# Transfer Problem and Exchange Rate Regimes

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**Abstract**

Different forms of shifts in wealth between countries have brought the transfer problem back into focus in international macroeconomics in recent years. In this paper, we study the choice of exchange rate regimes when a transfer takes place from home to foreign country using a two-country DSGE model. Our results support the "orthodox" view of Keynes (1929) that a transfer leads to terms of trade deterioration in the donor country, regardless of the choice of exchange rate regimes. Historical evidence shows that donor countries usually chose to abandon the specie-standard after some negative shocks, so that the countries had more flexible monetary policies to alleviate the transfer effects. Our model also implies flexible exchange rate can help to reduce the negative effects on consumption in the donor country. In contrast, however, the welfare analysis suggests that abandoning the gold standard and going to a floating exchange rate cannot make the donor country better off. This result holds even if nominal rigidities are present.

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# 1 Introduction

The economic effects of an international payment between countries, which is referred to as the "transfer problem" in international economics, have been studied extensively since the debate between Keynes (1929) and Ohlin (1929) in the 1920s. Transfer is a shift in wealth, which is a shift in purchasing power, between countries within a reasonably short period of time, and it exists in different forms. In economic history, the transfer between countries usually occurred in terms of a reparation payment after a war from the defeated party to the defeater. For instance: the Franco-Prussian war payment of 1871 - 1873; the reparation payment by Germany to the Allies after WWII; and the Gulf War reparation in the 1990s. Economic aid given to countries in need, in the event of a humanitarian crisis, or aid given to assist the development of a less developed country is also viewed as a transfer. Transfers sent by immigrants in form of remittances from developed to their less developed home countries also raise the study of the impact of migration on economic development. In recent years, the rising prices of resources in the global economy also give rise to a concern about transfers of income and wealth from the oil-importing countries to the oil-producing countries. In addition, global trade imbalances in which incomes are transferred from the trade-deficit countries (such as the US) to the trade-surplus countries (for instance, China) have led to studies on the current account adjustments.[1] All of these issues have brought the transfer problem back into focus in international macroeconomics.

A vast amount of literature has been written about the transfer problem in the past century. The transfer problem is originally studied in real models, which focused on the effects on terms of trade. Keynes (1929) and Ohlin (1929) study the German reparations after WWI, and focus on the impacts of transfers on terms of trade and real exchange rates. Keynes (1929) argues that a transfer leads to terms of trade and real exchange rate deterioration in the donor country, which leaves the donor with an extra burden. Ohlin (1929), however, criticizes Keynes' analysis, and argues that this "orthodox" view may not hold, since income effects can make the terms of trade adjustments redundant. The controversy surrounding the transfer problem is later discussed based on the marginal propensities to import and save out of the transfer payments and receipts (see Johnson, 1955 and Samuelson, 1952).[2] Other studies focus on taste differences (Jones, 1970), and the existence of trade impediments and market distortions (Bhagwati et al., 1983 and Bezmen, 2006).

[1]For example, see Mckinnon (2007), Corsetti, Martin and Pesenti (2008).

[2]In general, based on the full multiplier analysis in a world without trade impediments, three general outcomes are possible for the terms of trade in response to a transfer: (1) the terms of trade will not be affected by a negative transfer if the relevant sum of marginal propensities sum to unity; (2) if the sum of marginal propensities is less than one, terms of trade will deteriorate and the donor country will suffer a secondary burden; (3) when the sum of relevant marginal propensities to import and save exceeds unity, terms of trade will improve at the transfer paying countries and it may enjoy gains from the transfer (Morrison, 1992).

All of these previous models on the transfer problem are generally static.[3] Relatively few works have been done using a dynamic, general-equilibrium macroeconomics model to address the transfer problem. In this paper, the model is similar to that of Devereux and Smith (2007), in which they use a real, DSGE model to study the quantitative, macroeconomic transfer effects of the Franco-Prussian War indemnity of 1981-1873, and their model explains the historical paths of French net exports and the terms of trade. Our model differs from theirs, however, in that the transfer effect is studied in a two-country world with money and nominal rigidities. We focus on the effects of a transfer on consumption, output, terms of trade, and welfare, under different exchange rate regimes. We look at the transfer effects under both the fixed exchange rate and the flexible exchange rate regimes. Specifically, the fixed exchange rate is modeled as a gold standard as well as a hard peg maintained by the home country. We then compare the transfer effects under different regimes and ask how the paying country's economy reacts to the negative transfer when the choice of exchange rate regime is different.

The optimal choice of exchange rate regime has also been studied extensively in the literature.[4] Countries' choice of exchange rate system ranges from the fully fixed exchange rate and specie-standards to the floating exchange rate regime. Fixed exchange rate regime provides exchange rate stability, but a floating exchange rate has the advantage of monetary independence that allows the governments to use monetary policies in response to country-specific shocks in the presence of nominal rigidities (Friedman, 1953). Mundell (1963) incorporates capital mobility to Friedman's (1953) analysis and finds that the choice between fixed and flexible exchange rates depends on the degree of capital mobility and the source of shocks (that is, real or nominal shocks).[5]

In past centuries, the international monetary system has alternated between a commodity-based fixed rate system and a fiat money floating rate system. The classical gold standard was once the dominant international monetary system of the developed countries in the late-$19^{th}$ and early-$20^{th}$ centuries, where the currencies of these countries were fixed to gold at some rates set by their governments. The gold standard was good for maintaining the external balance through the price-specie flow mechanism, but not for maintaining the internal balance. This specie-standard emerged as a system that made international investment and trade more efficient in its time.[6]

After the WWI, however, the reconstituted gold standard failed, and all developed countries abandoned the gold standard system in the early-1930s. Countries followed a float-

[3]See Chipman (1974), and Brakman and van Marrewijk (1998) for literature reviews on the transfer problem.

[4]Bordo (2003) looks at the choice of exchange rate regime in a historical perspective.

[5]With international capital mobility, the floating exchange rate provides insulation against real shocks, while fixed exchange rate serves as a nominal anchor in response to nominal shocks.

[6]For instance, see Bordo and Rockoff (1996), Estevadeordal, Frantz and Taylor (2003), and Obstfeld and Taylor (2003).

ing exchange rate in the interwar period. The creation of the Bretton Woods adjustable peg system in 1944 was aimed "to combine the advantages of the gold standard (sound money) with those of floating (flexibility and independence)." (Bordo, 2003) After the breakdown of the Bretton Woods system in the 1970s, due to difficulties in controlling the capital mobility, most developed countries either went to floating exchange rates or joined the European Monetary Union (EMU).

A trade-off exists between the ability of national governments to affect the national monetary conditions and the commitment to gold standard or to a fixed exchange rate. Therefore, the common practice of governments in the gold standard system was to go off the gold during major crises, such as wars or economic downturns (Frieden, 1997).[7] For instance, the British government suspended gold convertibility in the midst of Napoleonic Wars in 1797. Moreover, during the Great Depression, Great Britain, Germany, most of Central and Eastern Europe, Canada and Japan went off the gold standard in 1931.[8] Eichengreen (1985) even states that "the historical record provides little support for the theorist's vision of the gold standard as an ideal monetary regime." Yeager (1984) notes that proponents of the gold standard suggest a gold standard during peacetime with temporary departures during wartime, with the idea that it is more effective to finance government spending during wartime by paper money. Chernyshoff, Jacks and Taylor (2005) use a static model and argue that the failure of the gold standard after the pre-war period was due to the increase in nominal rigidities so that the gold standard could not help to absorb macroeconomic volatility. Following these arguments, it appears that if a country needs to pay a transfer to another country, especially in the presence of nominal rigidities, the national government should abandon the gold standard, at least temporarily, to allow the domestic monetary policies to alleviate some of the negative effects of the transfer on the domestic economy.

Given these arguments, we set up a model to answer two questions: what are the economic effects of a transfer of wealth between countries? Is the donor country better off if it goes off the gold standard during the payment of transfer? From these questions, we try to shed light on aspects of the optimal exchange rate regime in the presence of an international transfer.[9]

Our model shows that a transfer from home to foreign country leads to terms of trade deterioration in the donor country under all exchange rate regimes studied, regardless of whether or not nominal rigidities exist. Consumption falls in the donor countries in all regimes, except in those under the flexible exchange rate with nominal rigidities. Welfare

[7]Frieden (1997) points out that the failure of the gold standard after the interwar period was due to the lack of an international focal point and to the weak domestic political support for an international monetary cooperation.

[8]The United States suspended the gold convertibility in 1933.

[9]This model focuses on the effect of an exogenous one-time transfer. Thus, it relates more closely with the literature of war reparation, one-time economic aid and/ or remittance effect, but not the current account adjustment literature.

of the donor country also drops as the transfer shifts the wealth of the donor country to the recipient country. We also find that the flexible exchange rate fails to alleviate some of the negative effects of the transfer, in comparison to the case under the gold standard, and welfare is lower under the flexible exchange rate regime compared to that under the gold standard and the fixed exchange rate. This result does not agree with the standard argument in the literature about going off the gold standard in face of a transfer shock.

The rest of this paper is organized as follows. Section 2 develops a two-country model of the effects of transfer. Section 3 examines the effects of transfer under different exchange rate regimes. Section 4 studies the welfare effects of transfer and section 5 concludes.

# 2 The model

Consider an infinite horizon two-country model without capital. There is a continuum of households along the unit interval, consuming home- and foreign-produced goods, and providing heterogeneous labour services to final goods firms. Firms are competitive, using local labour for production. Nominal wages are set in advance by households-workers, before the production takes place.

## 2.1 Households

There are two countries, Home and Foreign, in this model. Home households' preferences are given by:

$$\mathcal{U} = \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\chi}{1-\varepsilon} \left( \frac{M_t}{P_t} \right)^{1-\varepsilon} - \frac{\eta}{1+\psi} H_t^{1+\psi} \right) \tag{2.1}$$

where $M_t$ is the quantity of domestic money held by households, $\frac{1}{\psi}$ is the elasticity of labour supply, and $C_t$ is the composite of consumption of home- (X) and foreign-produced (M) goods, given by:

$$C_t = \left( \gamma^{\frac{1}{\theta}} C_{Xt}^{1-\frac{1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}} C_{Mt}^{1-\frac{1}{\theta}} \right)^{\frac{1}{1-\frac{1}{\theta}}} \tag{2.2}$$

$\gamma$ represents the relative preference for home-produced goods and $\theta$ is the elasticity of substitution between good X and good M. We assume $\gamma > \frac{1}{2}$, indicating there is some home bias in households' preferences. The price index is given by:

$$P_t = \left( \gamma P_{Xt}^{1-\theta} + (1-\gamma) P_{Mt}^{1-\theta} \right)^{\frac{1}{1-\theta}} \tag{2.3}$$

Households receive their wage income, inter-country transfers, initial money balances, and investment income.[10] With those incomes, they purchase consumer goods, hold money and accumulate bonds:

$$P_t C_t + B_{t+1} + M_t = W_t H_t + M_{t-1} + T_t + (1 + i_t) B_t \tag{2.4}$$

Households choose money balances and consumption of home and foreign goods to maximize utility, subject to their budget constraint. The demand for each good, $C_{Xt}$ and $C_{Mt}$, the demand for money balances and the corresponding Euler equation are:

$$C_{Xt} = \gamma \left( \frac{P_{Xt}}{P_t} \right)^{-\theta} C_t \tag{2.5}$$

$$C_{Mt} = (1 - \gamma) \left( \frac{P_{Mt}}{P_t} \right)^{-\theta} C_t \tag{2.6}$$

$$\frac{M_t}{P_t} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}}\right)^{\frac{1}{\varepsilon}}} \tag{2.7}$$

$$\frac{1}{1 + i_{t+1}} = \beta \frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}} \tag{2.8}$$

Foreign economy conditions are analogous to the home conditions, and foreign variables are denoted by an asterisk.

## 2.2 Firms

Final goods $X$ and $M$ are produced competitively using differentiated domestic labour inputs by home and foreign respectively. An individual producer in the home country has the production function:

$$X_t = \left( \int_0^1 h_t(i)^{1-\frac{1}{\lambda}} di \right)^{\frac{1}{1-\frac{1}{\lambda}}} \tag{2.9}$$

where $\lambda > 1$ is the elasticity of substitution between labour varieties, and $h_t(i)$ is the employment from individual $i$. This gives the labour demand for type $i$ labour as:

$$h_t(i) = \left( \frac{W_t(i)}{P_{Xt}} \right)^{-\lambda} X_t \tag{2.10}$$

Firms are competitive, and the price of the home goods in a symmetric equilibrium is determined as:

$$P_{Xt} = \left( \int_0^1 W_t(i)^{1-\lambda} di \right)^{\frac{1}{1-\lambda}} = W_t \tag{2.11}$$

[10] We assume the international transfers are distributed (withdrawn) directly to (from) the households by the government.

