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Real Business Cycles: Data from China

CYCLES DU BUSINESS REELS : LES DONNES EN PROVENANCE DE CHINE

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Abstract

Real business cycle (RBC) is an important concept for theoretical economic research. And it works well in U.S situation. In this paper, we use data from China in the classic RBC model. Firstly we restate this model in detail. Then we apply this model by using data from China, and set specific parameters appropriate for China. From the result, we find investment more volatile in China than in the U.S, and investment is more relative to GDP growth, which is consistent with the fact we know about economic growth in China.

Key words: Real Business Cycle; China's Economy; GDP; HP Filter

Résumé

Le cycle du Business réel (RBC) est un concept important pour les théories de la recherche économique. Et il fonctionne bien en situation U.S. Dans ce papier, nous utilisons les données en provenance de Chine dans le modèle classique de RBC. Tout d'abord nous rappeler ce modèle en détail. Ensuite, nous appliquons ce modèle en utilisant des données en provenance de Chine, et définir les paramètres spécifiques appropriées pour la Chine. D'après le résultat, nous trouvons l'investissement plus volatile en Chine qu'aux États-Unis, et de l'investissement est plus par rapport à la croissance du PIB, ce qui est cohérent avec le fait que nous savons sur la croissance économique en Chine.

Mots-clés: Cycle du Business réel; Economie de la Chine; le PIB; HP Filter

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INTRODUCTION

King and Rebelo (2000) analyze real business cycle in the U.S. And that paper shows what business cycle research is. Business cycles are quite important for macro economy, for each country. For example, everyone wants to know whether the Great Depression of the 1930s in the U.S. is determined by the theory of real business cycles. If the theory or rule of real business cycles could be found, the same tragedy could be avoided, and the whole economy might be strengthened.

However, this paper only studies the situation of the U.S., and the coefficients used in the RBC models are from the situation of U.S. In this paper, we try data from China, and use the coefficients fit to China's situation.

Actually, during my research, I found that some researches with RBC model and China's data have been done by several persons in China. These papers will be referred to in the paper or in the back of the paper.

In the following, section 2 describes some stylized facts of aggregate activity in China. Section 3 summaries basic neoclassical model widely used recently. In section 4, Matlab is used to simulate the values of output, consumption and so on with parameter values from China. Section 5 contains an extension of the baseline RBC model, and Matlab is used for simulation, too. The last section is a brief conclusion.

1. STYLIZED FACTS OF AGGREGATE ACTIVITY IN CHINA

Unlike King and Rebelo (2000), we cannot find data as much as their paper. We use the data from PWT 7.0 (http://pwt.econ.upenn.edu). In the following is a list of data PWT 6.2 can be used in this paper. They are yearly data from 1952 to 2009 of China.

Population
Real Gross Domestic Product per Capita
Consumption Share of CGDP
Government Share of CGDP
Investment Share of CGDP
Price Level of Gross Domestic Product
Price Level of Consumption
Price Level of Government
Price Level of Investment
Openness in Current Prices
Ratio of GNP to GDP
Real Gross Domestic Income (RGDPL adjusted for Terms of Trade changes)
Growth rate of Real GDP per capita (Constant Prices: Chain series)

2.1 Measuring Business Cycles with the HP Filter

HP filter is used to detrend the data. Cyclical output y_t^c is defined as current output y_t less a measure of trend output y_t^g, with trend output being a weighted average of past, current and future observations:

$$y_t^c = y_t - y_t^g = y_t - \sum_{j=-J}^{J} a_j y_{t-j}$$

Figure 1 display how cyclical output is constructed with China's yearly data.

