Nominal GDP Targeting In Small Open Economies

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Abstract

This paper examines the performance of (i) a nominal GDP growth targeting rule, (ii) a domestic inflation targeting rule and (iii) a fixed exchange rate rule in mitigating both demand and supply shocks on key macroeconomic aggregates in a small open economy. By solving a dynamic stochastic general equilibrium (DSGE) model in a context of a New Keynesian framework, this paper finds that small open economies, which implement nominal GDP targeting can stabilize real output and consumer-price-index inflation in the presence of a foreign total factor productivity (TFP) shock and a domestic preference shock, but cannot stabilize CPI inflation when the economy is subject to a domestic TFP shock, which contradicts the results from a closed economy. Another important finding is that small open economy's export "crowds out" home-good consumption through the price channel when the economy is hit by a foreign TFP shock. Moreover, relative price changes serve as a shock absorber to assists stabilizing the real economy under flexible exchange rate regimes.

Key words: Nominal GDP Targeting; Inflation Targeting; fixed exchange rate; Stabilization; Crowd out

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1 Introduction

The most recent financial crisis in the United States unfolded since the late-2000 has turned into a world wide economic crisis. Central banks responded by selling short-term government bonds to lower interest rate when implementing an expansionary monetary policy to raise money stock. However, the reach of zero lower bound in the short-term interest rate makes the standard monetary policy ineffective. One of the unconventional monetary policies that The Fed has conducted is quantitative easing, which is to purchase financial assets from financial institutions to raise the financial asset prices and lower their yield, while simultaneously increasing the money supply. Even still, the economy did not respond much after three rounds of quantitative easing. Against this backdrop, nominal GDP targeting, as one of the unconventional monetary policies provided central banks another option during the economic stagnation.

The main purpose of this study is to evaluates a nominal GDP growth rate targeting (NGDP-GT) rule in comparison with a domestic inflation targeting rule (PPIT)[1] and a fixed exchange rate rule (FIX-EX) in a calibrated New Keynesian model when a small open economy is subject to both demand and supply shocks. There are a lot of debate over the stability of nominal GDP targeting in a closed economy. As introduced in the first chapter: McCallum (1987), McCallum (1989), Hall & Mankiw (1994) ,Ball (1997), Svensson (1997) , Jensen (2002), Sumner (2014). However, there is no study in NGDP-GT in small open economies. In the literature of small open economies regarding nominal GDP targeting, Alba et al. (2012) assesses the welfare impact of foreign output shocks under different monetary polices for small open economies in East Asia. In the seven-policy pool which involves nominal GDP level targeting (NGDP-LT), the results demonstrate that NGDP-LT can stabilize output, but can not stabilize CPI

[1] Domestic inflation targeting is defined based on home good prices, which is measured by the producer price index (PPI)

inflation compared to FIX-EX and PPIT rule. PPIT rule can stabilize CPI inflation compared to the other two policy regimes. Alba et al. (2011) examines the role of fixed exchange rate regime, the Taylor rule and strict inflation targeting rule in the presence of a foreign output shock. It is found that compared to the Taylor rule, small open economies that follow either FIX-EX regime or strict inflation targeting tend to stabilize real exchange rate and inflation at the expense of output instability. In the literature of fixed and flexible regimes, one of the arguments is in favor of flexible regimes to cushion the economy against shocks. This hypothesis was proposed by Friedman (1953) and Mundell (1961) consecutively. Flexible exchange rates serve as a shock absorber in a small open economy in the presence of price stickiness. With a flexible exchange rate regime, the economy that can adjust relative prices more quickly renders a smoother path in output. However, fixed exchange rates restrain the relative prices to change only at a slower speed at which the price stickiness allows. The proposition made by Friedman and Mundell has subsequently motivated international macroeconomists to study different economies' responses to external shocks under different exchange rate regimes. Läufer & Sundararajan (1997), Obstfeld & Rogoff (2000), and Devereux (2004) generally confirms Friedman's proposition.

This paper contributes to the literature on nominal GDP targeting in the following aspects. First, the study proposes to assess NGDP-GT in small open economies, typically for OECD countries, and provides evaluation results to central banks that are considering to adopt NGDP-GT rule during the zero lower bound of interest rate. This paper finds that NGDP-GT can stabilize real output and CPI inflation when the economy is hit by a foreign TFP shock and a domestic preference shock, but can not stabilize CPI inflation under a domestic TFP shock, which contradicts the results from Chen (2016). Second, this paper also finds that small open economy's export "crowds out" home-good consumption through the price channel when the economy is subject to a positive foreign TFP shock. Finally, that relative price changes serve as a shock absorber to assists stabilizing the real economy under flexible exchange rate regimes is further verified.

The rest of this paper is organized as follows. Section 2 outlines the model. Section 3 discusses the main results. Section 4 tests robustness and Section 5 concludes.

2 The Model

The model is mainly based on Monacelli's (2004) dynamic stochastic general equilibrium(DSGE) model of a small open economy. Households are identical, infinitely lived ones who consume baskets of differentiated domestic and foreign tradable goods. Households hold bonds denominated in domestic currency and own the shares of home-based monopolistic competitive firms. They derive income from working, collecting profits of the domestic firms and and renting capital to the domestic firms.

2.1 Households

Households consume baskets of differentiated domestic and foreign goods which are both tradable and indexed by j. $P_{H,t} \equiv (\int_0^1 P_{H,t}^{1-\nu}(j)dj)^{\frac{1}{1-\nu}}$ and $P_{F,t} \equiv (\int_0^1 P_{F,t}^{1-\nu}(j)dj)^{\frac{1}{1-\nu}}$ are defined as, respectively, the utility-based price indices associated to the baskets of domestic and foreign goods, both expressed in units of the domestic currency. The subscript H, is the index for home and F for foreign. $P_{H,t}(j)$ and $P_{F,t}(j)$ are the prices of the individual domestic and foreign good i, where ν denotes the elasticity of substitution between varieties within each category (home goods or foreign goods). Households' utility maximization at any given expenditure on differentiated goods within each category yields the demand functions for any good variety j:

$$C_{H,t}(j) = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\nu} C_{H,t}; C_{F,t}(j) = \left(\frac{P_{F,t}(j)}{P_{F,t}}\right)^{-\nu} C_{F,t} \tag{1}$$

for all $j \in [0,1]$. $C_{H,t} \equiv (\int_0^1 C_{H,t}(j)^{\frac{\nu-1}{\nu}} dj)^{\frac{\nu}{\nu-1}}$ and $C_{F,t} \equiv (\int_0^1 C_{i,t}(j)^{\frac{\nu-1}{\nu}} di)^{\frac{\nu}{\nu-1}}$ are represent composite indexes of domestic and foreign (imported) goods, respectively. The households consume a CES aggregate of C_H and C_F:

