Chapter 2

Related Theories and Literature Reviews

2.1 Real Business Cycle Theory

Real business cycle theory (RBC theory) is the latest incarnation of the classical view of economic fluctuations. It assumes that the rate of technological change fluctuate randomly. In order to deal with the fluctuations, individuals rationally change their working hours and consumption of goods to maximize expected utility.

The basic RBC models contain the following features:

(1) A representative agent framework is adopted and focused on a representative firm and household, so the models can avoid aggregation problems.

(2) Firms and households optimize explicit objective functions subject to the resource and technology constraints by solving first order conditions.

(3) The cycle is driven by exogenous shocks of technology that cause fluctuation in production functions. The impact of these shocks on output is amplified by intertemporal substitution of leisure, which means that the more productivity, the higher cost of leisure, causing employment to increase.

(4) All agents have rational expectations and markets are perfectly competitive with continuous market clearing. There are no informational asymmetries.

(5) Real cycles are created by offering a propagation mechanism for the effects of shocks. There are several forms. First, agents generally seek to smooth consumption over time, so that an increase in output will be performed as an increase in investment or capital stock. Second, lags in the investment process can cause a shock today to impact future investment, and thus future output. Third, individuals will tend to substitute leisure intertemporally in response to transitory changes in wages, which means that when wages are temporarily higher, they will work harder, otherwise they will take more leisure instead. Fourth, firms may handle unexpected changes in demand by using inventories. If the inventories are depleted and meanwhile firms face increasing marginal costs, they would tend to be replenished only gradually, resulting in output rising for several periods (Stadler 1994).

2.1.1 Real Business Cycle Model

In the typical real business cycle models, aggregate output of a single good can be used for both consumption and investment purposes. The output is given by

$$Y_t = A_t F\left(K_t L_t\right) \tag{2.1}$$

where K_t is the capital stock, L_t is the labor input, and the term A_t denotes a stochastic productivity shift factor. The evolution of the technology parameter, A_t, is random and takes the form shown as follows:

$$A_{t+1} = \rho A_t + \varepsilon_{t+1}, \text{ where } 0 < \rho < 1, \ \varepsilon_{t+1} \sim i.d.d \ N\left(0, \sigma_\varepsilon^2\right)$$

The equation shows that the level of technology in any given period depends on the level prevailing in the previous period plus a random disturbance (Kydland and Prescott, 1996).

The representative agent maximizes the expected discounted sum of the current and future utility over an infinite time horizon. This maximization problem is given

$$U_t = \max E_t\left[\sum_{t=0}^{\infty} \beta^t u\left(C_t, 1 - L_t\right)\right], \quad 0 < \beta < 1 \tag{2.2}$$

where C_t is the representative agent's consumption of output, $1 - L_t$ is the leisure time, $E_t(\cdot)$ denotes the mathematical expectation operator, and β is the representative agent's discount factor. The resource constraints that agents face is shown as follows:

$$C_t + I_t \leq A_t F\left(K_t L_t\right) \tag{2.3}$$

$$L_t + Le_t \leq 1 \tag{2.4}$$

where Le_t denotes leisure time. The first equation indicates that the total amount of consumption plus investment cannot exceed production, and the second equation limits the total number of hours available to a maximum of 1. The capital stock evolves according to:

$$K_{t+1} = \left(1-\delta\right)K_t + I_t \tag{2.5}$$

where δ represents the rate of depreciation and I_t is current investment. In a one-good model, part of output without consumed becomes part of capital stock of next period as investment.

According to real business cycle theorists, small changes in the real wage will lead to a large response of labor supply, resulting from the intertemporal substitution of labor, which is a powerful propagation mechanism. Basing on this hypothesis, first introduced by Lucas and Rapping (1969), households change their labor supply over time, being more willing to work when real wages are temporarily high and less willingness when real wages are temporarily lower than normal.

Since the aggregate supply of labor depends on the individuals' decisions of labor supply, various factors which influence the amount of labor supply of individuals need to be considered. The benefits of current employment mainly relate to the income earned which can be used to consume goods and services. In order to earn income, workers will need to spend less time on leisure which encapsulates all non-income-producing activities. The utility function for the representative agents shows that both consumption and leisure generate utility. But in making their decisions of labor supply, workers need to consider both future and current consumption and leisure. To take future into account and decide how much labor to supply in the current period, workers need to consider how much the current real wage offers are above or below the normal one. The substitution effect of a higher real wage offer will tend to raise the quantity of labor supplied in the current period. However, since higher real wages also make workers feel wealthier, this will tend to reduce the supply of labor in the future. This wealth or income effect works in the opposite direction to the substitution effect. The impact of an increase in the current real wage on the amount of labor supplied will clearly depend on which of the above effects predominates. Real business cycle theorists distinguish between permanent and temporary alters in the real wage so as to analyze how rational individuals to respond intertemporally to changes in their economic environments that are caused by technological shocks. The intertemporal labor substitution hypothesis suggests two things.

