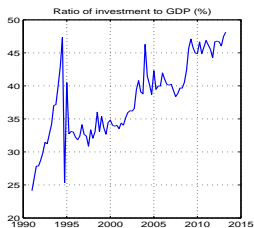


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Regimes switching

Dates of switching	Major events
December 1978	Introduction of economic reforms
Beginning of 1992	Advanced the reforms by Deng Xiaoping
Early 1990s	Price controls and rationing
January 1994	Ended the two-tiered foreign exchange system
1994	Major tax reforms and devaluation of RMB
1995-1996	Phased out out price controls and rationing
July 1997	Asian financial crises started in Thailand
November 1997	Began <i>privatization</i>
November 2001	Joined the WTO and <i>trade liberalization</i>
July 2005	Ended an explicit peg to the USD
September 2008	U.S. and world wide financial crisis
2009-2010	Fiscal stimulus of 4 trillion RMB investment

An important role of monetary aggregates in China

- ▶ The PBOC heavily regulates lending operations (lending rates, credit quotas, and “window guidance”) of the four largest commercial banks: Bank of China, Agricultural Bank of China, Industrial and Commercial Bank of China, and Construction Bank of China.
- ▶ With underdevelopment of other forms of financial intermediation, bank loans remain the major source of funding for Chinese domestic firms.
- ▶ Thus, broad monetary aggregates such as M2 represent a good approximation to the central bank’s policy tool as well as a financial intermediation in the transition of China’s economy.

An important role of reserve requirement in China

- ▶ Interest rates in the money market have been heavily regulated by the PBOC—in essence, no money market has existed until recently.
- ▶ The required reserves are used by the PBOC to influence the changes in money supply.

Question

- ▶ With all the major political and economic events, as well as many other such events on a smaller scale, how do we know which event affects cycles, which event affects volatilities, and which event triggers trend break?
- ▶ Chow (2002) and Lin (2011) offer an informative narrative of how the PBOC used money supply as a main tool to stabilize the *cycles* by expanding or cooling economic growth.
- ▶ The question is how to decouple cycles from trends and volatilities.

Econometric approach

Built on the VAR framework—Sims and Zha (1998), Christiano, Eichenbaum, and Evans (1999), and Waggoner, Sims, and Zha (2009).

The model

- ▶ Primitive form: $y'_t A_0 = c \left(s_t^\dagger \right) + \sum_{\ell=1}^p y'_{t-\ell} A_\ell + \varepsilon'_t \Xi^{-1} \left(s_t^* \right)$.
- ▶ The dimension of y_t is n .
- ▶ The switching processes represented by s_t^\dagger and s_t^* are independent of each other.
- ▶ Regimes: $s_t^\dagger \in \{1, \dots, h^\dagger\}$, $s_t^* \in \{1, \dots, h^*\}$.
- ▶ Reduced form: $y'_t = \tilde{c} \left(s_t^\dagger \right) + \sum_{\ell=1}^p y'_{t-\ell} B_\ell + u'_t$.
- ▶ $\tilde{c} \left(s_t^\dagger \right) = c \left(s_t^\dagger \right) A_0^{-1}$, $B_\ell = A_\ell A_0^{-1}$, $u'_t = \varepsilon'_t \Xi^{-1} \left(s_t^* \right) A_0^{-1}$.
- ▶ The covariance matrix for the reduced-form residuals u_t is $\Sigma \left(s_t^* \right) = \left(A_0 \Xi^2 \left(s_t^* \right) A_0' \right)^{-1}$.
- ▶ Companion form: $x_t = C \left(s_t^\dagger \right) + B x_{t-1} + \tilde{u}_t$.
- ▶ The dimension of x_t is $m \times 1$, where $m = np$. The dimension of $C \left(s_t^\dagger \right)$ is $m \times 1$. The dimension of B is $m \times m$. The dimension of \tilde{u}_t is $m \times 1$.

Separating trends from cycles

- ▶ Decompose B into eigenvalues and eigenvectors:

$$B = UDU^{-1} = [u_1, \dots, u_m] \begin{bmatrix} d_1 & 0 & 0 \\ 0 & \ddots & 0 \\ 0 & 0 & d_m \end{bmatrix} [u_1, \dots, u_m]^{-1},$$

where $d_1 \geq \dots \geq d_m$.