$$C_t = [\gamma^{\frac{1}{\rho}} (C_{H,t})^{\frac{\rho-1}{\rho}} + (1-\gamma)^{\frac{1}{\rho}} (C_{F,t})^{\frac{\rho-1}{\rho}}]^{\frac{\rho}{\rho-1}} \tag{2}$$

where $\gamma \in [0,1]$ is the share of home goods in total consumption, therefore,$1-\gamma$ is the natural index of openness, $\rho > 1$ stands for the elasticity of substitution between home goods and foreign goods. For simplicity, investment composite index $In_t(In_{H,t}, In_{F,t})$ has an identical expression. The utility-based consumer price index is given by:

$$P_t = [\gamma(P_{H,t})^{1-\rho} + (1-\gamma)(P_{F,t})^{1-\rho}]^{\frac{1}{1-\rho}} \tag{3}$$

The household's problem of allocating any given expenditure between domestic and foreign goods yields the demand functions for home goods and foreign goods:

$$C_{H,t} = \gamma \left(\frac{P_{H,t}}{P_t}\right)^{-\rho} C_t; C_{F,t} = (1-\gamma) \left(\frac{P_{F,t}}{P_t}\right)^{-\rho} C_t \tag{4}$$

The representative household seeks to maximize the utility function:

$$E_t \sum_{t=0}^{\infty} \beta^t \zeta_t [\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\psi}}{1+\psi}] \tag{5}$$

where E_t is the expectation operator, β the discount factor and $\beta \in (0,1)$,$\sigma > 0$ and $\psi > 0$. $1/\sigma$ implies the intertemporal elasticity of substitution, and ψ for the elasticity of labor substitution.ζ_t is a preference variable, which affects the marginal utility of consumption. C_t is the consumption and N_t is the labor supply of the household at time period of t. In each period, the representative household allocate his resources in consumption, investment and purchasing new bond asset, where the resource is derived from supplying labor, holding bonds and renting out his capital to domestic monopolistic competitive firms. Then the budget constraint of the household can be written as:

$$P_t(C_t + In_t) + E_t(B_{t+1}) = W_tN_t + Z_tK_t + (1 + i_t)B_t + \tau_t \tag{6}$$

where B_t represents the quantity of one-period nominally riskless bond that is purchased in period t and matures in period $t+1$. Each bond pays one unit of domestic currency at maturity. i_t is the nominal interest rate , W_t is the nominal wage, Z_t is the nominal rental cost and τ_t acts as the lump-sum transfer payment.

Capital accumulation follows:

$$K_{t+1} = (1 - \delta)K_t + In_t \tag{7}$$

where δ is the depreciation rate of physical capital. The new level of accumulated physical capital is composed of the remaining amount from the previous period and new investment.

Household's choices of C_t, N_t, B_{t+1}, In_t and K_{t+1} in maximizing the utility function subject to the budget constraint yield the following optimal conditions:

$$\frac{C_t^{-\sigma}}{N_t^{\psi}} = \frac{P_t}{W_t} \tag{8}$$

$$\beta E_t \left(\frac{C_{t+1}}{C_t}\right)^{-\sigma} = E_t \left(\frac{1}{1 + i_{t+1}} \frac{P_{t+1}}{P_t} \frac{\zeta_t}{\zeta_{t+1}}\right) \tag{9}$$

$$Q_t = \zeta_t C_t^{-\sigma} \tag{10}$$

$$Q_t = \beta E_t[\zeta_{t+1} C_{t+1}^{-\sigma} \frac{Z_{t+1}}{P_{t+1}} + Q_{t+1}(1-\delta)] \tag{11}$$

Equation (3.8) specifies the household's consumption-lesure choice. Equation (3.9), the Euler equation, states the optimal dynamic evolution of the household's consumption. Equation (3.10) demonstrates the intertemporal conditions for investment efficiency, where Q_t is the market value of one unit of new capital. Equation (3.11) determines the evolution of Q_t over time. This paper assumes an efficient capital market. Thus at steady state there is neither average nor marginal costs of adjustment. Hense, $\bar{Q} = 1$. As to the rest of the world, foreign households are assumed to have similar preferences as in the home country. The foreign demand for good j is give by:

$$C_{H,t}^*(j) = \left(\frac{P_{H,t}^*(j)}{P_{H,t}^*}\right)^{-\nu} C_{H,t}^* = \left(\frac{P_{H,t}(j)}{P_{H,t}}\right)^{-\nu} C_{H,t}^* \tag{12}$$

where $C_{H,t}^* = (1-\gamma^*)(\frac{P_{H,t}^*}{P_t^*})^{-\rho} C_t^*$. Equation (3.12) implies that a domestic producer faces a downward sloping demand for its product on the international markets. Therefore, the small economy maintains the ability to affect its own terms of trade.

Under the assumption of complete securities markets, a first order condition analogous to (51) must hold for the representative household in the foreign country:

$$\beta E_t\{(\frac{C_{t+1}^*}{C_t^*})^{-\sigma^*}(\frac{P_t^*}{P_{t+1}^*}) * (\frac{\epsilon_t}{\epsilon_{t+1}})\} = E_t(\frac{1}{1+i_{t+1}})[xv]$$

2.2 Domestic Firms

There is a continuum of monopolistically competitive firms indexed by $j \in [0,1]$. Firms employ capital and labor as input, using a nested CES production function with constant return to scale:

$$Y_t(j) = A_t K_t^{1-\alpha}(j) N_t^{\alpha}(j) \tag{13}$$

where the labor share in production $\alpha \in (0,1)$. This paper follows Monacelli (2004), domestic firms can be thought as divided into two units, a production and a pricing unit. The production unit chooses factor demands in a perfectly competitive fashion, taking the level of output as given. Cost minimization gives the static efficiency conditions for the choice of labor and capital, which implies that real marginal benefit equals to the real marginal cost for each input factor:

$$RMC_t \frac{\partial Y_t(j)}{\partial N_t(j)} = \frac{W_t}{P_{H,t}} \tag{14}$$

$$RMC_t \frac{\partial Y_t(j)}{\partial K_t(j)} = \frac{Z_t}{P_{H,t}} \tag{15}$$

where RMC_t is the real marginal cost. The above efficiency conditions also hold for aggregate indexes, because the production function is homogeneous of degree one. Typically, each firm faces the same real marginal cost at period t.

