Does the Optimal Monetary Policy Matter for the
Current Account Dynamics

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Abstract

This paper explores how monetary policies affect the current account in a sticky-price intertemporal optimizing model. The paper will investigate whether monetary policy will be effective for current account adjustment in the U.S. with a two-country model. The main issues addressed include: 1) what current account dynamics are generated with technology shocks and monetary shocks in a two-country open economy and 2) how should the monetary authority responds to these shocks to maximize the welfare of the household. Using a nonlinear solution method, we find that the current account dynamics depends on the intertemporal and intratemporal elasticity of substitution, the degree of monopolistic competition, the degree of local currency pricing and the type of shocks. With slow price adjustment, the current account reacts quite efficiently to technology shocks.

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1 Introduction

In recent years, researchers have been developing intertemporal optimizing sticky-price open economy macroeconomic models. The new wave of research was initiated by Obstfeld and Rogoff (1995)'s redux model.\textsuperscript{1} They introduced imperfect competition and sticky prices into the new open economy macroeconomic models. In these models, money may not be neutral, thus providing a potential role for monetary policies. Obstfeld and Rogoff (1995) show that with pre-set temporarily sticky prices and purchasing power parity (PPP), a positive home money shock generates a long-run improvement in the current account in their two-country model. Betts and Devereux (2000) also show that in a two-country world, with pricing-to-market, a domestic monetary expansion will in general improve the home current account as long as not all goods are using pricing-to-market.

There are many factors that affect the current account dynamics. Lane (2001a) demonstrates that the response of the current account in the short-run to a monetary shock depends on the parameter values of the elasticity of substitution between consumption of nontradables and tradables and the risk aversion measure. Devereux (2000) studies the impact of a devaluation on the current account with price-to-market and shows that the impact depends critically on the extent of pricing-to-market and also the intratemporal and intertemporal effects. Thoenissen (2003) claims that a key determinant of the dynamics of the current account is the initial net foreign asset position. Lombardo (2002) shows that the degree of competition qualitatively affects the current account response to nominal shocks in a two-country world. We build a two-country dynamic general equilibrium model with incomplete financial markets to analyze the dynamics of the current account after different shocks.

As there is the indeterminacy /non-stationary problem of the Obstfeld and Rogoff (1995) model, much of the subsequent research has made assumptions on either asset structure or preferences that effectively shut down the current account dynamics. The current account plays a crucial role in the transmission of shocks in Obstfeld and Rogoff

\textsuperscript{1}See Lane (2001b) for a comprehensive survey of the recent literature in this area.
It’s important to study monetary policies with the current account dynamics.

In this paper, we use the two-country model to analyze the effects of the optimal monetary policy on current account. In our model, with sticky prices, the current account responses to monetary shocks depend on the values of the elasticity of substitution between consumption of nontradables and tradables, the “intratemporal effect” and the risk aversion measure, the “intertemporal consumption smoothing effect”, the degree of monopolistic competition and the degree of local currency pricing. With our non-linear solution method, we are able to analyze the optimal monetary policy and how the optimal monetary policy will affect the current account dynamics with large shocks. We find that with sticky prices and monopolistic competition, given a simple monetary supply rule, the optimal monetary policy to an unexpected positive technology shock in the home country traded goods sector is to increase money supply for the home country. This optimal monetary policy will increase home household’s welfare at the expense of foreign welfare. With monopolistic competition and sticky prices, the optimal monetary policy can achieve higher welfare than with flexible prices for the home country. With the home technology improvement, sticky prices and monopolistic competition, the optimal monetary policy for a social planner is still to increase money supply. If the social planner choose to increase home money supply, the total welfare of home and foreign country will increase. However, this policy will improve home country welfare and decrease foreign country welfare. The optimal monetary policy will exacerbate the current account responses. We also show that in the case of no monopolistic competition, with only sticky prices, a social planner will not choose to increase the money supply, but a home policy maker will still choose to increase home money supply to improve home welfare at the expense of the foreign country. For the social planner, the current account already reacts quite efficiently to the technology shock in our model.

The detailed structure of the work is as follows. Section 2 presents the model. Section 3 presents the equilibrium of the model. Section 4 discusses the calibration and solution with flexible prices and then presents the more general case in which the prices are sticky. Finally, Section 5 concludes.
2 The Model

This paper assumes a perfect foresight two-country economy with incomplete financial markets, where the countries will be denoted home and foreign. Each country has a representative household, firms and a domestic government. The economy has two different types of goods—differentiated traded good and non-traded goods. Both goods sectors are monopolistically competitive. Foreign variables will be marked by an “∗”, and by an $f$ subscript when necessary.

2.1 Households

Both “Home” and “Foreign” countries are explicitly modelled. The two countries are symmetric. I’ll model the “home” country directly, and the “Foreign” can be derived using the same method. The home economy is populated by a continuum of consumers/households of measure unity. The representative household is endowed with a certain amount of time, which is divided between leisure and work. She consumes two types of goods—traded and non-traded goods. The household can hold three nominal financial assets: non-interest bearing home money $M$, and two types of non-contingent bonds, one denominated in home currency $B_h$ paying returns $i$, and the other denominated in foreign currency $B_f$ paying returns $i^*$. She gets income from labor income $W$, profits from domestic firms and lump-sum government transfers and pays back interests on the one-year bonds.

Preferences

The lifetime utility of the home representative household is:

$$\max \left\{ \sum_{t=0}^{\infty} \beta^t \left[ C_t^{1-\sigma} + \frac{\chi}{1-\epsilon} \left( \frac{M_t}{P_t} \right)^{1-\epsilon} - \frac{\eta}{1+\psi} H_t^{1+\psi} \right] \right\}$$

(2.1)

where $\beta \in (0,1)$ is the discount rate. $\sigma$ is the inverse of intertemporal elasticity of aggregate consumption. The household’s instantaneous utility depends positively on consumption, $C_t$, and real money balances, $\frac{M_t}{P_t}$, where $M_t$ is nominal balances held at the beginning of period $t$ and $P_t$ is a consumption based price index for period $t$. $\epsilon$ is the inverse of consumption elasticity of money demand for households. $H_t$ is the labor
effort at time $t$ and $\psi$ is the inverse of the elasticity of labor supply. Supply labor lowers utility. $\chi$ and $\eta$ are scale factors. So the preferences are additively separable in these three arguments.