The home goods market clearing condition is:

$$H_t = \gamma \left( \frac{P_{Xt}}{P_t} \right)^{-\theta} C_t + (1-\gamma) \left( \frac{P_{Xt}}{P_t^*} \right)^{-\theta} C_t^* \tag{2.12}$$

### 2.3 Wage-setting

We assume each individual $i$ is a monopolistic supplier of her own type of labour. Labour supply is chosen to maximize utility, and the utility-maximizing wage is derived as:

$$W_t(i) = \eta \frac{\lambda}{\lambda - 1} P_t C_t^{\sigma} h_t(i)^{\psi} \tag{2.13}$$

That is, wage is set as a markup over the "marginal disutility" of labour.

## 3 Effects of a transfer

In this section, we would like to investigate the effects of a transfer under different exchange rate regimes. First, we study the transfer effects under the fixed exchange rate regime, which is modeled as a gold standard setting. We also look at the case when the fixed exchange rate regime is maintained by the home country, which adjusts its domestic money supply endogenously to maintain the fixed rate. Then, the effects of transfer under the flexible exchange rate regime will be examined.

We also assume there are incomplete markets in the economy. The effects of a transfer will be washed out if we have a perfectly pooled equilibrium. Thus, we assume a transfer takes place unexpectedly at the initial period (period 0). Finally, we assume that nominal wages may be fixed in advance. We simply assume that the wages are fixed for only one period, and they can fully adjust after the first period. We will study the impacts of the transfer in the economy with flexible wages, and then compare the results with those of the fixed wage economy.

### 3.1 Gold standard economy

Assume there is a fixed world stock of gold, $\bar{M}$, and home and foreign countries can increase or reduce their share of world gold holding via balance of payments surpluses or deficits. The nominal money stock in the model is then thought of as species, and therefore, all prices are in terms of gold. Gold serves as the medium of exchange in this model. International bonds are also gold denominated.[11]

[11] We may also model the gold standard regime by assuming the home and foreign governments fix the prices of their domestic currency in terms of a specified amount of gold, with free convertibility. This setup will add extra equations to the model, linking the conversion rate between gold and currencies, however, the results will be the same as this commodity model. For simplicity, we use this commodity model for analysis.

### 3.1.1 Flexible wage (gold standard)

Using the setup in Section 2, we can obtain the full flexible wage symmetric equilibrium system under the gold standard (see Appendix A).

In equilibrium, the money market clears, and we have:

$$\bar{M} = M_t + M_t^* \tag{3.1}$$

In this economy, terms of trade is denoted as:

$$TOT_t = \frac{P_{Xt}}{P_{Mt}} \tag{3.2}$$

We log-linearize the model around the initial steady state to derive some useful analytical properties of the equilibrium. In the steady state, we have $C = C^* = \bar{C}$, $H = H^* = \bar{H}$, $M = M^* = \bar{M}$, $\frac{1}{1+i} = \beta$, $\frac{\bar{P_X}}{\bar{P_M}} = 1$, and $B = 0$. Let $\hat{z} = \ln\left(Z_t/\bar{Z}\right)$, that is, the hat variables are log differences from the steady state.[12]

With a fixed stock of gold in the world economy, log-linearized gold market clearing condition becomes:

$$0 = \hat{m}_t + \hat{m}_t^* \tag{3.3}$$

The two money market conditions imply that the relative money demand depends on the consumption difference and the terms of trade ($\hat{\tau}_t$):

$$\hat{m}_t - \hat{m}_t^* = (2\gamma - 1)\hat{\tau}_t + \frac{\sigma}{\varepsilon}(\hat{c}_t - \hat{c}_t^*) \tag{3.4}$$

The output difference also depends on the consumption difference and the terms of trade, and it can be derived from the two goods market clearing conditions[13]:

$$\hat{h}_t - \hat{h}_t^* = -4\theta\gamma(1-\gamma)\hat{\tau}_t + (2\gamma - 1)(\hat{c}_t - \hat{c}_t^*) \tag{3.5}$$

Using the labour market conditions and goods market clearing conditions, we get an expression for the terms of trade as:

$$\hat{\tau}_t = \left[\frac{\sigma + \psi(2\gamma - 1)}{2(1-\gamma) + 4\psi\theta\gamma(1-\gamma)}\right](\hat{c}_t - \hat{c}_t^*) \equiv \Phi(\hat{c}_t - \hat{c}_t^*) \tag{3.6}$$

That is, the change in terms of trade also depends on the consumption difference.

**Proposition 1** (Real interest rates, world consumption and output). *Under the gold standard when wages are flexible, the real interest rates are equalized across countries, and the world*

[12]See Appendix A for the full log-linearized system.

[13]The log-linearized goods market clearing conditions can also be interpreted as the world demand schedule of home and foreign goods.

*consumption and output changes are zero.*

*Proof.* The difference of home and foreign Euler equations is:

$$\sigma \left[ \left( \hat{c}_{t+1} - \hat{c}^*_{t+1} \right) - \left( \hat{c}_t - \hat{c}^*_t \right) \right] = -(2\gamma - 1) \left( \hat{\tau}_{t+1} - \hat{\tau}_t \right)$$

Combining this equation with equation (3.6), we can show:

$$\hat{c}_{t+1} - \hat{c}_t = \hat{c}^*_{t+1} - \hat{c}^*_t \tag{3.7}$$

which implies that real interest rates are equalized across countries.

By adding the home and foreign market clearing conditions and the pricing equations, we get $\hat{c}_t + \hat{c}^*_t = \hat{h}_t + \hat{h}^*_t$. Using this condition together with the labour market equilibrium conditions, we get $\hat{c}_t + \hat{c}^*_t = 0$, and hence:

$$\hat{c}_t + \hat{c}^*_t = \hat{h}_t + \hat{h}^*_t = 0 \tag{3.8}$$

□

Using the fact that real interest rates are equalized across countries and the movement in the world output is zero, as well as the condition that $\hat{m}_t = -\hat{m}^*_t$ from the world gold market clearing condition, we can derive the money balances, labour and terms of trade expressions as:

$$\hat{m}_t = \frac{2\gamma - 1}{2} \hat{\tau}_t + \frac{\sigma}{\varepsilon} \hat{c}_t \tag{3.9}$$

$$\hat{h}_t = -2\theta\gamma(1-\gamma)\hat{\tau}_t + (2\gamma - 1)\hat{c}_t = [-4\theta\gamma\Phi(1-\gamma) + (2\gamma - 1)]\hat{c}_t \tag{3.10}$$

$$\hat{\tau}_t = \left[ \frac{\sigma + \psi(2\gamma - 1)}{2(1-\gamma) + 4\psi\theta\gamma(1-\gamma)} \right] 2\hat{c}_t \equiv 2\Phi\hat{c}_t \tag{3.11}$$

We use the home country budget constraint to study the impact of a transfer on consumption, output and terms of trade.

Substitute (3.9), (3.10) and (3.11) into the log-linearized home budget constraint, we can get:

$$\begin{aligned} & \hat{c}_t + \frac{dB_{t+1}}{\bar{P}\bar{C}} + \omega \left( (2\gamma - 1)\Phi\hat{c}_t + \frac{\sigma}{\varepsilon}\hat{c}_t \right) \qquad (3.12) \\ = \quad & (1-\gamma)2\Phi\hat{c}_t + (2\gamma - 1)\hat{c}_t - 2\theta\gamma(1-\gamma)2\Phi\hat{c}_t + \omega \left( (2\gamma - 1)\Phi\hat{c}_{t-1} + \frac{\sigma}{\varepsilon}\hat{c}_{t-1} \right) + \frac{1}{\beta}\frac{dB_t}{\bar{P}\bar{C}} + \frac{dT_t}{\bar{P}\bar{C}} \end{aligned}$$

where $\omega = \frac{\bar{M}}{\bar{P}\bar{C}}$ and $dZ_t = Z_t - \bar{Z}$.

We can now use (3.12) to work out the impact of a one-time, unanticipated transfer away from the home country in period 0 (that is, $dT_0 < 0$).

In the period of the transfer taking place, we have $\hat{c}_{-1} = 0$ and $dB_0 = 0$. Since we already know that $\hat{c}_{t+1} = \hat{c}_t$ for $t \geq 0$, to keep consumption the same in every future period after 1, we must have $dB_{t+1} = dB_t$ for $t \geq 1$. Take the difference of period 0 and period 1 budget constraints, and use the period zero condition, rearrange, and we can solve for $\hat{c}_0$:

$$\hat{c}_0 = \frac{1-\beta}{\Delta}\frac{dT_0}{\bar{P}\bar{C}} < 0 \tag{3.13}$$

where $\Delta = 2(1-\gamma)(1-\Phi(1-2\theta\gamma)) + (1-\beta)\omega\left((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\right)$. The sufficient condition for the denominator, $\Delta$, to be positive is that $\theta \geq \frac{1}{2\gamma}$.[14] Thus, given a large enough elasticity of substitution between home and foreign goods, the impact of a transfer away from home on consumption is negative. The negative transfer also induces an immediate balance of payments deficit at home country, and the home terms of trade deteriorates:

$$\hat{m}_0 = \left((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\right)\hat{c}_0 < 0$$

$$\hat{\tau}_0 = 2\Phi\hat{c}_0 < 0$$

The transfer effect on home output depends on the elasticity of labour supply.[15] If the elasticity of labour supply is zero, that is, $\psi \to \infty$, the transfer has no effect on output, and we have:

$$\hat{h}_0 = 0$$

With infinite elasticity of labour supply, $\psi = 0$, we have:

$$\hat{h}_0 = -\left[1 - 2\gamma(1-\sigma\theta)\right]\hat{c}_0 > 0$$

Home output increases in response to a negative transfer if $\sigma\theta > 1$. The home capital account becomes negative after a transfer takes place:

$$\frac{dB_1}{\bar{P}\bar{C}} = \beta\frac{dT_0}{\bar{P}\bar{C}}\left(1 - \frac{(1-\beta)\omega\left((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\right)}{\Delta}\right) < 0$$

Therefore, the home country borrows abroad in period 0 to partly cushion the impacts of the

[14] Because $1 - \Phi(1-2\theta\gamma) > 0$ when $\theta \geq \frac{1}{2\gamma}$.

[15] In later sections, we calibrate the transfer effect using unit elasticity of labour supply. We find that with $\psi = 1$, output increases after a negative transfer under flexible wage.

transfer on consumption and gold holdings.

### 3.1.2 Sticky Wage (Gold Standard)

Now we look at the implication of the transfer with sticky nominal wages in the first period (that is, at the period of the transfer that takes place, so that $P_{X0} = W_0 = \bar{W}$ and $P^*_{M0} = W^*_0 = \bar{W}^*$). After realizing the negative transfer shock, wages can fully adjust from the second period onwards. When wages are fixed in period 0, then prices are also fixed.

The system of equilibrium conditions describing the first period is presented in Appendix A.[16] The difference of the period 1 Home and Foreign Euler equations yield:

$$\hat{c}_1 = \frac{\sigma(\hat{c}_0 - \hat{c}^*_0)}{2\left[\sigma + (2\gamma - 1)\Phi\right]} \tag{3.14}$$

We use the difference of the home and foreign country period 0 budget constraints, together with money demand equations, money market and goods market clearing conditions to get:

$$(\hat{c}_0 - \hat{c}^*_0)\left(2(1-\gamma) + \frac{\omega\sigma}{\varepsilon}\right) + \frac{2dB_1}{\bar{P}\bar{C}} = \frac{2dT_0}{\bar{P}\bar{C}} \tag{3.15}$$

Since equations (3.14) and (3.15) give us two conditions in three variables: $\{\hat{c}_1, (\hat{c}_0 - \hat{c}^*_0), \frac{dB_1}{\bar{P}\bar{C}}\}$, we need to use the period 1 and onwards conditions to solve for all three variables. Period 1 and period 2 budget constraints give an expression for $\hat{c}_1$ in terms of $(\hat{c}_0 - \hat{c}^*_0)$ and $\frac{dB_1}{\bar{P}\bar{C}}$.