- ▶ We have $x_t = \sum_{i=1}^m \alpha_{t,i} u_i$, where

$$\begin{bmatrix} \alpha_{t,1} \\ \vdots \\ \alpha_{t,m} \end{bmatrix} = U^{-1}x_t$$

Separating trends from cycles

- ▶ Suppose the first q largest eigenvalues are equal to or near a unit root (the root is above 0.99).
- ▶ The trend component is $x_t^p = \sum_{i=1}^q \alpha_{t,i} u_i$.
- ▶ The cycle component is $x_t^s = \sum_{i=q+1}^m \alpha_{t,i} u_i$.

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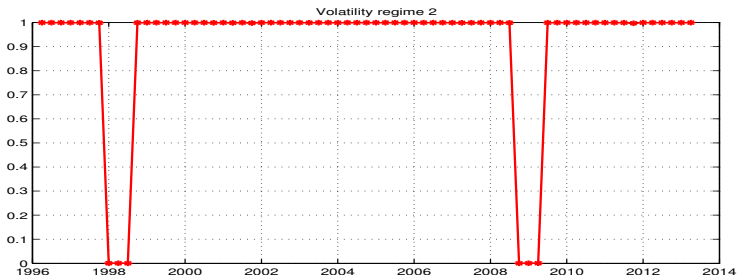
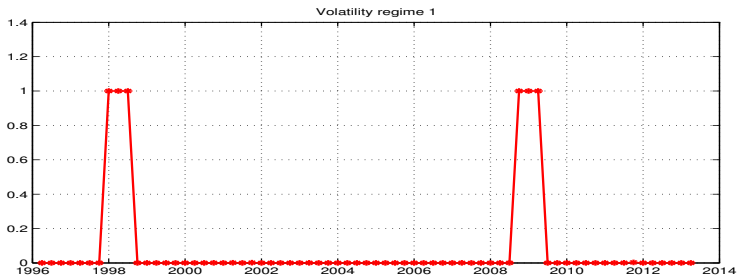
Empirical evidence

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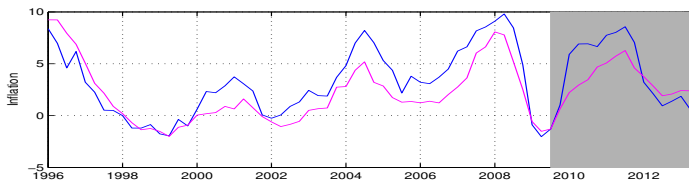
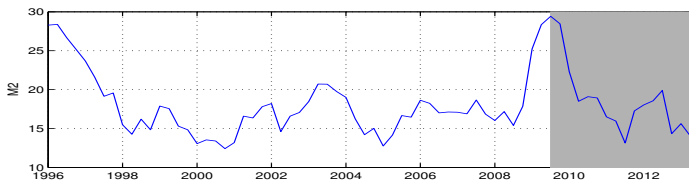
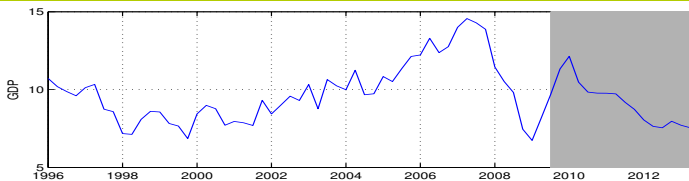
Model comparison

- ▶ With extensive model comparison, data do not favor many of the changes.
- ▶ Stochastic switches for volatility regime improve the fit considerably:
 - ▶ Large volatility in 1998Q1-1998Q3 (aftermath of the Asian financial crisis).
 - ▶ Large volatility in 2008Q3-2009Q2 (aftermath of the U.S. financial crisis).
 - ▶ Marginal data density (MDD) in log value: 1.447.9 (no switching) and 1507.5 (volatility regime).
- ▶ Data also favor a change in the intercept after the late volatility regime (2009Q3).
 - ▶ MDD in log value: 1508.6.

Estimated volatility regimes



Intercept change



First intercept regime in China—1995Q1-2009Q2

- ▶ The period of 1995Q1-2009Q2 can be characterized as the period of privatization and trade liberalization.
- ▶ Cheap labor supply, strong worldwide demand for China's exports, productivity gains from restructuring the state-owned-enterprises (SOEs), and reallocation of capital and labor between SOEs and domestic private enterprises (DPEs) are the most important aspects of privatization and trade liberalization during this period.
- ▶ The low-productive SOEs had access to bank loans, while the high-productive DPEs faced severe external finance constraints (Bai, Hsieh, and Qian, 2006; Song, Storesletten, and Zilibotti, 2011; Yang, 2012).
- ▶ In March of 1998, the PBOC began to use the RRR as an important instrument for conducting monetary policy.