The consumption index $C_t$ is a CES aggregate of traded and non-traded goods, and there are differentiated traded and non-traded goods

$$C_t = \left[ a^\frac{1}{\rho} C_N^{\frac{\rho - 1}{\rho}} + (1 - a)^\frac{1}{\rho} C_T^{\frac{\rho - 1}{\rho}} \right]^\frac{\rho}{\rho - 1}$$

where $\rho > 0$ is the constant elasticity of substitution between traded and non-traded goods and $a$ is the share of non-traded goods in the consumer price index. $C_N$ is an index of consumption of the non-traded goods, $C_T$ is the consumption of the traded goods. The consumption of traded goods are an aggregate over a continuum of home produced traded goods indexed by $i \in [0, 1]$ along with a continuum of foreign produced traded goods indexed by $i \in [0, 1]$.

$$C_T = \left[ b^\frac{1}{\theta} C_{Th}^{\frac{\theta - 1}{\theta}} + (1 - b)^{\frac{1}{\theta}} C_{Tf}^{\frac{\theta - 1}{\theta}} \right]^\frac{\theta}{\theta - 1}$$

where $\theta > 0$ is the constant elasticity of substitution between home and foreign produced traded goods and $b$ is the share of home produced traded goods in the tradable price index. $C_{Th}$ is an index of consumption of the home produced traded goods, $C_{Tf}$ is the home consumption of the foreign produced traded goods. The non-traded good, home and foreign produced traded goods are in turn defined over the consumption of differentiated goods, so that

$$C_N = \left[ \int_0^1 C_N(i)^{1 - \frac{1}{\lambda}} di \right]^{\frac{1}{1 - \frac{1}{\lambda}}}$$

$$C_{Th} = \left[ \int_0^1 C_{Th}(i)^{1 - \frac{1}{\lambda}} di \right]^{\frac{1}{1 - \frac{1}{\lambda}}}$$

The continuum of home produced non-traded goods are indexed by $i \in [0, 1]$. All consumption goods are perishable. $C_N(i)$ ($c_{Th}(i), c_{Tf}(i)$) denotes date $t$ consumption of the non-traded (home produced, foreign produced traded) good $i$ and $\lambda > 1$ denotes the elasticity of substitution among the differentiated goods.

The non-separability between traded and non-traded goods consumption means that shocks to the non-traded goods sector have spillover effects on traded good consumption
and hence the current account. For instance, in the case that traded good consumption rises together with non-traded goods consumption, a boom in the non-traded sector will cause an increase in demand for imports and a current account deficit.

The consumption price indices are defined as

\[ P_t = \left[ aP_{Nt}^{1-\rho} + (1-a)P_{Tt}^{1-\rho} \right]^{\frac{1}{1-\rho}} \]  

(2.2)

\[ P_{Nt} = \left[ \int_0^1 P_{Nt}(i)^{1-\lambda} di \right]^{\frac{1}{1-\lambda}} \]

\[ P_{Tt} = \left[ bP_{Tt}^{1-\theta} + (1-b)P_{Tft}^{1-\theta} \right]^{\frac{1}{1-\theta}} \]  

(2.3)

It is assumed that fraction \( s \) of firms exhibit local currency pricing (pricing to market PTM) and that the remaining fraction \( 1-s \) of firms exhibit producer currency pricing. \( p_{Tt} \) is the home currency prices, while \( p_{Tt}^* \) is the foreign currency prices.

\[ P_{Th} = \left[ \int_0^s p_{Th}(i)^{1-\lambda} di + \int_s^1 p_{Th}(i)^{1-\lambda} di \right]^{\frac{1}{1-\lambda}} \]

\( p_{Th}(i) \) represents home currency price of the home produced good and \( P_{Th} \) is the price index of home produced and home consumed traded goods.

\[ P_{Tf} = \left[ \int_0^s p_{Tf}(i)^{1-\lambda} di + \int_s^1 (e_t p_{Tf}^*(i))^{1-\lambda} di \right]^{\frac{1}{1-\lambda}} \]  

(2.4)

where \( p_{Tf}(i) \) is home currency price of a foreign PTM good \( i \), while \( p_{Tf}^*(i) \) is foreign currency price of a foreign non-PTM good. The exchange rate (home unit cost of foreign currency) is given by \( e_t \). \( P_{Tf} \) is the price index of foreign produced and home consumed traded goods, i.e. imports. And the price index of home exports may be expressed by:

\[ P_{Th}^* = \left[ \int_0^s p_{Th}^*(i)^{1-\lambda} di + \int_s^1 \left( \frac{1}{e_t} p_{Th}(i) \right)^{1-\lambda} di \right]^{\frac{1}{1-\lambda}} \]

where \( p_{Th}^*(i) \) is foreign currency price of a home PTM good \( i \), while \( p_{Th}(i) \) is home currency price of a home non-PTM good. \( P_{Th}^* \) is the price index of home produced and foreign consumed traded goods.

