Optimal Monetary Policy and the Dynamics of the Current Account

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Abstract
This paper explores how monetary policy affects the current account dynamics in a sticky-price intertemporal optimizing model. The main issues addressed include: 1) what current account dynamics are generated with technology shocks and monetary shocks in a small open economy and 2) how should the monetary authority respond to technology shocks to maximize the welfare of the households. Using a nonlinear solution method, we find that the current account dynamics depends on the parameter values of the intertemporal and intratemporal elasticities of substitution, the degree of monopolistic competition and the type of shocks. When there are monopolistic competition and sticky prices in the non-traded goods sector, the monetary authority is able to use monetary policy to increase the welfare of the households by eliminating the welfare loss from the monopolistic competition in the non-traded goods sector.

JEL classification: F32,F41
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1 Introduction

An open economy can run current account imbalances, thus enables different directions of movement of consumption and production in the short-run. For the last two decades, most of the current account literature emphasized the intertemporal approach.\footnote{See Obstfeld and Rogoff (1995b) for a survey on this literature.} Stressing the importance of consumption smoothing and investment, this literature focuses on a country’s intertemporal budget constraint: a current account deficit now means future trade surpluses. This line of research has its attractive feature that the reasoning is based on optimizing models, where they have explicit preferences, technology and capital market access. However, most of this literature has focused on non-monetary environments or flexible-price economies. In such models, money is always neutral, so that there is no room to analyze the effects of monetary policies on current account.

In recent years, researchers have been developing intertemporal optimizing sticky-price open economy macroeconomic models. The new wave of research is initiated by Obstfeld and Rogoff (1995a)’s \textit{redux} model.\footnote{See Lane (2001b) for a comprehensive survey of the recent literature in this area.} They introduce imperfect competition and sticky price into new open economy macroeconomic models. In these models, money may not be neutral, thus provides a more potent role for monetary policies. Obstfeld and Rogoff (1995a) show that with pre-set temporarily sticky prices and purchasing power parity (PPP), a positive home money shock generates a long-run improvement in 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. But there is the widely recognized indeterminacy/non-stationary problem of the Obstfeld and Rogoff (1995a) model. An economy’s net foreign assets follow a random walk. When the model is log-linearized, one is actually approximating its dynamics around a “moving steady state”. As variables wander
away from the initial steady state, the reliability of the log-linear approximation is low, especially for analysis with a longer time horizon than a short-run exercise. As Schmitt-Grohe and Uribe (2002) point out, the unconditional variances of endogenous variables are infinite, even if exogenous shocks are bounded.

As there is the indeterminacy /non-stationary problem of the Obstfeld and Rogoff (1995a) 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 (1995a). It’s important to study monetary policies with the current account dynamics. To solve the non-stationarity, 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. To make our model as tractable as possible, we will adopt this “premium” approach.

In this paper, we use a small open country dynamic general equilibrium model with incomplete financial markets to analyze dynamics of the current account after different shocks and the effects of the optimal monetary policy on current account. There are many factors that affect the current account dynamics. Lane (2001a) demonstrates that the response of current account in the short-run to a monetary shock depends on the parameter values of the elasticity of substitution between consumption of non-tradables 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.

In our model, we show that money is neutral under perfectly flexible prices. With sticky prices in the non-traded goods sector, 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 country’s initial net foreign asset position and the degree of competition. With our non-linear solution method, we are able to analyze what is 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 monetary supply rule, the optimal monetary policy to a 1% unexpected positive technology shock in the traded goods sector is to increase money supply. With monopolistic competition and sticky prices in the non-traded goods sector, the optimal monetary policy can achieve higher welfare than with flexible prices.

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 in the non-traded goods sector. Finally, Section 5 concludes.