Following Calvo (1983), the pricing unit is allowed to set prices on a staggered basis. Each period, a fraction $\phi_p \in (0,1)$ of firms that are randomly selected cannot adjust their prices while the remaining $1-\phi_p$ can adjust their prices. The parameter ϕ_p represents the degree of price rigidity. A larger ϕ_p implies that fewer firms adjust their prices and the expected time between price changes will be longer. Let ϕ_p^k be the probability that the price set at atime t will still hold at time $t+k$. Firm j's profit at $t+k$ is affected by their choice of price setting at the beginning of time t. Domestic firm j will choose $P_{H,t}^{New}(j)$to maximize the profit function:

$$E_t\{\sum_{k=0}^{\infty}\beta^k\phi_p^k\Lambda_{t,t+k}[P_{H,t}^{New}(j)-MC_{t+k}(j)]Y_{t+k}(j)\} \tag{16}$$

subject to the demand schedule $Y_{t+k}(j)\leq(\frac{P_{H,t}^{New}(j)}{P_{H,t+k}})^{-\nu}[C_{H,t+k}+In_{t+k}+C_{H,t+k}^{*}]$, where $\Lambda_{t,t+k}$ is the time-varying portion of the firm's discount factor, and $MC_{t+k}(j)$ is the nominal marginal cost of firm j.

The optimal pricing condition is:

$$P_{H,t}^{New}(j)=\frac{\nu}{\nu-1}\frac{E_t\{\sum_{k=0}^{\infty}\beta^k\phi_p^k\Lambda_{t,t+k}MC_{t+k}(j)Y_{t+k}(j)\}}{E_t\{\sum_{k=0}^{\infty}\beta^k\phi_p^k\Lambda_{t,t+k}Y_{t+k}(j)\}} \tag{17}$$

Equation (3.17) is the dynamic markup equation for price setting. In this setting, firms forecast future demand and marginal cost. When price stickyness index ϕ_p is set be to 0, This equation becomes $P_{H,t}^{New}(j)=(\nu/v-1)MC_t$, implying a constant real marginal cost- $RMC_t=\nu-1/\nu$. In a symmetric equilibrium where the law of large numbers holds, the domestic aggregate price composite reads:

$$P_{H,t}=[\phi_pP_{H,t-1}^{1-\nu}+(1-\phi_p)(P_{H,t}^{New})^{1-\nu}]^{1/1-\nu} \tag{18}$$

2.3 Terms of Trade, Exchange Rate and Uncovered Interest Rate Parity

The nominal exchange rate ϵ_t is the price of one unit of foreign currency in terms of domestic currency. With the law of one price:

$$P_{H,t}=\epsilon_tP_{H,t}^{*}[i]$$

$$P_{F,t} = \epsilon_t P^*_{F,t} [ii]$$

Terms of trade S_t is defined as the price of the imported good relative to the price of the domestic good:

$$S_t = \frac{P_{F,t}}{P_{H,t}} [iii]$$

The real exchange rate is then defined as:

$$\epsilon^r_t = \frac{\epsilon_t P^*_t}{P_t} [iv]$$

In a small open economy, changes in domestic price do not affect the foreign price level, so without losss of generality, the following equation stands:

$$P^*_{F,t} = P^*_t [v]$$

Domestic PPI inflation, import-good inflation and CPI inflation of the small open economy are defined respectively as:$\pi_{H,t} = log(P_{H,t}/P_{H,t-1})$, $\pi_{F,t} = log(P_{F,t}/P_{F,t-1})$ and $\pi_t = log(P_t/P_{t-1})$. Foreign inflation and foreign PPI inflation are defined respectively as,$\pi^*_t = log(P^*_t/P^*_{t-1})$ and $\pi^*_{F,t} = log(P^*_{F,t}/P^*_{F,t-1})$.

The no arbitrage condition which is also the uncovered interest parity condition can be written as:

$$\frac{1 + i^*_t}{1 + i_t} = \frac{\epsilon_t}{E_t(\epsilon_{t+1})} [xi]$$

2.4 Equilibrium

In a symmetric equilibrium where all firms make identical decisions in price setting, it holds that $P_{H,t}(j) = P_{H,t}$. Equilibrium in the domestic goods market requires:

$$C_{H,t} + C^{*}_{H,t} + In_t = F(A_{t,}K_t, N_t) = A_t K_t^{1-\alpha} N_t^{\alpha} \tag{19}$$

2.5 The Log-linearization of the model

The model is solved by taking log-linear approximation around the steady state. Thus, the model is described by a system of linear equations.

2.5.1 Aggregate Demand

By log-linearization consumer price index- Equation (3.3) and imposing the definition of inflation, deviation of CPI inflation reads[2]:

$$\hat{\pi}_t = \gamma \pi \hat{}_{H,t} + (1-\gamma)(\hat{p}_{F,t} - \hat{p}_{F,t-1}) \tag{20}$$

The uncovered interest parity reads:

$$\hat{i}_t - \hat{i}^{*}_t = E_t(\hat{\epsilon}_{t+1}) - \hat{\epsilon}_t \tag{21}$$

Log-linearizing Equation (3.9), the aggregate demand curve can be written as:

$$\sigma E_t(\hat{c}_{t+1}) - \sigma \hat{c}_t = E_t(\hat{i}_{t+1}) - E_t(\hat{\pi}_{t+1}) \tag{22}$$

This equation describes that the household's consumption decision is based on the

[2]Here after, the lower case letters with ˆ represent log-deviations from respective steady state values.

evolution of nominal interest rate and expected infaltion rate. Higher expected inflation will discourage household's future consumption and stimulate current consumption.

Log-linearizing domestic demand on home and foreign goods from Equation (3.1) and (3.2), together with log-linearization of Equation (3.3) and the definition of terms of trade, domestic demand on home and foreign goods are shown as:

$$\hat{c}_{H,t} = \rho(1-\gamma)\hat{s}_t + \hat{c}_t; \hat{c}_{F,t} = -\rho\gamma\hat{s}_t + \hat{c}_t \tag{23}$$

2.5.2 Aggregate Supply

The production function reads:

$$\hat{y}_t = \hat{a}_t + (1-\alpha)\hat{k}_t + \alpha\hat{n}_t \tag{24}$$

The forward-looking Philips curve for domestic PPI inflation is derived from the loglinearization of Equations (3.17) and (3.18):

$$\hat{\pi}_{H,t} = \beta E_t(\hat{\pi}_{H,t+1}) + \frac{(1-\phi_p)(1-\beta\phi_p)}{\phi_p}\widehat{rmc}_t \tag{25}$$

2.5.3 Market Equilibrium

The market equilibrium follows that:

$$\hat{y}_t = \frac{\bar{C_H}}{\bar{Y}}\hat{c}_{H,t} + \frac{\bar{C_H^*}}{\bar{Y}}\hat{c^*_{H,t}} + \frac{\bar{In}}{\bar{Y}}\hat{in}_t \tag{26}$$

