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Monetary Policies in a Small Open Economy Model with Labor Mobility and Remittances

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Abstract

This paper presents a model of a small open economy that allows for international labor mobility, thereby endogenizing migrant transfers or remittances. The resulting model is calibrated to the Philippine economy, of which labor migration and remittance inflows are key forces that drive the economy's growth. The model's impulse response functions illustrate that the presence of these features generates a different set of dynamics from the standard small open economy model (without labor mobility). Depending on the source of the shock, labor mobility and remittances can either exacerbate or cushion the impact of the shock on the economy. A temporary and unanticipated rise in the world interest rate leads to a drop in aggregate output in the environment with labor mobility compared to one without. In contrast, an adverse terms-of-trade shock of the same nature affects output less severely in the case with labor mobility. Finally, a welfare cost comparison of different monetary regimes reveals that policies fostering flexible exchange rates bring about welfare gains relative to a baseline policy of inflation targeting that places a small weight on fixing the nominal exchange rate (otherwise known as hybrid flexible inflation targeting). In particular, pegging the monetary base proves to be welfare-superior to six other simple rules, namely: non-traded price inflation, price-level, strict inflation, hybrid flexible inflation, exchange-rate, and export-price targeting (of which the ranking follows the order of enumeration). The ranking is preserved when labor mobility and remittances are absent in the model.

Keywords: Small open economy, DSGE, monetary policy, remittances, labor mobility, labor migration

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To GOD be the glory

Chapter 1

Introduction

Mainly for the reason that it provides local workers access to higher-wage labor markets, the phenomenon of international labor migration has grown significantly especially in developing countries. In turn, remittances or private transfers that might largely be motivated by a migrant worker's existing family ties back home, have become a major source of foreign earnings to these countries. IMF (2005) reports that migrant transfers are now the second-largest source of external funding for developing countries, following FDI. The largest source of remittances is the United States and the two largest remittance-recipient regions are Latin America and developing Asia. Given the magnitudes of these flows, the need to examine their impact on the economy is readily apparent.

This study aims to build a New Keynesian dynamic stochastic general equilibrium (DSGE) model of a small open economy that reflects labor emigration as practiced by many households in developing countries. Allowing for cross-country labor mobility in this micro-founded set-up makes remittances endogenously determined. There are a handful of DSGE models in the literature that incorporate remittance channels. Among these models that treat remittances as an exogenous shock are those of Durdu and Sayan (2008), Stepanyan and Tevosyan (2008) and Punzi (2009). And though the models of Chami et al. (2006), Mandelman and Zlate (2008), Acosta et al. (2009) and Punzi (2009) treat remittances as determined within the model, these same models are carried out in an environment with flexible prices. This study then is *the first to examine endogenous remittances in an environment with price rigidities*. The presence of nominal rigidities, in turn, motivates the second goal of the study, which is the examination of various monetary policies in this model environment. Appropriateness of alternative policies is assessed based on a welfare cost measure obtained by following the methodology of Schmitt-Grohé and Uribe (2007).

The model is calibrated to match moments of some Philippine data. Analysis is centered around the Philippine economy for a number of reasons. First, the yearly outflow of Filipino workers of about 14% of the labor force makes the Philippines the largest exporter of labor among Asian countries (Tan, 2006). Based on 2007 data[1], an estimated 8.72 million Filipinos reside overseas. This figure corresponds to 9.8 percent of the Filipino population. Second, this country has been one of the largest remittance-recipients among developing countries. For instance, the 2008 remittance[2] figure that translates into 11.2 percent of GDP places the Philippines in the top 4, only trailing behind India, China and Mexico (Mohapatra et al., 2009). Third, migrant remittances have served as a major and the least volatile source of the country's foreign exchange (Burgess and Haksar, 2005). In fact, remittances to the Philippines already exceed FDI. Fourth, the Philippines exemplifies a small open economy relative to the rest of the world. Lastly, the analysis of different monetary policies becomes more relevant to the

Philippine economy with its shift from monetary to inflation targeting in January 2002 and the need to explore alternative monetary policies that are more development-oriented, as expressed by Lim (2008).