2 The Model

This paper assumes a perfect foresight small open economy with a representative household, firms and a domestic government. The economy has two different types of goods—a homogeneous traded good and differentiated non-traded goods. The non-traded goods sector is monopolistically competitive. The price of the traded good is covered by the law of one price.\footnote{In the following, we normalize the foreign currency price of the traded good to unity and consider a flexible exchange rate regime so that the domestic currency price of the traded good and the nominal exchange rate are the same: $P_{T_t} = e_t$, where $e_t$ is the nominal exchange rate, defined as the number of domestic currency units per unit of foreign currency.}

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2.1 Households

The 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 differentiated non-traded goods. The consumer can hold two types of nominal assets: non-interest bearing home money $M$, a one-period noncontingent foreign debt $D$ denominated in foreign currency. She gets income from labor income, profits from domestic firms and lump-sum government transfers and pays back interests on the foreign debt.

**Preferences** The lifetime utility of the home representative household is:

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

(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 $t$. $H_t$ is the labor effort at time $t$.

The consumption index $C_t$ is a CES aggregate of traded and non-traded goods

$$C_t = \left[ a^{\frac{1}{\rho}} C_{Nt}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}} C_{Tt}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$$

where $\rho > 0$ is the constant elasticity of substitution between traded and non-traded goods. The non-traded good is in turn defined over the consumption of differentiated goods, so that

$$C_{Nt} = \left[ \int_0^1 C_{Ni}(i)^{1-\frac{1}{x}} di \right]^{\frac{1}{1-x}}$$

where $C_{Ni}$ is an index of consumption of the non-traded goods, $C_{Ti}$ is the consumption of traded good. There exists a continuum of home produced non-traded goods indexed by $i \in [0,1]$ and a homogeneous traded good. All consumption goods are perishable.
$C_{Nt}(i)$ denotes date $t$ consumption of the non-traded good $i$ and $\lambda > 1$ denotes the elasticity of substitution among non-traded goods.

The non-separability between traded and non-traded goods consumption means that shocks to the non-traded goods sector have spillover effects on the 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

$$P_t = \left[ aP_{Nt}^{1-\rho} + (1-a)P_{Tt}^{1-\rho} \right]^{\frac{1}{1-\rho}} \quad (2.2)$$

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

Assume the law of one price holds for the traded good, $P_t^*$ is the world price of the traded good and $e_t$ is the current exchange rate: $P_{Tt} = e_t P_t^*$.

Optimal consumption behavior implies that the individual demands for non-traded and traded good are given as:

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

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

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:

$$H_t = \int_0^1 H_{Nt}(i) di + H_{Tt}$$
**Household Budget Constraint** The household can hold two financial assets: local money and nominal debts denominated in foreign currency. The debts have a maturity of one period. The household’s budget constraint in period $t$ is:

$$M_t + e_t(1 + i_{t-1})D_{t-1} + P_tC_t = M_{t-1} + e_tD_t + T_t + W_t L_t + \Pi_t \quad (2.3)$$

where $D_t$ is the household’s stock of foreign currency debts that become due in period $t$. $i_{t-1}$ is the nominal interest rate on the foreign debt. The household owns the firms and $\Pi_t$ is the profit from the firms.

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 (2.3) holds in all periods and for all states of the world. Ruling out the Ponzi schemes, we can get the following first-order conditions:

$$\frac{W_t}{P_t} = \eta C_t^\sigma H_t^\psi \quad (2.4)$$

$$1 = \beta (1 + i_t) \frac{C_t^{-\sigma}P_t}{P_{t+1}} \frac{e_{t+1}}{e_t} \quad (2.5)$$

$$\chi \left( \frac{M_t}{P_t} \right)^{-\varepsilon} = C_t^{-\sigma} [1 - \beta \frac{C_{t+1}^{-\sigma}P_t}{C_t^{-\sigma}P_{t+1}}] \quad (2.6)$$

where equation (2.4) is the intratemporal optimal labor supply schedule, equation (2.5) is the intertemporal Euler condition and equation (2.6) is the optimal money demand schedule.