Optimal consumption behavior implies that demand will be allocated between traded and non-traded, home and foreign goods according to:

\[ C_{Tt} = (1-a)(\frac{P_{Tt}}{P_t})^{-\rho}C_t \quad C_{Nt} = a(\frac{P_{Nt}}{P_t})^{-\rho}C_t \]  

(2.5)
\[ C_{Tft} = (1 - b) \left( \frac{P_{Tft}}{P_{Tt}} \right)^{-\theta} C_{Tt} \quad C_{Th} = b \left( \frac{P_{Thh}}{P_{Tt}} \right)^{-\theta} C_{Tt} \]

with individual demands for non-traded and traded goods as:

\[ C_{Nt}(i) = \left[ \frac{P_{Nt}(i)}{P_{Nt}} \right]^{-\lambda} C_{Nt} \quad c_{Th}(i) = \left[ \frac{P_{Th}(i)}{P_{Th}} \right]^{-\lambda} C_{Th} \]

\[ c_{Tft}(i) = \left[ \frac{P_{Tft}(i)}{P_{Tft}} \right]^{-\lambda} C_{Tft} \quad \text{for} \quad i = 0, ..., s \]

\[ c_{Tft}(i) = \left[ \frac{e_{T} P_{Tft}(i)}{P_{Tft}} \right]^{-\lambda} C_{Tft} \quad \text{for} \quad i = s, ..., 1 \]

The household can provide different types of labor services. There exists a continuum of labor types, indexed by \( i \in [0, 1] \). Let \( H_t(i) \) denote the number of hours of type \( i \) labor. The variable \( H_t \) that appears in the utility function is defined as a sum of labor services in non-traded and traded goods sectors:

\[ H_t = \int_0^1 (H_{Nt}(h) + H_{Tt}(h)) dh \]

Analogous conditions apply to the foreign country.

**Household Budget Constraint** The household can hold three financial assets: local money and two types of non-contingent bonds, one denominated in home currency \( B_h \) paying returns \( i \), and the other denominated in foreign currency \( B_f \) paying returns \( i^* \). This set-up of our model implies incomplete asset markets. A well-known consequence is that the law of motion for bonds is not stationary. We make it stationary by imposing a very small quadratic cost on bond holdings. Schmitt-Grohe and Uribe (2001) and Bergin (2003) impose a “premium” on the asset return which is proportional to the outstanding stock of foreign debts. \(^2\)

The household’s budget constraint in period 1 is:

\[ B_{ht} + \epsilon_t B_{ft} + \frac{\phi_d}{2} \epsilon_t (B_{ft} - \bar{B}_f)^2 + M_t + P_t C_t = (1 + i_{t-1}) B_{ht-1} + \epsilon_t (1 + \bar{i}_{t-1}) B_{ft-1} + M_{t-1} + T_t + W_t H_t + \Pi_t \]

\(^2\)For alternative ways to induce stationarity, see Schmitt-Grohe and Uribe (2003), Devereux (2003) and Cavallo and Ghironi (2002).
where $\frac{\phi_d}{2} \epsilon_t (B_{ft} - \bar{B}_f)^2$ is the household’s convex costs of adjusting foreign currency asset holding. $B_{ht}$ and $B_{ft}$ are stock of home and foreign currency bond holdings that become due in period $t$. $\bar{B}_f$ is the long-run level of foreign currency bond holding, and $\phi_d$ is a constant parameter defining the portfolio adjustment cost function. $i_{t-1}$ and $i^*_{t-1}$ are the nominal interest rate on the home and foreign bonds. The household owns the firms and $\Pi_t$ is the profit from the firms and $T_t$ is the government lump-sum transfer.

The domestic households take $\bar{B}_f$ as given when deciding on the optimal holding of the foreign assets. The term $\frac{\phi_d}{2} e_t (B_{ft} - \bar{B}_f)^2$ can also represent a county-specific interest rate premium. Introducing the risk premium term as a function of debts forces wealth allocations in the long run to return to their initial distribution. In practice, the parameter $\phi_d$ will be set at a very low level in calibration of the model.

The representative household’s intertemporal consumption decisions and her demand for money are determined by maximizing the life-time utility specified in (2.1) subject to the restriction that the budget constraint (2.7) holds in all periods and for all states of the world. Ruling out Ponzi schemes, we get the following first-order conditions:

\begin{equation}
\frac{W_t}{P_t} = \eta C_t^{\sigma} H_t^{\psi} \tag{2.8}
\end{equation}

\begin{equation}
\chi \left( \frac{M_t}{P_t} \right)^{-\epsilon} = C_t^{1-\sigma} \left[ 1 - \beta \frac{P_{t+1}}{P_t} \frac{C_t^{\sigma}}{C_{t+1}^{1-\sigma}} \right] \tag{2.9}
\end{equation}

\begin{equation}
1 = \beta (1 + i_t) \frac{P_t}{P_{t+1}} \frac{C_t^{\sigma}}{C_{t+1}^{1-\sigma}} \tag{2.10}
\end{equation}

\begin{equation}
1 = \frac{\epsilon_{t+1}}{\epsilon_t} \frac{1 + i^*_t}{(1 + i_t)(1 + \phi_d (B_{ft} - B_f))} \tag{2.11}
\end{equation}

where equation (2.8) is the intratemporal optimal labor supply schedule, equation (2.10) is the intertemporal Euler condition, equation (2.9) is the optimal money demand schedule and equation (2.11) is the uncovered interest rate parity condition.

The home government issues the local currency, has no expenditures, and runs a balanced budget every period. The nominal lump-sum transfers from seigniorage revenues are then given by:

\[ T_t = M_t - M_{t-1} \]
We consolidate the public and private sectors to determine the resource constraint for the home economy. The current account may be computed in this model as:

\[ CA_t = \frac{(B_{ht} - B_{ht-1}) + e_t(B_{ft} - B_{ft-1})}{P_t} \]

\[ = \frac{i_{t-1}B_{ht-1} + e_t B_{ft-1}}{P_t} + \frac{e_tP^*_T h_t C^*_T h_t - P_{T ft} C_{T ft}}{P_t} \] \hspace{1cm} (2.12)

The current account is determined by the interest payment for past debt and net exports. The real exchange rate is: \( q_t = \frac{e_t}{P_t} P^* \). Hence, an increase (decrease) in the real exchange rate represents a real depreciation (appreciation).

