

China's macro-economy: some important econometric models

Gregory Chow
Princeton University

Outline

- 1. A model determining real GDP through a consumption function and an investment function.
- 2. A model to explain inflation.
- 3. A VAR model to evaluate the effects of exogenous change in money supply on aggregate output and the price level.
- 4. An aggregate production function
- 5. Other topics.
- References:
 - 1. *China's Economic Transformation*, Blackwell, 2007.
 - 2. *Interpreting China's Economy*, World Scientific, 2010.

Institutional background of the Chinese macro-economy

- 1949-1978. Central economic planning introduced. First Five-Year Plan 1953-1957. 12th Five-Year Plan, 2011-2015.
- 1978- present. Reform towards a market economy.
- China has a market economy: free entry of able entrepreneurs and high fraction of GDP produced by profit seeking enterprises, private and state-owned.

1. Model of Chinese national income determination, *Econ Letters*, Nov. 2009

- $Y = C + I + X$
- $C = c_1 + c_2 C_{t-1} + u_{1t}$
- $I = b_1 + b_2 (Y - Y_{t-1}) + b_3 I_{t-1} + u_{2t}$
- Consumption C is determined by the permanent income hypothesis of Hall (1978).
- Investment I is determined by the accelerations principle as derived below.
- Endogenous variables: Y, C, I .
- Exogenous variable: X
- Predetermined variables: $X, C_{t-1}, I_{t-1}, Y_{t-1}$ (or X_{t-1}).

Deriving the investment equation

- Assume that desired capital stock $K^* = \text{const} + aY$, and the change in capital stock $K_t - K_{t-1} = b(K_t^* - K_{t-1})$. Substitute $\text{const} + aY$ for K^* in this equation $K_t - K_{t-1} = b(\text{const} + aY - K_{t-1})$. Solve for K_t :
- $K_t = \text{const.} + abY_t + (1 - b) K_{t-1}$.
- gross investment $I_t = K_t - (1 - d)K_{t-1}$ d is rate of depreciation. Subtract from the above equation for K_t $(1 - d)[K_{t-1} = \text{const.} + abY_{t-1} + (1 - b)K_{t-2}]$ to obtain the following equation for investment
- $I_t = K_t - (1 - d)K_{t-1} = \text{const.} + ab[Y_t - (1 - d)Y_{t-1}] + (1 - b)I_{t-1}$.
- Given a small rate of depreciation of about 0.04, investment I_t depends on the rate of change in output Y according to the accelerations principle.

Estimation by 2-stage LS

- In the first stage Y_t is estimated by a regression on C_{t-1} , I_{t-1} , X_t and X_{t-1} to yield, with X assumed to be exogenous,
- (1) $Y_t^* = 140.8(116.4) + .8841(.0604) C_{t-1} + 1.4254(.0951) I_{t-1} - .4815(.2616) X_t + 1.4073(.2883) X_{t-1}$
 $R^2 = 0.9996; s = 273.4$
- The sample period is from 1978 to 2006.
- The number in parentheses after each coefficient is its standard error. The variables are measured in 100 million RMB in 1978 prices, with the price index in 2006 equal to 4.598 as shown in Table 1.

Estimated consumption function

- (2a) $C_t = 218.86 + 1.067(.074) C_{t-1} - 0.0051(.0371) Y_t^*$
 $R^2 = 0.9985; s = 271.24$
- This result confirms the permanent income hypothesis of Hall (1978) perfectly since the coefficient of C_{t-1} is almost exactly 1 and the coefficient of income Y is almost equal to zero. Given the result (2a) I have dropped the variable Y_t^* and re-estimated the consumption function to obtain
- (2) $C_t = 226.05(91.78) + 1.0570(.0079) C_{t-1}$ $R^2 =$
 $0.9985; s = 266.08$