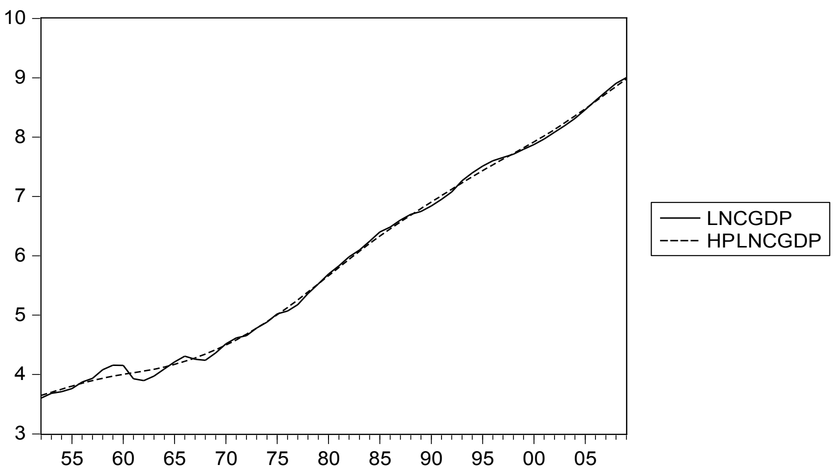

Figure 1
Output and HP Trend

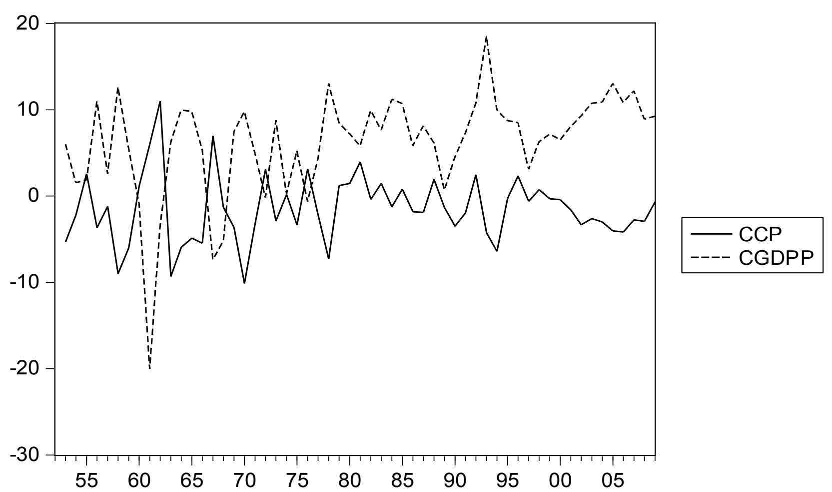

Figure 2
Consumption and Output

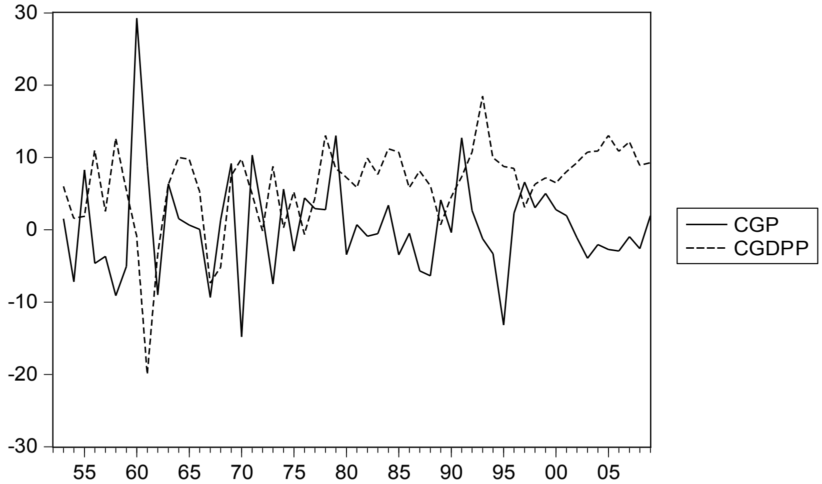

Figure 3
Government Consumption and Output

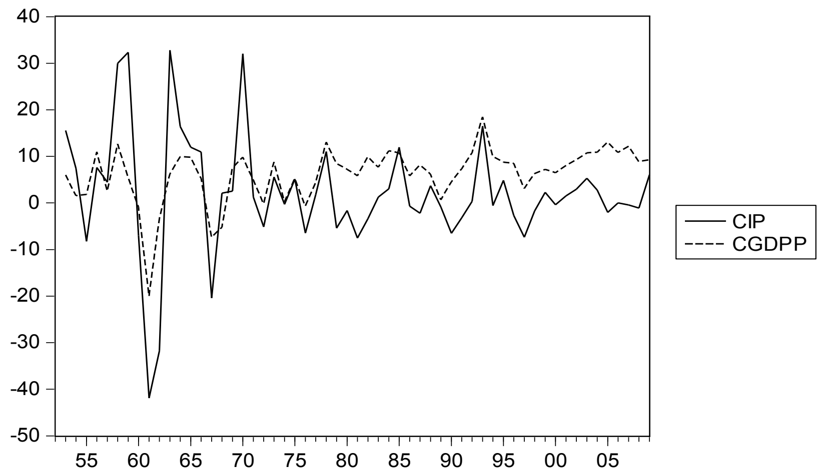

Figure 4
Investment and Output

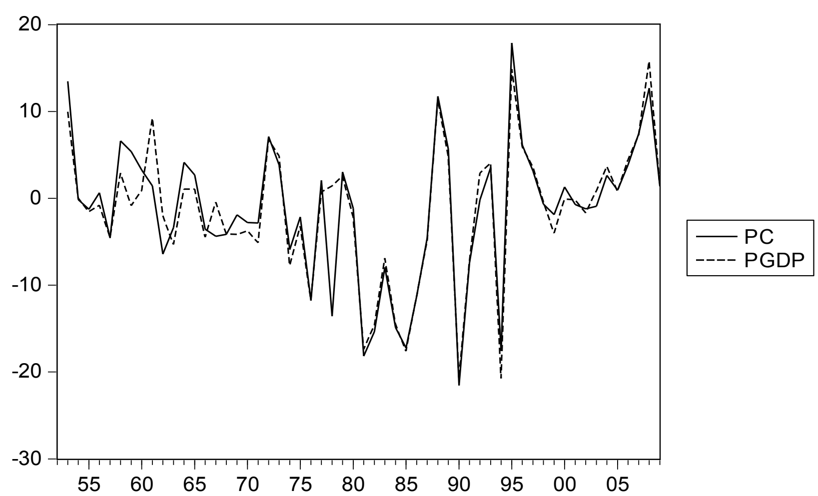

Figure 5
Price Level of Consumption and Output

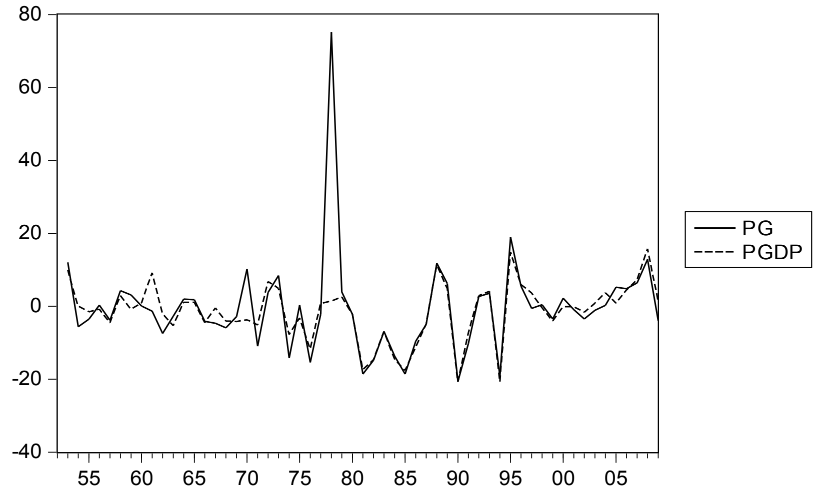

Figure 6
Price Level of Government Consumption and Output

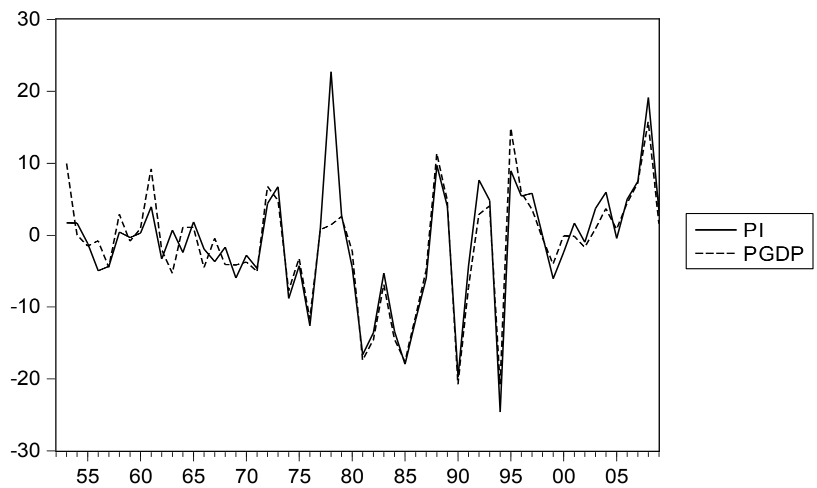

Figure 7
Price Level of Investment and Output

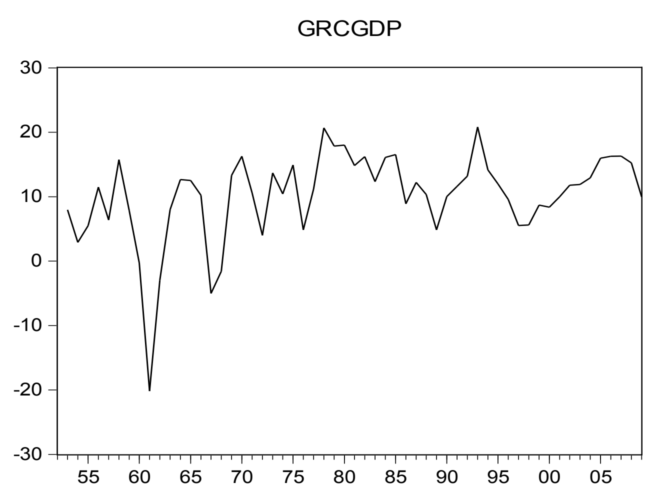