Then we get an equation of consumption difference at period 0 using $\hat{c}_1$ and equation (3.15):

$$\hat{c}_0 - \hat{c}^*_0 = \frac{2}{\left(2(1-\gamma) + \frac{\omega\sigma}{\varepsilon}(1-\beta)\right) + \left(\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}\frac{\beta}{1-\beta}\right)}\frac{dT_0}{\bar{P}\bar{C}} \tag{3.16}$$

The denominator is positive as long as $\Delta > 0$, or $\theta \geq \frac{1}{2\gamma}$. Thus, a transfer from the home country reduces home relative consumption in period 0.

From (3.16) and the goods market clearing conditions in the home country, we can state the following results:

**Proposition 2** (Gold standard, sticky wages)**.** *Under the gold standard and when wages are sticky in period 0, a negative transfer away from home leads to a fall in consumption, a fall in output, and a balance of payments deficit in period 0; however, terms of trade is not affected.*

[16] In this wage stickiness case, we omit the wage-setting equations, the zero-profit conditions, and the definitions of the consumer price index when we solve the model. To solve for the impact of transfer in the first period when wages are sticky, we must use the solution from the flexible wage system, because the sticky wage system contains variables dated period 1 (in which wages are flexible). Thus, we need to tie both solutions together.

*Proof.* In order to find the impacts of the negative transfer on consumption and output, we use the two money market equilibrium conditions in period 0 to get:

$$\hat{m}_0 + \hat{m}_0^* = \frac{\sigma}{\varepsilon}(\hat{c}_0 + \hat{c}_0^*) + \varphi\left(\sigma(\hat{c}_0 + \hat{c}_0^*) - \sigma(\hat{c}_1 + \hat{c}_1^*) + (\hat{p}_1 + \hat{p}_1^*)\right)$$

where $\varphi = \frac{\beta}{\varepsilon}(1-\beta)^{\frac{1}{\varepsilon}-1}$.

We know that $\hat{m}_0 + \hat{m}_0^* = 0$ and $\hat{c}_1 + \hat{c}_1^* = 0$ from the gold market clearing condition and the zero movement in world output. Moreover, from the period 1 money market conditions onwards, we have $\hat{p}_1 + \hat{p}_1^* = 0$. These conditions imply $\hat{c}_0 + \hat{c}_0^* = 0$. Thus, even with sticky wages, the transfer does not affect world consumption and output in the period that the transfer takes place, that is, $\hat{h}_0 + \hat{h}_0^* = 0$. Using these facts and money demand equations, goods market clearing conditions, and equation (3.16), we can get:

$$\begin{aligned}
\hat{c}_0 &= \frac{1}{\left(2(1-\gamma) + \frac{\omega\sigma}{\varepsilon}(1-\beta)\right) + \left(\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}\frac{\beta}{1-\beta}\right)}\frac{dT_0}{\bar{P}\bar{C}} < 0 \\
\hat{h}_0 &= \gamma\hat{c}_0 + (1-\gamma)\hat{c}_0^* = (2\gamma-1)\hat{c}_0 < 0 \\
\hat{m}_0 &= \frac{\sigma}{\varepsilon}\frac{1}{\left(2(1-\gamma) + \frac{\omega\sigma}{\varepsilon}(1-\beta)\right) + \left(\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}\frac{\beta}{1-\beta}\right)}\frac{dT_0}{\bar{P}\bar{C}} < 0
\end{aligned}$$

Since wages are sticky, prices are fixed as well. Thus, $\hat{\tau}_0 = \hat{p}_{Xt} - \hat{p}_{Mt} = 0$. □

Therefore, a transfer away from home to foreign country leads to a fall in period 0 home consumption when wages are sticky. There is a fall in home output rather than an increase when there are nominal rigidities.[17] The transfer does not affect the terms of trade when wages are sticky. Therefore, the negative transfer reduces home country output by lowering the demand for home product, and increases the foreign country output by raising the demand for foreign's product.

[17] This result holds for any value of the elasticity of labour supply.

## 3.2 Fixed exchange rate regime

Now assume that both home and foreign leave the gold standard, but instead, the home country maintains a fixed exchange rate with the foreign country by adjusting its domestic money supply endogenously.[18] We may think of this situation as one that the home country wants to have a hard peg arrangement, such as a currency board, to maintain exchange rate stability within the country. Home and foreign now have their own fiat currency, and the home money supply expands or contracts endogenously with the balance of payments and the state of the economy. What will be the effects of a transfer on home country with such an exchange rate arrangement in period 0?

Assume that the exchange rate is set at $\bar{S}$ so that $S_t = \bar{S}$ for $t \geq 0$. Once the two countries have suspended the gold standard, the condition $\bar{M} = M_t + M_t^*$ no longer holds. Prices are no longer in terms of species, but rather, in fiat money. Home and foreign monetary policies follow: $M_t = M_{t-1} + \mu_t$ and $M_t^* = M_{t-1}^* + \mu_t^*$, respectively, in which the foreign policy is exogenously determined by the foreign government, but the money supply at home is endogenously determined to maintain the fixed exchange rate.[19]

### 3.2.1 Flexible wage (fixed exchange rate)

The log-linearized terms of trade under this fixed exchange rate regime is:

$$\hat{\tau}_t = \hat{p}_{Xt} - \hat{p}_{Mt}^* \tag{3.17}$$

as $\hat{s}_t = 0$. Since the foreign monetary policy is exogenous, we have $\hat{m}_t^* = 0$. Change in home money stock, $\hat{m}_t$, on the other hand, is endogenously determined by the money balances conditions and the pricing rules:

$$\hat{m}_t = \left((2\gamma - 1)\Phi + \frac{\sigma}{\varepsilon}\right)(\hat{c}_t - \hat{c}_t^*) \tag{3.18}$$

From the market clearing conditions and pricing equations, we can show that the output difference under the fixed exchange rate is the same as the one in the gold standard system (equation (3.5)).

Besides, the Euler equations and pricing equations yield the same terms of trade expression as (3.6). Similar to the gold standard case, we can show equalization of real interest rates and zero world output movements as in proposition 1.

We perform the same exercise as those under the gold standard regime to derive the period 0 and period 1 budget constraints), and use the fact that $\hat{c}_1 = \hat{c}_0$ and $dB_1 = dB_2$ to

[18] On the other hand, foreign country's monetary policy is assumed to be exogenous.

[19] The full system of equilibrium conditions and log-linearized system can be found in Appendix B.

get:

$$\frac{dB_1}{\bar{P}\bar{C}} = \beta \frac{dT_0}{\bar{P}\bar{C}} < 0$$

and,

$$\hat{c}_0 = \frac{1-\beta}{2(1-\gamma)\left(1-\Phi(1-2\gamma\theta)\right)} \frac{dT_0}{\bar{P}\bar{C}} < 0 \tag{3.19}$$

When we compare (3.19) to the corresponding expression under the gold standard, we find that the denominator of the gold standard expression, $\Delta$, is smaller than the one in (3.19). This implies that the negative transfer has a larger negative effect on period 0 home consumption under the fixed exchange rate regime than that under the gold standard. That is, home consumption falls by a larger amount after a negative transfer under fixed exchange rate regime.

We can also show a fall in money balances and a terms of trade deterioration in the home economy:

$$\hat{m}_0 = \left((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\right) 2\hat{c}_0 < 0$$

$$\hat{\tau}_0 = 2\Phi\hat{c}_0 < 0$$

Since the fall in period 0 home consumption is larger under the fixed exchange rate regime, we can deduce that the negative transfer induces a larger balance of payments deficit and a larger terms of trade deterioration under the fixed exchange rate regime than under the gold standard.[20]

For home output, if the elasticity of labour supply is zero, then there is no change in home output (that is, $\hat{h}_0 = 0$). If the elasticity of labour supply is infinite, then:

$$\hat{h}_0 = -\left[1 - 2\gamma(1-\sigma\theta)\right]\hat{c}_0 > 0$$

That is, output increases, but by a larger amount than that under the gold standard.

### 3.2.2 Sticky wage (fixed exchange rate)

We now turn to the sticky wage environment. Using the same assumption as before, wages are sticky for one period only, and they can be adjusted fully from the second period onwards. Then we have: $P_{X0} = W_0 = \bar{W}$; $P^*_{M0} = W^*_0 = \bar{W}^*$; and $S_t = \bar{S}$ for $t \geq 0$.

Period 1 and period 2 home budget constraints, together with the difference of the

[20]Under the gold standard, we have $\hat{m}_0^{GS} = (2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\ \hat{c}_0 = (2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\ \frac{1-\beta}{\Delta}\frac{dT_0}{\bar{P}\bar{C}}$. Equation (3.2.1) implies: $\hat{m}_0^{fixed} = (2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\ 2\hat{c}_0 = (2\gamma-1)\Phi + \frac{\sigma}{\varepsilon}\ \frac{1-\beta}{(1-\gamma)(1-\Phi(1-2\gamma\theta))}\frac{dT_0}{\bar{P}\bar{C}}$. Since $\Delta > (1-\gamma)(1-\Phi(1-2\gamma\theta))$, we must have $0 > \hat{m}_0^{GS} > \hat{m}_0^{fixed}$.

home and foreign period 0 budget constraints imply:

$$\hat{c}_0 - \hat{c}_0^* = \frac{1}{(1-\gamma)\left[1+\frac{\beta}{1-\beta}\frac{(1-\Phi(1-2\gamma\theta))\sigma}{\sigma+\Phi(2\gamma-1)}\right]}\frac{dT_0}{\bar{P}\bar{C}} < 0 \tag{3.20}$$

if $\theta \geq \frac{1}{2\gamma}$.

The effects of a transfer under the fixed exchange rate regime with sticky wages are stated as follows:

**Proposition 3** (Fixed exchange rate, sticky wages)**.** *Under the fixed exchange rate regime and when wages are sticky in period 0, a negative transfer away from home reduces period 0 consumption, output level and money balances in the home country. Terms of trade is not affected by the negative transfer.*

*Proof.* To solve for home period 0 consumption, we use home and foreign money market conditions and the Euler equations to get:

$$\hat{c}_0 = \left[\frac{2(\sigma+\Phi(2\gamma-1))}{\beta\sigma(\frac{1}{\varepsilon}-1)} + 1\right]\hat{c}_0^* \tag{3.21}$$

Use this equation together with (3.20) and the home money demand, we can derive the $\hat{c}_0$ and $\hat{m}_0$ expressions respectively:

$$\begin{aligned} \hat{c}_0 &= \frac{2\left(\sigma+\Phi(2\gamma-1)\right)+\beta\sigma\left(\frac{1}{\varepsilon}-1\right)}{2(1-\gamma)\left[\left(\sigma+\Phi(2\gamma-1)\right)+\frac{\beta}{1-\beta}\sigma\left(1-\Phi(1-2\gamma\theta)\right)\right]}\frac{dT_0}{\bar{P}\bar{C}} < 0 \\ \hat{m}_0 &= \frac{\sigma}{\varepsilon}\frac{1}{(1-\gamma)\left[1+\frac{\beta}{1-\beta}\frac{(1-\Phi(1-2\gamma\theta))\sigma}{\sigma+\Phi(2\gamma-1)}\right]}\frac{dT_0}{\bar{P}\bar{C}} < 0 \end{aligned}$$

To solve for the impact of a negative transfer on home output, we use the $\hat{c}_0$ expression and the home market clearing condition to get:

$$\hat{h}_0 = \frac{2\gamma\left(\sigma+\Phi(2\gamma-1)\right)+\beta\sigma(\frac{1}{\varepsilon}-1)}{2\left(\sigma+\Phi(2\gamma-1)\right)+\beta\sigma(\frac{1}{\varepsilon}-1)}\hat{c}_0 < 0$$

for $\psi \geq 0$. Since wages are sticky, which imply prices are fixed as well, thus, $\hat{\tau}_0 = \hat{p}_{Xt} - \hat{p}_{Mt}^* = 0$. □

## 3.3 Flexible exchange rate regime

We assume both home and foreign follow a flexible exchange rate regime, and their money supplies are exogenously determined by each country's government.[21] With flexible exchange rate, the uncovered interest rate parity must hold in a world of perfect foresight:

$$(1 + i^*_{t+1}) = (1 + i_{t+1})\frac{S_t}{S_{t+1}} \tag{3.22}$$

However, purchasing power parity does not hold in this economy even if the law of one price holds for individual tradable goods, because of the presence of home bias in domestically produced goods in both countries.

The log-linearized terms of trade under the flexible exchange rate regime is:

$$\hat{\tau}_t = \hat{p}_{Xt} - \hat{p}^*_{Mt} - \hat{s}_t \tag{3.23}$$

We can derive the same output difference and terms of trade expressions as equations (3.5) and (3.6), even though the exchange rate is now fully flexible. Besides, we can show the results of proposition 1 hold under this exchange rate regime. Therefore, when wages are flexible, real interest rates are equalized across countries, and the world consumption and output have zero movements under the gold standard, the fixed exchange rate, as well as the flexible exchange rate regimes.