Estimated investment function

- (3a) $I_t = -399.04(139.79) + 2.4149(.6470) Y_t^* - 2.2861(.6281) Y_{t-1} + .2233(.2369) I_{t-1}$
 $R^2 = .9968; \quad s = 327.4$
- Note that the coefficient of Y_{t-1} is opposite in sign and slightly less in magnitude (because of the rate of depreciation) to the coefficient of Y_t^* . This confirms the accelerations principle that investment depends on the rate of change in income.
- Given the coefficients of Y_t^* and Y_{t-1} in equation (3a) to be almost equal in magnitude I replace these variables by the variable $(Y_t^* - Y_{t-1})$ to obtain the investment function
- (3) $I_t = -186.23(120.84) + 1.7782(.6513)(Y_t^* - Y_{t-1}) + .6866(.1589) I_{t-1}$
 $R^2 = .9960; \quad s = 359.28$

Model estimated using data 1952-1982, JPE 1985

- In Chow (1985) I reported results similar to equations (2) and (3) obtained by using Chinese annual data from 1952 to 1982.
- Consumption function: the coefficient of lagged consumption was almost equal to one and the coefficient of income was zero, supporting the permanent income hypothesis of Hall (1978).
- Investment equation: the coefficient of Y_{t-1} was negative and slightly less in magnitude than the coefficient of Y and I replaced these variables by their difference as in equation (3).
- The coefficient ab (a = ratio K/Y ; b = speed of adjustment) of this difference was smaller than 1.7782 for the period 1978-2006 possibly because the ratio a of capital stock to output was smaller and the adjustment coefficient b for capital stock to reach equilibrium was also smaller before 1978.
- Investment equation valid but parameters changed after 1978.