### 2.2 Firms and the Structure of Goods Markets

There are two types of firms in the country: (i) producers of non-traded consumption goods; (ii) producers of the traded consumption goods. Domestic producers use domestic labor as the only input and labor is immobile internationally. The period \( t \) production functions of the firms producing non-traded good and traded good \( i \) are concave and given by:

\[ Y_{Nt}(i) = A_{Nt} H_{Nt}(i)^{\alpha} \quad Y_{Tt}(i) = A_{Tt} H_{Tt}(i)^{\gamma} \]

where \( Y_{Nt} \) and \( Y_{Tt} \) are the firms’ outputs and \( \alpha < 1, \gamma < 1 \), while \( A_{Nt} \) and \( A_{Tt} \) are period \( t \) labor productivities. \( A_{Nt} \) and \( A_{Tt} \) are exogenous random variables.\(^3\)

Each firm is a monopolistic producer of a single differentiated goods. Under flexible prices, a monopolistic producer set prices as a mark-up over unit cost. The main objective of this paper is to address the optimal monetary policy with current account dynamics. In this respect, we will have to have price rigidity in our model. We assume that firms adjust their prices with an adjustment cost. We follow Sheshinski and Weiss (1977) and Rotemberg (1983) and introduce sluggish price adjustment by assuming that firms face a resource cost that is quadratic in the inflation rate of the goods it produces.

A fixed portion of traded goods firms in our model use PTM to set prices in the local...\(^4\)

\(^3\)In this perfect foresight model, \( A_{Nt} \) and \( A_{Tt} \) are assumed to be unity at steady state.
currency of their markets. This assumption requires a degree of market segmentation, which prevents goods market arbitrage from equalizing prices.

2.2.1 Non-traded Goods Sector

In the non-traded goods sector, with sticky prices, firms choose $p_{Nt}(i)$ to

$$\text{Max } \pi_{Nt}(i) = p_{Nt}(i)Y_{Nt}(i) - W_t H_{Nt}(i) - \frac{\delta}{2} \left[ \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right]^2 p_{Nt}(i)Y_{Nt}(i)$$

where price adjustment cost is $\frac{\delta}{2} \left[ \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right]^2 Y_{Nt}(i)$. The parameter $\delta$ measures the degree of price stickiness. The higher is $\delta$, the more sluggish is the adjustment of nominal prices. If $\delta = 0$, then prices are flexible. The producer of nontradable good $i$ maximizes

$$\Pi_{Nt}(i) = \sum_{j=0}^{\infty} \Omega_{t,t+j} \pi_{Nt}(i)$$

where $\Omega_{t,t+j} = \beta^j \frac{E_{t+j} C}{E_t C_t}$ is the pricing kernel used to value date $t+j$ pay-offs. As firms are owned by the representative household, it is assumed that firms value future payoffs according to the household’s intertemporal marginal rate of substitution in consumption.

The firms’ pricing decision is given by:

$$(1 - \lambda)Y_{Nt}(i) + \frac{\lambda}{\alpha} W_t H_{Nt}(i) - \delta \left\{ \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - \frac{(1 - \lambda)}{2} \left( \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right) \right\} \left( \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right) Y_{Nt}(i) + \delta \Omega_{t,t+1} \left( \frac{p_{Nt+1}(i)}{p_{Nt}(i)} - 1 \right) \frac{p_{Nt+1}^2(i)}{p_{Nt}(i)} Y_{Nt+1}(i) = 0$$

With sticky prices in the non-traded goods sector, the price of good $i$ equals the shadow value of one extra unit of output (the marginal cost), times a markup. Symmetric non-traded goods firms make identical choices in equilibrium. The mark up $\Psi_{t}(i)$ depends on output demand as well as on the impact of today’s pricing decision on today’s and tomorrow’s costs of adjusting the output price:

$$\Psi_{t}(i) = \lambda Y_{Nt}(i) \left\{ (\lambda - 1) Y_{Nt}(i) + \delta \left[ \left( \frac{p_{Nt}(i)}{p_{Nt-1}(i)} \right) + \frac{(1 - \lambda)}{2} \left( \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right) \right] \left( \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right) Y_{Nt}(i) - \Omega_{t,t+1} \left( \frac{p_{Nt+1}(i)}{p_{Nt}(i)} - 1 \right) \frac{p_{Nt+1}^2(i)}{p_{Nt}(i)} Y_{Nt+1}(i) \right\}^{-1}$$

If $\delta = 0$, i.e., if prices are fully flexible, $\Psi_{t}(i) = \lambda \frac{\lambda}{\lambda - 1}$ is the familiar constant-elasticity markup. If $\delta \neq 0$, price rigidity generates endogenous fluctuations of the markup. The
The optimal price setting rule for exports for PTM-firms (\(p_{NT+1}(i)\), \(p_{NT}(i)\), \(p_{NT-1}(i)\), \(Y_{NT}(i)\) and \(Y_{NT+1}(i)\)). The non-traded goods firms react to \(\frac{p_{NT+1}(i)}{p_{NT-1}(i)}\) dynamics in their pricing decisions. Changes in monetary policy generate changes in \(\frac{p_{NT+1}(i)}{p_{NT-1}(i)}\) dynamics. Hence, they affect the non-traded goods prices and the markup. Through this channel, they generate different dynamics of relative non-traded goods prices and the current account. If \(\lambda\) approaches infinity, firms have no monopoly power, and the markup reduced to 1, the competitive level. Under perfect competition, the presence of a cost of adjusting the price level is irrelevant to the firms decision. Some degree of monopoly power is necessary for nominal rigidity to matter.