The backbone of the model, i.e., before allowing for labor emigration and migrant transfers, borrows heavily from the set-up of Devereux et al. (2006).[3] Their model is appropriate to the Philippine economy because it is tailored towards an emerging market economy in two ways. First, the small open economy is subject to external real interest rate and terms of trade shocks that are calibrated from historical experience of Asian economies. The choice of shocks supports the literature on emerging market business cycles that emphasize the predominance of external shocks in explaining aggregate fluctuations. Mendoza (1995) shows that terms of trade shocks account for nearly one-half of actual GDP variability for a group of developing countries that includes the Philippines. For a similar group of emerging countries that also includes the Philippines, Uribe and Yue (2006) find that US real interest rate shocks explain about 20% of movements in aggregate activity. Second, the model allows for different degrees to which exchange rate movements feed through to the domestic price level. Calvo and Reinhart (2002) provide evidence that exchange rate pass-through to domestic prices is higher for emerging, as compared to industrial, economies. Devereux and Yetman (2010) estimate this value for the Philippines at 0.80 using 1970-2007 data. Similarly, Webber (1999) and Sahminan (2002) both agree that the country has on average almost complete exchange rate pass-through into import prices. Hence, the

[1] The data is from the Commission of Filipinos Overseas.

[2] "Total remittances" refers to the sum of the 1) workers' remittances, 2) compensation to employees, and 3) migrant transfers reported by each country. Data is available from the International Monetary Fund's Balance of Payments Statistics Yearbook.

benchmark model in this paper assumes that the economy faces a certain degree of incomplete pass-through into imported goods prices.

Inclusion of labor migration and remittances into the micro-founded model draws insights mainly from two papers - those of Mandelman and Zlate (2008) and Nakanishi et al. (2009). To examine the effects of alternative immigration policies, Mandelman and Zlate (2008) employ a two-country, real business cycle model that allows for labor mobility from the foreign (Mexico) to the home (US) economy. In line with their set-up, the small open economy model in this study presents a worker whose decision to work in a foreign country depends on two factors, namely: (1) foreign wages are higher than domestic wages at the steady state and (2) there are costs incurred in leaving home to work abroad. Mandelman and Zlate (2008) refer to these costs as the sunk costs of emigration which may include the costs of transportation, searching for employment, adjusting to a new lifestyle, working visa procedures, and the physical and emotional risk of being separated from family members and relatives, to name a few. In contrast to Mandelman and Zlate (2008), the current model does not take into account skill heterogeneity among workers and does not allow for a return of the immigrant worker to the home country, which is especially relevant during periods of economic downturns in the foreign country.

Nakanishi et al. (2009), on one hand, examine the impact of remittances on some macroeconomic variables under varying degrees of financial development using a DSGE model calibrated to the Philippine economy. Like the framework of

[3] The model presented by Devereux et al. (2006) distinguishes finance-constrained entrepreneurs from ordinary households. The model in this paper makes a simplifying assumption in that households and entrepreneurs are lumped as a single entity. That is, households own the firms in the economy.

Mandelman and Zlate (2008), their model envisions a household whose members either work in the domestic or foreign country. The migrant worker then faces the decision to channel his income on personal consumption in the foreign country or as remittance to his family member back home. The foreign consumption of the migrant worker, alongside the conventional domestic consumption, also enters into the utility function of the representative household. These are features of the Nakanishi et al. (2009) set-up that have been adopted to the model in this paper.

Welfare evaluation is drawn from the methodology proposed in Schmitt-Grohé and Uribe (2004, 2007) wherein second-order accurate equilibrium solutions to the policy functions of the model are computed for a second-order approximation of the welfare criterion. Acosta et al. (2009) and Devereux et al. (2006) also make use of the same method to obtain a welfare cost measure.

The resulting sticky-price small open economy model with labor migration and remittances generate economic decision-making dynamics that differ from an economy where households do not receive additional income from remittances. Depending on the source of the shock, these additional transfers can either cushion or exacerbate the impact of the shock on the economy. It would have been ideal to measure the gain or loss in welfare for an economy with labor mobility and remittances relative to one without. However, the difference in the models' utility functions make it difficult to obtain such a welfare cost measure. Instead, we move on to a welfare-cost comparison of alternative monetary policies and find that this model environment favors a flexible exchange rate regime over a fixed one. Specifically, we find that monetary targeting dominates the other simple monetary rules that include inflation targeting. The welfare cost ranking also appears robust to the absence of labor mobility and remittances.