Figure 8
Growth Rate of GDP per Capita

Figure 9
Consumption Share of GDP and its HP Filter

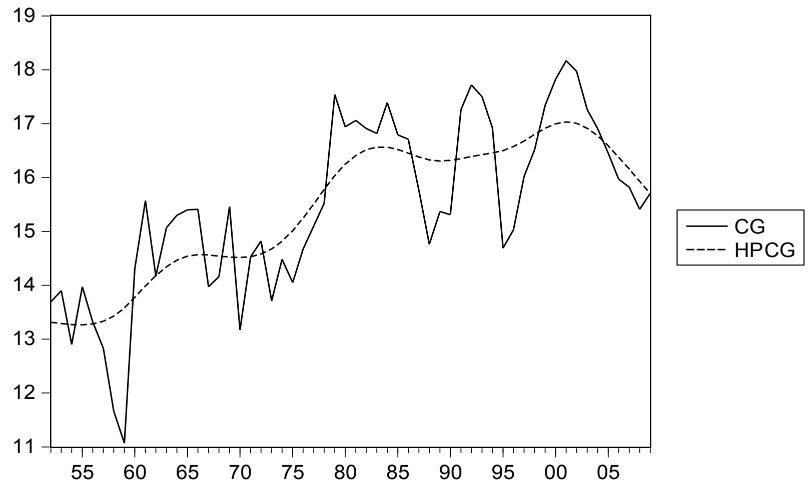

Figure 10
Government Consumption Share of GDP and its HP Filter

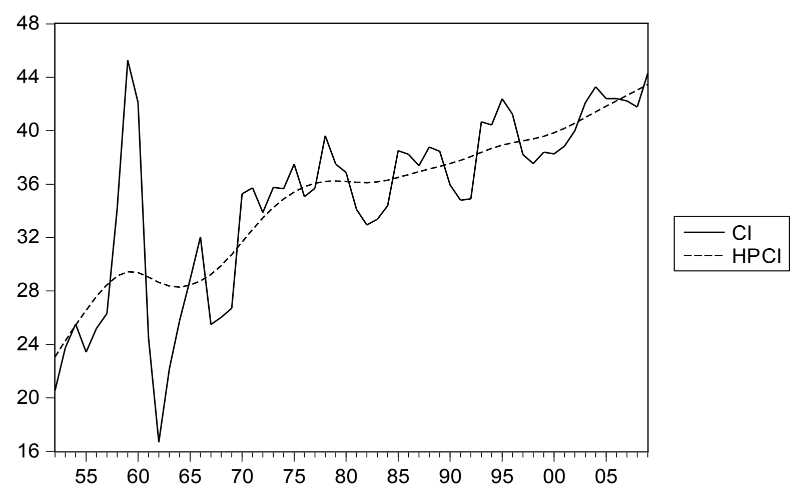

Figure 11
Investment Share of GDP and its HP Filter

The HP filter is derived by solving the following minimization problem,

$$\min_{\{y_t^g\}_{t=0}^{\infty}} \sum_{t=1}^{\infty} \left\{ \left(y_t - y_t^g\right)^2 + \lambda \left[\left(y_{t+1}^g - y_t^g\right) - \left(y_t^g - y_{t-1}^g\right) \right]^2 \right\}$$

If quarterly data was used, as in the paper offered by Robert G. King and Sergio T. Rebelo, the standard value chosen for the smoothing parameter λ is 1600. As it is discussed in the paper on HP filter, when yearly data is used, the smoothing parameter λ should be 100. HP filter has been widely used in business cycle research.

2.2 Some Stylized Facts of China Business Cycles

We use HP filter to produce cyclical components for some China macroeconomic variables, which cover from 1952 to 2009. The cyclical component of output is used as a reference variable and placed in each figure. Thus the relative volatility of the series and their comovement with output could be easily seen from the figures. Summary statistics for selected series are provided in Table 1.

Table 1
Business Cycle Statistics for China Economy

	Standard Deviation	Relative Standard Deviation	First Order Auto- Correlation	Contemporaneous Correlation with Output
Y	1.50	1.00	0.95	1.00
C	1.34	0.89	0.95	1.00
G	1.72	1.15	0.95	1.00
I	1.61	1.08	0.95	1.00

Note: All variables are in logarithms and have been detrended with the HP filter. Y is per capita output, C is per capita consumption, G is per capita government expenditure, I is per capita investment.

Volatility: Some facts are as follows, observed from the figures.