2.6 Monetary Policy Rules

In the NGDP growth targeting regime, policymakers observe and respond only to the nominal GDP growth rate. Nominal GDP growth assumes that the monetary authority commits to a certain growth rate of nominal GDP. This rule reads:

$$\frac{P_t Y_t}{P_{t-1} Y_{t-1}} = \bar{k} \tag{27}$$

where $\bar{k}$ is the growth rate of nominal GDP. Equation (3.27) can be log-linearized as:

$$\frac{\hat{y}_t}{\hat{y}_{t-1}} + \hat{\pi}_{H,t} = 0 \tag{28}$$

The formulation of domestic PPI targeting rule and fixed exchange rate regime can be written as, respectively:

$$\hat{\pi}_{H,t} = 0 \tag{29}$$

$$\hat{\epsilon}_t = 0 \tag{30}$$

2.7 Exogenous Stochastic Processes

The exogenous processes for the rest of the world is summarized as[3]

$$A_t^* = A_{t-1}^* exp(\epsilon_t^{a*}) \tag{31}$$

$$1 + i_t^* = (1 + i_{t-1}^*)^{\rho^{i*}} exp(\epsilon_t^{i*}) \tag{32}$$

Domestic exogenous variables evolve according to

$$A_t = A_{t-1} exp(\epsilon_t^a) \tag{33}$$

[3]We assume $\hat{i}_t^* \approx log(1 + i_t^*/1 + \overline{i^*})$

$$\zeta_t = \zeta_{t-1}^{\rho^\zeta} exp(\epsilon_t^\zeta) \tag{34}$$

with $E_t(\epsilon_{t+1}^\mu) = 0$, $E_t(\epsilon_{t+1}^\mu \epsilon_{t+1}^{\mu'}) = \Sigma$, $\mu =a^*$, i^*, a, ζ.

2.8 Steady State

Steady state variables are marked with a bar, assumed to be constant. The steady state foreign price level and terms of trade are normalized to one. At equilibrium, bonds' market is clear. In a symmetric equilibrium,, all firms make identical decisions. Thus we have $P_{H,t}(j) = P_{H,t}$, $Y_t(j) = Y_t$. The equilibrium in domestic goods market demands:

$$\bar{Y} = \bar{C_H} + \bar{C_H^*} + \bar{In} \tag{35}$$

Equation (3.11) implies that the rental cost of capital at steady state is:

$$\bar{Z} = \frac{1}{\beta} - 1 + \delta \tag{36}$$

From Equation (3.18), $\phi_p = 0$ at steady state, $\bar{MC} = \frac{\nu-1}{\nu}$.

Equation (3.13), (3.14) and (3.8) generate the the labor-output ratio:

$$\frac{\bar{N}}{\bar{Y}} = \frac{\alpha \bar{MC}}{\bar{P}(\bar{N})^\psi (\bar{C})^\sigma} \tag{37}$$

From Equation (3.13) and (3.15), the capital-output ratio is given by:

$$\frac{\bar{K}}{\bar{Y}} = \frac{(1-\alpha)\bar{MC}}{\bar{Z}} \tag{38}$$

This paper assumes that the small open economy's export equals to import at steady state so that $\bar{C_H^*} = \bar{C_F} = (1-\gamma)\bar{C}$. From Equation (3.9), which implies a steady state nominal interest rate $\bar{i} = (1/\beta) - 1$, Equation (3.7), which implies $\bar{In} = \delta\bar{K}$, and Equation (3.36), consumption at the steady state can be written as:

$$\bar{C} = [1 - \frac{(1-\alpha)\delta\bar{MC}}{\bar{Z}}]\bar{Y} \tag{39}$$

Hense, we have $\bar{Y} = \frac{\bar{Z}}{\bar{Z}-(1-\alpha)\delta\bar{MC}}$, $\bar{In} = \delta\bar{K} = \frac{\delta(1-\alpha)\bar{MC}}{\bar{Z}}\bar{Y}$, $\bar{C_H} = \gamma$ and $\bar{C_H^*} = 1-\gamma$.

2.9 Model Parameterization

The model is parameterized numerically in Table A.20. I follow parameterization of Monacelli (2004) where the discount rate β equals to 0.99, the quarterly capital depreciation rate δ is set to 0.025, the labor share of output α is 2/3, and the inverse elasticity of labor supply ψ is 3. The steady state markup $\nu/\nu-1$ is 1.2. The share of home-good consumption, γ, is set such that the steady-state sum of exports and imports is 40% of output ($\gamma = 0.75$). The elasticity of substitution between home and foreign produced goods ρ is set to 1.01. As widely accepted in the Calvo (1983) pricing, the probability of price adjustment is equal to 0.25, implying that the average frequency of price adjustment is four quarters. The inverse of elasticity of intertemporal substitution σ is 1.

The serial correlation parameters for the stochastic processes are $\rho^{i*} = \rho^{a*} = \rho^{a} = \rho^{\zeta} = 0.9$. For the sources of stochastic volatility, the standard deviations of foreign interest rate $\sigma_{\epsilon^{i*}}$ is set to 0.001, close to zero, the standard deviations of domestic productivity shock $\sigma_{\epsilon^{a}}$ is set to 0.007 as in McCallum & Nelson (1997), the standard deviations of foreign productivity shock $\sigma_{\epsilon^{a*}}$ is set to 0.01 and the standard deviation of the preference shock $\sigma_{\epsilon^{\zeta}}$ equals to 0.011, as estimated in Fuhrer et al. (1998).

3 Quantitative Results

3.1 Moment Conditions

3.1.1 NGDP targeting in presence of a positive domestic TFP shock

According to Table A.21, NGDP-GT performs the best in stabilizing small open economy's output, but not CPI inflation. However, it does not carry the properties from in closed economy to small open economies. The standard deviation of output under NGDP-GT framework is 17% lower than under the FIX-EX regime and 30% lower than PPIT. However, domestic CPI inflation produce the highest volatility under the NGDP-GT. Within our expectation, standard deviation of inflation under the PPIT ranks the lowest. Even though, NGDP-GT smooths the consumption path better than the other two regimes.

3.1.2 NGDP targeting in presence of a domestic demand shock

As in Table A.22, NGDP-GT performs the best in stabilizing output and CPI inflation. Standard deviation of inflation under NGDP-GT is 13% lower than under the PPIT and 72% lower than FIX-EX rule. In NGDPT regime, output is 24% and 77% less volatile than the other two scenarios respectively. As to consumption, NGDP-GT and PPIT are relatively more stable policy rules, which generate less fluctuations in consumption.

