CHAPTER 4

THE THEORECTCAL MODEL AND METHODOLOGY

This chapter presents the theoretical framework used to structure the model and the methodology of the study. The structure of the model is based on a New-Keynesian-Open-Economy-Macroeconomics (NOEM) initiated by Obstefeld and Rogoff (1995, 1996). The model closes to Svennsson (1998, 2000) but it is extended by introducing an energy (which is combined with the stock of capital and labor to produce the consumption goods.

According to the methodology of the study, the model is solved using the standard methodology to solve a rational expectation model. The popular algorithms of Qudiz and Sachs (1985), Backus and Driffill (1986) and Paul Soderlind (1999) are applied for solving the model.

4.1 Model Description

The model consists of two countries, which are Home (H) and Foreign (F). The world population is normalized to unity. The home country is smaller relative to the foreign country. The role of monetary policy, in this model, is stabilizing inflation and output gap based on a simple monetary policy rule recognized as Taylor rule, Taylor (1993), which implement through the interest rate instrument. The policies of home and foreign countries are solved independently.

The agents in each economy are consisted of households with identical infinitely-lived, monopolistically competitive firms with infinity-lived and public sectors. The households in each economy earn the wage income from supplying labor to imperfectly competitive firm. The firms produce goods for sale at domestic and foreign country. The input market is perfectly competitive. Additionally, households earn income from investment in capital and holding domestic and foreign assets. The capital and financial assets market are assumed to be complete. Households also receive dividend profits from firms and lump sum transfers from the government. It is further assumed that the households in the foreign and the home country share identical preferences and thus they solve the analogous problems.

The monopolistic competition firms combine labor, capital and energy to produce the differentiated goods. All goods can be substitute according to the constant elasticity substitution's manner. The firms can not adjust their price flexibility. They face some probability to fix their prices according to Calvo (1983). There are only tradable consumption goods and are traded across countries with no trade frictions.

The central bank will stabilize the inflation rate, and the output gap, through a interest rate instrument by using the Taylor rule.

There is no closed form solution for the model. The model, therefore, is log-linearized around steady state and calibrated using statistical data. Before proceeding the illustration of the model, it is noted here that any variables with the superscript * denote the foreign country and any variables without the superscript * denote the domestic country. Furthermore, the word "domestic" and "home" may be used interchangeably, also for "foreign" and "import".

4.1.1 Households

The utility level at time t of the infinitely representative household is derived from a composite consumption good index C_t, leisure $1-L_t$, where L_t is the quantity of labor supplied at time t, and holding the nominal money balances M_t. The real money balances $\frac{M_t}{P_t^c}$ enter in the utility function as he saves the time the household spent in his transaction, and then he can indirectly increase utility, where P_t^c denotes the consumer price index (CPI). The household discounts the future return at rate δ. The typically functional form of the representative household' utility is assumed to be separable between consumption, holding money balances, and the leisure as the following:

$$U_t = \mathbb{E}_t \sum_{\tau=0}^{\infty} \left\{ \delta^{\tau} \left[\frac{C_{t+\tau}^{1-\rho}}{1-\rho} + \frac{\chi}{1-\rho_M} \left(\frac{M_{t+\tau}}{P_{t+\tau}^c} \right)^{1-\rho_M} - \frac{\chi_L}{1+\rho_L} \left(L_{t+\tau} \right)^{1+\rho_L} \right] \right\} \tag{4.1}$$

where $\mathbb{E}_t$ is the expectation operator conditional on information in period t, $\rho > 0$ is the inverse of the intertemporal elasticity of substitution or relative risk aversion, $\rho_M > 0$ is the marginal utility of holding real money balances, $\rho_L > 0$ is the marginal disutility of labor, $\chi > 0$ and, $\chi_L > 0$ are the weight of real money balances and labor in a utility function, respectively.

The representative household earns income from supplying labor at the competitive nominal wage rate, W_t. Additionally, the representative household can access to the perfectly competitive international and domestic capital market. He can hold nominal domestic (foreign) bonds, B_t (F_t) that mature in period t, at an interest rate i_t $\left(i_t^*\right)$. It is also assumed that both kinds of bonds are riskless and foreigners do not hold domestic bonds. The household also earns the nominal rental rate R_t^K from owning K_t (capital stock at the starting of period t) and accumulates the capital stock K_{t+1} in period t. The law of motion of the capital stock is

$$K_{t+1} = \left(1-\delta_K\right)K_t + IN_t \tag{4.2}$$

where IN_t is the gross investment, δ_K is the constant depreciation rate of capital.

In addition, the representative household receives lump sum government transfers, Φ_t. The representative household owns all domestic firms, then he also receives the profits from firms, $\Upsilon_t = \int_{\omega}^{1} \Upsilon_t\left(j\right)dj$.

In summation, the lifetime budget constraint of the household can be stated as the following:

$$\begin{aligned} P_t^c C_t + M_{t+1} + S_t F_{t+1} + B_{t+1} + P_t^c K_{t+1} = M_t + \left(1+i_{t-1}^*\right)S_t F_t + \left(1+i_{t-1}\right)B_t \\ + \left(R_t^K + \left(1-\delta_K\right)P_t^c\right)K_t + W_t L_t + \Phi_t + \Upsilon_t \end{aligned} \tag{4.3}$$

with $S_t = \dfrac{P_t^F}{P_t^{F*}}$ is the nominal exchange rate (units of domestic currency per unit of foreign currency). Next, $i_t\,(i_t^*)$ denotes the nominal domestic (foreign) interest rate from time t to $t+1$. The foreign interest rate is exogenously determined, since the home economy is small relative to the foreign country.

Finally, in order to ensure that the household exhausts his intertemporal budget constraint, the household's wealth accumulation must satisfy the solvency conditions or ruling out the Ponzi conditions.

The household chooses a strategy plan $\{B_{t+1}, F_{t+1}, K_{t+1}, M_{t+1}, L_t, C_t\}_{t=0}^{t=\infty}$ to maximize his lifetime utility (4.1), taken as given the consumer price index, nominal exchange rate, wage rate, and rental rate, subject to constraints (4.2), (4.3) ,the initial values B_0, F_0, K_0, M_0, and no Ponzi conditions.

Leaving the household utility maximization for a while, and keeping on the definition of the composite consumption index, C_t, of the representative household at time t. The consumption index is a constant elasticity of substitution (CES) composition of the home produced goods and foreign (imported) goods as the following:

$$C_t = \left[(1-\omega)^{\frac{1}{\xi}} C_t^{H\,\frac{\xi-1}{\xi}} + \omega^{\frac{1}{\xi}} C_t^{F\,\frac{\xi-1}{\xi}} \right]^{\frac{\xi}{\xi-1}}, \quad 0 < \omega < 1. \tag{4.4}$$

where $\xi > 0$ is the intratemporal elasticity of substitution between the consumption sub indices of domestically produced goods, C^H, and imported goods, C^F.

Assuming that there exists continuum of firms in the home and foreign countries, they produce the differentiated goods in the unit interval $j \in [0,1]$, where the foreign goods are in the interval $[0,\omega]$ and the home produced goods are in $(\omega,1]$. Each of differentiated goods is produced by a single monopolistic competition firm detailed later. There is no bias in consumption and $(1-\omega)$ is the share of the domestically produced good in home consumption expenditure.