First, if a technological shock is transitory, then the offers of current above-normal real wage are temporary, workers will substitute work for current leisure to earn more money, and less work will be supplied in the future when the real wage is expected to be lower. Hence to supply more labor now also indicate to consume more leisure in the future and less leisure now. Therefore real business cycle theory predicts temporary changes in the real wage might cause a large supply response. Permanent technological shocks, by raising the future real wage, induce wealth effects which will tend to lower the current labor supply (Abel and Bernanke, 1992).

Second, some theorists have stressed the importance of real interest rates on labor supply in flexible price models (Barro, 1981, 1993). When the real interest rate increases, the households will supply more labor in the current period, because the value of income earned from todays' working relative to tomorrow has risen. This effect would reveal as a shift of the labor supply curve to the right.

We can therefore express the general form of the labor supply function in the real business cycle model as follows:

$$S_L = S_L\left(\frac{W}{P}, r\right), \text{ where } r \text{ is real interest rate}$$

The appropriate intertemporal relative price (IRP) is shown as:

$$IRP = (1+r)(W/P)_1 / (W/P)_2 \tag{2.6}$$

From the above equation, any shocks to the economy that result in either the real interest rate rising or the current real wage $(W/P)_1$ being temporarily high relative to the future real wage $(W/P)_2$, will increase labor supply and thus employment.

2.2 New Keynesian Theory

New Keynesian economics is a school of contemporary macroeconomics that tries to build microeconomic foundations for Keynesian economics. It was developed by dealing with the criticisms of Keynesian macroeconomics which introduced by New Classical macroeconomics. The key elements and properties of the New Keynesian models are (Gali, 2008):

(1) Monopolistic competition. The prices of goods and inputs are set by agents with monopolistic power in order to maximize their objectives.

(2) Nominal rigidities. Firms face some constraints on the frequency with which they can adjust the prices of the output they sell. Alternatively, firms may be subject to some costs of adjustment. The same kind of friction applies to workers by way of sticky wages.

(3) Non-neutrality monetary policy in short-run. From the existence of nominal rigidities, changes nominal interest rates in short-run (whether directly

adjusted by the central bank or changed in the money supply) are not suited by Fisher rule of expected inflation, thus causing variations in real interest rates. A change in money supply will also alter consumption and investment, and thus output and employment, because firms find it optimal to adjust the quantity supply of goods to match the new level of demand. In the long run, however, all prices and wages, adjusted by monetary policy, turn back to its natural equilibrium.
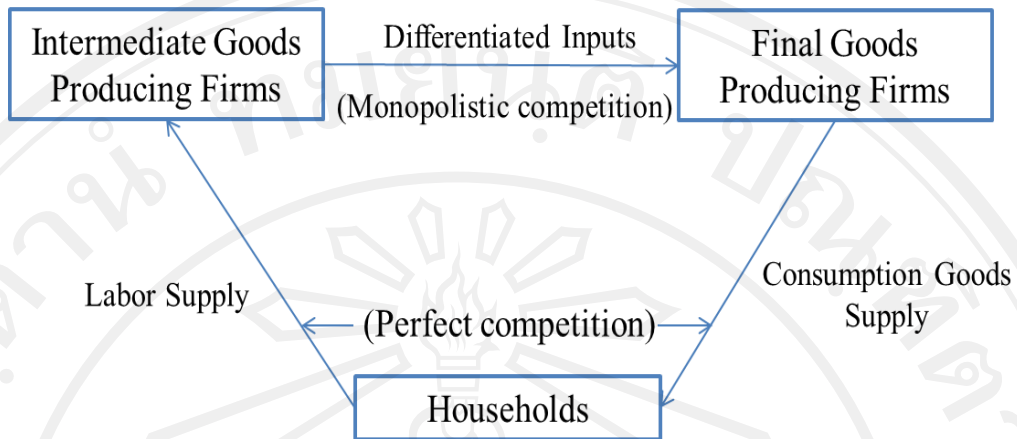
2.2.1 Monopolistic Competition

The economy populated by infinitely lived households, indexed by $i \in (0,1)$. Households are homogeneous in terms of preferences and have perfect access to asset markets and own capital stock in the economy which they rent to firms (Ahmad, 2010). Each period, representative agents seek to maximize:

$$U_t = E_t \left[\sum_{t=0}^{\infty} \beta^t u\left(C_t, N_t\right) \right] \quad 0 < \beta < 1 \tag{2.7}$$

where β is a discount factor of future utility. C_t is households' consumption of final goods and N_t denotes hours worked. The term E is the expectations operator.