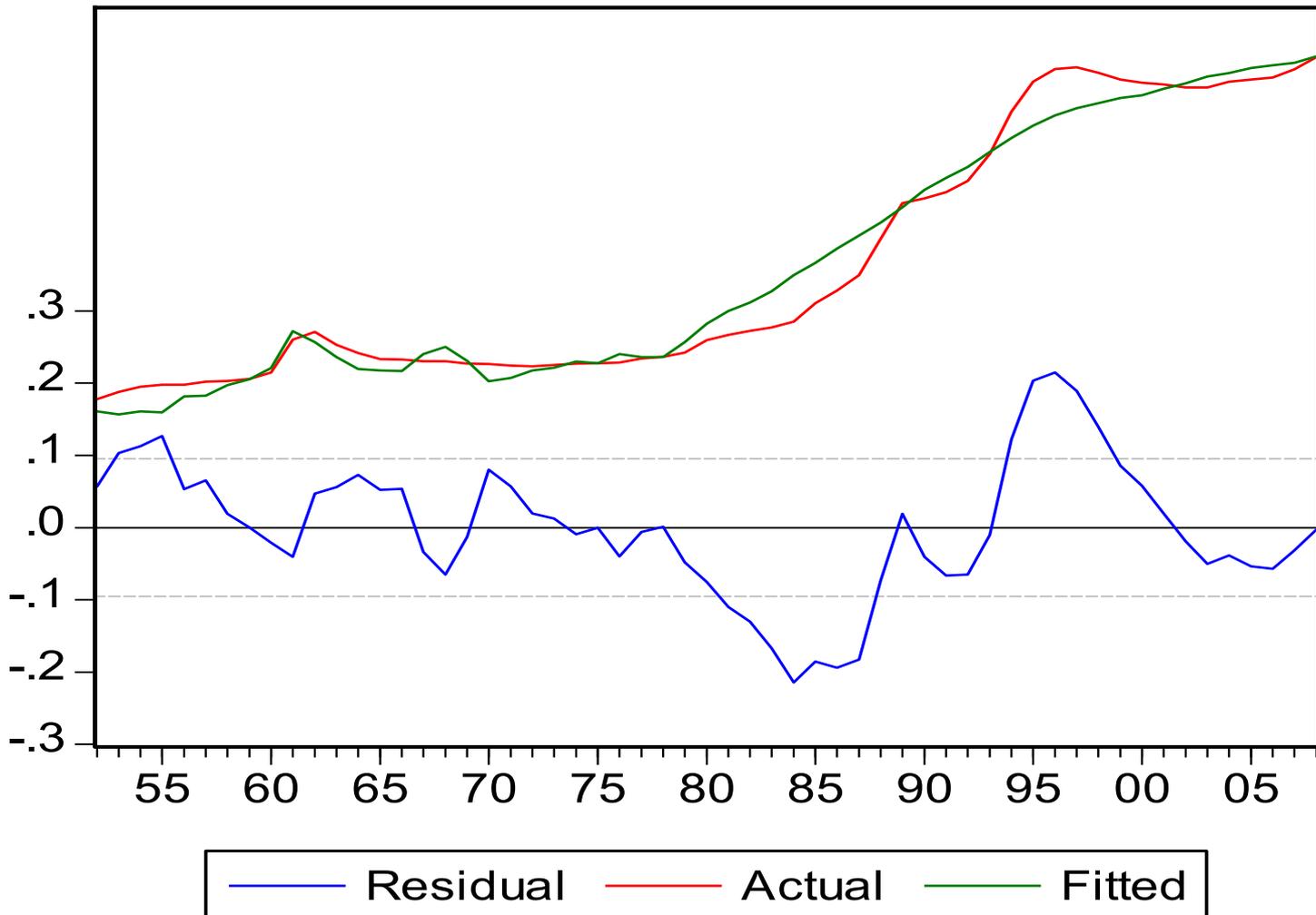
2. Model to determine inflation

- Requested by Premier Zhao Ziyang in June 1985 after currency in circulation had increased by 50% in 1984, and first published in 1987, using an error-correction model of Engle-Granger (1987).
- Cointegration relation of P and M/Y based on the quantity theory of money.
- Error correction to determine inflation or the rate of change in P .

The explanation of the price level P

- By the quantity theory of money,
- $P = v M/Y$, or $\ln P = \ln v + \ln(M/Y)$ suggesting that the most important variable explaining P is M/Y and the most important variable explaining $\ln P$ is $\ln(M/Y)$. Using data 1954-2008 I obtained
- $\log P_t^* = - .0702 + .3688 \log(M2_t/Y_t)$
- $R^2 = 0.9726; s = 0.952.0$
- We plot the estimation result in Figure 1.