The domestic consumption sub index C_t^H is defined as the sum of differentiated domestic goods. Formally it is defined as a constant return to scale aggregator according to Dixit and Stiglitz as the following:

$$C_t^H = \left[\left(\frac{1}{1-\omega} \right)^{\frac{1}{\vartheta}} \int_{\omega}^{1} C_t^H \left(j \right)^{\left(\frac{\vartheta-1}{\vartheta} \right)} dj \right]^{\frac{\vartheta}{(\vartheta-1)}}, \quad \vartheta > 1. \tag{4.5}$$

where $C_t^H \left(j \right)$ denotes consumption of domestically produced good $j \in (\omega, 1]$, and $\vartheta > 1$ is the elasticity of substitution among differentiated goods j produced with in a country. By assuming $\vartheta \neq \xi$, we allow the substitutability of goods within countries to differ from the substitutability of goods across countries.

The corresponding domestic produced good price index can be written as:

$$P_t^H = \left[\frac{1}{\left(1-\omega\right)} \int_{\omega}^{1} P_t^H \left(j \right)^{1-\vartheta} dj \right]^{\frac{1}{(1-\vartheta)}} \tag{4.6}$$

where $P_t^H \left(j \right)$ denotes the price of a domestic good j.

The imported consumption sub index C_t^F, analogously, is defined as:

$$C_t^F = \left[\left(\frac{1}{\omega} \right)^{\frac{1}{\vartheta}} \int_{0}^{\omega} C_t^F \left(j \right)^{\left(\frac{\vartheta-1}{\vartheta} \right)} dj \right]^{\frac{\vartheta}{(\vartheta-1)}} \tag{4.7}$$

where $C_t^F \left(j \right)$ is consumption of an imported good $j \in [0, \omega]$ of a representative domestic household at time t. The corresponding imported price index, in term of the domestic currency, P_t^F is defined as

$$P_t^F = \left[\left(\frac{1}{\omega} \right) \int_{0}^{\omega} S_t P_t^{F*} \left(j \right)^{1-\vartheta} dj \right]^{\frac{1}{(1-\vartheta)}} \tag{4.8}$$

where $P_t^{F*} \left(j \right)$ denotes the foreign currency price for foreign good j, and $S_t = \dfrac{P_t^F}{P_t^{F*}}$ is the nominal exchange rate.

The domestic consumer price index (CPI), P_t^c, is defined as:

$$P_t^c = \left[(1-\omega)\left(P_t^H\right)^{1-\xi} + (\omega)\left(P_t^F\right)^{1-\xi} \right]^{\frac{1}{1-\xi}} \tag{4.9}$$

Solving for the optimal allocation for differentiated goods, and for domestic and import goods, the household chooses C_t^H and C_t^F , given C_t , so as to minimize total expenditure $P_t^c C_t$ subject to consumption index (4.4). Then given C_t^H , and C_t^F , the household allocates spending over a variety of goods by minimizing $P_t^H(j)C_t^H(j)$ and $P_t^F(j)C_t^F(j)$ under restrictions defined in (4.5) and (4.7).

For the domestic country, the optimal allocation of expenditures among home and foreign variety of goods are taken the following demand function for all $j \in [0,1]$ [1]:

$$C_t^H(j) = \frac{1}{1-\omega}\left(\frac{P_t^H(j)}{P_t^H}\right)^{-\vartheta} C_t^H \qquad C_t^F(j) = \frac{1}{\omega}\left(\frac{P_t^F(j)}{P_t^H}\right)^{-\vartheta} C_t^F \tag{4.10}$$

Aggregating across differentiated goods, the optimal allocation of expenditures among home and foreign goods implies:

$$C_t^H = (1-\omega)\left(\frac{P_t^H}{P_t^c}\right)^{-\xi} C_t \qquad C_t^F = \omega\left(\frac{P_t^F}{P_t^c}\right)^{-\xi} C_t \tag{4.11}$$

According to (4.11), as the relative prices of domestic and imported goods rise, the demand for domestic and imported goods decreases. The price elasticity of these demand functions for domestic and imported goods are characterized as ξ .

It is assumed that the price is setting according to the producer currency pricing (PCP), the traded goods prices are rigid in the units of the currency of the country in which they are produced, which imply that the law of one price holds and that exchange rate movements are fully passed through import prices (expressed in buyer currency). Therefore, for the foreign country, the optimal allocation of expenditures among home and foreign goods, with the assumption of the law of one

[1] See Appendix A for the detail of the derivation.

price and purchasing power parities (PPP) , i.e., $\left(\frac{S_t P_t^{F,*}(j)}{S_t P_t^{F*}}\right)=\left(\frac{P_t^F(j)}{P_t^F}\right)$ and $\left(\frac{S_t P_t^{*F}}{S_t P_t^{c*}}\right)=\left(\frac{P_t^F}{P_t^c}\right)$, can be expressed as:

$$C_t^{F*}=\left(\frac{P_t^{F*}(j)}{P_t^{*F}}\right)^{-\vartheta}\left(\frac{P_t^{F*}}{P_t^{c*}}\right)^{-\xi}C_t^{*} \quad \text{and} \quad C_t^{H*}=\left(\frac{P_t^{H*}(j)}{P_t^{H*}}\right)^{-\vartheta}\left(\frac{P_t^{H*}}{P_t^{c*}}\right)^{-\xi}C_t^{*}$$

where the " * "demotes the foreign country, i.e., C_t^* denotes the composite consumption index of the foreign country, defined analogously as the home country.

Note here for the next notation that for any variables X , $X_{t+1|t}=\mathbb{E}_t\left[X_{t+1}\right]$ is the rational expectation of X_{t+1} in period $t+1$ conditional on the information available in period t. And the lower case letters denote for the percentage deviation from the deterministic steady state of the corresponding upper case letters.

Turning to the representative household utility's maximization problem, the representative household solves the problem (4.1) under a number of constraints as discussed above, yielding the following optimal conditions[2]:

$$\frac{W_t}{P_t^c}=\chi_L\frac{L_t^{\rho_L}}{C_t^{-\rho}} \tag{4.12}$$

$$\left(\frac{M_{t+1|t}}{P_{t+1|t}^c}\right)^{\rho^M}=\chi\left(\frac{1+i_{t+1|t}}{i_t}\right)C_t^{\rho} \tag{4.13}$$

$$\frac{C_t}{C_{t+1|t}}=\left(\delta\left(1+i_t\right)\frac{P_t^c}{P_{t+1|t}^c}\right)^{-\frac{1}{\rho}} \tag{4.14}$$

$$\left(\frac{C_{t+1|t}}{C_t}\right)^{-\rho}\delta\left[\left(\frac{R_{t+1|t}^K}{P_{t+1|t}^c}\right)+\left(1-\delta_K\right)\right]=1 \tag{4.15}$$

$$\delta\frac{C_{t+1|t}^{-\rho}}{C_t^{-\rho}}\frac{S_{t+1|t}}{S_t}\frac{P_t^c}{P_{t+1|t}^c}\left(1+i_t^*\right)=1 \tag{4.16}$$

[2] See, the detail of the derivation in Appendix A.

$$\delta\left(1+i_t\right)\frac{P_t^c}{P_{t+1}^c}\frac{C_{t+1}^{-\rho}}{C_t^{-\rho}}=1 \tag{4.17}$$

In equilibrium the marginal rate of inter-temporal substitution $U'\left(C_t\right)/\delta U'\left(C_{t+1|t}\right)$ or (4.14) has to be equal to the price-ratio $(1+r_t)$, with r_t denotes a real interest rate. The real interest rate (return between $t \to t+1$) is, therefore, the Fisher parity condition that is defined as:

$$1+i_t=\left[\frac{P_{t+1|t}^c}{P_t^c}\left(1+r_t\right)\right]$$

Except for the exchange rate risk, real rate of return in both countries are assumed to be equal. Log linear approximation of the optimal portfolio choice of domestic (4.17) and foreign bonds (4.16) under the perfect capital market implies the exchange rate fulfills the interest parity condition (UIP), which is given by:

$$1+i_t=\left(1+i_t^*\right)\frac{S_{t+1|t}}{S_t} \tag{4.18}$$

The UIP condition suggests that the difference between domestic and foreign nominal interest rate equals the expected future change in the nominal exchange rate. The UIP condition also implies that the domestic currency is expected to depreciate if the domestic interest rate is higher in equilibrium, to equalize the real return across countries.