Figure 2.1 Structure of Monopolistic Competition

In production sector, there are two types of firms. The first type is a perfectly competitive final goods firm producing final consumption goods using the intermediate goods as inputs (Sienknecht, 2011).

Each period, the final goods firms seek to maximize their profit by:

$$P_t Y_t - \int_0^1 P_t(i) Y_t(i) \, di \qquad (2.8)$$

subject to the constant elasticity substitution function

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} \, di \right)^{\frac{\varepsilon}{\varepsilon-1}} \qquad (2.9)$$

where P_t and $P_t(i)$ denote the price of final goods and intermediate goods. Y_t and $Y_t(i)$ are the output of final goods firms and intermediate firms.

The second type is a continuum of monopolistically competitive firms producing a differentiated intermediate good. The production function of a monopolistic competitive intermediate firm i is given as follows

$$Y_t(i) = N_t(i) \tag{2.10}$$

Total costs and marginal costs are then given by

$$TC_t(i) = \frac{W_t}{P_t} N_t(i), \quad MC_t(i) = \frac{W_t}{P_t} \tag{2.11}$$

where W_t is the nominal wage of workers. Intermediate goods firms' profit maximization in real terms is given by

$$E_t \sum_{k=0}^{\infty} \omega^k \Delta_{t,t+k} \left(\frac{P_t(i) Y_{t+k,t}(i)}{P_{t+k}} - MC_{t+k}(i) Y_{t+k,t}(i) \right) \tag{2.12}$$

subject to the demand function

$$Y_{t+k,t}(i) = \left(\frac{P_i(i)}{P_{t+k}}\right)^{-\varepsilon} Y_{t+k} \qquad (2.13)$$

where $\Delta_{t,t+k} = \beta^k \left(\frac{c_{t+k}}{c_t}\right)^{-\sigma}$ is the stochastic discount factor for real profits that flow

to the household who own the intermediate firms.

2.2.2 Price Stickiness

There are many different kinds of ways to formulate the idea of price

stickiness. Here, in this study, we will use a formulation known as Calvo pricing, after

the economist who first introduced it. Although Calvo price setting is not the most

realistic formulation of sticky prices, it is convenient to provide analytically

expressions, and its implications are similar to those of more realistic (but more

complicated) formulations (Whelan 2005).

The form of price rigidity faced by the Calvo firm is as follows. Each period,

only a fraction $(1 - \theta)$ of firms have ability to adjust their price; all other firms

cannot. When firms are going to adjust their price, they must take into account that the

price may be fixed for many periods. We assume they reset price by choosing a

log-price, z_t, that minimizes the "loss function"

$$L(z_t) = \sum_{k=0}^{\infty} (\theta\beta)^k E_t \left(z_t - p_{t+k}^*\right)^2 \qquad (2.14)$$

where β is a discount factor that between zero and one, and p_{t+k}^* is the log of the optimal price that the firm would set in period $t + k$ if there were no price rigidity.

The term $E_t(z_t - p_{t+k}^*)^2$ describes the expected loss in profits for the firm at time $t + k$ because of the fact that it will not be capable of setting a frictionless optimal price at that period. This quadratic function is intended just as an approximation to some more general profit function.

Each of the terms is affected by the choice variable z_t. Hence, each of the $(z_t - p_{t+k}^*)^2$ terms need to be differentiated with respect to z_t and then the sum of these derivatives is set equal to zero, which means

$$\left[\sum_{k=0}^{\infty}(\theta\beta)^k\right] z_t = \sum_{k=0}^{\infty}(\theta\beta)^k E_t p_{t+k}^* \tag{2.15}$$

Now, the geometric sum formula can be applied to simplify the left side of this equation. In other words, we use the fact that

$$\sum_{k=0}^{\infty}(\theta\beta)^k = \frac{1}{1-\theta\beta} \tag{2.16}$$

Then the solution of the form is obtained.

$$z_t = (1 - \theta\beta) \sum_{k=0}^{\infty} (\theta\beta)^k E_t p_{t+k}^* \qquad (2.17)$$

The equation shows that the optimal solution of the firm is to set its price equal to a weighted average of the prices that it would have expected to set in the future if there were no price rigidities. Unable to change price every period, the firm then tries to keep its price close to the right one.