·Consumption (CCP) is less volatile than output (CGDPP) (Figure 2);

·Government expenditure (CGP) is as volatile as output (CGDPP) (Figure 3);

·Investment (CIP)is more volatile than output (CGDPP) (Figure 4);

·Price Level of Consumption (PC) is more volatile than output (PGDP) in the years from 1952 to 1972, but as volatile as output afterwards (Figure 5);

·Price Level of Government (PG) is more volatile than output (PGDP) in the years from 1952 to 1972, but more volatile than output afterwards (Figure 6);

·Price Level of Investment (PI) is less volatile than output (PGDP) in the years from 1952 to 1972, but more volatile than output afterwards (Figure 7);

Comovement: Figure 2, 3 and 4 show that consumption, government expenditure and investment have a positive contemporaneous correlation with output. Figure 5, 6 and 7 show that price levels of GDP, consumption, government expenditure and investment have a negative contemporaneous correlation with output,

Persistence: The macroeconomic aggregates Y, C, G, and I display substantial persistence: the first order serial correlation for these detrended yearly variables is about 0.95. As the original paper says, this high serial correlation maybe the reason why there is some predictability to the business cycle. However, in China, the data may have been slightly modified to be more smoothly for some reasons.

2.3 Some Stylized Facts of Economics Growth

"Kaldor facts" of growth have been referred in the class, they are as follows:

Per capita output grows at a rate that is roughly constant;

The capital-output ratio is roughly constant;

The real rate of return to capital is roughly constant;

The shares of labour and capital in national income are roughly constant.

These "Great Ratios" are usually discussed because they have the value to be researched. However, only the growth rate of per capita output can be found in PWT. The per capita output, consumption, government consumption and investment have been logarithm and detrended with HP filter (Figure 8 – 11). The first fact from "Kaldor facts" is exactly right in China. The growth rate of per capita output grows at a constant rate. Although it has some fluctuations in the first twenty years, it grows at a constant rate afterwards. The other three facts could not be examined by data.

For other "Great Ratios", consumption-to-output ratio decreases rapidly from almost two thirds to one thirds, while government-to-output ratio increases rapidly from 16% to about 32%. Investment-to-output ratio does not have such a rapid increase or decrease, it increases in a low rate from 20% to about 30%.

3. THE BASIC NEOCLASSICAL MODEL

3.1 Model

Preferences:

$$E_0\sum_{t=0}^{\infty} b^t u\left(C_t, L_t\right), \qquad b>0$$

b : Discount factor
C_t : Consumption
L_t : Leisure
E_0 : Expectation of future values of C and L based on the information available at time zero.

Endowments:

$$N_t + L_t = 1$$

N_t : Work activities
L_t : Leisure activities
Technologvy:

$$Y_t = A_t F\left(K_t, N_t X_t\right)$$

Y_t : Output
A_t : Random "productivity shock"
K_t : Amount of capital
N_t : Amount of labor
X_t : The deterministic component of productivity

$$X_{t+1}=\gamma X_t, \qquad \gamma>1$$

γ: Growth rate of component of productivity

$$Y_t = C_t + I_t$$
$$K_{t+1} = I_t + (1-\delta)K_t$$

δ: Depreciation rate

3.2 Steady State

Some methods can be used to solve for the steady state for the basic RBC model. Two steps should be done. First, the utility function, the production function and the depreciation rate should be specified so that the steady state could be solved. Second, loglinear approximations should be taken to the resource constraints and the efficiency conditions. What's more, only special production and utility pairs allow for closed form solutions.

Utility function:

Basic neoclassical model with fixed labor supply:

$$u(C) = \frac{1}{1-\sigma}\left[C^{1-s} - 1\right]$$

Basic neoclassical model with endogenous labor supply:

$$u(c,L) = \frac{1}{1-\sigma}\left\{\left[Cv(L)\right]^{1-s} - 1\right\}$$

Production function:

Cobb-Douglas production function:

$$Y_t = A_t K_t^{1-a}\left(N_t X_t\right)^{a}$$

Solow residual:

$$\log\left(SR_t\right) = \log\left(Y_t\right) - a\log\left(N_t\right) - (1-a)\log\left(K_t\right)$$
$$= \log\left(A_t\right) + a\log\left(X_t\right)$$

Resource constraint:

$$N_t = 1 - L_t$$
$$y_t = A_t F\left(k_t, N_t\right)$$
$$y_t = c_i + i_i$$
$$\gamma k_{t+1} = i_i + (1-\delta)k_t$$