3.1.3 NGDP targeting in presence of a positive foreign TFP shock

Table A.23 shows that NGDP-GT performs the best in stabilizing small open economy's output and CPI inflation. Standard deviations of CPI inflation and output under NGDP-GT are, respectively, 66% and 85% lower than under the fixed exchange rate regime. The reason why fixed exchange rate regime causes high volatility in output is the prominent depreciation in nominal and real exchange rates following a positive foreign output shock. Relative price changes serve as a shock absorber to assists stabilizing the real economy under flexible exchange rate regimes. Why nominal and real exchange rates decrease rather than increase? It can be answered from two perspectives. First, I observe from the moment results that domestic home-goods consumption and domestic consumption are negatively related to foreign TFP. When the small open economy is subject to a positive foreign TFP shock, export increases dramatically. Positive foreign supply side shock cause foreign income to go up, rising in foreign demand push up small open economy's export, driving up home goods price level. The fact that export crowds out domestic home-goods consumption and domestic consumption through the price channel proves small open economy's export price in the international market is growing faster than home-good price, which drives down the nominal exchange rate. Though, inverse relationship between output and CPI inflation still holds since import price drop significantly. Second, foreign output or foreign income increases, demand for home goods in the international market increases, so as demand for home currency; foreign country's export to the small open economy also increases, demand for foreign currency also increases. Since it's a small open economy, the former demand effect (currency effect of export) dominates the later(currency effect of import), which drives up the nominal exchange rate.

Regarding consumption, NGDP-GT and PPIT, however, are not smooth regimes compared to the FIX-EX regime.

3.2 Impulse Responses

The impulse responses to a domestic TFP shock in Figure B.13 show that the performance of output and CPI inflation and consumption is in line with the moment conditions. Output and consumption deviation under the NGDP-GT is the least volatile.

Inflation deviation, however, is not stable under the NGDP-GT regime. Following a preference shock, as in Figure B.14, output and CPI inflation generate the least fluctuations under the NGDP-GT. When the economy is subject to a foreign TFP shock, the performance of output, inflation as well as consumption under NGDP-GT and PPIT are almost identical as in Figure B.15. Both outperform corresponding variables under the fixed exchange rate regime.

4 Robustness

In this section, I change the elasticity of substitution between home and foreign goods ρ from 1.01 to 1.5. Impulse responses are shown as Figure B.16, B.17 and B.18. The rankings of policy rules in stabilizing output, CPI inflation and consumption deviation are consistent with the ones in the benchmark model when the economy is hit by alternative shocks.

5 Conclusion

Through a dynamic stochastic general equilibrium model with sticky prices and imperfect competition in the goods market, this paper examines the performance of a nominal GDP growth targeting rule in small open economies. The alternative polices are a domestic inflation targeting rule and a fixed exchange rate rule. The simulation results display that whether nominal GDP growth targeting can stabilize the economy depends on the underlying shock. Interestingly, this regime does not carry its stability in CPI inflation from a closed economy to small open economies. This paper also finds the relative price change raise a small open economy's export and reduce its home-good consumption when the economy is hit by a positive foreign TFP shock.

Moreover, relative price changes serve as a cushion to stabilize the real economy under flexible exchange rate regimes.

Table 1: Values of Parameters

Parameter	Description	Value
β	Households' discount factor	0.99
σ	Risk aversion	1.00
ψ	Inverse elasticity of labor supply	3.00
ρ	Elasticity of substitution between home and foreign goods	1.01
δ	Quarterly capital depreciation rate	0.025
α	Labor share of output	0.67
ϕ_p	Price stickyness indicator	0.75
ν	Elasticity of substitution between varieties within home goods or foreign goods	6
γ	Share of home goods in total consumption	0.75
ρ_a	Serial correlation paramter for productivity	0.90
ρ_{i*}	Serial correlation paramter for foreign interest rate	0.90
ρ_{a*}	Serial correlation paramter for foreign productivity	0.90
ρ_ζ	Serial correlation paramter for domestic preference	0.90
σ_{ϵ^a}	Standard deviation of the innovation term in domestic TFP	0.007
$\sigma_{\epsilon^{a*}}$	Standard deviation of the innovation term in foreign TFP	0.01
σ_{ϵ^ζ}	Standard deviation of the innovation term in domestic preference	0.011

Table 2: Moment Conditions under alternative policy rules following a positive domestic TFP shock

Policy Regime	Moment Conditions	$\hat{y}$	$\hat{\pi}$	$\hat{c}$
NGDP-GT	$\bar{x}$	0.0000	0.0000	0.0000
	$std(x)$	0.0074	0.0029	0.0024
FIX-EX	$\bar{x}$	-0.0001	0.0000	0.0000
	$std(x)$	0.0089	0.0015	0.0026
PPIT	$\bar{x}$	-0.0001	0.0000	0.0000
	$std(x)$	0.0105	0.0005	0.0029

Table 3: Moment Conditions under alternative policy rules following a positive preference shock

Policy Regime	Moment Conditions	$\hat{y}$	$\hat{\pi}$	$\hat{c}$
NGDP-GT	$\bar{x}$	0.0000	0.0000	0.0000
	$std(x)$	0.0016	0.0007	0.0103
FIX-EX	$\bar{x}$	0.0000	0.0000	0.0000
	$std(x)$	0.0070	0.0025	0.0109
PPIT	$\bar{x}$	0.0000	0.0000	0.0000
	$std(x)$	0.0021	0.0008	0.0102

Table 4: Moment Conditions under alternative policy rules following a positive foreign TFP shock

Policies	Moments	$\hat{y}$	$\hat{\pi}$	$\hat{\pi_H}$	$\hat{c}$	$\hat{c_H^*}$	$\hat{c_F}$	$\hat{c_H}$
NGDP-GT	$std(x)$	0.00004	0.000025	0.000011	0.000129	0.010801	0.008228	0.00290
	$corr(x, \hat{a^*})$	-0.48180	0.97100	-0.22240	-0.97240	0.29240	-0.98600	-0.18630
FIX-EX	$std(x)$	0.00026	0.000073	0.000097	0.000103	0.010756	0.008244	0.00287
	$corr(x, \hat{a^*})$	0.52750	0.45490	0.45490	-0.97190	0.55890	-0.98300	-0.48750
PPIT	$std(x)$	0.00005	0.000023	0.000023	0.000125	0.01081	0.008227	0.00290
	$corr(x, y)$	-0.56410	0.97090	-0.47400	-0.97240	0.65990	-0.98390	0.24760