### 2.2.2 Domestically Produced Traded Goods Sector

In the domestically produced traded goods sector, the producer currency pricing firms choose \(p_{TTh}(i)\) and \(p_{TTh}^*(i)\) to

\[
\begin{align*}
\text{Max} & \quad \pi_{TTh}(i) = p_{TTh}(i)c_{TTh}(i) + e_{TTh}^*c_{TTh}^*(i) - W_iH_i(i) \\
& \quad - \frac{\delta}{2} \left[p_{TTh}(i) - 1\right]^2 p_{TTh}(i)c_{TTh}(i) - \frac{\delta}{2} e_{TTh}^*[p_{TTh}^*(i) - 1] - \frac{1}{2} p_{TTh}(i)c_{TTh}(i)^*
\end{align*}
\]

Non-PTM firms choose \(p_{TTh}(i)\) and \(p_{TTh}(i)\) to

\[
\begin{align*}
\text{Max} & \quad \pi_{TTh}(i) = p_{TTh}(i)c_{TTh}(i) + p_{TTh}(i)c_{TTh}(i)^* - W_iH_i(i) \\
& \quad - \frac{\delta}{2} \left[p_{TTh}(i) - 1\right]^2 p_{TTh}(i)c_{TTh}(i) - \frac{\delta}{2} e_{TTh}^*[p_{TTh}^*(i) - 1] - \frac{1}{2} p_{TTh}(i)c_{TTh}(i)^*
\end{align*}
\]

The optimal price setting rule for domestic sales of all home firms (\(i = 0, ..., 1\)) is:

\[
(1 - \lambda)c_{TTh}(i) + \frac{\lambda}{\gamma} W_i H_i(i)^{1-\gamma} c_{TTh}(i) - \delta \left( \frac{p_{TTh}(i)}{p_{TTh-1}(i)} - 1 \right) p_{TTh}(i)c_{TTh}(i) \\
- \frac{\delta}{2} (1 - \lambda) \left[ p_{TTh}(i) \right]^2 c_{TTh}(i) + \delta \left( \frac{p_{TTh}(i)}{p_{TTh-1}(i)} - 1 \right) \left[ p_{TTh}(i) \right] c_{TTh}(i) = 0
\]

The optimal price setting rule for exports for PTM-firms (\(i = 0, ..., s\)) is:

\[
(1 - \lambda)e_{TTh}c_{TTh}(i) + \frac{\lambda}{\gamma} W_i H_i(i)^{1-\gamma} c_{TTh}(i) - \delta e_{TTh} \left( \frac{p_{TTh}(i)}{p_{TTh-1}(i)} - 1 \right) p_{TTh}(i)c_{TTh}(i) \\
- \frac{\delta}{2} (1 - \lambda) e_{TTh} \left[ p_{TTh}(i) \right]^2 c_{TTh}(i) + \delta \left( \frac{p_{TTh}(i)}{p_{TTh-1}(i)} - 1 \right) \left[ p_{TTh}(i) \right] c_{TTh}(i) = 0
\]
The optimal price setting rule for exports for non PTM-firms \((i = s, \ldots, 1)\) is:

\[
(1 - \lambda)c_{Th}^*(i) + \frac{\lambda}{\gamma}W_{t}H_{Tt}(i)^{1-\gamma} \frac{c_{Th}^*(i)}{A_{Tt}p_{Th}(i)} - \delta\frac{p_{Th}(i)}{p_{Th-1}(i)}c_{Th}(i) - \frac{\delta(1 - \lambda)}{2}\left(\frac{p_{Th}(i)}{p_{Th-1}(i)} - 1\right)^2c_{Th}^*(i) + \delta\Omega_{t,t+1}\left(\frac{p_{Th+1}(i)}{p_{Th}(i)} - 1\right)\frac{p_{Th+1}(i)}{p_{Th}(i)}c_{Th}(i) = 0
\]

If prices are perfectly flexible, the price-setting is a mark-up over the marginal cost. However, in the presence of price adjustment costs, price-setting deviates from the simple markup with additional forward looking and backward looking terms. Price stickiness generated through adjustment costs allows all firms to reset prices if the costs of price stickiness become large.

\section{Equilibrium}

The home goods market clearing conditions are: domestically produced non-traded goods are all consumed domestically, domestically produced traded goods are consumed by both domestic and foreign consumers:

\[
Y_{Tt} = c_{Th} + c_{Th}^*
\]

The home bonds market clearing conditions are:

\[
B_{ht} + B_{ht}^* = 0
\]

Equilibrium is a set of 33 equations determining 33 sequences: \(B_{ht}, B_{ft}, B_{ht}^*, B_{ft}^*, e_t, \ i_t, \ i_t^*, \ W_t, W_t^*, \ C_t, C_t^*, \ H_{Nt}, H_{Nt}^*, \ H_{Tt}, H_{Tt}^*, \ C_{Th}, C_{Th}^*, C_{Tft}, C_{Tft}^*, P_t, P_t^*, \ P_{Nt}, P_{Nt}^*, P_{Tt}, P_{Tt}^*, P_{Tft}, P_{Tft}^*, P_{Th}, p_{Th}^*, p_{Th-1}, p_{Th-1}^*,\) The 33 equilibrium conditions are: the definition of demand conditions for non-traded goods and home/foreign produced traded goods (2.5 and 2.6), the overall price index (2.2), the home consumed traded goods price index (2.3), the price index for imports (2.4), the four price setting rules for domestic firms, the money demand condition (2.9), labor supply condition (2.8), the Euler equation (2.10), the interest parity condition (2.11), market clearing conditions for goods (3.14) and bonds (3.15), along with foreign counterparts for each of the above condition and the balance of payments constraint (2.12).
The Flexible-Price Equilibrium As all households and firms are identical, we can drop the subscript \( i \). We first consider the case when all prices are perfectly flexible. With flexible prices, PPP will hold and local currency pricing will not affect the firms pricing behavior. The labor working in either traded or non-traded goods sector will get the same wage rate:

\[
\gamma A_t H_t^\gamma^{-1} p_{Th} = \alpha A_t H_t^{\alpha^{-1}} p_{Nt}
\]

The price setting equations will become much easier and the markup will be just \( \lambda \).