### 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 good. 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 $i$ and traded good are concave and given by:

$$Y_{Ni}(i) = A_{Ni} H_{Ni}(i)^\alpha \quad Y_{Tt} = A_{Tt} H_{Tt}$$
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.\(^5\)

There are competitive profit maximizing firms in the traded good sector. This implies that the price is equal to marginal cost:

\[
W_t = \gamma P_{Tt} A_{Tt} H_{Tt}^{\gamma - 1} \tag{2.7}
\]

where \( W_t \) is the wage rate. In the non-traded goods sector, each production firm has monopolistic market power, and sets its price as a markup over the marginal cost. If non-traded goods prices were perfectly flexible, then the profit maximizing decision for firm \( i \) would imply:

\[
\frac{\lambda}{\lambda - 1} W_t = \alpha P_{Nt}(i) A_{Nt} H_{Nt}(i)^{\alpha - 1} \tag{2.8}
\]

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 non-traded goods 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 the non-traded good firm faces a resource cost that is quadratic in the inflation rate of the goods it produces:

\[
\pi_{Nt}(i) = P_{Nt}(i) Y_{Nt}(i) - W_t H_{Nt}(i) - \frac{\theta}{2} \left[ \frac{P_{Nt}(i)}{P_{Nt-1}(i)} - 1 \right]^2 P_{Nt}(i) Y_{Nt}(i)
\]

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

The producer of non-traded good \( i \) maximizes

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

\(^5\)In this simple model, \( A_{Nt} \) and \( A_{Tt} \) are assumed to be unity at steady state.
where $\Omega_{t,t+j} = \beta_j \frac{C_{t+j}}{P_{t+j}} P_t$ 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:

$$\{(1 - \lambda)Y_{Nt}(i) + \frac{\lambda}{\alpha} W_t H_{Nt}(i) - \theta((\frac{P_{Nt}(i)}{P_{Nt-1}(i)})^2 - \frac{1}{P_{Nt-1}(i)})P_{Nt}(i)Y_{Nt}(i)$$

$$- \frac{\theta(1 - \lambda)}{2}(\frac{P_{Nt}(i)}{P_{Nt-1}(i)} - 1)^2 Y_{Nt}(i)\}$$

$$+ \theta \frac{C_{t+1} \sigma_i}{C_{t-1} \sigma_i} \frac{P_t}{P_{Nt}(i)^\sigma} \{(\frac{P_{Nt+1}(i)}{P_{Nt}(i)^\sigma} - \frac{P_{Nt+1}(i)}{P_{Nt}(i)^\sigma})P_{Nt+1}(i)Y_{Nt+1}(i)\} = 0 \quad (2.9)$$

With sticky prices in the non-traded goods sector, the price of good $i$ equals to the product of 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:

$$\Psi_t(i) = \lambda Y_{Nt}(i) \left\{ (\lambda - 1)Y_{Nt}(i) + \theta \left[ (\frac{P_{Nt}(i)}{P_{Nt-1}(i)^\sigma} - \frac{1}{P_{Nt-1}(i)})P_{Nt}(i)Y_{Nt}(i) \right. \right.$$  

$$\left. + \frac{1 - \lambda}{2}(\frac{P_{Nt}(i)}{P_{Nt-1}(i)} - 1)^2 Y_{Nt}(i) \right\}^{-1} \quad (2.10)$$

If $\theta = 0$, i.e., if prices are fully flexible, $\Psi_t(i) = \frac{\lambda}{\sigma_i}$ is the familiar constant-elasticity markup. If $\theta \neq 0$, price rigidity generates endogenous fluctuations of the markup.

The markup $\Psi_t(i)$ depends on $P_{Nt+1}(i), P_{Nt}(i), P_{Nt-1}(i), Y_{Nt}(i)$ and $Y_{Nt+1}(i)$. The non-traded goods firms react to $\frac{P_{Nt}(i)}{P_{Nt-1}(i)}$ dynamics in their pricing decisions. Changes in monetary policy generate changes in $\frac{P_{Nt}(i)}{P_{Nt-1}(i)}$ 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.