The remainder of the paper is organized in five sections. Chapter 2 presents the theoretical model. Chapter 3 describes the method of welfare cost of evaluation. Chapter 4 details the empirical strategy. Chapter 5 presents a discussion of results and chapter 6 presents the paper's conclusion.

Chapter 2

Theoretical framework

We start with a small open economy with three domestic players - households, firms and monetary authority. While households have access to international and domestic capital markets, they also provide labor to domestic and foreign firms. Migrant household members send remittances to family members in the domestic economy from their foreign wages, after allocating for their own consumption. Domestic household members channel their income to domestic consumption, investment and payment of emigration costs, apart from interests on domestic and foreign loans. In addition, they absorb final goods that comprise imported and non-traded commodities. On the other hand, the economy has two actively-producing sectors that respectively produce non-traded and exportable goods. Two other sectors - importing and household absorption - simply serve to combine different produce into one bundle. Lastly, there is a body that sets the monetary policy of the economy.

The model economy features three sources of nominal rigidities. One originates in the non-traded sector, where there is monopolistic competition among identical firms and sluggish price adjustment à la Rotemberg (1982). The other is due to a household demand for money motivated by a cash-in-advance constraint in the purchase of domestic final goods. The third comes from introducing a pseudo-firm that acts as a monopolistic domestic importer. This third feature is incorporated to the model to make way for examination of varying degrees of exchange rate pass-through into imported goods prices. The degree of exchange-rate vulnerability is modeled as an adjustment cost of the same nature faced by the firms in the non-traded sector. These elements create an incentive for the conduct of monetary policy.

Furthermore, the model is augmented to incorporate habit formation in domestic and foreign consumption. As Schmitt-Grohé and Uribe (2005) stress, habit formation in the model allows for a smoother response of consumption to expansionary shocks giving an impulse response that matches more closely to actual data.

2.1 Households

The economy is populated by a continuum of infinitely-lived households of measure one. We envision a household with two members, one who is bound to work in the home and the other, in a foreign country. The representative household's preferences are described by the following utility function with habit formation:

$$\mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U \left(C_{D_t} - \varrho_D C_{D_{t-1}}, C_{F_t} - \varrho_F C_{F_{t-1}}, H_{D_t}, H_{F_t} \right), \tag{2.1}$$

where $\mathbf{E}_t$ denotes the mathematical expectation conditional on information available in period t, C_{Z_t} stands for consumption and H_{Z_t} for labor effort, where Z could mean D for domestic or F for foreign.[4] At time t, households take as given the process for $C_{Z_{t-1}}$. The parameter $\beta \in (0,1)$ denotes a subjective discount factor while the parameter $\varrho_Z \in (0,1)$ represents the intensity of habit formation. The single-period utility index U is assumed to be concave and smooth; increasing in its first and second arguments and decreasing in its third and fourth arguments.

Specifically, the utility function takes the form:

$$U(\cdot) = \frac{(C_{D_t} - \varrho_D C_{D_{t-1}})^{1-\sigma_D}}{1-\sigma_D} + \frac{(C_{F_t} - \varrho_F C_{F_{t-1}})^{1-\sigma_F}}{1-\sigma_F} - \eta \frac{(H_{D_t} + H_{F_t})^{1+\psi}}{1+\psi}, \tag{2.2}$$

where $1/\sigma_Z$ and $1/\psi$ are the intertemporal elasticities of substitution in consumption and labor supply,[5] respectively. η represents the disutility of labor.

Domestic consumption, C_{D_t}, is an index of the consumption of non-traded and imported goods given by the constant elasticity of substitution (CES) function: $C_{D_t} = \left[a^{\frac{1}{\rho}} C_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}} C_{M_t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}$, where $\rho \geq 1$ denotes the elasticity of substitution between C_{N_t} and C_{M_t} and $a \in [0,1]$ can be interpreted as a measure of openness.[6]

Domestic households have access to debt, D_t and B_t, that are, respectively, denominated in foreign and domestic currencies. Trade in foreign loans is subject

[4]Arguments with a D (or F) superscript represent the workings of the domestic (migrant) household member.