Equation (4.12) shows the optimal labor supply which equates the real wage with the marginal rate of substitution between leisure and consumption. Equation (4.13) is the optimal holdings of the real money balances. Equation (4.14) is the consumption Euler equation representing the optimal intertemporal consumption allocation, with $\left(1+i_t\right)\frac{P_t^c}{P_{t+1|t}^c}$ denotes the gross real interest rate. The consumption Euler equation links the marginal disutility of foregoing consumption in the current period to the marginal benefit of increasing consumption in the following period.

4.1.2 International Condition

Note, again, that through out the paper the lowercase letters denote for the log deviation around the deterministic steady state of the corresponding upper case letters, excluding i_t. And the deviation from the steady state of the interest rate i_t is denoted as $\hat{i}_t$.

The domestic CPI inflation is defined as the change in the consumer price index $\Pi_t^c = \dfrac{P_t^c}{P_{t-1}^c}$ or

$$\pi_t^c = p_t^c - p_{t-1}^c \tag{4.19}$$

The real exchange rate is given by $Q_t = \dfrac{S_t P_t^{F*}}{P_t^H}$, by the log-linearization the real exchange rate, $d\ln\left(Q_t\right) = q_t$, is defined as:

$$q_t \equiv s_t + p_t^{F*} - p_t^H \tag{4.20}$$

where $p_t^H \equiv d\left(\ln P_t^H\right)$ is the domestically produced goods price index, $p_t^{F*} \equiv d\left(\ln P_t^{F*}\right)$ is the imported goods price index in term of foreign currency, and $s_t = d\ln\left(S_t\right)$ is deviation from the steady state of the nominal exchange rate.

According to the uncover interest rate parity condition (UIP), there are empirical evidences show that the nominal exchange rates often departure from the level implied by fundamental. Therefore variants of the moel are explored in which the Euler of conditions for foreign bond holding (4.16) , is disturbed by a stationary exogenous stochastic variables, Ω_t, which it is referred as foreign-exchange risk premium. Formally, it can be stated as the following:

$$\delta \frac{C_{t+1|t}^{-\rho}}{C_t^{-\rho}} \frac{S_{t+1|t}}{S_t} \frac{P_t^c}{P_{t+1|t}^c} \Omega_t \left(1 + i_t^*\right) = 1 \tag{4.21}$$

Therefore by loglinear approximation of (4.21) and (4.17), the UIP can be stated as

$$\hat{i}_t - \hat{i}_t^* = s_{t+1|t} - s_t + \Omega_t \tag{4.22}$$

where $\hat{i}_t = d\ln(i_t)$ denotes deviation from the deterministic steady state of domestic nominal interest rate, and Ω_t denotes deviation from the steady state of the foreign-exchange risk premium, Ω_t is assumed to follow a stationary univariate AR(1) process:

$$\Omega_{t+1} = \gamma_\Omega \Omega_t + v_{\Omega,t+1}, \qquad 0 < \gamma_\Omega < 1 \tag{4.23}$$

Solving for s_t from (4.20) and substituting it into the interest rate parity condition (4.22), we shall obtain

$$q_{t+1|t} = q_t + \hat{i}_t - \pi^H_{t+1|t} - \hat{i}_t^* + \pi^*_{t+1|t} - \Omega_t \tag{4.24}$$

where $\pi^H_{t+1|t}\left(\pi^*_{t+1|t}\right) = d\ln\Pi^H_{t+1|t}\left(d\ln\Pi^*_{t+1|t}\right)$ is the domestic (foreign) inflation expectation conditional on information available in period t.

It is assumed that foreign output gap, inflation rate and interest rate are all exogenous, in the model. For simplicity, it is further assumed that the deviation from trend of foreign inflation $d\ln\left(\Pi_t^*\right) = \pi_t^*$, interest rate ($d\ln i_t^* = \hat{i}_t^*$), and foreign output gap $d\ln\left(Y_t^*\right) = y_t^*$ follow stationary univariate AR (1) processes:

$$y^*_{t+1} = \gamma^*_{y^*} y^*_t + v_{y^*,t+1}, \qquad 0 < \gamma^*_y < 1 \tag{4.25}$$

$$\pi^*_{t+1} = \gamma^*_\pi \pi^*_t + v_{\pi^*,t+1}, \qquad 0 < \gamma^*_\pi < 1 \tag{4.26}$$

$$i^*_{t+1} = \gamma^*_i \pi^*_t + v_{i^*,t+1}, \qquad 0 < \gamma^*_i < 1 \tag{4.27}$$

where $v_{y^*,t+1}$, $v_{i^*,t+1}$ and $v_{\pi^*,t+1}$ are zero mean and identical independently distributed (i.i.d.) shocks.

The world oil prices are also assumed to take the AR(1) process, which can be expressed as the following:

$$p^w_{t+1} = \gamma_{p^w} p^w_t + v_{p^w,t+1}, \qquad 0 < \gamma_{p^w} < 1 \tag{4.28}$$

where $v_{p^w,t+1}$, is assumed to be zero mean and identical independently distributed (i.i.d.) shocks.

4.1.3 Aggregate Demand

This subsection presents the aggregate demand equation. It is assumed that the approximate one period lag necessary to affect aggregate demand and consumption decisions is predetermined one period in advance, following Svensson (1998, 2000). By combining the log-linearized of the Euler consumption, using log-linearized expressions for CPI inflation, domestic demand for domestic and imported goods, foreign demand for domestic goods, and imposing the equilibrium conditions, aggregate demand for the domestic country in terms of the output gap, as detailed in Appendix B, can be expressed as:

$$\begin{aligned} y_{t+1|t} \equiv{}& \beta_y y_t - \beta_\varphi \varphi_{t+1|t} + \beta_y^* y_{t+1|t}^* + \beta_q q_{t+1|t} + \beta_{in} in_{t+1|t} - \beta_e \left(p_{t+1|t}^W + q_{t+1|t} + e_{t+1|t} \right) \\ & - \beta_f \left(f_{t+2|t} - \left(1 + i_t^*\right) f_{t+1|t} \right) - \left(\gamma_y^n - \beta_y \right) y_t^n \end{aligned} \tag{4.29}$$

where $\varphi_t \equiv \sum_{\tau=0}^{\infty} \left(i_{t+\tau} - \pi_{t+\tau+1|t}^H \right)$. Under the expectation hypothesis, φ_t expresses a deviation from the mean of long-term interest rate, because it is the sum of current and expected future deviations of real interest rate. All the coefficients and detail of the derivation are provided in Appendix B.

With $y_t \equiv y_t^H - y_t^n$ denotes the deviation from steady state of domestic output gap. The output gap is measured by the deviation of domestic aggregate demand, y_t^H, from its natural level or flexible equilibrium output level, y_t^n. The natural level of output, y_t^n, defined by Woodford (2003) is the equilibrium level of output that obtains in the absence of nominal price rigidities.

Equation (4.29) represents a nontraditional IS curve that relates the output gap not only to the interest rate, but also to the expected future output gap, expected future nominal exchange rate, and expected future investment. Additionally, the foreign output and foreign interest rate that measures economic activity of the foreign country can be used to explain fluctuations of domestic output as well.