The Steady State Stationarity fails for an open economy whenever the equilibrium rate of aggregate per capita consumption growth is independent of the economy’s aggregate per capita net foreign assets. The constant consumption in the steady state does not determine a unique steady state for net foreign assets. In our model, the foreign bond holding adjustment cost ensures the stationarity of the model. The cost \( \phi \Delta e_t (B_{ft} - \bar{B}_f)^2 \) captures that when the economy-wide holdings of foreign-currency denominated assets are different from the steady state level, \( \bar{B}_f \), individual agents have to pay extra cost. When the equilibrium aggregate level of foreign debts in the economy is equal to \( \bar{B}_f \), this cost will disappear. This yields determinacy of steady state levels of real variables.

4 Calibration and Solution

4.1 Calibration

As this is a perfect foresight, rational expectation model, we can use a non-linear solution technique—multiple shooting method. This method is used to solve two-point boundary problems. Lipton, Poterba, Sachs, and Summers (1982) give a detailed discussion. This solution technique allows us to avoid the approximation errors from log-linearization and gives us a trajectory of the current account after a shock. As this is a non-linear technique, we can accommodate large shocks in the model.

We follow the open economy macro literature in picking parameter values for our
basic experiments. The inverse of the intertemporal elasticity of substitution \( \sigma \) is set at 2, following Backus, Kehoe, and Kydland (1995). The rate of time preference is set at 0.01, so that the subjective discount factor is 0.99. The value of \( \eta \) is a scale factor for labor supply, so we set it to 2.5. The share of non-traded goods in the consumer price index \( a \) is set at 0.5, following the evidence cited in Cook and Devereux (2001) for Malaysia and Thailand. The share of home goods in the traded goods aggregator, \( b \), is set at 0.7, reflecting the 30% share of imports in GDP for the home country. The inverse of the elasticity of labor supply is set to 0.5, so that \( \psi = 0.5 \). This is roughly following Rotemberg and Woodford (1998). The elasticity of substitution between non-traded and traded goods is set at 0.75 which follows directly from Ostry and Reinhart (1992). The elasticity of substitution between home and foreign traded goods \( \theta \) is set to 2 following Obstfeld and Rogoff (2004). The elasticity of substitution between varieties of differentiated goods is \( \lambda \), and this governs the equilibrium markup of price over cost in all the firms. We follow Rotemberg and Woodford (1998), where they set \( \lambda = 7.66 \) which implies an average mark-up of 15%. We assume that non-traded goods production is relatively labor intensive, with \( \alpha = 0.7 \), and traded goods is relatively non-labor intensive, with \( \gamma = 0.3 \). The consumption elasticity of money demand for household is equal to \( \frac{1}{\epsilon} \) in this model. According to Mankiw and Summers (1986), this variable is very close to unity and hence \( \epsilon \) is set to 1. For the price stickiness, the price adjustment cost is set at \( \delta = 20 \), which implies that 87% of the price has adjusted 4 periods after a monetary shock. Bond adjustment cost, \( \psi_d = 0.007 \) following the estimate of Schmitt-Grohe and Uribe (2003), is necessary in order to negate the unit root associated with the incompleteness of the asset markets. The share of local pricing firms \( s \) is set to 0.9 according to estimates of Bergin (2003). Table 1 in the appendix reports the baseline calibration assumptions.

---

4In Rotemberg and Woodford (1998), the inverse of the elasticity of labor supply is set to 0.47.
4.2 Impulse Response Analysis

4.2.1 Current Account Dynamics with Flexible Prices

From the household’s first-order conditions, we can get:

\[
\frac{C_{Tt+1}}{C_{Tt}} = \left[ \beta (1 + it) \frac{P_{Tt}}{P_{Tt+1}} \right]^{\frac{1}{\sigma}} \left[ \frac{P_{t}}{P_{Tt+1}} \right]^{\frac{1}{\sigma} - \rho} \tag{4.16}
\]

This is similar as in Lane (2001a). The consumption growth depends on the sequence of relative prices, \((\frac{P_{Tt}}{P_{Tt+1}})^{\frac{1}{\sigma}}\) and the 2nd term \(\left[ \frac{P_{t}}{P_{Tt+1}} \right]^{\frac{1}{\sigma} - \rho}\). For the 2nd term, this is the price ratio of current and future aggregate price level relative to the price of traded goods. The consumption of traded goods can either go up or go down. If \(\frac{P_{t}}{P_{Tt}}\) is currently low comparing to its future value, this encourages present consumption over future consumption, i.e. \(C_{Tt}\) will tend to increase. Meanwhile, the relative higher future traded goods price also encourages consumption substitution from traded goods to non-traded goods, i.e. \(C_{Tt}\) will decrease. The former effect dominates if the intertemporal elasticity of substitution \(\frac{1}{\sigma}\) is greater than the intratemporal elasticity of substitution \(\rho\), i.e. \(\frac{1}{\sigma} > \rho\). Considering the above effects, we can see that non-traded and traded goods consumption is highly positively correlated when \(\frac{1}{\sigma} > \rho\). The spillover between non-traded and traded consumption is less positively correlated, maybe even negatively correlated when the intratemporal substitution effect dominates the intertemporal substitution effect, i.e. \(\frac{1}{\sigma} < \rho\).

With perfectly flexible prices, money is indeed neutral in our model. Monetary policies only affect nominal variables, not real variables. We also calibrate the current account dynamics to technology shocks in the traded good sector. The technology shock process takes the following form:

\[
\ln A_{Tt+1} = \mu_1 \ln A_{Tt} + \epsilon_{Tt+1} \tag{4.17}
\]

where \(\epsilon_{Tt+1}\) is the technology shock in the traded good sector, \(\mu_1 = 0.42\) (following Schmitt-Grohe and Uribe (2003)). Upon the persistent technology shock, as the traded good’s production is more efficient, the output of the traded good increases. With our
basic calibration, the real exchange rate appreciates, domestic consumption of traded goods increases, people tend to smooth out the temporary technology improvement by saving more and current account goes into surplus. With \( \frac{1}{\sigma} < \rho \), the intratemporal effect dominates the intertemporal effect, the traded goods and non-traded goods consumption tend to be negatively correlated. With an unexpected 1% technology improvement in the home traded goods sector, the current account demonstrates a 0.13% surplus of the current GDP ratio. When \( \frac{1}{\sigma} = 2 > \rho \), the non-traded and traded goods consumption moves together. This will encourages more of the traded goods consumption. Upon the same technology shock, the current account response will be showing less surplus than when \( \frac{1}{\sigma} < \rho \). Now, the current account demonstrates a 0.11% surplus of the current GDP ratio. Figure 1 shows the current account, traded and non-traded consumption responses to the traded sector technology shock with \( \frac{1}{\sigma} < \rho \) and \( \frac{1}{\sigma} > \rho \). The impulses are percentage deviations from the initial steady states except for the current account responses.