Using the period 0 and period 1 budget constraints to solve for $\hat{c}_0$:

$$\hat{c}_0 = \frac{1-\beta}{2(1-\gamma)[1-\Phi(1-2\theta\gamma)]}\frac{dT_0}{\bar{P}\bar{C}} < 0 \tag{3.24}$$

The sufficient condition for positive coefficient is $\theta \geq \frac{1}{2\gamma}$. A large elasticity of substitution between home and foreign goods leads to a negative transfer impact on period 0 home consumption under flexible exchange rate regime.

The transfer away from home will cause the home's terms of trade to deteriorate, but it does not have any impact on the exogenous money supply at period 0:

$$\hat{\tau}_0 = 2\Phi\hat{c}_0 < 0$$

$$\hat{m}_0 = 0$$

The effect of transfer on period 0 home output also depends on the elasticity of labour supply. In particular, the transfer does not affect the output level if the elasticity of labour supply is

[21] The full system of equilibrium conditions under the flexible exchange rate regime is in Appendix C.

zero, while the transfer increases output if the elasticity of labour supply is infinite:

$$\hat{h}_0 = -[1 - 2\gamma(1 - \theta\sigma)]\hat{c}_0 > 0$$

Capital account becomes negative when the home country gives a transfer to foreign country, that is, again, home country needs to borrow to finance the transfer:

$$\frac{dB_1}{\bar{P}\bar{C}} = \beta\frac{dT_0}{\bar{P}\bar{C}} < 0$$

When prices and wages are flexible, we show that the effects of transfer on the home economy are the same under both fixed and flexible exchange rate regimes. With nominal flexibility, prices can freely adjust in response to shocks to the economy, and hence, the choice of exchange rate regime does not generate any real effect on the economy.[22]

### 3.3.1 Sticky wage (flexible exchange rate)

We use the same assumption as in the previous two sub-sections that wages are fixed for the first period only, and they can fully adjust from the second period onwards. From period 1 onwards, the equilibrium conditions will be the same as those under the flexible wage case.

Period 0 Euler equations and period 1 pricing equations give:

$$\hat{c}_1 = \frac{\sigma(\hat{c}_0 - \hat{c}_0^*) + (1 - 2\gamma)\hat{s}_0}{2\left[\sigma + (2\gamma - 1)\Phi\right]} \tag{3.25}$$

When we compare this equation to the analogous equations under the gold standard and the fixed exchange rate, we can see that exchange-rate pass-through affects period 1 consumption under the flexible exchange rate.

We can show from the money market conditions, good market conditions, and the Euler equations that:

$$c_0 + c_0^* = h_0 + h_0^* = 0$$

as home and foreign money supplies are exogenous ($m_0 = m_0^* = 0$). Then the exchange rate is derived as:

$$\hat{s}_0 = -\frac{\sigma}{(1 - \gamma)\left(\beta + \varepsilon(1 - \beta)\right)}\hat{c}_0 \tag{3.26}$$

Using this expression together with (3.25) and period 1 and period 2 budget constraints,

[22] However, in the specie-standard economy, the economy is also constrained by the stock of species even if there is no nominal rigidity. Therefore, the effects of transfer on the donor country are different under the gold standard.

we can derive the effect of transfer on period 0 consumption as:

$$\hat{c}_0 = \frac{1}{2(1-\gamma) + (2\gamma\theta - 1)\frac{\sigma}{\varepsilon} + \frac{\beta}{1-\beta}\Psi} \frac{dT_0}{\bar{P}\bar{C}} \tag{3.27}$$

where $\Psi = \left[\frac{(1-\gamma)(1-\Phi(1-2\gamma\theta))}{\sigma+(2\gamma-1)\Phi}\right]\left[2\sigma - \frac{\sigma(1-2\gamma)}{(1-\gamma)(\beta+\varepsilon(1-\beta))}\right]$.

The denominator of this equation is positive if $\theta \geq \frac{1}{2\gamma}$. This indicates that a negative transfer reduces the home consumption in period 0.

We state the effects of transfer at period 0 under the sticky-wage flexible exchange rate environment as follows:

**Proposition 4** (Flexible exchange rate, sticky wages)**.** *Under the flexible exchange rate regime and when wages are sticky in period 0, a negative transfer away from home reduces period 0 home consumption. Home output increases in response to the negative transfer, and the terms of trade deteriorates in period 0.*

*Proof.* The transfer effect on consumption can be seen directly from equation (3.27); that is:

$$\hat{c}_0 = \frac{1}{2(1-\gamma) + (2\gamma\theta - 1)\frac{\sigma}{\varepsilon} + \frac{\beta}{1-\beta}\Psi} \frac{dT_0}{\bar{P}\bar{C}} < 0$$

From home labour market condition, we find the period 0 home output is:

$$\hat{h}_0 = \left[2\gamma\left(1 - \frac{\sigma}{\varepsilon}\theta\right) - 1\right]\hat{c}_0$$

The coefficient is negative for large $\theta$. Thus, home output increases after a negative transfer: $\hat{h}_0 > 0$.

Therefore, under the flexible exchange rate regime with sticky wages, home consumption is lowered by the transfer from home to foreign, and output increases when the value of $\theta$ is reasonably large. Terms of trade falls as the nominal exchange rate depreciates ($\hat{s}_0 > 0$) after the transfer takes place. Home money balances and terms of trade are:

$$\hat{m}_0 = 0$$

$$\hat{\tau}_0 = \frac{\sigma}{(1-\gamma)(\beta + \varepsilon(1-\beta))}\hat{c}_0 < 0$$

□

### 3.4 Comparing the transfer effects under different policy regimes

We look at the effects of a negative transfer under the gold standard, the fixed exchange rate and the flexible exchange rate regimes, with both flexible and sticky wages in the previous sub-sections. Table 1 summarizes the results when wages are flexible.

**Table 1: Effects of Transfer on Home Country, Flexible Wages**

| Regime | $\hat{c}_0$ | Regime | $\hat{m}_0$ |
|---|---|---|---|
| Gold Std | $\hat{c}_0^{GS} = \frac{1-\beta}{\Delta}\frac{dT_0}{PC} < 0$ | Gold Std | $\hat{m}_0^{GS} = ((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon})\hat{c}_0^{GS} < 0$ |
| Fixed ER | $\hat{c}_0^{fixed} = \frac{1-\beta}{2(1-\gamma)[1-\Phi(1-2\gamma\theta)]}\frac{dT_0}{PC} < 0$ | Fixed ER | $\hat{m}_0^{fixed} = ((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon})2\hat{c}_0^{fixed} < 0$ |
| Flexible ER | $\hat{c}_0^{flex} = \frac{1-\beta}{2(1-\gamma)[1-\Phi(1-2\gamma\theta)]}\frac{dT_0}{PC} < 0$ | Flexible ER | $\hat{m}_0^{flex} = 0$ |
| Regime | $\hat{h}_0$ $(\psi \to \infty)$ | Regime | $\hat{\tau}_0$ |
| Gold Std | $\hat{h}_0^{GS} = 0$ | Gold Std | $\hat{\tau}_0^{GS} = 2\Phi\hat{c}_0^{GS} < 0$ |
| Fixed ER | $\hat{h}_0^{fixed} = 0$ | Fixed ER | $\hat{\tau}_0^{fixed} = 2\Phi\hat{c}_0^{fixed} < 0$ |
| Flexible ER | $\hat{h}_0^{flex} = 0$ | Flexible ER | $\hat{\tau}_0^{flex} = 2\Phi\hat{c}_0^{flex} < 0$ |
| Regime | $\hat{h}_0$ $(\psi = 0)$ | Regime | $\frac{dB_1}{PC}$ |
| Gold Std | $\hat{h}_0^{GS} = -[1-2\gamma(1-\sigma\theta)]\hat{c}_0^{GS} > 0$ | Gold Std | $\frac{dB_1^{GS}}{PC} = \beta\frac{dT_0}{PC}[1 - \frac{(1-\beta)\omega((2\gamma-1)\Phi+\frac{\sigma}{\varepsilon})}{\Delta}] < 0$ |
| Fixed ER | $\hat{h}_0^{fixed} = -[1-2\gamma(1-\sigma\theta)]\hat{c}_0^{fixed} > 0$ | Fixed ER | $\frac{dB_1^{fixed}}{PC} = \beta\frac{dT_0}{PC} < 0$ |
| Flexible ER | $\hat{h}_0^{flex} = -[1-2\gamma(1-\sigma\theta)]\hat{c}_0^{flex} > 0$ | Flexible ER | $\frac{dB_1^{flex}}{PC} = \beta\frac{dT_0}{PC} < 0$ |

where
$\Delta = 2(1-\gamma)(1-\Phi(1-2\theta\gamma)) + (1-\beta)\omega((2\gamma-1)\Phi + \frac{\sigma}{\varepsilon})$ and $\Phi = \frac{\sigma+\psi(2\gamma-1)}{2(1-\gamma)+4\psi\theta\gamma(1-\gamma)}$.

Several results can be drawn from Table 1. When wages are flexible, nominal exchange rate flexibility becomes immaterial in the fiat money world as prices and wages can fully adjust in response to the negative transfer. The change in consumption, output, terms of trade, and capital account are the same under the flexible and fixed exchange rates. The changes in money balances are different under these two regimes since the home government adjusts its money supply endogenously to maintain a pre-set exchange rate under the fixed exchange rate regime, while the money supply is exogenously determined under the flexible exchange rate.

When comparing the results to those of the gold standard, the negative transfer leads to a larger fall in consumption under the flexible and fixed exchange rate regimes. Terms of trade also deteriorates by a smaller amount under the gold standard than the other two fiat money regimes. When home pays the transfer to foreign country, there is an outflow of gold under the gold standard. Home country has a balance of payments deficit while the foreign has a surplus. Prices then fall in the home country and increase in foreign, which can be explained by the price-specie flow model of Hume (1752). The fall in home good demand due to the fall in home wealth will be offset by the increase in demand caused by the fall in price. Since the home and foreign governments cannot print money in this gold standard environment, when the foreign country imports more home produced goods, there's an export of gold from foreign back to the home country. Gold standard is then served as a shock absorber when a transfer takes place.

When the elasticity of labour supply is infinite, home output increases by a larger amount under the flexible and fixed exchange rate regimes. Since the negative transfer leads to a more severe terms of trade deterioration under the flexible and fixed exchange rate, home goods become relatively cheaper than foreign goods. This terms of trade effect induces a larger foreign demand for home goods. In addition, with home bias, home households also demand more home goods than foreign goods. Therefore, home output increases by a larger amount to meet the increase in demand due to the direct income effect of transfer, and the indirect effect through the terms of trade.

To summarize the degree of transfer effects when wages are flexible, we have:

**Proposition 5** (Effects of transfer under flexible wages)**.** *When wages are flexible, the transfer effects on home consumption, output, terms of trade and capital account are the same under both the fixed and flexible exchange rate regimes. Under the gold standard, however, home consumption falls by a smaller amount and output increases by less. Terms of trade also deteriorates by a smaller magnitude, which leads to a smaller fall in capital account. That is:*

$$\begin{aligned}
0 &> \hat{c}_0^{GS} > \hat{c}_0^{flex} = \hat{c}_0^{fixed} \\
\hat{h}_0^{flex} &= \hat{h}_0^{fixed} > \hat{h}_0^{GS} > 0 \qquad (when\ \psi = 0) \\
0 &= \hat{m}_0^{flex} > \hat{m}_0^{GS} > \hat{m}_0^{fixed} \\
0 &> \hat{\tau}_0^{GS} > \hat{\tau}_0^{flex} = \hat{\tau}_0^{fixed} \\
0 &> \frac{dB_1^{GS}}{\bar{P}\bar{C}} > \frac{dB_1^{flex}}{\bar{P}\bar{C}} = \frac{dB_1^{fixed}}{\bar{P}\bar{C}}
\end{aligned}$$

*Proof.* The proof follows from the results of Table 1. □

Therefore, suspending the gold standard does not necessarily lessen the negative effects of a transfer on the home economy when prices and wages are flexible. Instead, gold standard can help to stabilize the donor country's economy in response to a negative transfer. What happens when there are nominal rigidities?

Table 2 summarizes the effects of transfer on the home economy when wages are sticky.