4.1.4 Production Sectors

Each country has a continuum of infinitely intermediate goods firms, $1-\omega$ of these are located in the home country and ω in the foreign country. The firms in the home country are indexed by j. Firms in both home and foreign countries are in a monopolistic competition market. Each firm produces a differentiated good. Differentiated good can be substituted according to the elasticity of substitution defined in the previous section.

The inputs used in the production function of firm j are the labor L^j, capital K^j and energy or oil E^j [3]. Firm j^{th} produces good, $Y_t^H(j)$, using the following

$$Y_t^H(j) = A_t Q\left(V_t^j\left(L_t^j, K_t^j\right), E_t^j\right) \tag{4.30}$$

where V_t^j is the value added function depended on the labor and capital input use, which $V(\bullet)$ is increasing in its arguments. The introduction of $V(\bullet)$ allows to assume that $Q(\bullet)$ is homogenous degree one on its two arguments. With A_t is an exogenous productivity affecting all firms systematically and is assumed to follow:

$$a_{t+1} = \gamma_a a_t + v_{a,t+1} \tag{4.31}$$

with $a_t = \log(A_t), v_{a,t+1}$ is $iid \sim \left(0, \sigma_a^2\right)$

To keep the model as simple as possible, it is assumed that the oil exporting country takes the price of oil as given and exports the quantity of oil that meets the oil importing country's demand for oil.

The staggered price adjustment is introduced by assuming that in the beginning of any period intermediate goods firms are free to set a new price with probability $1-\alpha$, following Calvo (1983). Thus, each period a measure constant $1-\alpha$ of (randomly selected over time) intermediate goods firms reset their prices, $\tilde{P}_t^H(j)$, while a fraction α keep their prices unchanged. Therefore, an average the price

[3] It is assumed that capital and labor are immobile internationally.

remains unchanged for $\frac{1}{1-\alpha}$ periods. In summation intermediate goods firms cannot change their prices unless they receive a random price change signal. Profits at some future date $t+s$ are affected by the choice of price at time t only if the firm has not received another opportunity to adjust between t and $t+s$. The probability of this is α^s.

Under the Calvo (1983) price setting assumption, in equilibrium producers that can choose a new price in period t will choose the same new price since they face the same problem. Therefore, we drop j, i.e., $\tilde{P}_t^H(j) = \tilde{P}_t^H$. The domestic price index is an average of the price charged by the fraction $1-\alpha$ of firms who can reset their price in period t and the average of the remaining fraction α of all firms who must keep their price the same as in the previous periods. Thus, the index of output prices can be shown - by making use of the Law of Large Numbers - to be a weighted average of prices reset in period t and the previous period's price index as the following:

$$P_t^H = \left[\alpha\left(P_{t-1}^H\right)^{1-\vartheta} + (1-\alpha)\left(\tilde{P}_t^H\right)^{1-\vartheta}\right]^{\frac{1}{1-\vartheta}} \tag{4.32}$$

In period t, the intermediate good firm j chooses L_t^j, K_t^j, E_t^j, and $P_t^H(j)$ so as to maximize life-time profit subject to the production function (4.30) and demand constraint $Y_t^H(j) = \left(\frac{P_t^H(j)}{P_t^H}\right)^{-\vartheta} Y_t^H$, where Y_t^H is the total demand for domestically produced output. Firms are assumed to meet all demand at posted prices.

In summary the firm j optimization problem can be stated as the following

$$\max_{\tilde{P}_t^H(j)} \mathfrak{L}_t(j) = \mathbb{E}_t \sum_{\tau=0}^{\infty} (\alpha\delta)^{\tau} \Lambda_{t+\tau} \left\{ \frac{\tilde{P}_t^H(j)}{P_{t+\tau}^H} Y_{t+\tau}^H(j) - \frac{W_{t+\tau}}{P_{t+\tau}^H} L_{t+\tau}^j - \frac{R_{t+\tau}^K}{P_{t+\tau}^H} K_{t+\tau}^j - \frac{P_{t+\tau}^E}{P_{t+\tau}^H} E_{t+\tau}^j \right\} \tag{4.33}$$

subject to demand for good of firm j ,

$$Y_{t+\tau}^{H}\left(j\right)=\left(\frac{\tilde{P}_{t}^{H}\left(j\right)}{P_{t+\tau}^{H}}\right)^{-\vartheta}Y_{t+\tau}^{H} \tag{4.34}$$

And

$$\begin{aligned} L_{t+\tau}^{j} &= \frac{1}{A_t}\mathbb{F}_1\left(\left(\frac{\tilde{P}_{t}^{H}\left(j\right)}{P_{t+\tau}^{H}}\right)^{-\vartheta}Y_{t+\tau}^{H}\right) \\ K_{t+\tau}^{j} &= \frac{1}{A_t}\mathbb{F}_2\left(\left(\frac{\tilde{P}_{t}^{H}\left(j\right)}{P_{t+\tau}^{H}}\right)^{-\vartheta}Y_{t+\tau}^{H}\right) \\ E_{t+\tau}^{j} &= \frac{1}{A_t}\mathbb{F}_3\left(\left(\frac{\tilde{P}_{t}^{H}\left(j\right)}{P_{t+\tau}^{H}}\right)^{-\vartheta}Y_{t+\tau}^{H}\right) \end{aligned} \tag{4.35}$$

are the input requirement functions for the individual firm. W_t, R_t denote the wage rate and the rental cost, and $P_t^E = P_t^W Q_t$ is the domestic currency oil price which is equal to the world oil price, P_t^W, multiply by exchange rate, Q_t.

In equilibrium the market clearing for the labor and rental capital market requires $L_t = \int_{\omega}^{1} L_t^j dj$, $K_t = \int_{\omega}^{1} K_t^j dj$, which is total demand for labor and capital.

According to the first order condition for optimal price setting, combining with the price adjustment process, and the market clearing conditions for the labor, and capital, the log-linearized around the non-stochastic steady state of the aggregate supply curve can be stated, leaving the full derivation in Appendix C, as the following:

$$\begin{aligned} \left(1-\alpha_{\pi}\right)\pi_{t+2|t}^{H} &= -\alpha_{\pi}\pi_{t}^{H}-\alpha_{y}\beta_{y}y_{t}+\alpha_{y}\beta_{\varphi}\varphi_{t}-\alpha_{y}\beta_{y}^{*}y_{t+1|t}^{*}+\left[\alpha_{y}\beta_{q}+\alpha_{q}\right]\left(\hat{i}_{t}^{*}-\pi_{t+1|t}^{*}+\Omega_{t}\right) \\ &+\left[1+\alpha_{y}\left(\beta_{\varphi}+\beta_{q}\right)+\alpha_{q}\right]\pi_{t+1|t}^{H}+\alpha_{y}\left[\gamma_{y}^{n}-\beta_{y}\right]y_{t}^{n}-\alpha_{y}\beta_{in}in_{t+1|t} \\ &-\left[\alpha_{y}\left(\beta_{\varphi}+\beta_{q}\right)+\alpha_{q}\right]\hat{i}_{t}-\left[\alpha_{q}+\alpha_{y}\beta_{q}\right]q_{t}-\alpha_{p}\left(\tilde{r}_{t+1|t}^{k}+\tilde{p}_{t+1|t}^{E}\right) \end{aligned}$$

(4.36)

Equation (4.36) is the non-traditional New Keynesian Phillips curve. It is extended to take the account of the effects of variations in real capital rental cost and real oil price ($\tilde{r}^k$, $\tilde{p}^E$),costs of imported goods implied by the real exchange rate (q), and the foreign country economic conditions $\left(y^*, \pi^*, i^*\right)$.