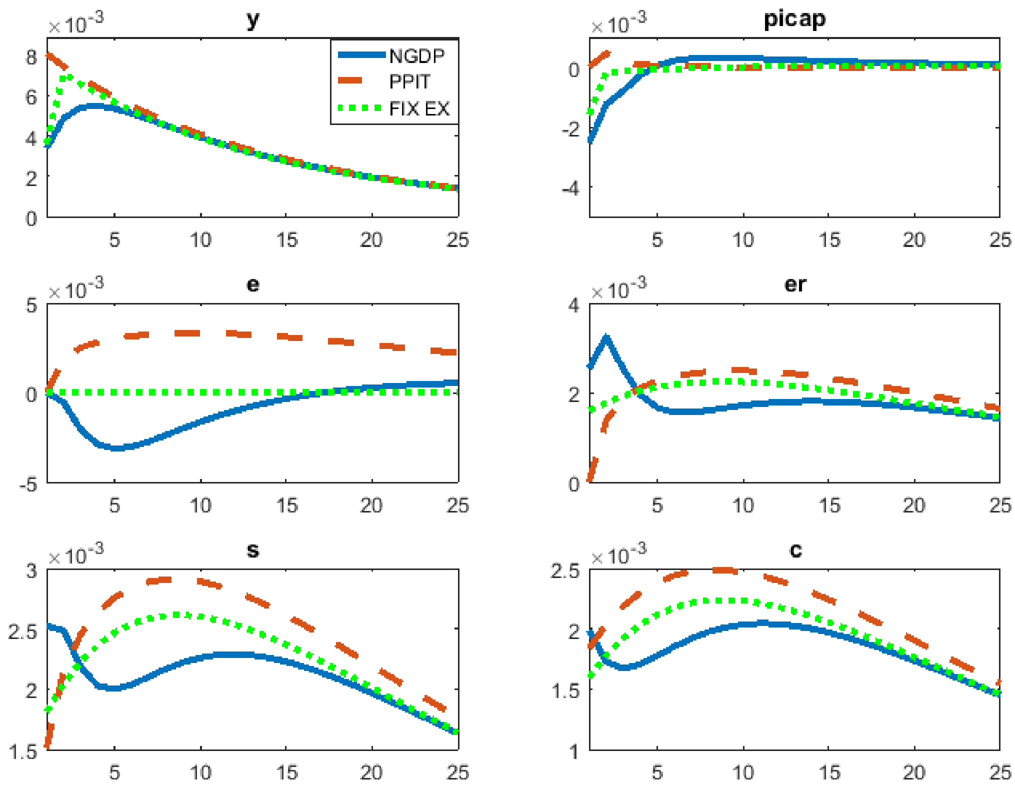

Figure 1: Impulse Responses to a positive TFP shock

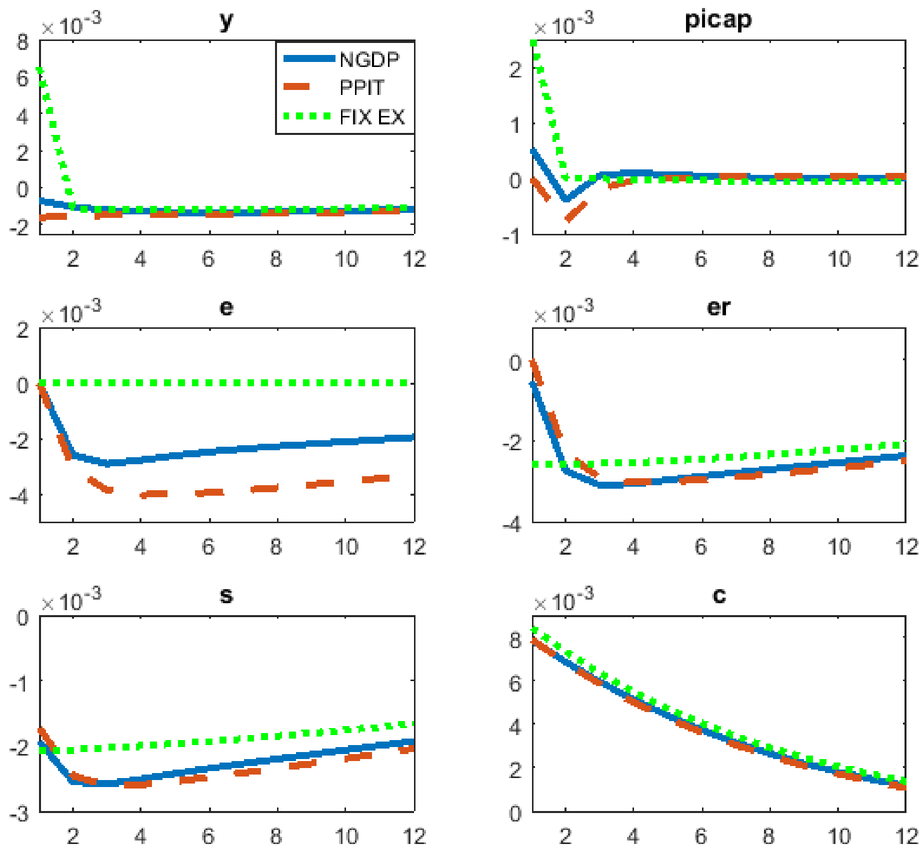

Figure 2: Impulse Responses to a positive preference shock

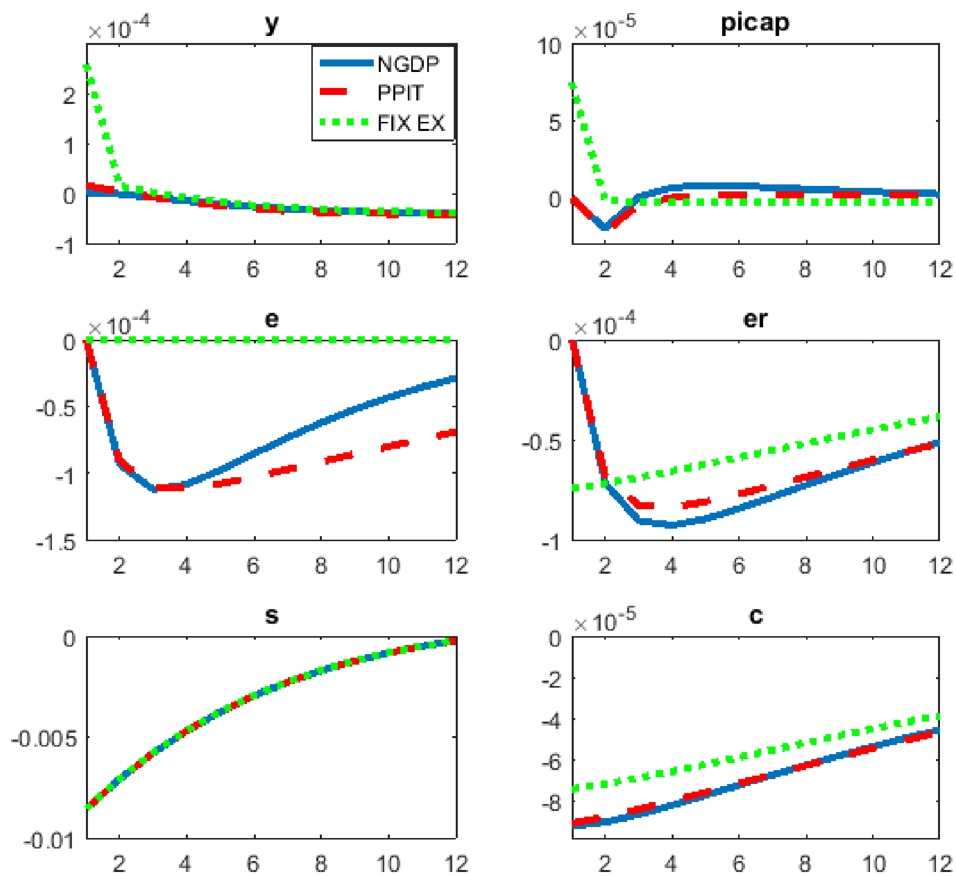

Figure 3: Impulse Responses to a positive foreign TFP shock

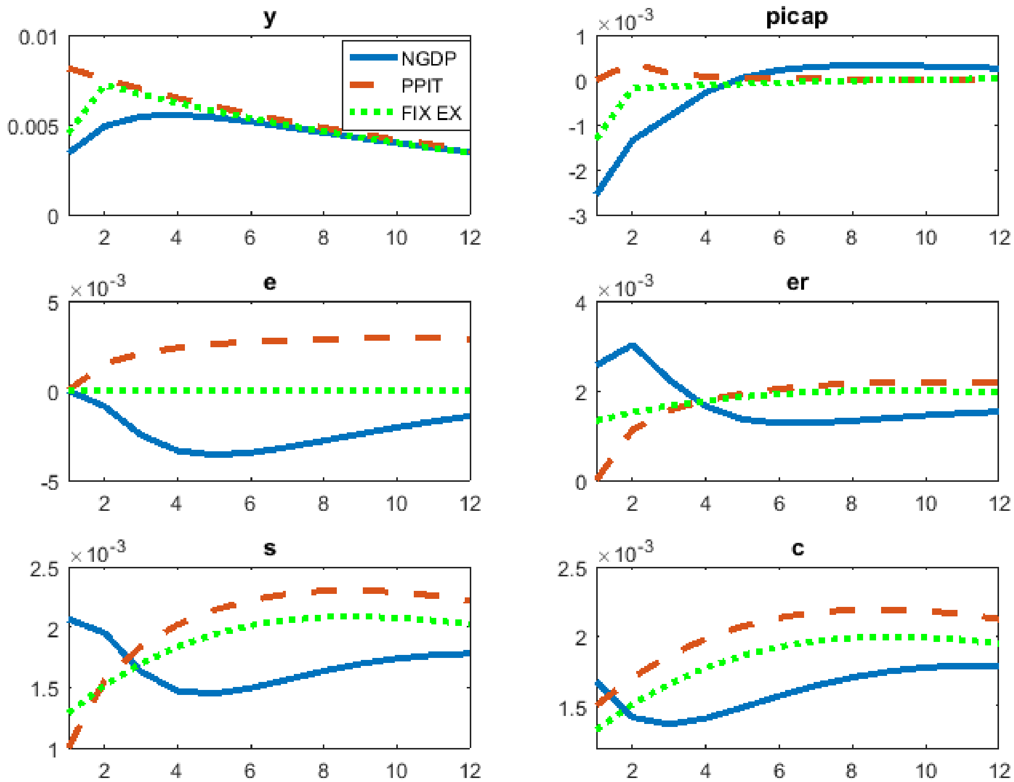

Figure 4: Impulse Responses to a positive TFP shock, $\rho = 1.5$

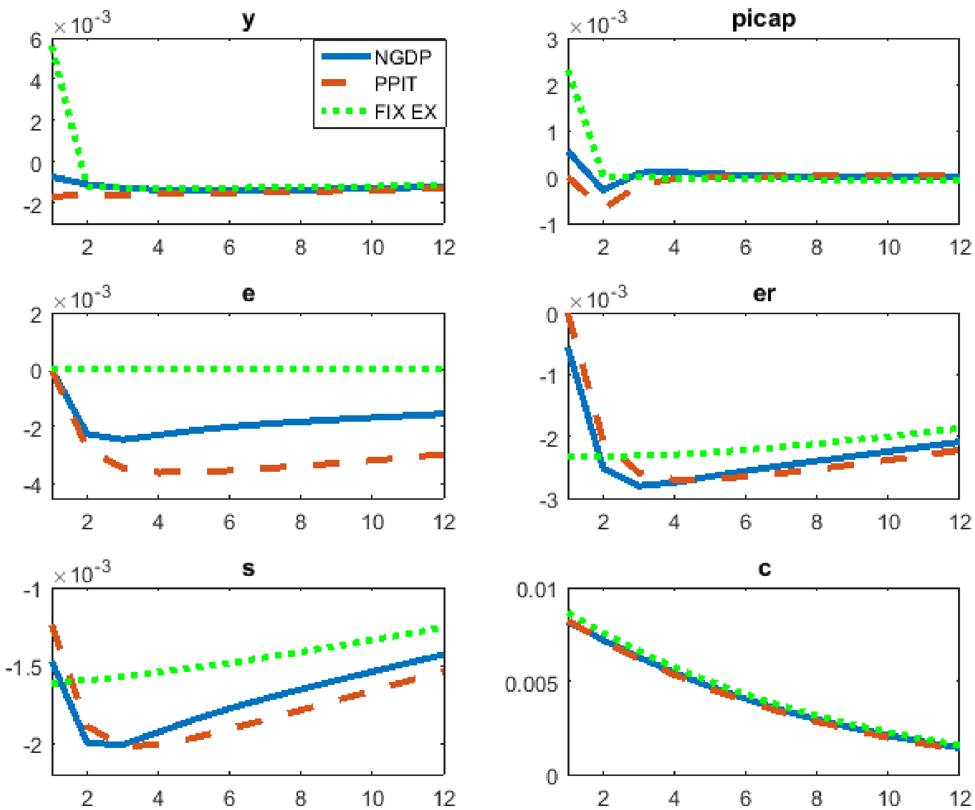

Figure 5: Impulse Responses to a positive Preference shock, $\rho = 1.5$

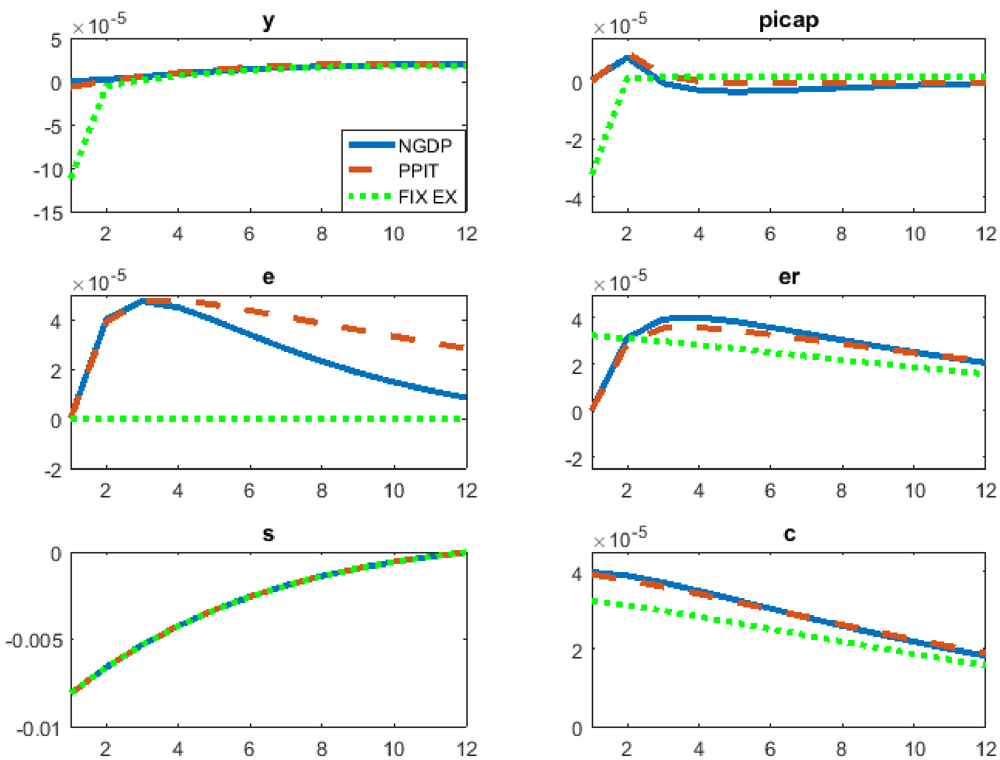

Figure 6: Impulse Responses to a positive foreign TFP shock, $\rho = 1.5$

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Log-Linearized Equations of Chapter 3

Notation: Small letters represent log-deviation from steady state levels (except for i_t and π_t), $e_t$represents the log-deviation of ϵ_t, ϵ_t^a denotes the log-deviation of ϵ_t^A, mc_t is the log-deviation of rmc_t