**Table 2: Effects of Transfer on Home Country, Sticky Wages**

| Regime | $\hat{c}_0$ |
|---|---|
| Gold Standard | $\hat{c}_0^{GS} = \frac{1}{[2(1-\gamma)+\frac{\omega\sigma}{\varepsilon}(1-\beta)]+[\frac{\beta}{1-\beta}\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}]}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Fixed ER | $\hat{c}_0^{fixed} = \frac{2[\sigma+\Phi(2\gamma-1)]+\beta\sigma(\frac{1}{\varepsilon}-1)}{2(1-\gamma)[(\sigma+\Phi(2\gamma-1))+\frac{\beta}{1-\beta}\sigma(1-\Phi(1-2\gamma\theta))]}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Flexible ER | $\hat{c}_0^{flex} = \frac{1}{2(1-\gamma)+(2\gamma\theta-1)\frac{\sigma}{\varepsilon}+\frac{\beta}{1-\beta}\Psi}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Regime | $\hat{h}_0\ (\psi \geq 0)$ |
| Gold Standard | $\hat{h}_0^{GS} = (2\gamma-1)\hat{c}_0^{GS} < 0$ |
| Fixed ER | $\hat{h}_0^{fixed} = \frac{2\gamma(\sigma+\Phi(2\gamma-1))+\beta\sigma\left(\frac{1}{\varepsilon}-1\right)}{2(\sigma+\Phi(2\gamma-1))+\beta\sigma\left(\frac{1}{\varepsilon}-1\right)}\hat{c}_0^{fixed} < 0$ |
| Flexible ER | $\hat{h}_0^{flex} = [2\gamma(1-\frac{\sigma}{\varepsilon}\theta)-1]\hat{c}_0^{flex} > 0$ |
| Regime | $\hat{m}_0$ |
| Gold Standard | $\hat{m}_0^{GS} = \frac{\sigma}{\varepsilon}\frac{1}{(2(1-\gamma)+\omega\frac{\sigma}{\varepsilon}(1-\beta))+(\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}\frac{\beta}{1-\beta})}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Fixed ER | $\hat{m}_0^{fixed} = \frac{\sigma}{\varepsilon}\frac{1}{(1-\gamma)[1+\frac{\beta}{1-\beta}\frac{(1-\Phi(1-2\gamma\theta))\sigma}{\sigma+\Phi(2\gamma-1)}]}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Flexible ER | $\hat{m}_0^{flex} = 0$ |
| Regime | $\hat{\tau}_0$ |
| Gold Standard | $\hat{\tau}_0^{GS} = 0$ |
| Fixed ER | $\hat{\tau}_0^{fixed} = 0$ |
| Flexible ER | $\hat{\tau}_0^{flex} = \frac{\sigma}{(1-\gamma)(\beta+\varepsilon(1-\beta))}\hat{c}_0^{flex} < 0$ |
| Regime | $\frac{dB_1}{\bar{P}\bar{C}}$ |
| Gold Standard | $\frac{dB_1}{\bar{P}\bar{C}}^{GS} = \frac{\beta}{1-\beta}\frac{\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}-\omega\frac{\sigma}{\varepsilon}(1-\beta)}{2(1-\gamma)+\omega\frac{\sigma}{\varepsilon}(1-\beta)+\frac{\Delta\sigma}{\sigma+(2\gamma-1)\Phi}\frac{\beta}{1-\beta}}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Fixed ER | $\frac{dB_1}{\bar{P}\bar{C}}^{fixed} = \frac{\beta}{1-\beta}\frac{(1-\Phi(1-2\gamma\theta))\sigma}{(\sigma+\Phi(2\gamma-1))[1+\frac{\beta}{1-\beta}\frac{(1-\Phi(1-2\gamma\theta))\sigma}{\sigma+\Phi(2\gamma-1)}]}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |
| Flexible ER | $\frac{dB_1}{\bar{P}\bar{C}}^{flex} = \frac{\beta}{1-\beta}\frac{\Psi}{2(1-\gamma)+(2\gamma\theta-1)\frac{\sigma}{\varepsilon}+\frac{\beta}{1-\beta}\Psi}\frac{dT_0}{\bar{P}\bar{C}} < 0$ |

When wages are sticky, the transfer effects on consumption, output, terms of trade, and balance of payments under different exchange rate regimes cannot be compared analytically. We calibrate the transfer effects for comparison, and the parameter values are described in Table 3.

The coefficient of relative risk aversion, $\sigma$, usually takes values in the interval [1,6] in the literature, and we set $\sigma = 2$. We assume the discount factor, $\beta$, equals to 0.96, so that the steady-state real interest rate is about 4 percent. The elasticity of labour supply is set to unity (that is, $\psi = 1$), following Christiano, Eichenbaum, and Evans (1997). The elasticity of substitution between home and foreign goods is estimated to be between [1,2] in

**Table 3: Benchmark Calibration: Parameter Values**

| Parameter | Value | Description |
|---|---|---|
| $\sigma$ | 2 | Coefficient of relative risk aversion |
| $\eta$ | 1 | Weight on labour supply in period utility |
| $\psi$ | 1 | Inverse of elasticity of labour supply |
| $\beta$ | 0.96 | Discount factor (annual real interest rate = $\frac{1-\beta}{\beta}$ ) |
| $\varepsilon$ | 2 | Inverse of elasticity of money |
| $\theta$ | 1.5 | Elasticity of substitution between imports and exports |
| $\gamma$ | 0.75 | Relative preference for domestically produced goods |
| $\omega$ | 1 | Steady-state money balances to consumption ratio, $\frac{\bar{M}}{\bar{P}\bar{C}}$ |
| $\eta\frac{\lambda}{\lambda-1}$ | 1.1 | Gross steady-state markup |

the literature (Chari et al. (1998)), and we set $\theta = 1.5$, following Backus et al. (1994). We assume $\gamma = 0.75$, that is, households have home bias towards domestically produced goods in both countries. The steady-state money balances to consumption ratio, $\omega$, is set to 1, which matches the average value of M1 to nominal consumption ratio in the data.[23] Chari, Kehoe and McGrattan (2000) get an estimate of the elasticity of money demand of 0.39, and Hoffman, Rasche and Tieslau (1995) find the elasticity of money demand is about 0.5 in the US and Canada; thus, we set $\varepsilon = 2$. In the steady state, $\lambda$ determines the markup of price over marginal costs in the wage-setting equation. We assume a 10 percent markup so that we get $\lambda = 11$.

Using these parameter values, we calibrate the effects of a transfer from home to foreign on different home variables, and the results are presented in Table 4.[24]

**Table 4: Effects of Transfer on Home Country under Sticky Wages, Benchmark Calibration**

| *Change in* | Gold Standard | Fixed ER | Flexible ER |
|---|---|---|---|
| $\hat{c}_0$ | -0.0369 | -0.0640 | -0.0194 |
| $\hat{h}_0$ | -0.0185 | -0.0446 | 0.0340 |
| $\hat{m}_0$ | -0.0369 | -0.0774 | 0 |
| $\hat{\tau}_0$ | 0 | 0 | -0.1495 |
| $\frac{dB_1}{\bar{P}\bar{C}}$ | -0.9447 | -0.9807 | -0.9660 |

[23] Collard and Dellas (2005) find that $\frac{M1}{PC} = 1.245$ in the period from 1960 to 2000 in the US, and find after 1980, the average value is about 0.75.

[24] The calibration is performed by setting $\frac{dT_0}{\bar{P}\bar{C}} = -1$, that is, home transfers one unit of $\bar{P}\bar{C}$ to the foreign country.

Comparing these calibrated results, we can summarize the effects of transfer under sticky wages as follows:

**Proposition 6** (Effects of transfer under sticky wages). *When wages are sticky, the responses of home economy to a negative transfer are different under the gold standard, the fixed exchange rate and the flexible exchange rate regimes. Consumption falls by the least amount when exchange rate is flexible, under the benchmark calibration. Output increases under the flexible exchange rate, but falls under the gold standard and fixed exchange rate. To summarize, we have:*

$$
\begin{aligned}
0 &> \hat{c}_0^{flex} > \hat{c}_0^{GS} > \hat{c}_0^{fixed} \\
\hat{h}_0^{flex} &> 0 > \hat{h}_0^{GS} > \hat{h}_0^{fixed} \\
0 &= \hat{m}_0^{flex} > \hat{m}_0^{GS} > \hat{m}_0^{fixed} \\
0 &= \hat{\tau}_0^{GS} = \hat{\tau}_0^{fixed} > \hat{\tau}_0^{flex} \\
0 &> \frac{dB_1^{GS}}{\bar{P}\bar{C}} > \frac{dB_1^{flex}}{\bar{P}\bar{C}} > \frac{dB_1^{fixed}}{\bar{P}\bar{C}}
\end{aligned}
$$

*Proof.* The results follow from Table 4. □

When there are nominal rigidities, the exchange rate regime matters. The effects of transfer on the home economy are different under the flexible and fixed exchange rate.

Under the benchmark calibration with sticky wages and flexible exchange rate, the negative transfer also leads to the smallest fall in consumption, just like the case when wages are flexible. Under the fixed exchange rate regime, consumption falls by the largest amount. Prices and wages are not able to adjust in response to the transfer; in addition, the home government needs to further adjust its money supply to maintain the fixed exchange rate, which exacerbates the negative effect of the transfer on consumption.

One major difference in the results under the flexible and sticky wage models is the transfer effects on home output (compare Table 1, 2 and 4). When wages are flexible, home output increases under all three exchange rate regimes after the transfer takes place.[25] The increase in output is due to the increase in foreign demand, since foreign wealth increases and home goods are relatively cheaper than foreign goods through the terms of trade adjustment.

When wages are sticky, home output falls under the gold standard and the fixed exchange rate. In the presence of home bias in domestically produced goods, the increase in foreign demand is not large enough to offset the fall in home demand due to the wealth effect.

[25] This is true for $\psi \geq 0$.

**Table 5: Effects of Transfer on Home Country under Sticky Wages, Different Parameter Values**

(a) $\theta = 0.5$

| *Change in* | Gold Standard | Fixed ER | Flexible ER |
|---|---|---|---|
| $\hat{c}_0$ | -0.2564 | -0.6880 | -0.2396 |
| $\hat{h}_0$ | -0.1282 | -0.4880 | 0.05991 |
| $\hat{m}_0$ | -0.2564 | -0.800 | 0 |
| $\hat{\tau}_0$ | 0 | 0 | -1.8433 |
| $\frac{dB_1}{PC}$ | -0.6154 | -0.800 | -0.9401 |

(b) $\omega = 0.5$

| *Change in* | Gold Standard | Fixed ER | Flexible ER |
|---|---|---|---|
| $\hat{c}_0$ | -0.0378 | -0.0640 | -0.0194 9 |
| $\hat{h}_0$ | -0.0189 | -0.0446 | 0.0340 |
| $\hat{m}_0$ | -0.0378 | -0.0774 | 0 |
| $\hat{\tau}_0$ | 0 | 0 | -0.1495 |
| $\frac{dB_1}{PC}$ | -0.9622 | -0.9807 | -0.9660 |

Besides, when wages are sticky, the terms of trade is irresponsive to the negative transfer under the gold standard and the fixed exchange rate. There is no indirect effect that increases home goods demand via the terms of trade deterioration, and hence, there is a net decrease in home output after a transfer when there are nominal rigidities.

However, when exchange rate is flexible and wages are sticky, output change remains positive after the transfer takes place, which is the same as in the flexible wage environment. When wages are sticky, the change in exchange rate affects the general price level at home. The exchange rate depreciation (and hence, terms of trade deterioration) at home increases foreign demand, which increases the home output. Together with the increase in foreign demand for home good that arises from the increase in foreign wealth, the net change in demand for home goods is positive. Therefore, a transfer from home leads to a rise in home output under the sticky-wage, flexible exchange rate environment.

Table 5 shows the transfer effects when we lower $\theta$ to 0.5, and $\omega$ to 0.5 respectively. The results in proposition 6 continue to hold when the elasticity of substitution between imports and exports, and the money to consumption ratio are low.[26] Since flexible exchange rate can reduce the fall in consumption and lead to an increase in output after a negative transfer, going off the gold helps stabilizing the home consumption fluctuations when there are nominal rigidities.

[26] We find that the results in proposition 6 does not hold when there is no home bias ($\gamma = 0.5$), or when the value of $\omega$ is unreasonably large. In these cases, gold standard leads to a smaller drop in consumption than the flexible exchange rate after the transfer.