The aggregate supply equation depends on both lagged inflation and expected future inflation. Additionally, the price of inputs, oil prices and capital costs, will affect the aggregate supply according to the input resources allocation and the marginal productivity of the inputs. By the assumption of the sticky price, some firms cannot move their price freely for responses to inputs prices increase. Then they cannot make profits and leave from the economy. The production resources will move to firms who can freely adjust their price to cover their increasing costs and are still in the economy. The existing firms change their inputs allocation, given the output, resulting in their price setting.

4.1.5 Government and Central Bank

For simplicity it is assumed that there is no government spending[4]. Therefore, the government budget constraint is simply given by

$$M_{t+1} - M_t - \Phi_t = 0 \tag{4.37}$$

The government budget constraint requires that all the revenue associated with money creation must be returned to the private sector in the form of net lump transfers in each period.

The monetary policy in the economy is characterized as a simple Taylor rule (Taylor (1993)), which is explicitly shown in equation (4.38). The policy requires that if there is a rise in expected inflation, nominal interest rates should rise sufficiently to increase real interest rates. The Central bank manages the short term nominal interest rate, i_t, in response to fluctuations in CPI inflation and the output gap. The interest rate reaction function of the central bank is considered by

[4] Under Ricardian equivalence, it is assumed without loss of generality, that a zero net supply of domestic bonds.

$$i_t = i + f_\pi \pi_t^c + f_y y_t \tag{4.38}$$

where $f_\pi > 0$, $f_y > 0$ are the weighted consumer price index inflation and output gap on the policy function. With i is the steady state nominal interest rate.

Luksanasut (2001) estimates the Taylor rule for Thailand before changing the exchange rate regime from fixed to managed float (1997) as the following form:

$$i_t = 3.40 + \pi_t^c + 0.5\left\{y_t + \left(\pi_t^c - \pi^{c*}\right)\right\} \tag{4.39}$$

where π^{c*} is the future inflation targeting which is considered with in the range of 0%-3.5%. And the Bank of Thailand has, since early 2000, signaled its policy stance with the 14-day repurchase rate.

4.2 Model in State Space Form

According to previous section, the model and the mechanism of the model are presented. Next, it is the step of solving the model. As seen in the previous section, the problem is expressed as a dynamic program with expectational terms. The model is solved by using the algorithms of Oudiz and Sachs (1985) and Backus and Driffill (1986). In order to use this popular algorithm, the optimization constraints need to be written in state-space form. In this section, therefore, provides the state space form of the model. The system of equations of the model can be written in the state-space form as the following (see Svensson 2000, Leitemo 1999 for a similar exposition):

$$\mathbf{X}_t = \left(\pi_t^H, y_t, \pi_t^*, y_t^*, i_t^*, \Omega_t, y_t^n, q_{t-1}, i_{t-1}, p_t^W, r_t^k, k_t, f_t, e_t\right)^{/} \tag{4.40}$$

$$\mathbf{x}_t = \left(q_t, \varphi_t, in_t^H, \pi_{t+1|t}^H, c_t, c_t^H\right)^{/} \tag{4.41}$$

$$\mathbf{v}_t = \left(v_t, \eta_t^H, v_{\pi^*,t}, \eta_t^*, v_{\Omega,t}, \eta_t^n, 0, 0, v_{p^W,t}, v_{r^K,t} 0, 0, 0\right)^{/} \tag{4.42}$$

where $\mathbf{X}_t$ denotes an $n_1 \times 1$ column vector of predetermined state variables, $\mathbf{x}_t$ denotes an $n_2 \times 1$ column vector of forward-looking variables (non-predetermined variables), and $\mathbf{v}_t$ denotes an $n_1 \times 1$ column vector of innovations to the predetermined state $\mathbf{X}_t$.

The economy of the model can be represented in a state-space form as follows:

$$\begin{bmatrix} \mathbf{X}_{t+1} \\ \mathbf{x}_{t+1|t} \end{bmatrix} = \begin{bmatrix} \mathbf{A_{11}} & \mathbf{A_{12}} \\ \mathbf{A_{21}} & \mathbf{A_{22}} \end{bmatrix} \begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} + \mathbf{Bi_t} + \begin{bmatrix} \mathbf{v}_{\mathrm{t+1}} \\ \mathbf{0} \end{bmatrix} \tag{4.43}$$

The central bank uses the simple Taylor rule as (4.38), we, then, substituting for i_i in (4.43). The state space representation can be stated as

$$\begin{bmatrix} \mathbf{X}_{t+1} \\ \mathbf{x}_{t+1|t} \end{bmatrix} = \left(\mathbf{A} - \mathbf{BF}\right) \begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} + \begin{bmatrix} \mathbf{v}_{\mathrm{t+1}} \\ \mathbf{0} \end{bmatrix} \tag{4.44}$$

where $\mathbf{X}_t^{\prime}, \mathbf{x}_t^{\prime}$ denotes an $n \times 1$ column vector, where $n = n_1 + n_2$, and $\mathbf{A}$ is the $n \times n$ matrix, $\mathbf{B}$ are the $n \times 1$ vector of coefficients and $\mathbf{v}_{t+1}$ is the vector of shocks assumed to be serially and contemporaneously uncorrelated with zero mean. The matrices $\mathbf{A}$, and $\mathbf{B}$, contain the structural parameters of the economy which are conformable with $\mathbf{X}_t$, and $\mathbf{x}_t$. The vector $\mathbf{F}$ is the policy weight for economic target variables.

4.3 The Solution of The Model

In the previous section, the state space form of the model is presented for preparing to solve the model. This section provides the methodology for solving the model. As mentioned, the popular algorithms that solve this kind of model are developed by Qudiz and Sachs (1985) and Backus and Driffill (1986). Paul Soderlind (1999) provides a popular implementation of the Backus and Driffill (1986) algorithm in details. The following shows the solution algorithm according to Paul Soderlind.

Recall that

$$\begin{bmatrix} \mathbf{X}_{t+1} \\ \mathbf{x}_{t+1|t} \end{bmatrix} = \mathbf{D} \begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} + \begin{bmatrix} \mathbf{v}_{t+1} \\ \mathbf{0} \end{bmatrix} \text{ where } \mathbf{D} = \mathbf{A} - \mathbf{BF}$$

The model can be solved according to the following steps

1. Taking the expectation of the system conditional on information set in period t

$$\begin{bmatrix} \mathbf{X}_{t+1} \\ \mathbf{x}_{t+1|t} \end{bmatrix} = \mathbf{D} \begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} \tag{4.45}$$

2. Decomposition the matrix $\mathbf{D}$ using Schur decomposition, yield

$$\mathbf{T} = \mathbf{Z}^H \mathbf{D} \mathbf{Z} \tag{4.46}$$

   where $\mathbf{Z}$ is a unitary $n \times n$ matrix $\mathbf{Z^H Z = I}$, $\mathbf{Z^H}$ denotes the transpose of the complex conjugate of $\mathbf{Z}$, and $\mathbf{T}$ is an $n \times n$ upper triangular Schur form with the eigenvalues along the diagonal

3. Premultiplying (4.47) with $\mathbf{Z^{-1} = Z^H}$ and post multiplying with $\mathbf{Z}$ give

$$\mathbf{D = ZTZ^H} \tag{4.47}$$

4. Reordering the n_θ eigenvalues with the modulus smaller than one come first and partitioning a matrix $\mathbf{T}$ according to[5]

$$\mathbf{T} = \begin{bmatrix} \mathbf{T_{\theta\theta}} & \mathbf{T_{\theta\delta}} \\ \mathbf{0} & \mathbf{T_{\delta\delta}} \end{bmatrix} \tag{4.48}$$

   where n_θ is stable and n_δ is unstable eigenvalues. $\mathbf{T}_{\theta\theta}$ is $n_\theta \times n_\theta$, and $\mathbf{T}_{\delta\delta}$ is $n_\delta \times n_\delta$. This reordering is for exploiting the initial conditions for the vector $\mathbf{X}_t$