2.3 Government

The government issues the local currency, has no expenditures, and runs a balanced budget every period. The nominal lump-sum transfers of seignorage revenues $T_t$ are given by:

$$T_t = M_t - M_{t-1}$$

2.4 Debt Elastic Interest Rate

This set-up of our model implies incomplete asset markets. A well-known consequence is that this model will display non-stationary dynamics, so that linearizing the model around the initial steady state could yield a poor approximation of the nonlinear model. In our rational expectation model, we use a nonlinear solution to avoid the approximation error of log-linearization and also accommodate large shocks. We follow Schmitt-Grohe and Uribe (2001) and Bergin (2003) and impose a “premium” on the asset return which is proportional to the outstanding stock of foreign debts.

The nominal return of the debt is closely related to its world nominal interest rate $\bar{i}_t$.

$$i_t = \bar{i}_t + \psi_2(e^{D_t-\bar{d}} - 1) \quad (2.11)$$

where $\bar{d}$ is the aggregate level of foreign debt. The nominal interest rate of the debt depends on the real holdings of the foreign debts in the entire home economy. This means that domestic households take $\bar{d}$ as given when deciding on the optimal holding of the foreign debt. The term $\psi_2(e^{D_t-\bar{d}} - 1)$ is a country-specific interest rate premium. As borrowers, the consumers will be charged a premium over the foreign interest rate; as lenders, they will receive a remuneration lower than the foreign interest rate. Another way to describe this cost is to assume the existence of intermediaries in the
foreign asset market (which are owned by the foreign households) who can borrow from and lend to households of the rest of the world at the rate $i^*_t$, but can borrow from and lend to households of the home country at the rate $i_t$. For characterizing the incomplete financial structure, we do not really need to introduce this additional cost. However, this will be useful in pinning down a well-defined steady state for consumption and assets. The primary motivation for including this term here is to remove the element of nonstationarity in the model. 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 $\psi_2$ will be set at a very low level in calibrating of the model.\footnote{In our paper, this elasticity of the interest rate premium is set at $7 \times 10^{-3}$.}

3 Equilibrium

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. Combine equations (2.3) and (2.7), we can get

$$(1 + i_{t-1})D_{t-1} = D_t + P_t^* [A_T H_T^\gamma - (1 - a) (P_{Tt} / P_t)^\gamma C_t]$$

(3.12)

This is the market equilibrium condition. The labor working in either traded or non-traded goods sector will get the same wage rate,

$$\frac{\lambda}{\lambda - 1} e_t P_t^* A_{Tt} H_{Tt}^{\gamma-1} = \alpha A_{Nt} H_{Nt}^{\alpha-1} P_{Nt}$$

(3.13)

The equilibrium of this fully flexible price economy is a collection of 8 sequences $(D_t, P_t, C_t, e_t, H_{Tt}, H_{Nt}, P_{Nt}, i_t)$ satisfying 8 equilibrium conditions. These include (3.12), (3.13), the three household first-order equations, the debt-elastic interest rate equation (2.11), the price index (2.2) and the non-tradable goods market clear condition. Please refer to the appendix for the 8 equilibrium equations with perfectly flexible prices.
**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 debt elastic interest rate ensures the stationarity of the model. The cost $\psi_2(e^{D_t-d_t} - 1)$ captures that when the economy-wide holdings of foreign-currency denominated debts are above (below) the steady state level, $\bar{d}$, individual agents receive less (more) than the gross rate of return. When the equilibrium aggregate level of foreign debts in the economy is equal to $\bar{d}$, this cost will disappear. This yields determinacy of steady state levels of real variables. We denote steady state levels of variables without time subscript $t$. The steady state level of domestic interest rate $i$ is equal to the world interest rate $i^* = \frac{1-\beta}{\beta}$.

$$iD = P^* \left[ A_T H_T^\gamma - (1-a)(\frac{P^*}{P/e})^{-\rho} C \right]$$

$$\alpha A_N H_N^{-1} (P_N/e) = \frac{\lambda}{\lambda-1} P^* A_T^\gamma H_T^{-1}$$

$$\frac{P^* A_T^\gamma H_T^{-1}}{(P/e)} = \eta C^\alpha (H_N + H_T)^\psi$$

$$(P/e) = \left[ a(P_N/e)^{1-\rho} + (1-a)P^{*1-\rho} \right]^{\frac{1}{1-\rho}}$$

$$A_N H_N^\alpha = a \left[ \frac{(P_N/e)}{(P/e)} \right]^{-\rho} C$$

Given the initial steady state level of $D$, we can solve for the steady state level of the real variables $C, H_T, H_N, \frac{P}{e} and \frac{P_N}{e}$.