4.2.2 Current Account Dynamics with Sticky Prices

The price stickiness is modelled by a price adjustment cost in the differentiated goods firms. The parameter \( \delta \) measures the degree of price stickiness in the non-traded goods sector. In our basic calibration \( \theta = 20 \), the 87% goods prices adjusted within one year with a 1% one-time money supply shock. In this section, we only study the case where the country has zero initial net foreign assets.

Money Supply Shocks For simplicity, we assume that money supply is characterized in terms of a money supply rule. The money supply rule is:

\[
\ln M_t = \ln M_{t-1} + \mu (\ln M_{t-1} \ln M_{t-2}) + \epsilon_{Mt}
\]

where \( \mu = 0.5 \), and \( \epsilon_{Mt} \) is the unexpected money supply shock.

With a 1% unexpected temporary money growth shock, money supply increases permanently. The surprise monetary expansion stimulates extra demand, and hence production of home non-traded goods. The home country will increase traded goods
consumption, the increased demand for traded goods will cause foreign country to produce more traded goods and less non-traded goods. When $\frac{1}{\sigma} < \rho$, the spillover between non-traded consumption and traded consumption is negative or marginally positive, as the intratemporal substitution effect dominates the intertemporal substitution effect. Home value of imports increases slowly to the new steady state after the shock. With fast exports increase, the current account shows an improvement of 0.06%. If we change the value of $\sigma$ so that $\frac{1}{\sigma} > \rho$, the spillover between non-traded consumption and traded consumption is positive, increased consumption of non-traded goods also stimulates consumption of the traded good, since the elasticity of substitution between the consumption of non-traded and traded goods is low (relative to the intertemporal elasticity of substitution). The imports increase dramatically by nearly 3%. This will cause an initial current account deficit 0.15%. Figure 2 shows the current account responses to an unexpected 1% positive money growth shock with $\sigma = 2$ and $\sigma = 0.5$ when $\rho = 0.75$.

Equation (2.13) shows that changes in monetary supply generate changes in $P_{i}N_t\left(i\right)/P_{i-1}\left(i\right)$ dynamics, and this effect exists for all prices. These changes will affect the markup and the current account. With monopolistic competition, the output falls below the competitive level. At steady state, as $\lambda$ increases, the markup decreases. With less monopolistic competition, the firms are more competitive and have higher output. The surprise monetary expansion shock will increase the output and tend to correct the monopolistic distortion. In the case of our basic calibration, with $\frac{1}{\sigma} < \rho$, the current account improves upon the monetary shock. With a higher $\lambda$, there will be less monopolistic distortion, the output level at the steady state will be less distorted, meaning converging to the high output level without the monopolistic competition. The output expanding effect of the monetary shock will be less effective with less monopolistic distortion. The home traded goods consumption will increase less with less monopolistic distortion. This will be reflected by either more exports or less imports. Under the specification $\frac{1}{\sigma} < \rho$, with higher $\lambda$, the positive current account response to the monetary shock will become less significant. Figure 3 demonstrates the current account responses to an unexpected 1% positive money growth shock with different levels of markup. With the lower markup, the net exports in the current account (2.12) deteriorates when $\frac{1}{\sigma} < \rho$. This is the same
result as Lombardo (2002).

However, Figure 4 shows that with $\frac{1}{\sigma} > \rho$, the current account improves with the lower markup. The reason for this result is that, as $\frac{1}{\sigma} > \rho$, the home traded consumption increases, and will increase less with a higher $\lambda$. So now with the higher $\lambda$ and lower markup, the home country’s imports increase less. Therefore, the current account improves. From Figure 3 and Figure 4, we can see that the current account responds by less to the monetary shock with less monopolistic competition.

We have assumed that a fraction $s$ of firms using local currency pricing when pricing their exports. Devereux (2000) shows that when all exports prices are set in producer currency, the current account responses are dominated by the “expenditure-switching” effects of exchange rate change. When export prices are set all by pricing-to-market, the response of current account depends on the intertemporal “consumption smoothing” effect. In our calibration, when both foreign and home country are symmetric $b = 0.5$ and elasticity of substitution between home and foreign produced traded goods is low $\theta = 0.75$, higher fraction $s = 0.9$ of firms using local currency pricing will cause the current account to respond more 0.1% of GDP compare to with low $s = 0.1$ with 0.005% of GDP current account improvement. While with our basic calibration, $s$ works with the elasticity of substitutions to affect the current account responses. Figure 5 and Figure 6 shows the current account responses with different level of local currency pricing.

**Technology Shocks** We still use the technology shock Equation (4.17) in the traded good sector. Figure 7 shows the current account response to an unexpected 1% increase of the traded good technology. Upon the technology shock, the traded good sector will increase its production as the production is more efficient. With our basic calibration, the magnitude of the current account response is 0.08% of the current period GDP upon the shock.
4.2.3 Current Account Dynamics with Optimal Monetary Policy

In this section, we study the optimal monetary policy with current account movements and how the current account with the optimal monetary policy responds to a temporary technology shock in the traded good sector. We study the case that the net foreign asset is initially zero. The technology shock process takes the form of (4.17). We assume that the monetary authority receives perfect information about the current state of the economy. So the optimal active monetary policy is that the money supply responds instantly to the technology shock. Upon the unexpected technology shock in the traded good sector, the monetary authority immediately realizes what the temporary technology shock is and sets appropriate money supply to maximize the welfare of the household. The money supply rule is:

$$
\ln M_t = \ln M_{t-1} + \mu (\ln M_{t-1} - \ln M_{t-2}) + \epsilon_M t \quad \epsilon_M = a_1 \epsilon T_1
$$

and now $\mu=0.5$ and $a_1$ is the parameter that has to be determined optimally by the monetary authority.