5. Define the auxiliary variables

---

[5] δ is "recycling" notation here

$$\begin{bmatrix} \boldsymbol{\theta}_t \\ \boldsymbol{\delta}_t \end{bmatrix} = \mathbf{Z}^{\mathbf{H}} \begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} \tag{4.49}$$

6. Using (4.47) in (4.45) and then premultiply with $\mathbf{Z}^{\mathbf{H}}$

$$\mathbf{Z}^{\mathbf{H}} \begin{bmatrix} \mathbf{X}_{t+1|t} \\ \mathbf{x}_{t+1|t} \end{bmatrix} = \mathbf{Z}^{\mathbf{H}}\mathbf{Z}\mathbf{T}\mathbf{Z}^{\mathbf{H}} \begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} \tag{4.50}$$

$$\begin{bmatrix} \boldsymbol{\theta}_{t+1|t} \\ \boldsymbol{\delta}_{t+1|t} \end{bmatrix} = \mathbf{Z}^{\mathbf{H}}\mathbf{Z}\mathbf{T} \begin{bmatrix} \boldsymbol{\theta}_t \\ \boldsymbol{\delta}_t \end{bmatrix}$$

$$= \begin{bmatrix} \mathbf{T}_{\theta\theta} & \mathbf{T}_{\theta\delta} \\ \mathbf{0} & \mathbf{T}_{\delta\delta} \end{bmatrix} \begin{bmatrix} \boldsymbol{\theta}_t \\ \boldsymbol{\delta}_t \end{bmatrix}$$

7. Solving the System of $\boldsymbol{\theta}_{t+1|t}$ and $\boldsymbol{\delta}_{t+1|t}$. Since $\mathbf{T}_{\delta\delta}$ contains the roots outside the unit circle, $\boldsymbol{\delta}_t$ will diverge as t increases unless $\boldsymbol{\delta}_0 = \mathbf{0}$. Any stable solution requires that $\boldsymbol{\delta}_t = \mathbf{0}$ for all t. Then $\boldsymbol{\theta}_{t+1|t} = \mathbf{T}_{\theta\theta}\boldsymbol{\theta}_t$, and it can be solved for $\boldsymbol{\theta}_0$
8. Inverting (4.49) and partitioning as the following

$$\begin{bmatrix} \mathbf{X}_t \\ \mathbf{x}_t \end{bmatrix} = \begin{bmatrix} \mathbf{Z}_{X\theta} & \mathbf{Z}_{X\delta} \\ \mathbf{Z}_{x\delta} & \mathbf{Z}_{x\delta} \end{bmatrix} \begin{bmatrix} \boldsymbol{\theta}_t \\ \boldsymbol{\delta}_t \end{bmatrix} = \begin{bmatrix} \mathbf{Z}_{X\theta} \\ \mathbf{Z}_{x\delta} \end{bmatrix} \boldsymbol{\theta}_t \tag{4.51}$$

Given the initial condition for $\mathbf{X}_0$, from (4.51) , we have

$$\mathbf{X} = \mathbf{Z}_{X\theta}\boldsymbol{\theta}_0 \tag{4.52}$$

9. Solving for $\boldsymbol{\theta}_0 = \mathbf{Z}_{X\theta}^{-1}\mathbf{X}_0$. $\mathbf{Z}_{X\theta}$ is invertible , the necessary condition is the number of stable roots equal the number of backward looking variables. If the number of stable roots is less than the number of predetermined variables, there is no stable solution. If the number of stable roots is larger than the number of predetermined variables, there is an infinite number of stable solutions.

10. From (4.44), we know that $\mathbf{X_{t+1}} - \mathbf{X_{t+|t}} = \mathbf{v_{t+1}}$ Using (4.51), yield

$$\mathbf{Z}_{X\theta}\left(\boldsymbol{\theta}_{\mathbf{t+1}} - \boldsymbol{\theta}_{\mathbf{t+1|t}}\right) = \mathbf{v}_{\mathbf{t+1}} \tag{4.53}$$

which it can find

$$\boldsymbol{\theta}_{\mathbf{t+1}} = \boldsymbol{\theta}_{\mathbf{t+1|t}} + \mathbf{Z}_{X\theta}^{-1}\mathbf{v}_{\mathbf{t+1}} \tag{4.54}$$

Combined with $\boldsymbol{\theta}_{t+1|t} = \mathbf{T}_{\theta\theta}\boldsymbol{\theta}_t$, we have

$$\boldsymbol{\theta}_{\mathbf{t+1}} = \mathbf{T}_{\theta\theta}\boldsymbol{\theta}_t + \mathbf{Z}_{X\theta}^{-1}\mathbf{v}_{\mathbf{t+1}} \tag{4.55}$$

11. Using (4.51) in (4.55) , yield

$$\begin{aligned} \mathbf{X}_{\mathbf{t+1}} &= \mathbf{Z}_{X\theta}\mathbf{T}_{\theta\theta}\mathbf{Z}_{X\theta}^{-1}\mathbf{X}_{\mathbf{t}} + \mathbf{v}_{\mathbf{t+1}} \\ \mathbf{x}_{\mathbf{t}} &= \mathbf{Z}_{x\theta}\mathbf{Z}_{X\theta}^{-1}\mathbf{X}_{\mathbf{t}} \end{aligned} \tag{4.56}$$

The model in this study will be solved by using the computational algorithm of Paul Soderlind (1999) which can be found from his web page.

4.4 Model Summary

This section will summarize the key equations used to simulate the model. The equations summarized in this section will be stacked in the state space form presented in the previous section.

Again, note here that the lowercase letters denote for the percentage deviation from the steady state of the uppercase letters (excluding i_t and i_t^*). The deviation from the steady state of interest rate is denoted by $\hat{i}_t$ and $\hat{i}_t^*$ According to the equation system of (4.43), the equations contained in this system are the following:

1. Aggregate Supply

$$\pi_{t+1}^H = \alpha_\pi \pi_t^H + \left(1-\alpha_\pi\right)\pi_{t+2|t}^H + \alpha_y y_{t+1|t} + \alpha_q q_{t+1|t} + \alpha_p\left(\tilde{r}_{t+1|t}^k + \tilde{p}_{t+1|t}^E\right) + v_{t+1}$$

2. Expected Future Inflation

$$\left(1-\alpha_{\pi}\right)\pi_{t+2|t}^{H}=-\alpha_{\pi}\pi_{t}^{H}-\alpha_{y}\beta_{y}y_{t}+\alpha_{y}\beta_{\varphi}\varphi_{t}-\alpha_{y}\beta_{y}^{*}y_{t+1|t}^{*}-\left[\alpha_{y}\left(\beta_{q}-\beta_{e}\right)+\alpha_{q}\right]\left(\pi_{t+1|t}^{*}-\hat{i}_{t}^{*}-\Omega_{t}\right)$$
$$+\left[1+\alpha_{y}\left(\beta_{\varphi}+\beta_{q}-\beta_{e}\right)+\alpha_{q}\right]\pi_{t+1|t}^{H}+\alpha_{y}\left[\gamma_{y}^{n}-\beta_{y}\right]y_{t}^{n}-\alpha_{y}\beta_{in}in_{t+1|t}$$
$$-\left[\alpha_{y}\left(\beta_{\varphi}+\beta_{q}-\beta_{e}\right)+\alpha_{q}\right]\hat{i}_{t}-\left[\alpha_{q}+\alpha_{y}\left(\beta_{q}-\beta_{e}\right)\right]q_{t}-\alpha_{p}\left(\tilde{r}_{t+1|t}^{k}+\tilde{p}_{t+1|t}^{E}\right)$$
$$-\alpha_{y}\left[-\beta_{e}\left(p_{t+1|t}^{W}+e_{t+1|t}\right)-\beta_{f}\left(f_{t+2|t}-\left(i_{t+1|t}^{*}+f_{t+1}\right)\right)\right]$$