**The Sticky-Price Equilibrium** For the sticky price equilibrium, we also have 8 equations and now we have equation (2.9) instead of (3.13).

The current account with sticky prices may be computed as:

$$CA_t = -\frac{e_t (D_t - D_{t-1})}{P_t} = -\frac{e_t i_{t-1} D_{t-1}}{P_t} + \frac{P_{T_t}}{P_t} \{ Y_{T_t} - C_{T_t} \} \text{ net exports}$$
The current account is determined by the interest payment for past debt and net exports. The real exchange rate is:

\[ q_t = \frac{e_t P^*_t}{P_t} \]

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.

We follow the open economy macro literature in picking parameter values for our basic experiments. The inverse of the intertemporal elasticity of substitution 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 just a scale factor, so we set it arbitrarily to unity. 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 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)\(^7\). 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 varieties of non-traded goods is \( \lambda \), and this governs the equilibrium markup of price over cost in the non-traded goods sector. 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 production is relatively capital intensive, with \( \beta = 0.3 \).\(^7\)

\(^7\)In Rotemberg and Woodford (1998), the inverse of the elasticity of labor supply is set to 0.47.
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, we follow Ireland (2001) and choose the price adjustment cost parameter $\theta = 77$. Table 1 in the appendix reports the baseline calibration assumptions.

In this paper, we also investigate whether initial holdings of foreign debts/assets will affect the current account responses to the various shocks. As documented by Lane and Milesi-Ferretti (2001), net foreign assets over GDP vary across countries and are different from zero. They argue that the level of net foreign assets is a key state variable and a crucial determinant of the benefits of international financial integration. The values of the steady state net debt position relative to consumption set between -0.5 and 0.5 appear reasonable for OECD countries.

4.2 Impulse Response Analysis

4.2.1 Current Account Dynamics with Flexible Prices

**Money Supply Shocks** With perfectly flexible prices, money is indeed neutral in our model. Under a 1% unforeseen permanent money supply shock, the prices (domestic price and non-traded goods prices) instantly adjust and jump to the new equilibrium levels by 1%, and the current account remains at zero at all times. The fact that the small open economy holds positive or negative initial debt does not affect the result in this analysis.

**World Interest Rate Shocks** With zero initial debt holding, upon a temporary 1% increase of the world interest rate, domestic currency depreciates, exports increases and imports decreases. The current account will go into surplus upon the positive temporary world interest rate shock in period 1, then go back to balance the next period. With a positive debt holding, the current account goes into surplus in period
1 upon the shock, then goes down to deficit in period 2, and goes back to zero at last in period 3. Upon the shock, as the domestic interest rate increases, consumption decreases, household works more, traded good output increases. Household consumes less and produces more of the traded good, so the current account improves right away. However, as the economy is holding debt, it has to pay higher interests, this increased interest payment causes the current account to dive into deficit in the next period. As the shock is only temporary, everything goes back to its initial equilibrium level again. Similarly, if the country holds foreign assets initially, the current account improves right away in period 1 and will not go to zero in period 2 because of the increased interest income from holding foreign assets, but still goes back to balance finally. See Figure 1 for the current account responses to a 1% temporary increase of the world interest rate.

**Technology Shocks with Zero Initial Net Foreign Assets** We also calibrate the current account dynamics to technology shocks in the traded good sector. The technology shock process takes the following form:

\[ \ln A_{T_{t+1}} = \mu_1 \ln A_{T_t} + \epsilon_{T_{t+1}} \]  \hspace{1cm} (4.14)

where \( \epsilon_{T_{t+1}} \) is the technology shock in the traded good sector, \( \mu_1 = 0.95 \) (following the real business cycle literature). Upon the persistent technology shock, as the traded good’s production is more efficient, the output of the traded good increases.