[5]At the same time, $1/\psi$ is the Frisch elasticity of labor supply.

[6]It can be shown that for $\rho = 1$, the CES function transforms into a Cobb-Douglas function, as shown in Appendix A.2. Equivalently, $1 - a$ is a measure of the degree of home bias.

to small portfolio adjustment costs. A household that borrows an amount D_t in period t faces a portfolio adjustment cost of $\frac{\psi_D}{2}(D_t - D)^2$ (expressed in terms of the domestic consumption good), where D is the nonstochastic steady state level of debt. The household can borrow an amount D_t directly in terms of foreign currency at a given interest rate of i_t^*, or an amount B_t at an interest rate i_t.

In addition, domestic households in period t expect foreign-currency denominated remittances, $Remit_t$, from the migrant household member. The amount of remittances is determined after wage earnings are allocated to foreign consumption, as given below.

$$Remit_t = W_{F_t} H_{F_t} - C_{F_t} \tag{2.3}$$

Equation (2.3) implicitly states that P_{Ft} is set to 1. W_{Ft} is hourly wage earnings, assumed to be greater than the domestic real hourly wage rate, W_{Dt}, at every period t, in this fashion: $W_{F_t} = \frac{1}{\nu^W} \frac{W_{D_t}}{P_{D_t}}$, where $\nu^W > 1$. Also, migrant workers that send an amount $Remit_t$ face a cost $\frac{\psi_{Rem}}{2}(Remit_t - Remit)^2$ (also expressed in the domestic good), where $Remit$ is the nonstochastic steady state level of remittances. Though such cost, like the portfolio adjustment cost, is added to close the small open economy model as suggested by Schmitt-Grohé and Uribe (2003), it may also represent fees charged by remittance service providers. In practice, these remittance fees vary according to the amount of money sent. Upon collection of the money, the receiver party also pays a certain amount of remittance tax.

On one hand, households face a cost of emigration that is denominated as a constant fraction, $f_e \in (0, 1)$, of the migrant worker's period-by-period earnings, i.e., $f_e W_{F_t} H_{F_t}$. Apart from practical reasons, this cost is introduced so that despite higher foreign wages, domestic labor supply will be greater than its foreign counterpart in the steady state. Also, while this cost can be incorporated immediately in (2.3), we opt to place it as a separate term in the consolidated budget constraint below for computational reasons.

Moreover, households rent out capital stocks, K_{N_t} and K_{X_t}, to the non-traded and export sectors, respectively. Correspondingly, they receive payments R_{N_t} and R_{X_t} for a unit of these stocks from the firms in each sector. Capital stocks in both sectors evolve according to

$$K_{N_{t+1}} = \left[\frac{I_{N_t}}{K_{N_t}} - \frac{\psi_I}{2} \left(\frac{I_{N_t}}{K_{N_t}} - \delta \right)^2 \right] K_{N_t} + (1-\delta) K_{N_t} \tag{2.4}$$

$$K_{X_{t+1}} = \left[\frac{I_{X_t}}{K_{X_t}} - \frac{\psi_I}{2} \left(\frac{I_{X_t}}{K_{X_t}} - \delta \right)^2 \right] K_{X_t} + (1-\delta) K_{X_t}, \tag{2.5}$$

where δ is the rate of capital depreciation, I_{X_t} and I_{N_t} are investment in the two sectors and ψ_I is an adjustment cost parameter. As per Devereux et al. (2006), this adjustment cost of investment is introduced so that the marginal return to investment in terms of capital goods is declining in the amount of investment undertaken, relative to the current capital stock. Since investment in new capital requires the same mix of goods as the domestic household's consumption basket, the nominal price of a unit of investment in either sector is P_{D_t}, the price index corresponding to C_{D_t}.