"Lagrangian":

$$L = \sum_{t=0}^{\infty}\beta^t u(c_t, L_t) + \sum_{t=0}^{\infty}\beta^t\lambda_t\left[A_t F(k_t, N_t) + (1-\delta)k_t - c_t - \gamma k_{t+1}\right] + \sum_{t=0}^{\infty}\beta^t w_t\left[1 - L_t - N_t\right]$$

The first order conditions (the efficiency conditions):

$$C_t{:}D_1 u(c_t, L_t) = \lambda_t$$
$$L_t{:}D_2 u(c_t, L_t) = w_t$$
$$N_t \lambda_t A_t D_2 F(k_t, N_t) = w_t$$
$$k_{t+1}\beta\lambda_{t+1}\left[A_{t+1}D_1 F(k_{t+1}, N_{t+1}) + 1 - \delta\right] = \gamma\lambda_t$$

$$TVC{:} \qquad \lim_{s\to\infty} E_t \beta^{t+s}\lambda_{t+s}k_{t+s+1}$$

The resource constraints, the efficiency conditions and TVC yield:

$$c_t = c\left(k_t, A_t\right)$$
$$N_t = N\left(k_t, A_t\right)$$
$$k_{t+1} = k\left(k_t, A_t\right)$$

4. THE REAL BUSINESS CYCLE SHOCK

AR(1) process of $\log\left(A_t\right)$:

$$\log(A_t) = \rho\log(A_{t-1}) + \varepsilon_t$$
$$\log(X_t) = \log(X_{t-1}) + \log(\gamma)$$

4.1 Great Ratios in the Steady State:

Unlike the situation in the U.S., I should find the specific values for China's parameters. These specific values of the parameters come from the paper by Kunting, Chen, Liutang, Gong and Hengfu, Zhou (2004). And some values could be the same as the original paper. Otherwise, some values are from the research of others, or from the Internet.

The value selections for the parameters are as follows:

$s = 1$: Coefficient of risk aversion
$b = 0.915$: Yearly discount factor
$q = 3.48$: From utility function

$$u(c_t, L_t) = \log(c_t) + \frac{\theta}{1-\eta}(L_t^{1-\eta} - 1)$$

η=1: From utility function

$$u(c_t, L_t) = \log(c_t) + \frac{\theta}{1-\eta}(L_t^{1-\eta} - 1)$$

γ=1.016:A yearly gross growth rate of technical progress

α=0.25:Labor income share. From

$$\log(SR_t) = \log(A_t) + a \log(X_t)$$

δ=0.1:Yearly depreciation rate

ρ=0.9:From AR(1) process of $\log(A_t)$:

$$\log(A_t) = \rho \log(A_{t-1}) + \varepsilon_t$$

σ=0.012:Standard deviation of ε_t

Table 2
Calibration of Baseline Model

σ	b	θ	η	γ	α	δ	ρ	σ
1	0.915	3.48	1	1.016	0.25	0.1	0.9	0.012

4.2 Loglinearizing the Model Economy

$$-\hat{c}_t = \hat{\lambda}_t$$

$$-\eta \hat{L}_t = (\hat{\lambda}_t + \hat{w}_t)$$

$$\hat{w}_t = \hat{A}_t + (1-\alpha)(\hat{k}_t - \hat{N}_t)$$

$$(N)\hat{N}_t + (L)\hat{L}_t = 0$$

$$\left(\frac{c}{y}\right)\hat{c}_t + \left(\frac{i}{y}\right)\hat{i}_t = \hat{y}_t = \hat{A}_t + \alpha \hat{N}_t + (1-\alpha)\hat{k}_t$$

$$\hat{N}_t = \frac{L}{\eta N}(\hat{\lambda}_t + \hat{w}_t)$$

The cirumflex over a variable denotes proportionate deviations of that variable from its steady state level, $\hat{c}_t = \log(c_t / c)$, etc.