$$(2A)c_{H,t} = \rho p_t - \rho p_{H,t} + c_t \tag{40}$$

$$(2B)c_{F,t} = \rho p_t - \rho p_{F,t} + c_t \tag{41}$$

$$(4)p_t = \gamma(\frac{\bar{P_H}}{\bar{P}})p_{H,t} + (1-\gamma)(\frac{\bar{P_F}}{\bar{P}})p_{F,t} \tag{42}$$

$$(7)k_{t+1} = k_t + \delta(in_t - k_t)ORk_{t+1} = (1-\delta)k_t + \delta in_t \tag{43}$$

$$(8)\sigma c_t + \psi n_t = w_t - p_t \tag{44}$$

$$(9)\sigma E_t(\hat{c}_{t+1}) - \sigma\hat{c}_t = E_t(\hat{i}_{t+1}) - E_t(\hat{\pi}_{t+1}) \tag{45}$$

$$(10,11) - \sigma c_t = -\sigma c_{t+1} + (1-\beta+\beta\delta) * rz_{t+1} \tag{46}$$

$$(12)c_{H,t}^* = \rho p_t^* - \rho p_{H,t}^* + c_t^* \tag{47}$$

$$(15) mc_t + a_t + (-\alpha)k_t + \alpha n_t = rz_t + p_t - p_{H,t} \tag{48}$$

$$(18)(19) \hat{\pi}_{H,t} = \beta E_t(\hat{\pi}_{H,t+1}) + \frac{(1-\phi_p)(1-\beta\phi_p)}{\phi_p} mc_t \tag{49}$$

$$(20)(21) \hat{i_t} = (1-\chi)\omega_\pi \hat{\pi}_t + (1-\chi)\omega_y y_t + (1-\chi)\frac{\omega_\epsilon}{1-\omega_\epsilon} e_t + \chi \hat{i}_{t-1} (MPRegimeI) \tag{50}$$