Aside from loans, capital rent, and wages, households earn income from firm dividends, Π_t, and government transfers, T_t. Household earnings are then channeled to consumption, investment, emigration fees, interest on loans, and portfolio adjustment and remittance costs payments. These monetary flows are consolidated in the budget constraint of the representative household:[7]

$$
\begin{aligned}
&P_{D_t}(C_{D_t} + I_{N_t} + I_{X_t}) + M_t + S_t f_e W_{F_t} H_{F_t} + (1 + i^*_{t-1}) S_t D_{t-1} \\
&+ (1 + i_{t-1}) B_{t-1} + P_{D_t} \frac{\psi_D}{2} (D_t - D)^2 + P_{D_t} \frac{\psi_{Rem}}{2} (Remit_t - Remit)^2 \\
&\leq W_{D_t} H_{D_t} + R_{N_t} K_{N_t} + R_{X_t} K_{X_t} + M_{t-1} + S_t D_t + B_t + S_t Remit_t + T_t + \Pi_t.
\end{aligned} \tag{2.6}
$$

Such budget constraint is expressed in domestic currency, made possible through the nominal exchange rate, S_t.

Equation (2.6) indicates that at the beginning of period $t \geq 0$, the household starts with money balances M_{t-1} carried from the previous period and demands money at the amount of M_t. This demand for money originates from a cash-in-advance constraint of the form,

$$
M_t \geq \nu P_{D_t} C_{D_t}, \tag{2.7}
$$

where $\nu \geq 0$ is a parameter denoting the fraction of consumption expenditures that must be backed with monetary assets.

Solving the household's problem entails finding the set of stochastic processes $\{C_{D_t},\ C_{F_t},\ H_{D_t},\ H_{F_t},\ D_t,\ B_t,\ M_t,\ I_{N_t},\ I_{X_t},\ K_{N_{t+1}},\ K_{X_{t+1}},\ Remit_t,\ \lambda_{D_t},\ \lambda_{F_t},\ \zeta_t,\ Q_{N_t},\ Q_{X_t}\}_{t=0}^{\infty}$ that maximizes (2.1) subject to (2.3)-(2.7) and some borrowing limit that prevents the household from engaging in Ponzi-type schemes, taking as given the price sequences $\left\{P_{D_t}, W_{D_t}, R_{N_t}, R_{X_t}, i^*_{t-1}, i_{t-1}, S_t\right\}_{t=0}^{\infty}$ and the initial

[7]Note that foreign consumption and wages are no longer included in (2.6) as they are already implied in the remittance equation (2.3).

conditions K_{N_0}, K_{X_0}, D_{-1}, i^*_{-1}, B_{-1}, i_{-1}, M_{-1}, $C_{F_{-1}}$, and $C_{D_{-1}}$. We let $\beta^t\lambda_{F_t}$, $\beta^t\lambda_{D_t}Q_{N_t}$, $\beta^t\lambda_{D_t}Q_{X_t}$, $\beta^t\lambda_{D_t}$ and $\beta^t\lambda_{D_t}\zeta_t$ denote, respectively, the Lagrange multipliers associated with (2.3), (2.4), (2.5), (2.6) and (2.7), respectively. Kindly refer to Appendix A.1 for the detailed solution.

2.1.1 Optimal consumption and labor supply decisions

The first-order conditions corresponding to domestic consumption and labor supply are as follows, where λ_{D_t} is the marginal utility of income.

$$\lambda_{D_t} = \frac{(C_{D_t} - \varrho_D C_{D_{t-1}})^{-\sigma_D}}{P_{D_t}(1+\nu\zeta_t)} \tag{2.8}$$

$$\eta(H_{D_t} + H_{F_t})^{\varphi} = \lambda_{D_t} W_{D_t} \tag{2.9}$$

We see from the above equations that domestic money holding distorts both the labor-leisure choice and the intertemporal allocation of consumption. Correspondingly, the household identifies the optimal mix of non-traded and imported goods that will minimize her expenditures subject to the total supply of goods for domestic consumption. Demand for these goods are represented by the following expressions:

$$C_{N_t} = a\left(\frac{P_{N_t}}{P_{D_t}}\right)^{-\rho} C_{D_t}$$

$$C_{M_t} = (1-a)\left(\frac{P_{N_t}}{P_{D_t}}\right)^{-\rho} C_{D_t},$$

where the domestic price index is defined as $P_{D_t} = \left[aP_{N_t}^{1-\rho} + (1-a)P_{M_t}^{1-\rho}\right]^{\frac{1}{1-\rho}}$. P_{N_t} and P_{M_t} are the respective unit prices of non-traded and imported goods.