Second intercept regime in China—2009Q3-2013Q2

- ▶ In the aftermath of the world wide financial meltdown in September of 2008, the government put in 4 trillion RMB investment in 2009 and 2010 as a fiscal stimulus.
- ▶ But the most conspicuous stimulus was given by the PBOC with a sharp increase in M2 growth in 2009-2010 (in contrast to an increase in the Federal Reserve's balance sheet).
- ▶ These efforts aimed partly at stabilizing the fluctuations caused by the financial crisis and partly at stemming the tide of an inevitable lower growth trend.
- ▶ Thus it is important to extract trend and cyclical components from the data in one single time-series framework.

Estimated results

- ▶ Decomposition of growth rates (annualized %):

Regime	Intercept Changes					
	Data		Trend		Cycle	
	I	II	I	II	I	II
M2	16.38	15.48	17.93	15.86	-1.55	-0.38
Inflation	2.69	4.27	3.57	3.15	-0.88	1.11
Investment	12.25	9.05	11.08	8.00	1.17	1.04
Exports	11.56	9.90	3.34	4.69	8.22	5.20
Imports	10.06	10.78	6.33	3.63	3.72	7.14
GDP	9.36	8.46	9.80	9.30	-0.43	-0.83

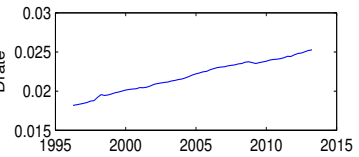
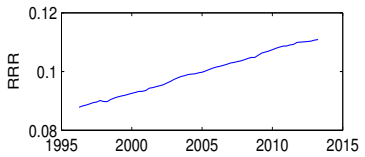
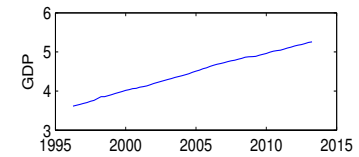
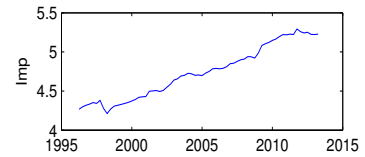
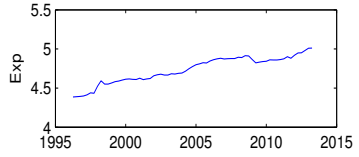
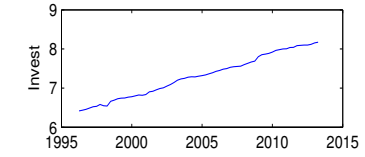
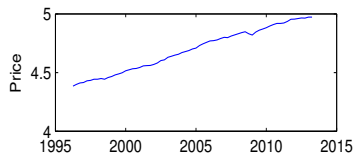
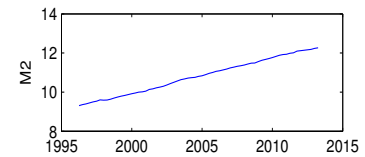
- ▶ Cyclical fluctuations contribute to a considerably large portion of growth changes in prices, exports, and imports.
- ▶ A nontrivial fraction of growth in investment and output is also driven by cyclical fluctuations.
- ▶ Slower trend growth of output in Regime II is driven by slower trend growth of both M2 and investment, as well as exports (see the distribution).

68% error bands for growth rates under intercept changes

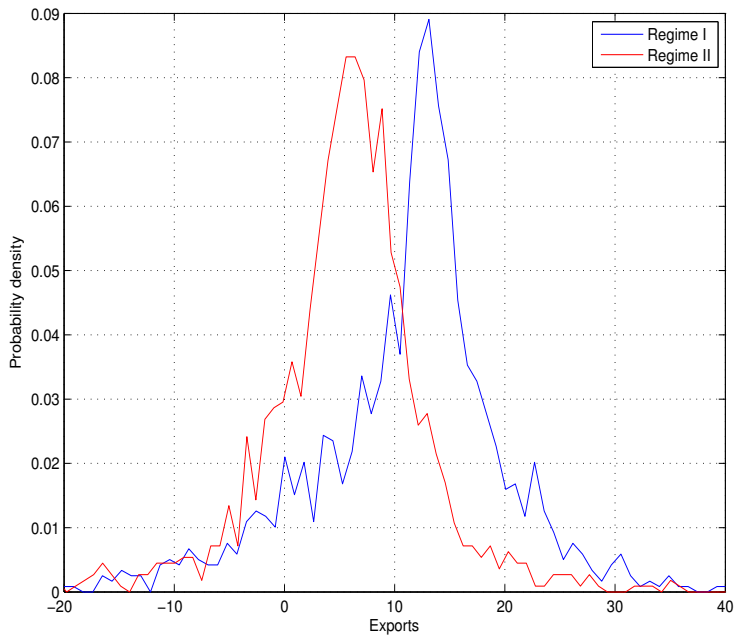
Regime I—Higher Growth						
	Trend			Cycle		
	Low	Estimate	High	Low	Estimate	High
M2	13.07	17.93	18.28	-1.96	-1.55	3.30
Inflation	2.14	3.57	4.37	-1.70	-0.88	0.54
Investment	9.39	11.08	14.81	-2.61	1.17	2.83
Exports	2.67	3.34	18.34	-6.85	8.22	8.66
Imports	6.79	6.33	19.93	-9.94	3.72	3.18
GDP	7.34	9.80	11.21	-1.85	-0.43	1.99