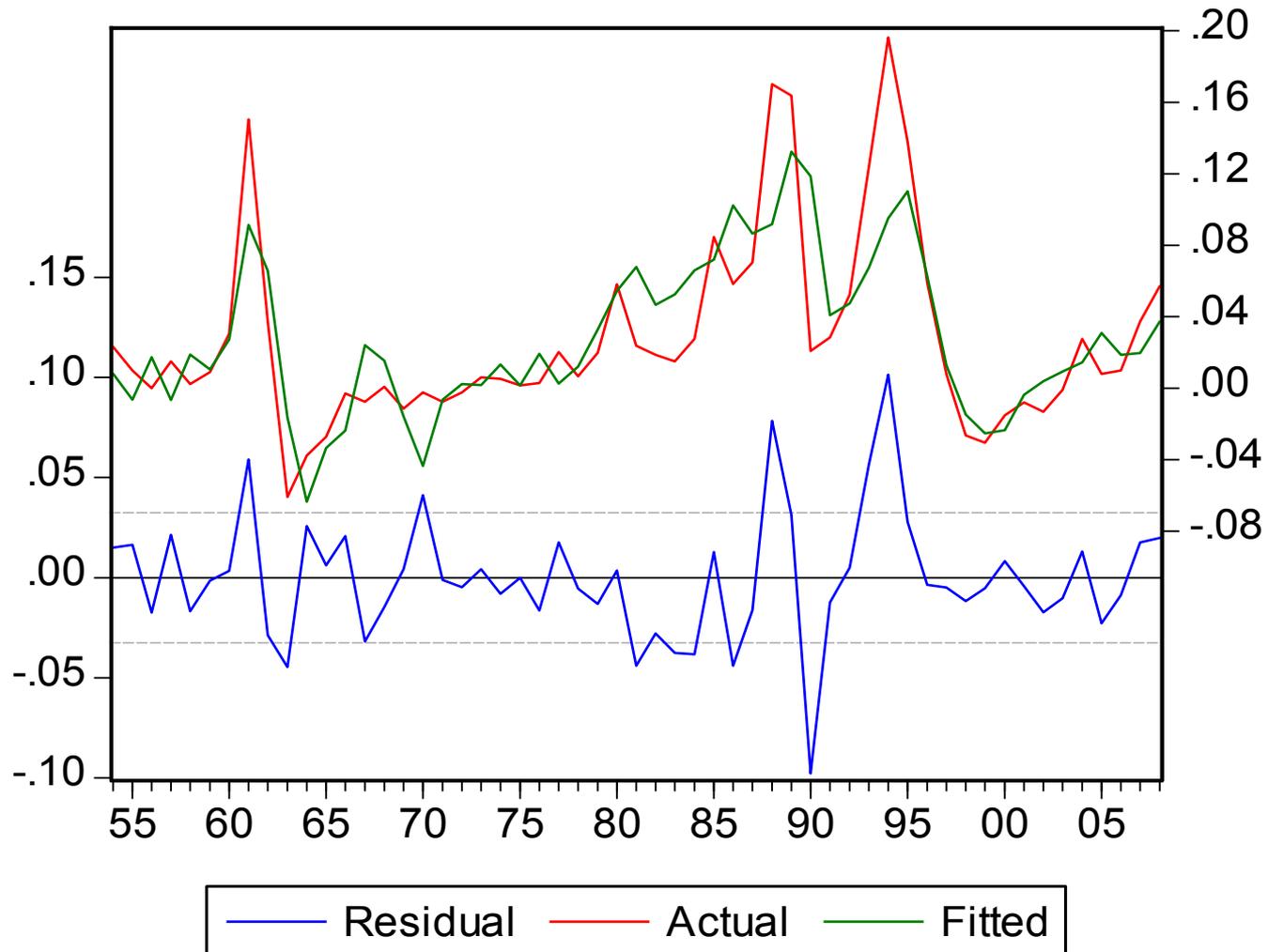
Figure 1.



Equation to explain inflation

- Let $u_t = \log(P_t) - \log(P_t^*)$ be the estimated trend deviation of the log price level or the error correction term. We then regress $\Delta \log(P_t)$ on $\Delta \log(M2_t/Y_t)$, $\Delta \log(P_{t-1})$, and u_{t-1} , following the regression of Chow (1987).
- $$\Delta \log(P_t) = \text{const.} + 0.155(.040) \Delta \log(M2_t/Y_t) + 0.532(.087) \Delta \log(P_{t-1}) - .155(.047) u_{t-1}$$
$$R^2 = 0.6293; s = .0325$$

Inflation rate: actual and fitted



Chow test for the inflation equation

- The following reports the result of the Chow test for parameter stability using $t=1979$ as the break point. The result provides extremely strong support for parameter stability of this equation.
- Chow Breakpoint Test: 1979
- F-statistic = 0.835138; Prob. $F(4,47) = 0.509767$
- Note:
- The same model for inflation applies in period of central economic planning. Price index increased by 16.2 percent in 1961 because real GDP was reduced by over 30 percent as a result of the Great Leap.

Policy relevance of the above equation to explain inflation

- Summer of 1985 Premier Zhao Ziyang was much concerned about inflation because currency in circulation had increased by 50 percent in 1984.
- I estimated such an equation, showing that inflation in 1985 would be below 9 percent. **Note: data mostly from period of planning.**
- When Zhao greeted me at dinner party he hosted for my family his first remark was about my forecast of inflation .
- I did not follow closely the high rate of increase in money supply and the associated fairly high rate of inflation in 1986-1988, although I was working with the Commission for Economic Reform; Reform is concerned with institutional changes and not current problems of macro-economic policy.
- Tiananmen event of June 4 1989 was due to inflation and corruption.
- Zhao was responsible for allowing inflation to get out of hand even when he had an excellent economic sense about institutional problems. This shows that knowledge of economics or good economic advice is important for government leaders.