Meanwhile, the optimal allocations attributed to foreign consumption and labor supply (equations (2.10)-(2.11) below) imply that the unit of labor effort directed abroad is determined by domestic labor supply and the purchasing ability of the foreign wage rate, after accounting for emigration and remittance costs. In this model, domestic and foreign labor supplies are highly substitutable.

$$(C_{F_t} - \varrho_F C_{F_{t-1}})^{-\sigma_F} = \lambda_{D_t}[S_t - P_{D_t}\psi_{Rem}(Remit_t - Remit)] \tag{2.10}$$

$$\eta(H_{D_t} + H_{F_t})^{\varphi} = \lambda_{D_t} W_{F_t}[S_t(1 - f_e) - P_{D_t}\psi_{Rem}(Remit_t - Remit)] \tag{2.11}$$

The assumptions that $\frac{W_{F_t}}{P_{D_t}} > \frac{W_{D_t}}{P_{D_t}}$ and $0 < f_e < 1$ create the incentive to work abroad at every t.

2.1.2 Money and bond holdings decisions

The associated first-order conditions for foreign and domestic bonds and money holdings, respectively, are as follows:

$$S_t \lambda_{D_t}\left[1 - \frac{P_{D_t}\psi_D(D_t - D)}{S_t}\right] = \beta(1 + i_t^*)\mathbf{E}_t \lambda_{D_{t+1}} S_{t+1} \tag{2.12}$$

$$\lambda_{D_t} = \beta(1 + i_t)\mathbf{E}_t \lambda_{D_{t+1}} \tag{2.13}$$

$$\frac{1}{1 - \zeta_t} = 1 + i_t. \tag{2.14}$$

The left-hand side of equations (2.12) and (2.13) state that if the household decides to borrow a unit today, current consumption increases by one unit (minus the marginal portfolio adjustment cost for equation (2.12)). This increase in today's utility from extra consumption must be offset by the disutility from a decline in tomorrow's consumption as income will then be channeled to debt repayment plus interest, as conveyed by the right-hand side of these equations. Lastly, equation (2.14) implies that the opportunity cost of holding money is equal to the gross domestic interest rate.

2.1.3 Capital accumulation and investment decisions

Investment decisions lead to the following equations that implicitly state the investment demand from the two sectors.

$$Q_{N_t}\left[1-\psi_I\left(\frac{I_{N_t}}{K_{N_t}}-\delta\right)\right]=P_{D_t} \tag{2.15}$$

$$Q_{N_t}\left[1-\psi_I\left(\frac{I_{N_t}}{K_{N_t}}-\delta\right)\right]=P_{D_t} \tag{2.16}$$

Q_{Z_t} can be inferred as the shadow price of installed capital, or Tobin's Q. At the same time, solving for $K_{Z_{t+1}}$ leads to the equation for Q_{Z_t}:

$$\begin{aligned}Q_{N_t}=\beta\mathbf{E}_t\frac{\lambda_{D_{t+1}}}{\lambda_{D_t}}\Bigg\{R_{N_{t+1}}+Q_{N_{t+1}}\Bigg[(1-\delta)-\frac{\psi_I}{2}\left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}}-\delta\right)^2\\+\psi_I\left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}}-\delta\right)\left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}}\right)\Bigg]\Bigg\},\end{aligned} \tag{2.17}$$

$$\begin{aligned}Q_{X_t}=\beta\mathbf{E}_t\frac{\lambda_{D_{t+1}}}{\lambda_{D_t}}\Bigg\{R_{X_{t+1}}+Q_{X_{t+1}}\Bigg[(1-\delta)-\frac{\psi_I}{2}\left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}}-\delta\right)^2\\+\psi_I\left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}}-\delta\right)\left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}}\right)\Bigg]\Bigg\}.\end{aligned} \tag{2.18}$$

2.2 Firms

There are two actively producing sectors, the export and non-traded sectors. The export sector is characterized by perfectly competitive firms, whereas firms in the non-traded sector operate in a monopolistically competitive environment.