The firm's optimal pricing strategy without frictions is assumed to contain setting prices as a fixed markup plus marginal cost:

$$p_t^* = \mu + mc_t \qquad (2.18)$$

Therefore, the optimal reset price can be written as

$$z_t = (1 - \theta\beta) \sum_{k=0}^{\infty} (\theta\beta)^k E_t (\mu + mc_{t+k}) \qquad (2.19)$$

2.2.3 The New-Keynesian Phillips Curve

The aggregate price level in the Calvo economy is just a weighted average of the aggregate price level of last period and the new reset price, where the parameter of weight is determined by θ:

$$p_t = \theta p_{t-1} + (1-\theta) z_t \qquad (2.20)$$

This can be rewritten in a way to express the reset price by a function of the current and past aggregate price levels

$$z_t = \frac{1}{1-\theta}(p_t - \theta p_{t-1}) \qquad (2.21)$$

As we know, the first-order stochastic difference equation is

$$y_t = ax_t + bE_t y_{t+1} \qquad (2.22)$$

can be solved as

$$y_t = a\sum_{k=0}^{\infty} b^k E_t x_{t+k} \qquad (2.23)$$

Examining the equation of optimal reset price, it shows that z_t will obey a first-order stochastic difference equation with

$$y_t = z_t \qquad (2.24)$$

$$x_t = \mu + mc_t \tag{2.25}$$

$$a = 1 - \theta\beta \tag{2.26}$$

$$b = \theta\beta \tag{2.27}$$

So the reset price can be written in the form of

$$z_t = \theta\beta E_t z_{t+1} + (1 - \theta\beta)(\mu + mc_t) \tag{2.28}$$

Substituting z_t with $\frac{1}{1-\theta}(p_t - \theta p_{t-1})$ which get above

$$\frac{1}{1-\theta}(p_t - \theta p_{t-1}) = \frac{\theta\beta}{1-\theta}(E_t p_{t+1} - \theta p_t) + (1 - \theta\beta)(\mu + mc_t) \tag{2.29}$$

After a series of re-arrangements, this equation can be shown as

$$\pi_t = \beta E_t \pi_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}(\mu + mc_t - p_t) \tag{2.30}$$

where $\pi_t = p_t - p_{t-1}$ represents the inflation rate.

This equation is known as the New-Keynesian Phillips Curve. It indicates that inflation can be expressed as a function of two factors: the first factor is the next period's expected inflation rate, $E_t\pi_{t+1}$; the second is the gap between the frictionless optimal price level $\mu + mc_t$ and the current price level p_t, which means that inflation depends positively on real marginal cost, $mc_t - p_t$.

Firms in the Calvo model would like to adjust their price as a fixed markup over marginal cost. If the ratio of marginal cost to price is getting high, then this will generate pressures of inflation because those firms that can adjust their price will increase the reset price.

2.3 Literature reviews

2.3.1 Foreign literature reviews

Iacoviello and Neri (2006) investigated the ability of a two-sector model to quantify the role of the housing market in business fluctuations. They used US data which cover eight quarterly macroeconomic variables over the period from the first quarter of 1965 to the last quarter of 2005 to estimate the structural parameters of the model via maximum likelihood methods. They found a robust empirical support for feedback effects from housing to the rest of the economy, mostly working through the effects on non-durable consumption that spill over-through borrowing-from shocks in the housing sector.

Pari ès and Notarpietro (2008) estimated a two-country Dynamic Stochastic General Equilibrium model for the US and the Euro area including relevant housing market features and examine the monetary policy implications of housing-related disturbances. The model is estimated on US and Euro data by means of Bayesian likelihood methods. The data from each country cover 11 key macroeconomic quarterly time series from the first quarter of 1981 to the last quarter of 2005. Their estimation results documented the various implications of credit frictions for the propagation of macroeconomic disturbances and the conduct of monetary policy. They found that allowing for some degree of monetary policy response to fluctuations in the price of residential goods improves the empirical fit of the model and is consistent with the main features of optimal monetary policy response to housing-related shocks.