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

\[ \frac{C_{T_{t+1}}}{C_{T_t}} = \left[ \beta (1 + i_t) \right]^\frac{1}{\sigma} \left[ \frac{P_t}{P_{T_t}} \right]^{\frac{1}{\sigma} - \rho} \]

This is the same as in Lane (2001a). The consumption growth depends on the sequence of relative prices. If the aggregate price level relative to the price of traded goods is currently low comparing to its future value, this encourages present consumption over future consumption. Meanwhile, the relative higher future traded goods price also encourages consumption substitution from traded goods to non-traded goods.
former effect dominates if the intertemporal elasticity of substitution $\frac{1}{\sigma}$ is greater than the intratemporal elasticity of substitution $\rho$, i.e. $\frac{1}{\sigma} > \rho$, the spillover between non-traded and traded consumption is positive. When $\frac{1}{\sigma} < \rho$, the spillover between non-traded and traded consumption is negative, as the intratemporal substitution effect dominates the intertemporal substitution effect.

With an unexpected 1% temporary persistent technology shock in the traded good sector, the traded good sector’s output will increase as the production of the traded good is more efficient. As real exchange rate appreciates, domestic consumption of the traded good also increases. The increase in the output of the traded good is greater than the increase in the consumption of the traded goods, the current account goes into surplus upon the impact of the shock. With our basic calibration, upon the 1% technology shock in the traded good sector, the current account demonstrates a 0.27% surplus of the current period GDP ratio. As the technology shock is very persistent, the output of the traded good gradually decreases from the maximum level upon the impact. After 18 quarters, the consumption becomes greater than the production of the traded good, the current account sinks into deficit and reaches a 0.039% GDP ratio deficit after 37 quarters.

With the technology shock, in our basic calibration $\sigma = 2$, i.e. $\frac{1}{\sigma} < \rho = 0.75$, the spillover between non-traded and traded consumption is negative. If we change $\sigma = 0.5$, so that $\frac{1}{\sigma} > \rho$, the non-traded consumption moves together with the traded consumption to the same direction. In this case, the traded good consumption increases more than in the case where $\sigma = 2$. Upon the shock, the current account still goes into surplus, but less than in the basic case, only 0.24% of the current GDP. Figure 2 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 non-traded goods sector. The parameter $\theta$ measures the degree of price stickiness in the non-traded goods sector. In our basic calibration $\theta = 77$, the non-traded goods prices fully adjust 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 non-traded goods. When $\frac{1}{\sigma} < \rho$, the spillover between non-traded consumption and traded consumption is negative, as the intratemporal substitution effect dominates the intertemporal substitution effect. Increased consumption of non-traded goods means that the traded good consumption decreases. Increased production of non-traded goods also crowds out the production of the traded good. As a result, the traded production decreases upon the shock. Both consumption and production of the traded good decrease. In our basic calibration, the inverse elasticity of labor supply is 0.5, the production of traded good decreases less, so the current account improves upon the impact of the shock. 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). At the same time, non-traded goods production crowds out the traded good production. So the current account goes into deficit. Figure 3 shows the current account responses.
to an unexpected 1% positive money growth shock with $\sigma = 2$ and $\sigma = 0.5$ when $\rho = 0.75$.

With the same monetary shock, the inverse elasticity of labor supply $\psi$ also affect the responses of the current account. When the inverse elasticity of labor supply increase and the elasticity of labor supply decreases, household is willing to provide less labor with the shock. As the demand for non-traded goods increase, the labor supply for non-traded goods has to increase. The traded good output decreases more with the same shock. The current account will show less surplus upon the shock. Figure 4 gives the current account responses to the monetary shock with different elasticity of labor supply.