Dinner party hosted by Premier Zhao, July 15, 1985



How inflation of 1988-9 was stopped

- Meeting with Economic Reform Commission in Hong Kong on March 14-16, 1989, mainly to discuss inflation. See photo.
- To reduce P we tried to reduce the amount of money actually used to purchase commodities and bid up their prices.
- Solution: Increased interest rate to over 10 percent per year which reduce the velocity of circulation v in $Mv = PY$. Given M and Y , P will be reduced when v is reduced. Increasing the rate of interest is an important tool in monetary policy.
- Inflation today. Proposed to reduce money supply by raising exchange rate of RMB to prevent inflow of foreign exchange. 如何消灭通货膨胀, 第一财经日报, 12/7/2010

Meeting with Economic Reform Commission Hong Kong March 14-16, 1989



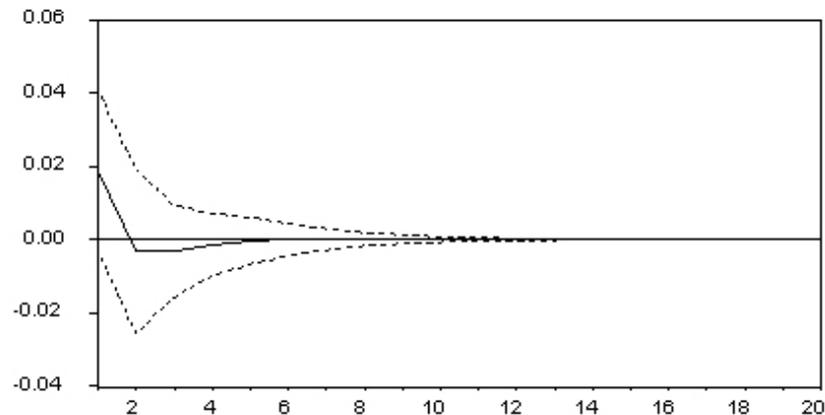
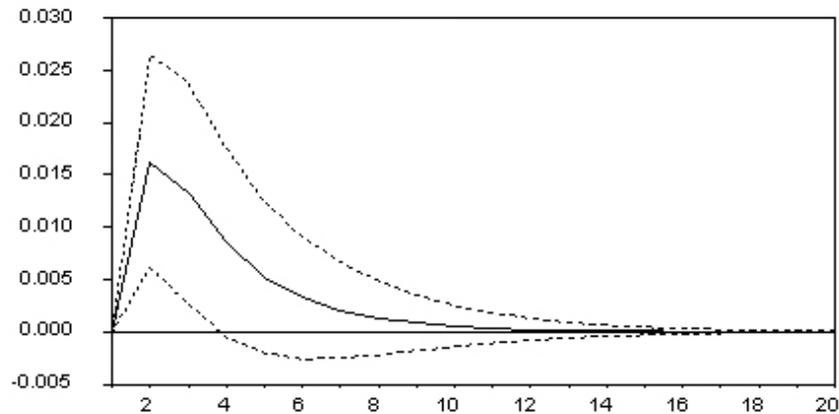
Larry Lau, Gregory Chow, Liu Hongru (vice chair), S. C. Tsiang, An Ziwen (chair), Tony Koo.

3. Vector Auto-regression VAR: effects of exogenous change in M on P and Y

Let p , y and m denote the natural log of the price level P , real output Y and money supply M_1 respectively.

$$\begin{aligned} p_t &= a_0 + a_1 p_{t-1} + a_2 y_{t-1} + a_3 m_{t-1} + a_4 p_{t-2} \\ &\quad + a_5 y_{t-2} + a_6 m_{t-2} + u_{1t} \\ y_t &= b_0 + b_1 p_{t-1} + b_2 y_{t-1} + b_3 m_{t-1} + b_4 p_{t-2} \\ &\quad + b_5 y_{t-2} + b_6 m_{t-2} + u_{2t} \\ m_t &= c_0 + c_1 p_{t-1} + c_2 y_{t-1} + c_3 m_{t-1} + c_4 p_{t-2} \\ &\quad + c_5 y_{t-2} + c_6 m_{t-2} + u_{3t} \end{aligned} \quad (6.8)$$

Impulse response of p and y to Chinese M1 shocks – Friedman proposition confirmed



Friedman's proposition on the effects of monetary shocks on price and output confirmed.