In this economy, we have two kinds of distortions—nominal rigidity and monopolistic competition. With a 1% unexpected positive technology shock in the home traded good sector, the sector increase its production as the production is more efficient now. Due to the monopoly distortion in all goods sectors, the output is already sub-optimally low. The home monetary authority can increase its money supply and choose the optimal money supply level to increase the welfare of the household. This unanticipated monetary expansion upon the technology shock leads to increases in home real economic activities. As the prices are sticky, domestic output is demand-determined in the short-run. The surprise monetary expansion boosts the home current demand, including the home demand for the non-traded goods and causes the non-traded goods outputs to increase above the sub-optimal level. The increased amount of money also works with the technology shock, which boosts the total home employment above the steady state level in the short run. Equivalently, this nominal shock increases the employment above the natural level and eliminates part of the existing distortions in the home economy. This effect for the home country comes from two channels: 1) the increased money
supply will enable the firm to adjust less to decrease the welfare loss from sticky prices; 2) the increased home money supply will minimize the monopolistic distortion. This result corresponds to the benefits from surprise inflation in Barro and Gordon (1983). The surprise monetary expansion gives rise to the discretionary monetary policy as the monetary authority can exploit the firms pricing decision when it makes the monetary policy. Because the economy starts off in a sub-optimally low equilibrium, the expansion of the money supply improves household’s welfare.

For the foreign country, the home monetary expansion will cause home country to suffer due to the term of trade effect. The home monetary expansion will cause the home country to increase its demand for traded goods. With higher importing price for foreign goods, foreign country will work more and consume less. This will cause the foreign country to suffer a loss of their utility/welfare.

With the basic calibration, home monetary authority will choose a 15% money injection. This will improve home country’s welfare by 0.05% compared to without the monetary policy. The home welfare improvement comes at the expenses of the foreign country. This home money supply expansion will cause the foreign country’s welfare to decrease by 0.04%. If we have a social planner, who will treat the home and foreign country equally, the social planner still will choose to increase home money supply upon the unforeseen home technology shock. The social planner will choose to increase the home money supply by 14.5%, and this policy will increase the total welfare of home and foreign by 0.0036%. In this case, the optimal monetary policy will exacerbate the current account responses.

To see whether the monetary policy can increase the household’s welfare with only one distortion—price rigidity, we use firm subsidies to get rid of the markup distortion in the production. We still assume that the government runs balanced budgets. The government taxes all goods firm revenues at a rate that compensates for monopoly power in a zero-inflation steady state and removes the markup over the marginal cost charged by firms in a flexible-price world. The firm output is taxed at a tax rate $\tau$. The tax rate is determined by $1 - \tau = \frac{\lambda}{1 - \lambda}$, which gives $\tau = -\frac{1}{\lambda - 1}$. Because $\lambda > 1$, the tax rate
is negative, firms receive a subsidy on their revenues and pay lump-sum taxes.

Firm revenues are taxed at a constant, proportional rate $\tau$. In addition, firms receive a lump-sum transfer/tax from the government, $Tf_t$. The non-traded goods firms’ profit then become

$$\pi_{Nt}(i) = (1 - \tau)p_{Nt}(i)Y_{Nt}(i) + Tf_t - W_t H_{Nt}(i) - \frac{\theta}{2} \left[ \frac{p_{Nt}(i)}{p_{Nt-1}(i)} - 1 \right]^2 p_{Nt}(i)Y_{Nt}(i)$$

We can derive the traded goods profit functions in the same way. In this case, there is no monopolistic distortion. The outputs are already at the optimal level. The surprise home monetary expansion can not increase the production above the optimal level from the social planner’s point of view. However, for home monetary authority, a home monetary injection upon the technology shock can still improve home household’s welfare by 0.03%. Again, this home welfare improvement comes at the expense of the foreign country.

5 Conclusions and Future Research

In this paper, we show that the current account dynamics depend on the parameter values of intertemporal and intratemporal elasticities of substitution, the degree of monopolistic competition and the degree of local currency pricing. With monopolistic competition, surprise monetary expansion responding to an unexpected technology shock will increase home household’s welfare at the expense of the foreign country. We also shows that in the case of no monopolistic competition, with only one distortion–sticky prices, as a social planner, the current account reacts quite efficiently to the technology shock in our model and no monetary expansion is needed. But for home monetary authority, a home monetary injection upon the technology shock can still improve home household’s welfare.

For future research, we can calibrate our model to US economy and explore the effect of different monetary rules on US current account dynamics. We can also show what will be the dynamics of US real economic variables when the US current account deficit goes to zero.
References


Table 1. Baseline Calibration

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Figure 1: Impulse responses with flexible prices to an unexpected positive 1% technology shock in the traded good sector.
Figure 2: Impulse responses with sticky prices to an unexpected positive 1% monetary shock.

Blue solid line—σ=2, ρ=0.75; Red dotted line—σ=0.5, ρ=0.75
Figure 3: Impulse responses with sticky prices to an unexpected positive 1% monetary shock. sigma=2

Blue line—\( \lambda = 7.66 \); Red line—\( \lambda = 15 \); Green line—\( \lambda = 50 \)
Figure 4: Impulse responses with sticky prices to an unexpected positive 1% monetary shock. sigma=0.5
Figure 5: Impulse responses with sticky prices to an unexpected positive 1% monetary shock. b=0.7; theta=0.75

Blue line—s=0.1; Red line—s=0.9
Figure 6: Impulse responses with sticky prices to an unexpected positive 1% monetary shock.
Figure 7: Impulse responses with sticky prices to an unexpected positive 1% monetary shock.