Equation (2.10) shows that changes in monetary supply generate changes in $\frac{P_{Nt}(t)}{P_{Nt-1}(t)}$ dynamics, and this will affect the markup and the current account. With monopolistic competition, the non-traded goods’ output fall below the competitive level. At steady state, as $\lambda$ increases, the markup of the non-traded goods firm decreases. With less monopolistic competition, the non-traded firms are more competitive and have higher output of non-traded goods. The surprise monetary expansion shock will increase the output in the non-traded goods sector and tend to correct the monopolistic distortion. With a higher $\lambda$, as the equilibrium non-traded outputs are already higher, the monetary expansion will cause the non-traded goods’ outputs to increase less. So the traded good output will decrease less with a higher $\lambda$ \(^8\). In out basic calibration, when $\frac{1}{\sigma} < \rho$, so the increased the consumption of non-traded goods accompanied by decreased consumption of the traded good. As non-traded consumption increases less with a higher $\lambda$, the traded consumption also decreases less. So now, we have both consumption and production of the traded good decrease less with the lower markup. Figure 5 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 (3.14) deteriorates when $\frac{1}{\sigma} < \rho$. This is the same result\(^8\).

\(^8\)The increased non-traded goods production will crowd out the traded good production.
as Lombardo (2002).

However, Figure 6 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 traded consumption increases together with the non-traded consumption, and will increase less with a higher $\lambda$. So now with the higher $\lambda$ and lower markup, the traded output decreases less and traded consumption increases less. Therefore, the current account improves.

**Technology Shocks** We still use the technology shock Equation (4.14) 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 now. The increase in the output is greater than the increase in the consumption of the traded good and the current account demonstrates surplus upon the impact of the shock. With our basic calibration, the magnitude of the current account response is 0.27% of the current period GDP upon the shock. The current account has an over-adjustment deficit up to 0.039% of the current GDP.

### 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 (4.14). 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:

$$\ln M_t = \ln M_{t-1} + \mu(\ln M_{t-1} - \ln M_{t-2}) + \epsilon_{Mt} \quad \epsilon_{M1} = a_1\epsilon_{T1}$$

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 in the non-traded goods sector. With a 1% unexpected positive technology shock in the traded good sector, the sector increase its production as the production is more efficient now. The increased production of the traded good crowds out the non-traded goods production. Due to the monopoly distortion in the non-traded goods sector, the non-traded goods’ output is already sub-optimally low. The monetary authority can increase the 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 real economic activities. As the prices are sticky in the non-traded goods sector, domestic output is demand-determined in the short-run. The surprise monetary expansion boosts the current 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 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 economy. This effect 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 money supply will minimize the monopolistic distortion for the non-traded goods sector. 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 non-traded goods sector improves household’s welfare.
With the basic calibration, the optimal value of the magnitude of the money injection parameter $a_1$ equals to 12.4. Upon the unforeseen 1% technology shock in the traded good sector, the monetary authority can increase its money supply by 12.4%. This optimal monetary policy will increase the household’s welfare by 0.00954%. The monetary policy can enable the household to have a 0.0095% higher welfare than in a flexible prices economy. The optimal monetary policy also affects the current account responses and magnifies the initial current account/GDP responses upon the shocks by 39.4%. Figure 8 shows the impulse responses under sticky prices and with the optimal monetary policy.

If there is no monopolistic competition in the non-traded goods sector, the benefit for the monetary authority to use the surprise money expansion will virtually disappear. The monetary authority will not be able to exploit the non-traded goods’ firms pricing decisions. This amounts to a commitment monetary policy. 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 non-traded goods sector. We assume that the government runs balanced budgets. The government taxes non-traded 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 non-traded good firm output $P_{Nt}(i)Y_{Nt}(i)$ 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 $T_{f_t} = \tau P_{Nt}(i)Y_{Nt}(i)$.

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

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

In this case, there is no monopolistic distortion in the non-traded goods sector. The non-traded outputs are already at the optimal level. The surprise monetary expansion
can not increase the non-traded goods’ production above the optimal level. The optimal monetary policy only increases the household’s welfare by a negligible amount. With only price rigidity distortion in this economy, the optimal level of the money injection parameter \( a_1 \) equals to 0.01. Upon the unforeseen 1% technology shock in the traded good sector, the monetary authority can increase its money supply by 0.01%. This optimal monetary policy will increase the household’s welfare by a negligible \( 2 \times 10^{-8} \% \). This indicates that it can not enable the household to have higher welfare than in a flexible prices economy. The optimal monetary policy also affects the current account responses, the policy magnifies the initial current account/GDP responses upon the shock by only 0.03%. Figure 9 shows the current account responses under sticky prices, flexible prices and with the optimal monetary policy.