Two other sectors simply serve as packagers of commodities, without utilizing household resources. Firms from the import sector buy goods from abroad and repackage these goods for sale in the domestic economy. Another set of firms wraps these imported goods together with the non-traded goods for household absorption.

A detailed solution of the succeeding equations is presented in Appendix A.3.

2.2.1 Export sector

All goods ready for export are produced by identical firms using capital and labor resources from households according to the following Cobb-Douglas production function:

$$Y_{X_t} = A_X K_{X_t}^{\gamma} H_{X_t}^{1-\gamma}, \tag{2.19}$$

where A_X is a productivity parameter and $0 < \gamma < 1$ is the share of capital expenditures to total firm revenues. The profit-maximizing firm's demand for capital and labor inputs are then determined by the following equations:

$$R_{X_t} K_{X_t} = \gamma P_{X_t} Y_{X_t} \tag{2.20}$$

$$W_{D_t} H_{X_t} = (1-\gamma) P_{X_t} Y_{X_t}, \tag{2.21}$$

where Y_{Xt} is the quantity of export goods produced and P_{Xt} is the unit price of these commodities. We assume that the law of one price holds for export goods and thus, we have

$$P_{X_t} = S_t P^*_{X_t}, \tag{2.22}$$

with $P^*_{X_t}$ as the unit price of the same commodity in foreign currency.

2.2.2 Non-traded sector

There is a continuum of identical firms in the non-traded sector that each produces a differentiated good. The technology used by firm $i \in [0,1]$ to produce its own variety of the non-traded good takes the form

$$Y_{N_t}(i) = A_N K_{N_t}(i)^{\alpha} H_{N_t}(i)^{1-\alpha},$$

where A_N and α are similarly defined as in (2.19). Firm i's demand for capital and labor inputs are determined after minimizing its expenditures subject to the production of the desired amount of output. The implicit demand for the two inputs are provided by the following first-order conditions:

$$R_{N_t}K_{N_t}(i) \ = \alpha MC_{N_t}(i)Y_{N_t}(i)$$
$$W_{D_t}H_{N_t}(i) = (1-\alpha)MC_{N_t}(i)Y_{N_t}(i),$$

where $MC_{Nt}(i)$ is the nominal marginal cost faced by firm i.

Accordingly, firm i's target output level, $Y_{N_t}(i)$, comes from consumers' demand for its differentiated good (refer to Appendix A.3.2), as described below:

$$Y_{N_t}(i) = \left(\frac{P_{N_t}(i)}{P_{N_t}}\right)^{-\lambda} Y_{N_t}. \tag{2.23}$$

The level of total demand for non-tradables, Y_{N_t}, is a CES aggregate: $Y_{N_t} = \left[\int_0^1 Y_{N_t}(i)^{\frac{\lambda-1}{\lambda}} di\right]^{\frac{\lambda}{\lambda-1}}$. Parameter λ is the elasticity of substitution across varieties of the non-traded good.

Able to produce its own variety of the non-traded good, firm i has the power to set its price, $P_{N_t}(i)$, in the market. A pricing constraint in the spirit of Rotemberg (1982), however, is imposed to introduce nominal rigidity in the system. Hence, in as much as the firm wants to increase its price to the optimum as a result of a demand or marginal cost shock, it can only do so gradually as it is constrained by this convex price adjustment cost.

To determine $P_{N_t}(i)$, firm i maximizes the present discounted value of its profits subject to the demand for its product, presented in equation (2.23). The objective function of the firm may be presented in the following manner:

$$\mathbf{E}_t \sum_{k=0}^{\infty} \Gamma_{t,t+k} \left\{ P_{N_{t+k}}(i) Y_{N_{t+k}}(i) - MC_{N_{t+k}}(i) Y_{N_{t+k}}(i) \right.$$
$$\left. - \ P_{D_{t+k}} \frac{\psi_{P_N}}{2} \left(\frac{P_{N_{t+k}}(i)}{P_{N_{t+k-1}}(i)} - 1 \right)^2 \right\}.$$

The stochastic discount factor, $\Gamma_{t,t+k}$, is defined as $\Gamma_{t,t+k} = \beta^{t+k} \lambda_{D_{t+k}}$.