4.3 Business Cycle Moments

The result of the basic RBC model is in the following:

Table 3
Business Cycle Statistics for Basic RBC Model

	Standard Deviation	Relative Standard Deviation	First Order Auto- Correlation	Contemporaneous Correlation with Output
Y	1.21	1.00		1.00
C	0.53	0.44		0.82
I	3.34	2.75		0.93
N	0.57	0.47		0.97
Y/N	0.71	0.59		0.96

Note: All variables are in logarithms and have been detrended with the HP filter. Y is per capita output, C is per capita consumption, I is per capita investment, N is per capita hours.

Volatility of output and its components: for the numbers in Table 1 and 3, the Kydland-Prescott variance ratio is $0.65=(1.21/1.50)^2$, suggesting that the RBC model explains 65% of business fluctuations. However, this single parameter does not have properly ability to explain the business fluctuations; it has been used widely but not accepted widely.

From the second column of Tables 1 and 3, we can discuss the volatility of business cycle statistics. In the model, investment is about three times more volatile than output (where the ratio of standard deviations is 3.34/1/21=1.75); however, in data from China, this ratio is 1.61/1.50=1.08. Consumption is almost the same volatile as output in the actual economy (where the ratio of standard deviations is 1.34/1.50=0.89), but in the model, it is obviously smoother than output (where the ratio of standard deviations is 0.53/1.21=0.44). Among other statistics, per capita hours and productivity are both smoother than output.

5. BASIC NEOCLASSICAL MODEL WITH FIXED LABOR SUPPLY

The original paper has already offered two extensions for the Basic Neoclassical Model: Neoclassical model with lower labor supply elasticity and variable capital utilization. In this section, I will show how the basic neoclassical model with fixed labor supply works with parameter values from China.

$$\hat{N}_t = \frac{L}{\eta N}\left(\hat{\lambda}_t + \hat{w}_t\right) = \frac{1-N}{\eta N}\left(\hat{\lambda}_t + \hat{w}_t\right)$$

$(1\text{-}N)/\eta N$ is the λ -constant elasticity of labor supply. Instead of valuing it 1 or 4, we make $\eta=\infty$, then $(1-N)/\eta N \to 0$ for all N. That means the labor supply elasticity is zero and labor supply is fixed.

The values of the parameters are showed as follows. Only η has been modified from 1 to ∞ for this model, while other parameters are held the same.

Table 4
Calibration of Fixed-Labor-Supply Model

σ	b	θ	η	γ	α	δ	ρ	σ
1	0.915	3.48	∞	1.016	0.25	0.1	0.9	0.012

The result of this extended model is in the following:

Table 5
Business Cycle Statistics for Fixed-Labor-Supply Model

	Standard Deviation	Relative Standard Deviation	First Order Auto- Correlation	Contemporaneous Correlation with Output
Y	1.11	1.00		1.00
C	0.74	0.67		0.96
I	4.04	3.63		0.94

Note: All variables are in logarithms and have been detrended with the HP filter.

The Kydland-Prescott variance ratio in this model is $0.55=(1.11/1.50)^2$, suggesting that the RBC model explains 55% of business fluctuations.

CONCLUSION

Real business cycle is an important concept for theoretical economic research. And it works well in U.S situation. In this paper, we use data from China in the classic RBC model. Firstly we restate this model in detail. Then we apply this model by using data from China, and set specific parameters appropriate for China. From the result, we find investment more volatile in China than in the U.S, and investment is more relative to GDP growth, which is consistent with the fact we know about economic growth in China.

The original paper offered by Robert G. King and Sergio T. Rebelo is so useful that I think more Chinese macroeconomists should pay attention to it, and use it to explain China economy. However, some facts in China are different from those in the U.S, or other countries. Therefore, extension and modification are needed when RBC model is used in China. Values of the parameters should be re-examined carefully.

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