Regime II—Lower Growth						
	Trend			Cycle		
	Low	Estimate	High	Low	Estimate	High
M2	10.88	15.86	15.56	-0.08	-0.38	4.59
Inflation	1.66	3.15	3.63	0.62	1.11	2.60
Investment	5.69	8.00	10.63	-1.58	1.04	3.34
Exports	-0.38	4.69	11.16	-1.34	5.20	10.14
Imports	2.11	3.63	13.90	-3.12	7.14	8.59
GDP	5.17	9.30	8.75	-0.29	-0.83	3.27

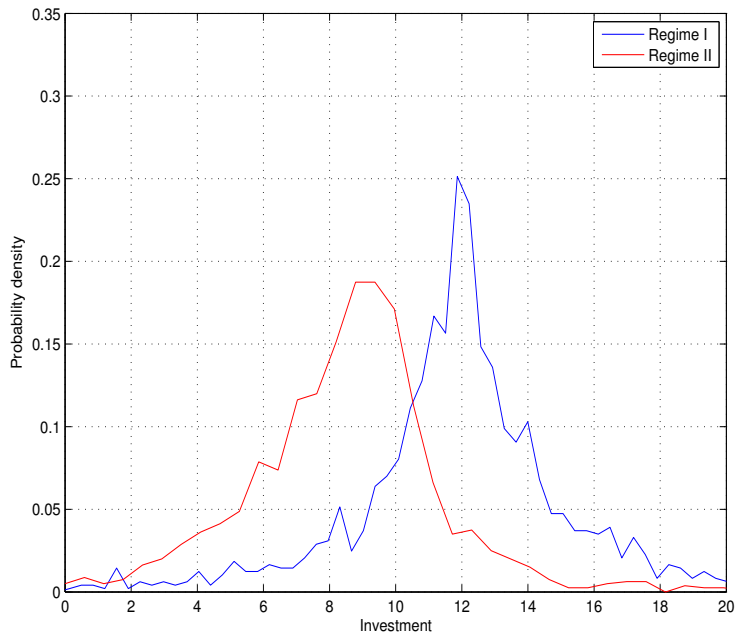
Estimated trends



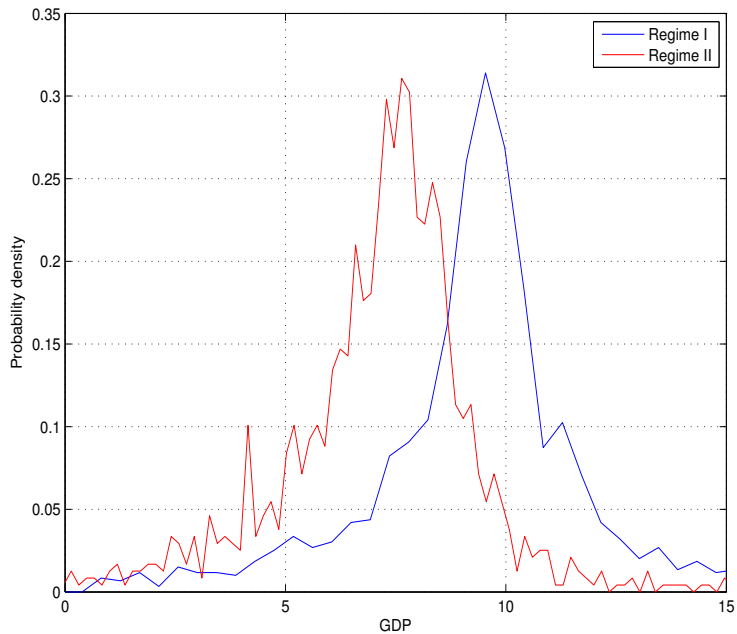
Estimated trend distributions: Exports



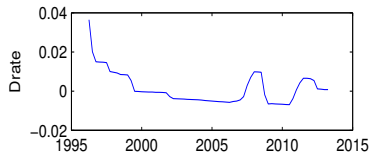
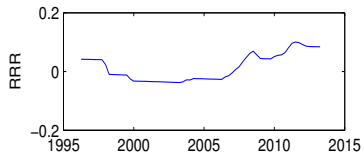
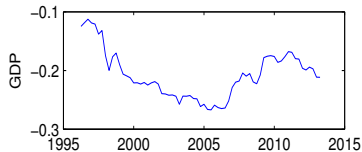
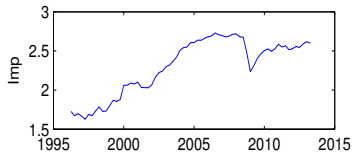
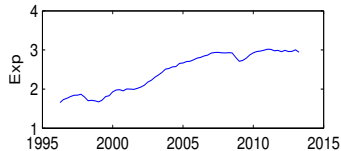
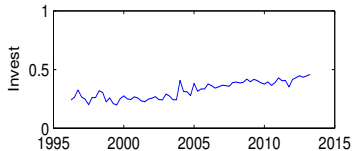
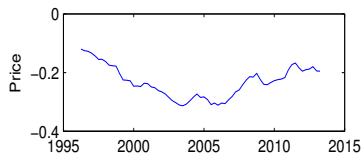
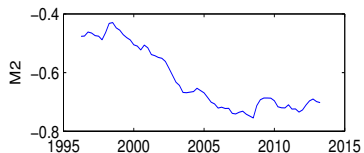
Estimated trend distributions: Investment



Estimated trend distributions: GDP



Estimated cycles



Some facts about the cyclical movements

- ▶ The cycles are very long.
- ▶ Prices, GDP, reserve requirement, and the deposit rate tend to comove.
- ▶ Imports, exports, investment tend to comove.
- ▶ There is little comovement between investment and GDP.
- ▶ The relationships between exports and GDP are weak.
- ▶ Money supply tends to move in opposite with investment and the external sector (imports and exports) than with GDP.

Correlations over business cycles

	M2	Prices	Investment	Exports	Imports	GDP	RRR	D Rate
M2	1.0000	0.4016	-0.7759	-0.9794	-0.9602	0.3951	-0.3706	0.4835
Price	0.4016	1.0000	0.0584	-0.2758	-0.5252	0.9116	0.6828	0.7910
Investment	-0.7759	0.0584	1.0000	0.8485	0.7230	-0.0177	0.6597	-0.2223
Exports	-0.9794	-0.2758	0.8485	1.0000	0.9398	-0.2901	0.4880	-0.4525
Imports	-0.9602	-0.5252	0.7230	0.9398	1.0000	-0.5617	0.2044	-0.5551