$$y_t - y_{t-1} + p_t - p_{t-1} = 0(MPRegimeII - NGDPT) \tag{51}$$

$$(22) y_t = a_t + (1-\alpha)k_t + \alpha n_t \tag{52}$$

$$(23) y_t = \frac{\bar{C_H}}{\bar{Y}} c_{H,t} + \frac{\bar{C_H^*}}{\bar{Y}} c^*_{H,t} + \frac{\bar{In}}{\bar{Y}} in_t \tag{53}$$

Terms of trade and Exchange rate

$$e_t = p_{H,t} - p^*_{H,t}[i] \tag{54}$$

$$e_t = p_{F,t} - p^*_{F,t}[ii] \tag{55}$$

$$s_t = p_{F,t} - p_{H,t}[iii] \tag{56}$$

$$p^*_{F,t} = p^*_t[v] \tag{57}$$

$$e^r_t = e_t + p^*_t - p_t[iv] \tag{58}$$

$$\hat{\pi}_{H,t} = p_{H,t} - p_{H,t-1}[vi] \tag{59}$$

$$\hat{\pi}^*_t = p^*_t - p^*_{t-1}[xi] \tag{60}$$

Uncovered interest parity condition:

$$\hat{i}_t - \hat{i}^*_t = E_t(e_{t+1}) - e_t[xiii] \tag{61}$$

Model-related equations of the rest of the world

$$p^*_t = 0[xiv] \tag{62}$$

$$\sigma^* E_t(c^*_{t+1}) - \sigma^* c^*_t + e_{t+1} - e_t = E_t(\hat{i}_{t+1}) - E_t(\hat{\pi}^*_{t+1})[xv] \tag{63}$$