## 4 Welfare effect

In this section, we look at the effects of transfer on home welfare. We measure welfare by the change in consumer's utility. Recall that the home household's utility is given as:

$$\mathcal{U} = \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} + \frac{\chi}{1-\varepsilon} \left( \frac{M_t}{P_t} \right)^{1-\varepsilon} - \frac{\eta}{1+\psi} H_t^{1+\psi} \right) \tag{4.1}$$

Following Obstfeld and Rogoff (1995), we can separate the welfare changes into two parts by writing the utility as $\mathcal{U} = \mathcal{U}^R + \mathcal{U}^M$, where $\mathcal{U}^R$ represents the change in utility due to consumption and output changes, while $\mathcal{U}^M$ indicates the welfare changes that are induced by changes in real money balances. Since the economy reaches the steady state from period 1 onwards, therefore, we can write $\mathcal{U}^R$ and $\mathcal{U}^M$ as:

$$\mathcal{U}^R = \left( \frac{C_0^{1-\sigma}}{1-\sigma} - \frac{\eta}{1+\psi} H_0^{1+\psi} \right) + \frac{\beta}{1-\beta} \left( \frac{C_1^{1-\sigma}}{1-\sigma} - \frac{\eta}{1+\psi} H_1^{1+\psi} \right) \tag{4.2}$$

and

$$\mathcal{U}^M = \frac{\chi}{1-\varepsilon} \left( \frac{M_0}{P_0} \right)^{1-\varepsilon} + \frac{\beta}{1-\beta} \frac{\chi}{1-\varepsilon} \left( \frac{M_1}{P_1} \right)^{1-\varepsilon} \tag{4.3}$$

We approximate the welfare effects by total differentiating the household's utility around the steady state, and the changes in welfare become:

$$d\mathcal{U}^R = \bar{C}^{1-\sigma} \left[ \hat{c}_0 - \Gamma \hat{h}_0 + \frac{\beta}{1-\beta} \left( \hat{c}_1 - \Gamma \hat{h}_1 \right) \right] \tag{4.4}$$

and

$$d\mathcal{U}^M = \bar{C}^{1-\sigma} \Lambda \left[ (\hat{m}_0 - \hat{p}_0) + \frac{\beta}{1-\beta} (\hat{m}_1 - \hat{p}_1) \right] \tag{4.5}$$

where $\Gamma = \frac{\lambda-1}{\lambda} \gamma^{\frac{1}{\theta-1}} \left[ \gamma^{\frac{1}{1-\theta}} + (1-\gamma)^{\frac{1}{1-\theta}} \right]$ and $\Lambda = \chi^{\frac{1}{\varepsilon}} (1-\beta)^{\frac{\varepsilon-1}{\varepsilon}} \bar{C}^{\frac{\sigma}{\varepsilon}-1}$.

Obstfeld and Rogoff (1995) analyze the effects of consumption and output changes on welfare, but not the real-balance effect. When they study the effects of a monetary shock on $d\mathcal{U}^R$, they find that a monetary expansion has first order positive effect on welfare through the increase in world consumption. As marginal utility of money is positive in their model, positive monetary shock is welfare-improving, which would not reverse the positive welfare effect. Thus, they do not have to calculate $d\mathcal{U}^M$ and the results are still unambiguous.

However, this may not be true in our model, in which we focus on the effects of a transfer, especially when the economy is under the gold standard. When home makes a transfer to foreign, foreign country will increase its demand for home goods, as well as the demand for gold. This would lessen the fall in home consumption and lead to a smaller welfare loss under the gold standard through the changes in consumption and output. On the other hand, because of the fixed supply of gold in the world economy, the increase in demand for gold by the foreign country will make home to lose some of its gold in addition to the transfer. This additional transfer of gold from home to foreign may have negative welfare effects through the real balances. Therefore, it is important to include $d\mathcal{U}^M$ in our welfare analysis, as the fall in home gold holding may generate welfare loss which can overturn our results.

We calibrate the effects of negative transfer on home's welfare using (4.4) and (4.5), and the calibrated results of the benchmark model are presented in Table 6.

**Table 6: Effects of Transfer on Welfare, Benchmark Calibration**

| *Flexible Wages*<br>Regime | $d\mathcal{U}^R$ | + | $d\mathcal{U}^M$ | = | $d\mathcal{U}$ |
|---|---|---|---|---|---|
| Gold Std | -25.9616 | | -0.085198 | | -26.0468 |
| Fixed ER | -27.2187 | | -0.089323 | | -27.3080 |
| Flex ER | -27.2187 | | -0.089323 | | -27.3080 |
| *Sticky Wages*<br>Regime | $d\mathcal{U}^R$ | + | $d\mathcal{U}^M$ | = | $d\mathcal{U}$ |
| Gold Std | -24.5389 | | -0.052188 | | -24.5911 |
| Fixed ER | -25.0603 | | -0.097702 | | -25.1580 |
| Flex ER | -27.2161 | | -0.091165 | | -27.3072 |

When wages are flexible, a transfer from home to foreign country lowers the welfare of home country through the fall in consumption and disutility of labour supply ($d\mathcal{U}_R$). The welfare drops by a larger amount under the flexible (and fixed) exchange rate than that under the gold standard. The fall in real money balances also worsens the home welfare ($d\mathcal{U}_M$), but by a much smaller magnitude. Although home loses some of its gold holding in addition to the transfer, its impact is not large enough to wash out the "gain" in welfare by staying in the gold standard. Money balances also lower the welfare, under both the flexible and fixed exchange rates. This suggests that going off the gold standard will worsen the welfare of the donor country when wages are fully flexible.

Similar results hold when wages are sticky. From Table 6, a negative transfer leads to a smaller welfare drop under the gold standard than under the other exchange rate regimes. The welfare falls by the largest amount under the flexible exchange rate, since the increase in home output due to direct wealth effect and indirect terms of trade effect lead to a large disutility of labour, which makes households worse off. Thus, the donor country would be better off if it stayed in the gold standard after a transfer takes place, even if there are nominal rigidities.

We find that the welfare ranking is insensitive to the value of $\theta$ and $\gamma$, but is sensitive to

**Table 7: Effects of Transfer on Welfare, Low $\omega$ ($\omega = 0.5$)**

| *Flexible Wages* Regime | $d\mathcal{U}^R$ | + | $d\mathcal{U}^M$ | = | $d\mathcal{U}$ |
|---|---|---|---|---|---|
| Gold Std | -26.5753 | | -0.043606 | | -26.6189 |
| Fixed ER | -27.2187 | | -0.044662 | | -27.2633 |
| Flex ER | -27.2187 | | -0.044662 | | -27.2633 |
| *Sticky Wages* Regime | $d\mathcal{U}^R$ | + | $d\mathcal{U}^M$ | = | $d\mathcal{U}$ |
| Gold Std | -25.1194 | | -0.026718 | | -25.1461 |
| Fixed ER | -25.0603 | | -0.048851 | | -25.1091 |
| Flex ER | -27.2161 | | -0.045583 | | -27.2617 |

the value of $\omega$. Table 7 shows the welfare effect when $\omega = 0.5$. We find that the gold standard gives the highest welfare when wages are flexible, and the fixed exchange rate regime gives the highest when there are nominal rigidities. Flexible exchange rate regime, however, yields the lowest welfare under both the flexible wages and sticky wages, and this result holds for any reasonable value of $\omega$.[27]

## 5 Concluding remarks

We develop a two-country model to study the transfer problem under different exchange rate regimes. Keynes' "orthodox" view is also justified as the terms of trade deteriorates regardless of the choice of exchange rate systems. The conventional wisdom suggests it is optimal for countries to abandon the gold standard in face of economic crises such as war or economic downturn. In terms of stabilizing the domestic consumption, our model suggests that the donor country should follow the conventional wisdom and go floating. However, our welfare analysis implies the transfer paying country is better off to stay within the gold standard system since the gold standard regime can absorb some of the negative effects from the transfer, even with nominal rigidities.

The gold standard or the fixed exchange rate, however, is difficult to be maintained by the developed countries in today's highly integrated world. The costs of losing domestic policy autonomy are larger than the benefits from exchange rate stability to the developed countries. Developing countries, on the other hand, tend to go for exchange rate stability because of the "fear of floating". The existence of this bipolarity cannot be explained in this simple model. Furthermore, capital and investment are absent from this model. A promising future extension to this study would be to include capital in the model to see if the same

[27]For some unreasonably large values of $\omega$, we find that instead of the flexible exchange rate, but the fixed exchange rate gives the lowest welfare under the sticky wages.

surprising results remind.

# 6 Appendices

## A Equilibrium conditions under the gold standard

### (a) Flexible wage

The full system of equilibrium conditions under the gold standard with flexible wages is:

$$\frac{M_t}{P_t} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}}\right)^{\frac{1}{\varepsilon}}} \tag{A.1}$$

$$\frac{M_t^*}{P_t^*} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}}\right)^{\frac{1}{\varepsilon}}} \tag{A.2}$$

$$W_t = \eta \frac{\lambda}{\lambda - 1} P_t C_t^{\sigma} H_t^{\psi} \tag{A.3}$$

$$W_t^* = \eta \frac{\lambda}{\lambda - 1} P_t^* C_t^{*\sigma} H_t^{*\psi} \tag{A.4}$$

$$H_t = \gamma \left(\frac{P_{Xt}}{P_t}\right)^{-\theta} C_t + (1-\gamma) \left(\frac{P_{Xt}}{P_t^*}\right)^{-\theta} C_t^* \tag{A.5}$$

$$H_t^* = (1-\gamma) \left(\frac{P_{Mt}}{P_t}\right)^{-\theta} C_t + \gamma \left(\frac{P_{Mt}}{P_t^*}\right)^{-\theta} C_t^* \tag{A.6}$$

$$P_t C_t + B_{t+1} + M_t = P_{Xt} H_t + M_{t-1} + T_t + (1+i_t) B_t \tag{A.7}$$

$$\frac{1}{1+i_{t+1}} = \beta \frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}} \tag{A.8}$$

$$\frac{1}{1+i_{t+1}} = \beta \frac{P_t^* C_t^{*\sigma}}{P_{t+1}^* C_{t+1}^{*\sigma}} \tag{A.9}$$

$$P_t = \left[\gamma P_{Xt}^{1-\theta} + (1-\gamma)(P_{Mt})^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{A.10}$$

$$P_t^* = \left[(1-\gamma) P_{Xt}^{1-\theta} + \gamma P_{Mt}^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{A.11}$$

$$P_{Xt} = W_t \quad (A.12)$$
$$P_{Mt} = W_t^* \quad (A.13)$$

$$\bar{M} = M_t + M_t^* \quad (A.14)$$

This system gives 14 equations in 14 variables:
$\{C_t, C_t^*, M_t, M_t^*, H_t, H_t^*, W_t, W_t^*, P_{Xt}, P_{Mt}, B_{t+1}, i_{t+1}, P_t, P_t^*\}$.

The log-linearized version of these conditions are:

$$\hat{m}_t - \hat{p}_t = \frac{\sigma}{\varepsilon}\hat{c}_t - \frac{1}{\varepsilon}\left(\frac{1}{1+\bar{i}}\right)\hat{i}_{t+1} \quad (A.15)$$
$$\hat{m}_t^* - \hat{p}_t^* = \frac{\sigma}{\varepsilon}\hat{c}_t^* - \frac{1}{\varepsilon}\left(\frac{1}{1+\bar{i}}\right)\hat{i}_{t+1} \quad (A.16)$$

$$\hat{w}_t = \hat{p}_t + \sigma\hat{c}_t + \psi\hat{h}_t \quad (A.17)$$
$$\hat{w}_t^* = \hat{p}_t^* + \sigma\hat{c}_t^* + \psi\hat{h}_t^* \quad (A.18)$$

$$\hat{h}_t = -\theta\hat{p}_{Xt} + \gamma\hat{c}_t + (1-\gamma)\hat{c}_t^* + \gamma\theta\hat{p}_t + (1-\gamma)\theta\hat{p}_t^* \quad (A.19)$$
$$\hat{h}_t^* = -\theta\hat{p}_{Mt} + (1-\gamma)\hat{c}_t + \gamma\hat{c}_t^* + (1-\gamma)\theta\hat{p}_t + \gamma\theta\hat{p}_t^* \quad (A.20)$$

$$\hat{c}_t + \frac{dB_{t+1}}{\bar{P}\bar{C}} + \omega\hat{m}_t = (\hat{p}_{Xt} - \hat{p}_t) + \hat{h}_t + \omega\hat{m}_{t-1} + \frac{dT_t}{\bar{P}\bar{C}} + (1+\bar{\imath})\frac{dB_t}{\bar{P}\bar{C}} \quad (A.21)$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_{t+1} = \hat{p}_t + \sigma\hat{c}_t - \hat{p}_{t+1} - \sigma\hat{c}_{t+1} \quad (A.22)$$
$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_{t+1} = \hat{p}_t^* + \sigma\hat{c}_t^* - \hat{p}_{t+1}^* - \sigma\hat{c}_{t+1}^* \quad (A.23)$$

$$\hat{p}_t = \gamma\hat{p}_{Xt} + (1-\gamma)\hat{p}_{Mt}^* \quad (A.24)$$
$$\hat{p}_t^* = (1-\gamma)\hat{p}_{Xt} + \gamma\hat{p}_{Mt}^* \quad (A.25)$$

$$\hat{p}_{Xt} = \hat{w}_t \quad (A.26)$$
$$\hat{p}_{Mt}^* = \hat{w}_t^* \quad (A.27)$$

where:

$\omega = \frac{\bar{M}}{\bar{P}\bar{C}} = \left(\frac{\chi}{1-\beta}\right)^{1-\varepsilon} \left[\gamma^{\frac{1}{\theta-1}} \frac{1}{\eta} \frac{\lambda-1}{\lambda} \left(\gamma^{\frac{1}{1-\theta}} + (1-\gamma)^{\frac{1}{1-\theta}}\right)^{-\psi}\right]^{\frac{\frac{\sigma}{\varepsilon}-1}{\sigma+\psi}}$,

$dZ_t = Z_t - \bar{Z}$. Also, at equilibrium, $\frac{1}{1+\bar{i}} = \beta$.