GDP	0.3951	0.9116	-0.0177	-0.2901	-0.5617	1.0000	0.6139	0.7135
RRR	-0.3706	0.6828	0.6597	0.4880	0.2044	0.6139	1.0000	0.3631
D Rate	0.4835	0.7910	-0.2223	-0.4525	-0.5551	0.7135	0.3631	1.0000

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Recap

- ▶ Trend inflation appears not to be a problem.
- ▶ Rapid trend growth in investment seems to be a driving force of impressive trend growth of GDP.
- ▶ Cyclical fluctuations, even after controlling for a switch in intercept, are important for China's economy.
- ▶ Cyclical fluctuations of exports and imports move together with those of investment.
- ▶ Cyclical fluctuations of investment and exports, however, do *not* comove with those of GDP (fiscal policy implications).
- ▶ Leaning-against-wind monetary policy:
 - ▶ M2 moves in opposite with both GDP and inflation over the business cycle.
 - ▶ The required reserve rate and the deposit rate comove with both GDP and inflation over the business cycle.

Conclusion

- ▶ In the transition of China's macroeconomy, monetary aggregates such as M2, as well as required reserves and the deposit rate, play a substantive role in both fluctuations and growth of aggregate output.
- ▶ Moving beyond privatization and trade liberalization, financial liberalization (as confirmed by the November 2013 plenum of China) is needed in the future:
 - ▶ Economic growth may face a trend break or a long cycle with more reliance on an increase of domestic demand (consumption).
 - ▶ Fluctuations of M2 will inevitably play a less important role in both growth and cycles as financial reforms go beyond the banking sector.
- ▶ Any structural macro model should take into account all these salient features. [▶ Back to Introduction](#)