3. Domestic inflation

$$\pi_{t+1}^{H}=\pi_{t+1|t}^{H}+v_{t+1}$$

4. Aggregate Demand

$$y_{t+1|t}\equiv\beta_{y}y_{t}-\beta_{\varphi}\varphi_{t+1|t}+\beta_{y}^{*}y_{t+1|t}^{*}+\beta_{q}q_{t+1|t}+\beta_{in}in_{t+1|t}-\beta_{e}\left(p_{t+1|t}^{W}+q_{t+1|t}+e_{t+1|t}\right)$$
$$-\beta_{f}\left(f_{t+2|t}-\left(i_{t+1|t}^{*}+f_{t+1}\right)\right)-\left(\gamma_{y}^{n}-\beta_{y}\right)y_{t}^{n}$$

5. Consumption Index

$$c_{t}=c_{t+1|t}-\left(\frac{1}{\rho}\right)\left(\hat{i}_{t}-\pi_{t+1|t}^{c}\right)$$

6. Real Exchange Rate Parity Condition

$$q_{t+1|t}=q_{t}+\hat{i}_{t}-\pi_{t+1|t}^{H}-\hat{i}_{t}^{*}+\pi_{t+1|t}^{*}-\Omega_{t}$$

7. Future Expected Real Domestic Interest Rate

$$\varphi_{t+1|t}=\varphi_{t}-\hat{i}_{t}+\pi_{t+1|t}^{H}$$

8. Domestic-goods Real Interest Rate

$$r_{t}=\hat{i}_{t}+\pi_{t+1|t}^{H}$$

9. Capital Stock

$$k_{t+1}=\left(1-\delta_{K}\right)k_{t}+\delta_{K}in_{t}$$

10. Natural rate of Output

$$y_{t+1}^{n}=\gamma_{y^{n}}y_{t}^{n}+v_{y^{n},t+1},\qquad 0<\gamma_{y^{n}}<1$$

11. Foreign Inflation

$$\pi_{t+1}^{*}=\gamma_{\pi}^{*}\pi_{t}^{*}+v_{\pi^{*},t+1},\qquad 0<\gamma_{\pi}^{*}<1$$

12. Foreign Output

$$y^*_{t+1} = \gamma^*_y y^*_t + v_{y^*,t+1}, \qquad 0 < \gamma^*_y < 1$$

13. Foreign Exchange Premium

$$\Omega_{t+1} = \gamma_\Omega \Omega_t + v_{\Omega,t+1} \qquad 0 < \gamma_\Omega < 1$$

14. Foreign Interest Rate

$$\hat{i}^*_{t+1} = \gamma_{i^*} \hat{i}^*_t + v_{i^*,t+1} \qquad 0 < \gamma_{i^*} < 1$$

15. World Oil Price Process

$$p^W_{t+1} = \gamma_{p^W} p^W_t + v_{p^W,t+1} \qquad 0 < \gamma_{P^w} < 1$$

4.5 Qualitative Analysis of Oil Price Shocks

This section provides the qualitative analysis of oil price shocks. The explanation of the relationships of oil price shocks on economic activities corresponds to the model in previous section. The effects of oil price shocks on the economic activity in this model are similar to the basic explanation of the effects of negative supply shocks in which rising oil prices are indicative of the reduced availability of an important input to the production function.

The oil prices will have the direct effect on the production sector through firm's maximization problem. [equation (4.33)]. The assumption of imperfect competition in goods market and the price setting assumption let firms to increase markups over marginal cost, consequently increasing in the domestic CPI inflation and its expectation [equation (4.9), (4.32), and (4.36)]. Increase in prices of goods reduces the demand for firms' output as a result. [equation (4.34)]. In addition, the rising in oil prices reduces quantity of oil used which directly reduces produced output and marginal productivity of labor and capital. Those effects operate through production function and firm's maximization problem [equation (4.30), and (4.33)].

The wage rate and capital rental cost are reduction according to the reduction in their marginal productivity. Consequently, through optimization of household, the labor hour and capital accumulation decrease [equation (4.15) and (4.12)]. The capital stocks of the economy will be decreased according to the reduction in incentive for capital investment [equation (4.2)], and, finally, the reduction in aggregate output. All the consequences discussed will pass through aggregate economic activities via aggregate demand and aggregate supply equation [equation (4.29) and (4.36)].

All of the effects of oil prices increase explained so far can summarize to state as there are the potentially inverse relationship between oil price shocks and the output growth, and the positive relationship between oil price shocks and inflation. Viewing oil in this way will create both direct and indirect effects from its price.

Due to the open economy feature, the domestic CPI inflation resulting from oil prices increase as discussed above will affect the real exchange rate as well [equation (4.20)]. The exchange rate, then, will pass through the foreign imported good's price and put up the pressure to CPI inflation, again. Additionally, foreign asset holding is subsequently affected from oil price shocks. Due to the reduction in the capital return or marginal productivity of the domestic capital, saving of household may move toward to foreign asset holding [equation (4.3)].

Due to the rising in CPI inflation and the reduction in the output (increasing in output gap), the monetary policy, then, takes a role for fighting inflation and stabilizing the output through equation (4.38). Consequently, the policy rate is put upward. The result from increasing in the interest rate in the short run for fighting inflation will reduce output as well. The monetary policy, therefore, need to concern the weight between inflation, f^{π} , and output gap , f^{y}, on the interest rate policy. Additionally, the exchange rate will be affected from increasing in the interest rate.

In regards to a small open economy feature, the foreign conditions; foreign exchange premium, inflation, interest rate, output [equation (4.23), (4.25)-(4.27)] also influence aggregate demand and aggregate supply of the domestic economy in both direct and indirect channel. The higher incomes of foreign country lead to higher consumption and push up imported goods from the domestic country, as a result. The higher foreign inflation will pass through the increase in foreign interest rate, and in turn, the real exchange rate will be affected [equation (4.29) and (4.36)]. Those effects, finally, influence the domestic's interest rate and economic activities.

Figure 4.1 shows the summation of the mechanism of the model. The numbers on the line which link between each block in the figure denote the equations' number corresponding to the text.

Considering the historical relationships between oil price shocks and inflation, and interest rate, in case of the Thailand data, Figure 4.1, Figure 4.2 and Figure 4.3 show the relationships between oil prices, interest rates, and the inflation rates. From those figures, it can be seen that the relationships were relatively unchanged: rising oil prices led to higher inflation and, in turn, higher interest rate for fighting inflation[6].

[6] Cunadoa, J. and F. Perez de Graciab (2005) show the empirical evidence, in Asian Countries including Thailand, of the relationships between oil prices and inflation rate, and between oil prices and economic activity.