## (b) Sticky wage

The equations describing the first period (period 0) can be described as:

$$\frac{M_0}{P_0} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\right)^{\frac{1}{\varepsilon}}} \tag{A.28}$$

$$\frac{M_0^*}{P_0^*} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\right)^{\frac{1}{\varepsilon}}} \tag{A.29}$$

$$H_0 = \gamma \left(\frac{P_{X0}}{P_0}\right)^{-\theta} C_0 + (1-\gamma) \left(\frac{P_{X0}}{P_0^*}\right)^{-\theta} C_0^* \tag{A.30}$$

$$H_0^* = (1-\gamma) \left(\frac{P_{M0}}{P_0}\right)^{-\theta} C_0 + \gamma \left(\frac{P_{M0}}{P_0^*}\right)^{-\theta} C_0^* \tag{A.31}$$

$$P_0 C_0 + B_1 + M_0 = P_{X0} H_0 + M_{-1} + T_0 \tag{A.32}$$

$$\frac{1}{1+i_1} = \beta \frac{P_0 C_0^{\sigma}}{P_1 C_1^{\sigma}} \tag{A.33}$$

$$\frac{1}{1+i_1} = \beta \frac{P_0^* C_0^{*\sigma}}{P_1^* C_1^{*\sigma}} \tag{A.34}$$

$$\bar{M} = M_0 + M_0^* \tag{A.35}$$

This system gives 8 equations in 8 variables: $\{C_0, C_0^*, M_0, M_0^*, H_0, H_0^*, B_1, i_1\}$.

We log-linearized these conditions and get the following:

$$\hat{m}_0 = \frac{\sigma}{\varepsilon}\hat{c}_0 - \frac{1}{\varepsilon}\left(\frac{1}{1+\bar{i}}\right)\hat{i}_1 \tag{A.36}$$

$$\hat{m}_0^* = \frac{\sigma}{\varepsilon}\hat{c}_0^* - \frac{1}{\varepsilon}\left(\frac{1}{1+\bar{i}}\right)\hat{i}_1 \tag{A.37}$$

$$\hat{h}_0 = \gamma\hat{c}_0 + (1-\gamma)\hat{c}_0^* \tag{A.38}$$

$$\hat{h}_0^* = (1-\gamma)\hat{c}_0 + \gamma\hat{c}_0^* \tag{A.39}$$

$$\hat{c}_0 + \frac{dB_1}{\bar{P}\bar{C}} + \omega\hat{m}_0 = \hat{h}_0 + \frac{dT_0}{\bar{P}\bar{C}} \tag{A.40}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_1 = \sigma\hat{c}_0 - \hat{p}_1 - \sigma\hat{c}_1 \tag{A.41}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_1 = \sigma\hat{c}_0^* - \hat{p}_1^* - \sigma\hat{c}_1^* \tag{A.42}$$

$$0 = \hat{m}_0 + \hat{m}_0^* \tag{A.43}$$

## B Equilibrium conditions under fixed exchange rate regime

### (a) Flexible wage

The full equilibrium conditions under fixed exchange rate regime with flexible wages are as follows:

$$\frac{M_t}{P_t} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}}\right)^{\frac{1}{\varepsilon}}} \tag{B.1}$$

$$\frac{M_t^*}{P_t^*} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}^*}\right)^{\frac{1}{\varepsilon}}} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}} \frac{\bar{S}}{\bar{S}}\right)^{\frac{1}{\varepsilon}}} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}}\right)^{\frac{1}{\varepsilon}}} \tag{B.2}$$

$$W_t = \eta \frac{\lambda}{\lambda - 1} P_t C_t^{\sigma} H_t^{\psi} \tag{B.3}$$

$$W_t^* = \eta \frac{\lambda}{\lambda - 1} P_t^* C_t^{*\sigma} H_t^{*\psi} \tag{B.4}$$

$$H_t = \gamma \left(\frac{P_{Xt}}{P_t}\right)^{-\theta} C_t + (1-\gamma) \left(\frac{P_{Xt}}{\bar{S} P_t^*}\right)^{-\theta} C_t^* \tag{B.5}$$

$$H_t^* = (1-\gamma) \left(\frac{\bar{S} P_{Mt}^*}{P_t}\right)^{-\theta} C_t + \gamma \left(\frac{P_{Mt}^*}{P_t^*}\right) C_t^* \tag{B.6}$$

$$P_t C_t + B_{t+1} + M_t = W_t H_t + M_{t-1} + \mu_t + T_t + (1+i_t) B_t \tag{B.7}$$

$$\frac{1}{1+i_{t+1}} = \beta \frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}} \tag{B.8}$$

$$\frac{1}{1+i_{t+1}} = \beta \frac{P_t^* C_t^{*\sigma}}{P_{t+1}^* C_{t+1}^{*\sigma}} \frac{\bar{S}}{\bar{S}} = \beta \frac{P_t^* C_t^{*\sigma}}{P_{t+1}^* C_{t+1}^{*\sigma}} \tag{B.9}$$

$$P_t = \left[\gamma P_{Xt}^{1-\theta} + (1-\gamma)(\bar{S} P_{Mt}^*)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{B.10}$$

$$P_t^* = \left[(1-\gamma) \left(\frac{P_{Xt}}{\bar{S}}\right)^{1-\theta} + \gamma P_{Mt}^{*1-\theta}\right]^{\frac{1}{1-\theta}} \tag{B.11}$$

$$P_{Xt} = W_t \tag{B.12}$$
$$P^*_{Mt} = W^*_t \tag{B.13}$$

$$M_t = M_{t-1} + \mu_t \tag{B.14}$$
$$M^*_t = M^*_{t-1} + \mu^*_t \tag{B.15}$$

Now, the terms of trade is:

$$TOT = \frac{P_{Xt}}{P_{Mt}} = \frac{P_{Xt}}{\bar{S}P^*_{Mt}} \tag{B.16}$$

The log-linearized version of conditions (B.1) to (B.13) are described as follows:

$$\hat{m}_t - \hat{p}_t = \frac{\sigma}{\varepsilon}\hat{c}_t - \frac{1}{\varepsilon}\left(\frac{1}{1+\bar{i}}\right)\hat{i}_{t+1} \tag{B.17}$$
$$\hat{m}^*_t - \hat{p}^*_t = \frac{\sigma}{\varepsilon}\hat{c}^*_t - \frac{1}{\varepsilon}\left(\frac{1}{1+\bar{i}}\right)\hat{i}_{t+1} \tag{B.18}$$

$$\hat{w}_t = \hat{p}_t + \sigma\hat{c}_t + \psi\hat{h}_t \tag{B.19}$$
$$\hat{w}^*_t = \hat{p}^*_t + \sigma\hat{c}^*_t + \psi\hat{h}^*_t \tag{B.20}$$

$$\hat{h}_t = -\theta\hat{p}_{Xt} + \gamma\hat{c}_t + (1-\gamma)\hat{c}^*_t + \gamma\theta\hat{p}_t + (1-\gamma)\theta\hat{p}^*_t \tag{B.21}$$
$$\hat{h}^*_t = -\theta\hat{p}^*_{Mt} + (1-\gamma)\hat{c}_t + \gamma\hat{c}^*_t + (1-\gamma)\theta\hat{p}_t + \gamma\theta\hat{p}^*_t \tag{B.22}$$

$$\hat{c}_t + \frac{dB_{t+1}}{\bar{P}\bar{C}} + \omega\hat{m}_t = (\hat{p}_{Xt} - \hat{p}_t) + \hat{h}_t + \omega\hat{m}_{t-1} + \frac{d\mu_t}{\bar{P}\bar{C}} + \frac{dT_t}{\bar{P}\bar{C}} + (1+\bar{\imath})\frac{dB_t}{\bar{P}\bar{C}} \tag{B.23}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_{t+1} = \hat{p}_t + \sigma\hat{c}_t - \hat{p}_{t+1} - \sigma\hat{c}_{t+1} \tag{B.24}$$
$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_{t+1} = \hat{p}^*_t + \sigma\hat{c}^*_t - \hat{p}^*_{t+1} - \sigma\hat{c}^*_{t+1} \tag{B.25}$$

$$\hat{p}_t = \gamma\hat{p}_{Xt} + (1-\gamma)\hat{p}^*_{Mt} \tag{B.26}$$
$$\hat{p}^*_t = (1-\gamma)\hat{p}_{Xt} + \gamma\hat{p}^*_{Mt} \tag{B.27}$$

$$\hat{p}_{Xt} = \hat{w}_t \quad (B.28)$$

$$\hat{p}^*_{Mt} = \hat{w}^*_t \quad (B.29)$$

$$\hat{m}_t = \hat{m}_{t-1} + \frac{d\mu_t}{\bar{M}} \quad (B.30)$$

$$\hat{m}^*_t = \hat{m}^*_{t-1} + \frac{d\mu^*_t}{\bar{M}} \quad (B.31)$$

### (b) Sticky wage

The period 0 equilibrium conditions now become:

$$\frac{M_0}{P_0} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\right)^{\frac{1}{\varepsilon}}} \quad (B.32)$$

$$\frac{M^*_0}{P^*_0} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i^*_1}\right)^{\frac{1}{\varepsilon}}} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\frac{\bar{S}}{\bar{S}}\right)^{\frac{1}{\varepsilon}}} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{*\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\right)^{\frac{1}{\varepsilon}}} \quad (B.33)$$

$$H_0 = \gamma \left(\frac{P_{X0}}{P_0}\right)^{-\theta} C_0 + (1-\gamma)\left(\frac{P_{X0}}{\bar{S}P^*_0}\right)^{-\theta} C^*_0 \quad (B.34)$$

$$H^*_0 = (1-\gamma)\left(\frac{\bar{S}P^*_{M0}}{P_0}\right)^{-\theta} C_0 + \gamma\left(\frac{P^*_{M0}}{P^*_0}\right)^{-\theta} C^*_0 \quad (B.35)$$

$$P_0C_0 + B_1 + M_0 = W_0H_0 + M_{-1} + \mu_0 + T_0 + (1+i_0)B_0 \quad (B.36)$$

$$\frac{1}{1+i_1} = \beta\frac{P_0C_0^\sigma}{P_1C_1^\sigma} \quad (B.37)$$

$$\frac{1}{1+i_1} = \beta\frac{P^*_0C_0^{*\sigma}}{P^*_1C_1^{*\sigma}}\frac{\bar{S}}{\bar{S}} = \beta\frac{P^*_0C_0^{*\sigma}}{P^*_1C_1^{*\sigma}} \quad (B.38)$$

$$M_0 = M_{-1} + \mu_0 \quad (B.39)$$

$$M^*_0 = M^*_{-1} + \mu^*_0 \quad (B.40)$$

We log-linearized these conditions and get the following:

$$\hat{m}_0 = \frac{\sigma}{\varepsilon}\hat{c}_0 - \frac{\beta}{\varepsilon}\hat{i}_1 \tag{B.41}$$

$$\hat{m}_0^* = \frac{\sigma}{\varepsilon}\hat{c}_0^* - \frac{\beta}{\varepsilon}\hat{i}_1 \tag{B.42}$$

$$\hat{h}_0 = \gamma\hat{c}_0 + (1-\gamma)\hat{c}_0^* \tag{B.43}$$

$$\hat{h}_0^* = (1-\gamma)\hat{c}_0 + \gamma\hat{c}_0^* \tag{B.44}$$

$$\hat{c}_0 + \frac{dB_1}{\bar{P}\bar{C}} + \omega\hat{m}_0 = \hat{h}_0 + \omega\hat{m}_{-1} + \frac{d\mu_0}{\bar{P}\bar{C}} + \frac{dT_0}{\bar{P}\bar{C}} + \frac{1}{\beta}\frac{dB_0}{\bar{P}\bar{C}} \tag{B.45}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_1 = \sigma\hat{c}_0 - \hat{p}_1 - \sigma\hat{c}_1 \tag{B.46}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_1 = \sigma\hat{c}_0^* - \hat{p}_1^* - \sigma\hat{c}_1^* \tag{B.47}$$

$$\hat{m}_0 = \hat{m}_{-1} + \frac{d\mu_0}{\bar{M}} \tag{B.48}$$

$$\hat{m}_0^* = \hat{m}_{-1}^* + \frac{d\mu_0^*}{\bar{M}} \tag{B.49}$$

We get these expressions using the fact that $\hat{w}_0 = \hat{w}_0^* = \hat{p}_0 = \hat{p}_0^* = \hat{p}_{X0} = \hat{p}_{M0}^* = \hat{s}_t = 0$ because wages are fixed for 1 period, and exchange rates are fixed over time.