Iacoviello and Neri (2008) studied the contribution of the housing market to business fluctuations using US data which cover ten quarterly series from the first quarter of 1965 to the last quarter of 2006 and Bayesian methods with a two-sector model. The estimated model, which contains nominal and real rigidities and collateral constraints, showed that: first, a large fraction of the upward trend in real housing prices over the last 40 years can be accounted for by slow technological progress in the housing sector; second, residential investment and housing prices are very sensitive to monetary policy and housing demand shocks; third, the wealth effects from housing on consumption are positive and significant, and have become more

important over time. The structural nature of the model can be implied identify and quantify the sources of fluctuations in house prices and residential investment and to measure the contribution of housing booms and busts to business cycles.

Bao et al. (2009) constructed a DSGE model with a housing sector for a small open economy and estimated using Australian data including five observable variables targeting period from the second quarter of 1993 to the first quarter of 2008 and Bayesian methods to obtain insights about the effects of a number of shocks on the importance of housing. A comparison of the impulse responses for the model with and without the housing sector shows the role played by the relative flexibility of housing and goods prices in determining the dynamics of housing and consumption expenditure.

Funke and Paetz (2010) developed an open-economy DSGE model with a housing-market sector and a borrowing constraint. Contrary to standard conventions, domestic households are allowed to invest in foreign housing and vice versa. Using Bayesian methods, the model is applied to quarterly data of Hong Kong for eight macroeconomic variables for the sample period from the first quarter of 1985 to the second quarter of 2010. The results showed that Hong Kong's housing market is quite open to foreign investment, and perhaps more significantly, that variations in the loan-to-value ratio and housing preference shocks largely explain business cycle volatility.

2.3.2 Chinese literature reviews

Sun and Sen (2010) studied a benchmark Bayesian Dynamic General Equilibrium model with Taylor's rule and a modified Smets-Wouters model with a monetary growth rule to simulate China's monetary policy transmission process. The estimated values of the parameters in the model by Bayesian approach based on China's quarterly time series data feature the unique characters of China's economy compared with that in the US and the Euro area. The simulation results in terms of the Taylor's rule and money growth rule (MacCullum Rule) highlight the monetary transmission mechanisms of China's monetary policy and the diverse contributions of monetary shocks and non-monetary shocks to China's business cycle.

Xiao and Peng (2011) introduced real estate into a DSGE model to testify whether the housing price is the focus of contemporary monetary policy. Also by stimulation, they compared the efforts of monetary policies between taking housing price into the monetary policy rules and not. The model is estimated by Bayesian method using macro data from the first quarter of 2003 to the last quarter of 2010. The main conclusions are: the central bank of China had already followed a modified Taylor rule which responds to house price during 2003 to 2010; the modified monetary policies that responds to housing prices fluctuations did well in restraining house price, but it will lead to persistent inflation and negative deviation of the output and home consumption level; an increase in down payment ratio of housing mortgage will causes housing prices to reduce in stationary state.

Liu and Yuan (2011) set up a dynamic stochastic general equilibrium model including financial accelerator which used simulation method to study the monetary policy influence on house price, housing investment and consumption. The parameter of the model is solved by calibration with data of China. The result of research showed that the financial accelerator mechanism significantly transmitted and magnified the effect of monetary policy impact. Comparing with no financial accelerator, the model with financial accelerator displayed that the effect was greater, and more fit the character of actual data.

Tan and Wang (2011) examined the mechanism of credit expansion and housing price on financial stability using Multivariate GARCH and built the dynamic stochastic general equilibrium model to explain the mechanism of the Chinese economy. The parameters are calibrated with China's data. The simulations showed that factors affecting the banking stability include: housing prices, credit fluctuations, and their combination; credit and capital tightening which are caused by feedback mechanisms of banks; macroeconomic volatility. Price fluctuations, credit fluctuations, and their combination have a strong GARCH effect. However, the policy stripping of non-performing loans has no continuity.

Li et al. (2011) applied the simulation method on the basis of Dynamic Stochastic General Equilibrium Model with housing sector and the test of spillover effect based on VAR GARCH(1, 1)-Asymetric-BEKK Model to analyze the relationship between monetary policy and house price. The data analyzed is monthly

data from January 1998 to April 2010. The results showed that when monetary policy

regulates and controls house market, the central bank should focus on the quantity

instrument of monetary policy. Meanwhile, the role of price instrument of monetary

policy should not be ignored because quantity instrument may increase the effect of

price on macro-economy. As to price instrument of monetary policy, the liberalized

interest rate has a bigger influence on house market than regulated interest rate; for

asymmetry effect of monetary policy, the effect of quantity instrument on house price

is bigger than that of price instrument.