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 types of shocks. With monopolistic competition in the non-traded goods sector, surprise monetary expansion responding to an unexpected technology shock will increase the household’s welfare.

For future research. 1) In our model, there is no monopolistic competition in the traded good sector, adding monopolistic competition in the traded good sector may help us to better understand the current account determination. Devereux (2000) shows that the degree of local currency pricing (LCP) will also affect the behavior of the current account. Adding LCP in this model, we can explore how the local currency pricing affects the optimal monetary policy and the current account dynamics. 2) Labor is the only factor in this paper. Since output is demand-determined in the short run, this modelling of the supply side enhances tractability. However, Chari, Kehoe, and McGrattan (2002) argue that adding capital is important because monetary shocks
can cause investment booms by reducing the short-run interest rate. Adding capital in this model may make the current account dynamics more profound. 3) Extending the model to a two-country world will help us understand better the real exchange rate dynamics and the effects of monetary authorities interactions.

References


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**APPENDIX**

A  Flexible Price equilibrium Conditions

The flexible price equilibrium conditions:

\[(1 + i_t)D_{t-1} = D_t + P_t^* [A_{t} H_{t}\gamma - (1 - a)(\frac{P_{t}}{\bar{P}_{t}})^{-\rho} C_t]\] (A.15)

\[\frac{\lambda}{\lambda - 1} e_t P_t^* A_{t} \gamma H_{t}\gamma - 1 = \alpha A_{Nt} H_{Nt}^{-1} P_{Nt}\] (A.16)

\[\frac{e_t P_t^* A_{t} \gamma H_{t}\gamma - 1}{P_t} = \eta C_t^{-\sigma} (H_{Nt} + H_{Tt})^{\psi}\] (A.17)

\[P_t = \left(\alpha P_{Nt}^{1-\rho} + (1 - a) P_{Tt}^{1-\rho}\right)^{1/\psi}\] (A.18)

\[A_{Nt} H_{Nt}^\alpha = a (\frac{P_{Nt}}{P_t})^{-\rho} C_t\] (A.19)

\[(\frac{M_t}{P_t})^{-\epsilon} = \frac{1}{\chi} C_t^{-\sigma} \left(1 - \beta \frac{C_t^{-\sigma}}{C_t^{-\sigma}}\right)\] (A.20)

\[1 = \beta e_{t+1} C_t^{-\sigma} \frac{P_t}{e_t C_t^{-\sigma} P_{t+1}} (1 + i_t)\] (A.21)

\[i_t = i_t^* + \psi_2 (e^{D_t - \bar{d}} - 1)\] (A.22)

B  Tables

Table 1 reports the baseline calibration assumptions. I took the parameter values from other papers.

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Figure 1: Current account responses with flexible prices to a 1% temporary world interest rate increase
Figure 2: Impulse responses with flexible prices to an unexpected positive 1% technology shock in the traded good sector.

\[ \sigma = 2, \quad \rho = 0.75 \]
\[ \sigma = 0.5, \quad \rho = 0.75 \]
Figure 3: Impulse responses to an unexpected 1% money supply increase

\[ \sigma = 2, \quad \rho = 0.75 \]
\[ \sigma = 0.5, \quad \rho = 0.75 \]
Figure 4: Impulse responses to an unexpected 1% money supply increase
Figure 5: Impulse responses to an unexpected 1% money supply increase
Figure 6: Impulse responses to an unexpected 1% money supply increase
Figure 7: Current account responses to a 1% positive technology shock in the traded good sector

Figure 8: Current account responses to the optimal monetary policy with no firm subsidies
Figure 9: Current account responses to the optimal monetary policy with firm subsidies