## C Equilibrium conditions under flexible exchange rate regime

### (a) Flexible wage

Then, the equilibrium conditions under the flexible exchange rate regime are as follows:

$$\frac{M_t}{P_t} = \frac{\chi^{\frac{1}{\varepsilon}} C_t^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}}\right)^{\frac{1}{\varepsilon}}} \tag{C.1}$$

$$\frac{M_t^*}{P_t^*} = \frac{\chi^{\frac{1}{\varepsilon}} {C_t^*}^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}^*}\right)^{\frac{1}{\varepsilon}}} = \frac{\chi^{\frac{1}{\varepsilon}} {C_t^*}^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_{t+1}} \frac{S_{t+1}}{S_t}\right)^{\frac{1}{\varepsilon}}} \tag{C.2}$$

$$W_t = \eta \frac{\lambda}{\lambda - 1} P_t C_t^{\sigma} H_t^{\psi} \tag{C.3}$$

$$W_t^* = \eta \frac{\lambda}{\lambda - 1} P_t^* C_t^{*\sigma} H_t^{*\psi} \tag{C.4}$$

$$H_t = \gamma \left(\frac{P_{Xt}}{P_t}\right)^{-\theta} C_t + (1-\gamma) \left(\frac{P_{Xt}}{S_t P_t^*}\right)^{-\theta} C_t^* \tag{C.5}$$

$$H_t^* = (1-\gamma) \left(\frac{S_t P_{Mt}^*}{P_t}\right)^{-\theta} C_t + \gamma \left(\frac{P_{Mt}^*}{P_t^*}\right) C_t^* \tag{C.6}$$

$$P_t C_t + B_{t+1} + M_t = W_t H_t + M_{t-1} + \mu_t + T_t + (1+i_t) B_t \tag{C.7}$$

$$\frac{1}{1+i_{t+1}} = \beta \frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}} \tag{C.8}$$

$$\frac{1}{1+i_{t+1}} = \beta \frac{P_t^* C_t^{*\sigma}}{P_{t+1}^* C_{t+1}^{*\sigma}} \frac{S_t}{S_{t+1}} \tag{C.9}$$

$$P_t = \left[\gamma P_{Xt}^{1-\theta} + (1-\gamma)(S_t P_{Mt}^*)^{1-\theta}\right]^{\frac{1}{1-\theta}} \tag{C.10}$$

$$P_t^* = \left[(1-\gamma) \left(\frac{P_{Xt}}{S_t}\right)^{1-\theta} + \gamma P_{Mt}^{*1-\theta}\right]^{\frac{1}{1-\theta}} \tag{C.11}$$

$$P_{Xt} = W_t \tag{C.12}$$

$$P_{Mt}^* = W_t^* \tag{C.13}$$

$$M_t = M_{t-1} + \mu_t \tag{C.14}$$
$$M_t^* = M_{t-1}^* + \mu_t^* \tag{C.15}$$

(C.14) and (C.15) are the exogenous money supply rules in the home and foreign countries respectively, where $\mu_t$ and $\mu_t^*$ are the exogenous monetary transfers within the country. This system gives 15 equations to solve for 15 variables:
$\{C_t, C_t^*, M_t, M_t^*, P_t, P_t^*, i_{t+1}, W_t, W_t^*, H_t, H_t^*, P_{Xt}, P_{Mt}^*, S_t, B_{t+1}\}$.

The terms of trade under this regime is denoted as:

$$TOT = \frac{P_{Xt}}{S_t P_{Mt}^*}$$

We log-linearized the above system and get the following equations:

$$\hat{m}_t - \hat{p}_t = \frac{\sigma}{\varepsilon}\hat{c}_t - \frac{\beta}{\varepsilon}\hat{i}_{t+1} \tag{C.16}$$
$$\hat{m}_t^* - \hat{p}_t^* = \frac{\sigma}{\varepsilon}\hat{c}_t^* - \frac{\beta}{\varepsilon}\hat{i}_{t+1} - \frac{1}{\varepsilon}\frac{\beta}{1-\beta}(\hat{s}_t - \hat{s}_{t+1}) \tag{C.17}$$

$$\hat{w}_t = \hat{p}_t + \sigma\hat{c}_t + \psi\hat{h}_t \tag{C.18}$$
$$\hat{w}_t^* = \hat{p}_t^* + \sigma\hat{c}_t^* + \psi\hat{h}_t^* \tag{C.19}$$

$$\hat{h}_t = -\theta\hat{p}_{Xt} + \gamma\hat{c}_t + (1-\gamma)\hat{c}_t^* + \gamma\theta\hat{p}_t + (1-\gamma)\theta\hat{p}_t^* + (1-\gamma)\theta\hat{s}_t \tag{C.20}$$
$$\hat{h}_t^* = -\theta\hat{p}_{Mt}^* + (1-\gamma)\hat{c}_t + \gamma\hat{c}_t^* + (1-\gamma)\theta\hat{p}_t + \gamma\theta\hat{p}_t^* - (1-\gamma)\theta\hat{s}_t \tag{C.21}$$

$$\hat{c}_t + \frac{dB_{t+1}}{\bar{P}\bar{C}} + \omega\hat{m}_t = (\hat{p}_{Xt} - \hat{p}_t) + \hat{h}_t + \omega\hat{m}_{t-1} + \frac{d\mu_t}{\bar{P}\bar{C}} + \frac{dT_t}{\bar{P}\bar{C}} + (1+\bar{i})\frac{dB_t}{\bar{P}\bar{C}} \tag{C.22}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_{t+1} = \hat{p}_t + \sigma\hat{c}_t - \hat{p}_{t+1} - \sigma\hat{c}_{t+1} \tag{C.23}$$
$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_{t+1} = \hat{p}_t^* + \sigma\hat{c}_t^* - \hat{p}_{t+1}^* - \sigma\hat{c}_{t+1}^* + \hat{s}_t - \hat{s}_{t+1} \tag{C.24}$$

$$\hat{p}_t = \gamma\hat{p}_{Xt} + (1-\gamma)(\hat{s}_t + \hat{p}_{Mt}^*) \tag{C.25}$$
$$\hat{p}_t^* = (1-\gamma)(\hat{p}_{Xt} - \hat{s}_t) + \gamma\hat{p}_{Mt}^* \tag{C.26}$$

$$\hat{p}_{Xt} = \hat{w}_t \tag{C.27}$$
$$\hat{p}^*_{Mt} = \hat{w}^*_t \tag{C.28}$$

$$\hat{m}_t = \hat{m}_{t-1} + \frac{d\mu_t}{\bar{M}} \tag{C.29}$$
$$\hat{m}^*_t = \hat{m}^*_{t-1} + \frac{d\mu^*_t}{\bar{M}} \tag{C.30}$$

### (b) Sticky wage

The conditions describing the flexible exchange rate equilibrium at period 0 with sticky wages are:

$$\frac{M_0}{P_0} = \frac{\chi^{\frac{1}{\varepsilon}} C_0^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\right)^{\frac{1}{\varepsilon}}} \tag{C.31}$$
$$\frac{M^*_0}{P^*_0} = \frac{\chi^{\frac{1}{\varepsilon}} {C_0^*}^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i^*_1}\right)^{\frac{1}{\varepsilon}}} = \frac{\chi^{\frac{1}{\varepsilon}} {C_0^*}^{\frac{\sigma}{\varepsilon}}}{\left(1 - \frac{1}{1+i_1}\frac{S_1}{S_0}\right)^{\frac{1}{\varepsilon}}} \tag{C.32}$$

$$H_0 = \gamma \left(\frac{P_{X0}}{P_0}\right)^{-\theta} C_0 + (1-\gamma)\left(\frac{P_{X0}}{S_0 P^*_0}\right)^{-\theta} C^*_0 \tag{C.33}$$
$$H^*_0 = (1-\gamma)\left(\frac{S_0 P^*_{M0}}{P_0}\right)^{-\theta} C_0 + \gamma \left(\frac{P^*_{M0}}{P^*_0}\right)^{-\theta} C^*_0 \tag{C.34}$$

$$P_0 C_0 + B_1 + M_0 = W_0 H_0 + M_{-1} + \mu_0 + T_0 + (1+i_0)B_0 \tag{C.35}$$

$$\frac{1}{1+i_1} = \beta \frac{P_0 C_0^\sigma}{P_1 C_1^\sigma} \tag{C.36}$$
$$\frac{1}{1+i_1} = \beta \frac{P^*_0 C_0^{*\sigma}}{P^*_1 C_1^{*\sigma}} \frac{S_0}{S_1} \tag{C.37}$$

$$M_0 = M_{-1} + \mu_0 \tag{C.38}$$
$$M^*_0 = M^*_{-1} + \mu^*_0 \tag{C.39}$$

The log-linearized conditions are:

$$\hat{m}_0 - (1-\gamma)\hat{s}_0 = \frac{\sigma}{\varepsilon}\hat{c}_0 - \frac{\beta}{\varepsilon}\hat{i}_1 \tag{C.40}$$

$$\hat{m}_0^* + (1-\gamma)\hat{s}_0 = \frac{\sigma}{\varepsilon}\hat{c}_0^* - \frac{\beta}{\varepsilon}\hat{i}_1 - \frac{1}{\varepsilon}\frac{\beta}{1-\beta}(\hat{s}_0 - \hat{s}_1) \tag{C.41}$$

$$\hat{h}_0 = \gamma\hat{c}_0 + (1-\gamma)\hat{c}_0^* + 2\gamma\theta(1-\gamma)\hat{s}_0 \tag{C.42}$$

$$\hat{h}_0^* = (1-\gamma)\hat{c}_0 + \gamma\hat{c}_0^* - 2\gamma\theta(1-\gamma)\hat{s}_0 \tag{C.43}$$

$$\hat{c}_0 + \frac{dB_1}{\bar{P}\bar{C}} + \omega\hat{m}_0 = -(1-\gamma)\hat{s}_0 + \hat{h}_0 + \omega\hat{m}_{-1} + \frac{d\mu_0}{\bar{P}\bar{C}} + \frac{dT_0}{\bar{P}\bar{C}} + \frac{1}{\beta}\frac{dB_0}{\bar{P}\bar{C}} \tag{C.44}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_1 = \sigma\hat{c}_0 - \hat{p}_1 - \sigma\hat{c}_1 + (1-\gamma)\hat{s}_0 \tag{C.45}$$

$$-\frac{\bar{i}}{1+\bar{i}}\hat{i}_1 = \sigma\hat{c}_0^* - \hat{p}_1^* - \sigma\hat{c}_1^* + \hat{s}_0 - \hat{s}_1 - (1-\gamma)\hat{s}_0 \tag{C.46}$$

$$\hat{m}_0 = \hat{m}_{-1} + \frac{d\mu_0}{\bar{M}} \tag{C.47}$$

$$\hat{m}_0^* = \hat{m}_{-1}^* + \frac{d\mu_0^*}{\bar{M}} \tag{C.48}$$

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