- Impulse response function (of k) – increase in the mean of future y_{t+k} and p_{t+k} if u_{3t} were one unit larger.
- Friedman's proposition as summarized by Bernanke (2004): In response to a monetary shock, output will increase within a few months but the effect will disappear shortly and price will increase much later but the effect will be long lasting. Friedman had told me it would be valid for China before I began this study.
- Proposition is valid for China as shown by impulse response function of $\ln Y$ and $\ln P$ in response to a monetary shock. Functions of the same shape based on US data can be found in Chow and Shen (2005).
- It helps to explain "overheating in China since 2002 and more recent inflation due to increase in M as a result of export surplus. Lecture in Bank of China – Zhu Min host.
- Chapter 22 of *Interpreting China's Economy* predicted inflation in 2010. Recommended revaluation of RMB.

4. Aggregate production function

- By estimating a Cobb-Douglas production function $Y = A e^{\alpha t} K^{\beta} L^{\gamma}$
- I found the exponent of capital stock β to be 0.6, and of labor γ to be 0.4. Total factor productivity did not increase ($\alpha = 0$) from 1952 to 1978 but increased by 2.8% per year ($\alpha = .028$) after 1979.
- Other supporting evidence supporting estimates 0.6 and 0.4 found in Chow(1985), Chow (QJE, 1993), Buck(1930) and Mankiw, Romer, and Weil (QJE, 1992)

5. Possible topics for Q&A in *Interpreting China's Economy*

Chinese edition 中国经济随笔

Part 1 Economic Development

- . **Entrepreneurship Propelling Economic Changes in China**
 1. **China's Economic Reform: Retrospect and Prospect**
 2. **Review of Economic Development of China in twenty years since 1989**
 3. **In what way has the Chinese government changed since the 1980s.**
 4. **Why China's Economy has grown so rapidly**
 5. **China's History and its human capital**
 6. **China's GDP will exceed the US in 2020: a re-estimation of the result**
 7. **From receiving foreign investment to investing overseas**
 8. **From learning in scientific research and education to innovations.**
 9. **How will the Chinese society continue to improve**

Part 2. Economic Analysis

- 10. A first lesson in micro-economics: demand for education in China
- 11. Supply and demand for healthcare in China
- 12. Is the price of urban housing in China determined by market forces?
- 13. A lesson in macroeconomics: the determination of consumption and investment
- 14. Exchange rate, money supply and the overheating of the Chinese macro-economy
- 15. Using Friedman's theory to explain inflation and overheating of the Chinese macro-economy
- 16 . Should China revalue its RMB: email exchanges between Gregory Chow and Ronald McKinnon
- 17. How are prices of stocks in China determined?
- 18. How are the movements of prices of stocks in the Shanghai and New York Stock Exchanges related?
- 19. Misunderstanding of China in the Western Press
- 20. Are Chinese official statistics reliable?
- 21. Will China have serious inflation?
- 22. How to put “seek truth from facts” into practice.

Part 3 Economic Policy

- **23. From economic research to social change**
- **24. Has China solved its population problem?**
- **25. The problem of rural poverty in China**
- **26. Why is healthcare in China so expensive?**
- **27. How to solve the problem of income inequality**
- **28. Can we understand corruption using tools of economics?**
- **29. How to improve the regulation of pollution in China**
- **30. Two Successful experience in solving energy and environment problems in China**
- **31. A Proposal to limit the emission of CO2 through the UN**

- Thank you