Figure 4.1

Mechanism of the Model

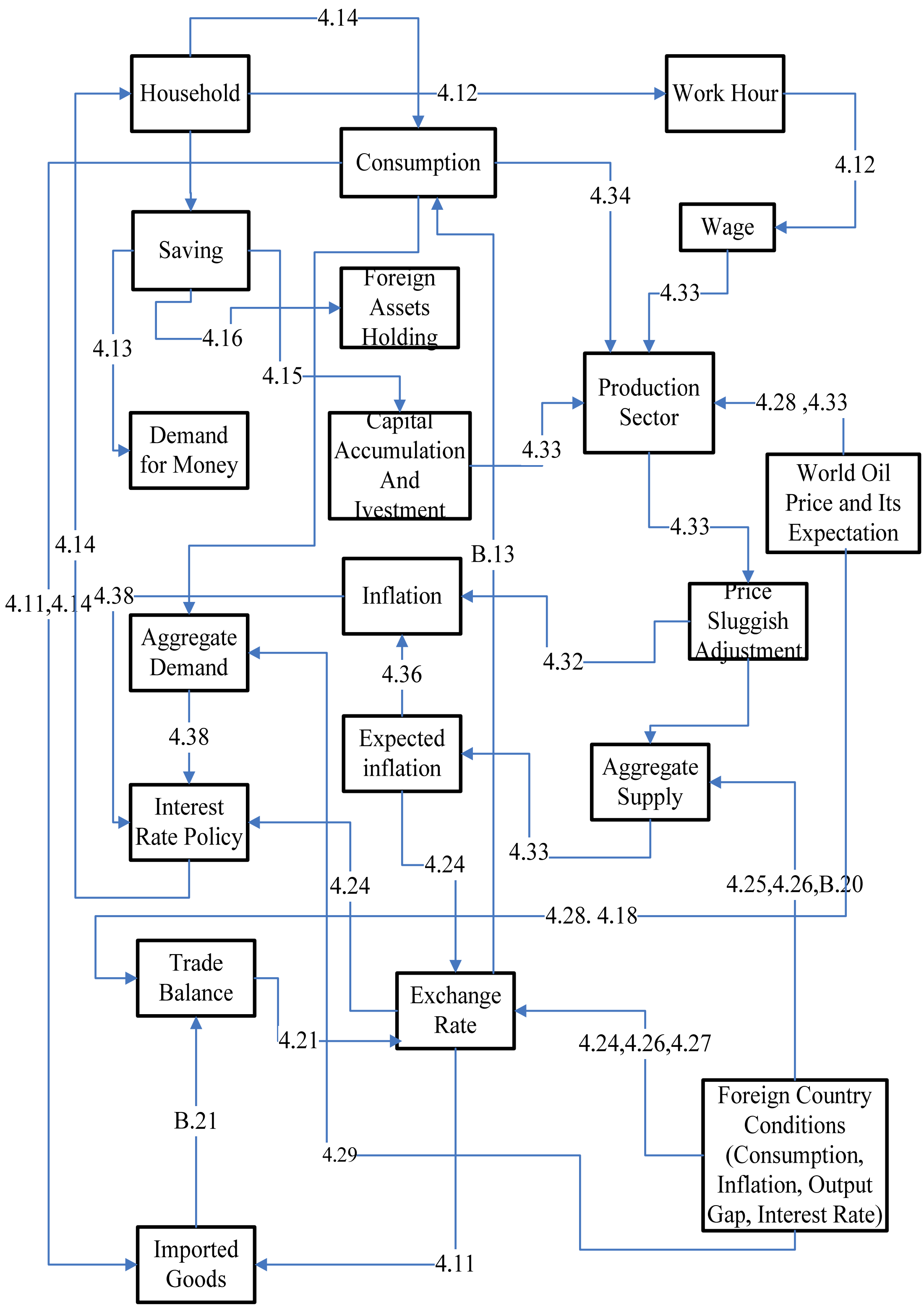

Figure 4.2

Oil Prices and Headline Inflation

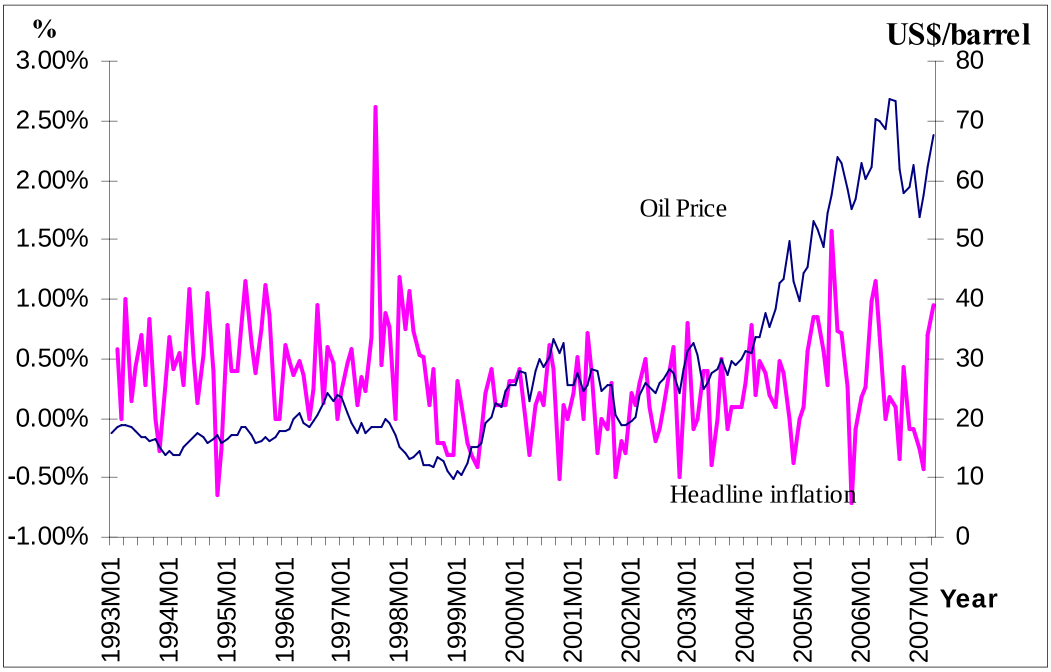

Figure 4.3

Oil Prices and Interest Rate

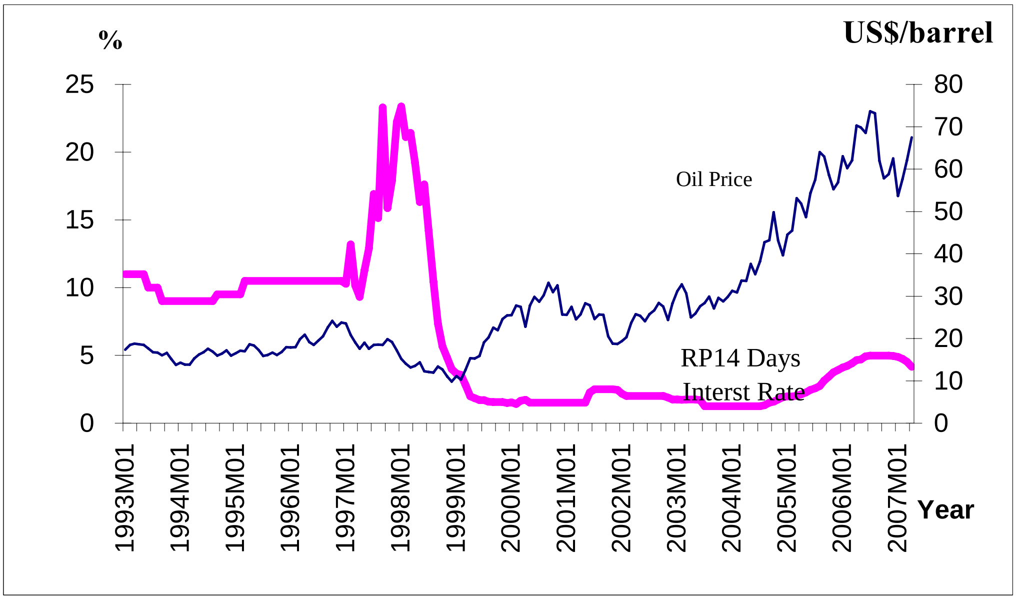

Figure 4.4

Inflation and Interest rate