Accordingly, the aggregate optimal price-setting equation adhered by all firms in this sector is one that follows a dynamic adjustment process, as written below after imposing firm symmetry (i.e., $P_{N_t}(i) = P_{N_t}$):

$$P_{N_t} = \frac{\lambda}{\lambda - 1} MC_{N_t} - \frac{\psi_{P_N}}{\lambda - 1} \frac{P_{D_t}}{Y_{N_t}} \frac{P_{N_t}}{P_{N_{t-1}}} \left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1 \right)$$
$$+ \frac{\psi_{P_N}}{\lambda - 1} \mathbf{E}_t \left[\frac{\Gamma_{t,t+1}}{\Gamma_{t,t}} \frac{P_{D_{t+1}}}{Y_{N_t}} \frac{P_{N_{t+1}}}{P_{N_t}} \left(\frac{P_{N_{t+1}}}{P_{N_t}} - 1 \right) \right]. \tag{2.24}$$

Without adjustment costs, i.e., $\psi_{P_N} = 0$, firms simply set the price as a mark-up over marginal cost as monopolists do.

2.2.3 Import sector

To allow for the possibility of a delay in the adjustment of imported goods prices to exchange rate movements, the behavior of firms in this sector is modeled in the same fashion as that of the non-traded firms. That is, there is a continuum of domestic monopolistic importers that also face a cost of price adjustment. Importer firm i buys goods produced abroad at the price $S_t P_{M_t}(i)^*$ and sells to the home market at $P_{M_t}(i)$. Similar to (2.24), the movement of the imported goods price *index* can be written as

$$P_{M_t} = \frac{\lambda}{\lambda - 1} S_t P^*_{M_t} - \frac{\psi_{P_M}}{\lambda - 1} \frac{P_{D_t}}{T_{M_t}} \frac{P_{M_t}}{P_{M_{t-1}}} \left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1 \right) + \frac{\psi_{P_M}}{\lambda - 1} \mathbf{E}_t \left[\frac{\Gamma_{t,t+1}}{\Gamma_{t,t}} \frac{P_{D_{t+1}}}{T_{M_t}} \frac{P_{M_{t+1}}}{P_{M_t}} \left(\frac{P_{M_{t+1}}}{P_{M_t}} - 1 \right) \right], \tag{2.25}$$

where T_{M_t} is the level of aggregate demand for imports by the domestic economy. A higher value of ψ_{P_M} implies a lower rate of exchange rate pass-through into imported goods prices. On the other hand, complete pass-through ($\psi_{P_M} = 0$) denotes a firm setting its import price every period as a markup over the foreign price. Following Devereux et al. (2006), we set $P^*_{M_t} = 1$. Hence, shocks to the terms of trade feed into the economy through $P^*_{X_t}$.

2.2.4 Household absorption sector

Lastly, there is a firm that acts as a middleman between households and firms. This firm simply collects nontraded and imported goods from domestic firms and sells the resulting bundle to the households. The bundle, Y_t, is again defined as a CES aggregate:

$$Y_t = \left[a^{\frac{1}{\rho}} Y_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}} T_{M_t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}. \tag{2.26}$$

Maximizing profits at every period t, the representative firm determines its optimal demand for nontraded and imported goods from domestic firms as expressed below.

$$Y_{N_t} = a\left(\frac{P_{N_t}}{P_{D_t}}\right)^{-\rho} Y_t \tag{2.27}$$

$$T_{M_t} = \ (1-a)\left(\frac{P_{M_t}}{P_{D_t}}\right)^{-\rho} Y_t \tag{2.28}$$

2.3 Monetary authority

Different monetary rules are considered and the associated welfare costs of business cycles evaluated. In all the monetary policy rules enumerated below, it is assumed that the central bank's policy instrument is the nominal interest rate. Also, the variables without t subscript appearing below refer to their non-stochastic steady state values.

The first of such rules is strict inflation targeting. With this rule, that the monetary authority only concerns itself with fluctuations in the rate of inflation. This monetary policy is introduced to contrast the baseline policy which is of the flexible type. Specifically, the central bank faces the following simple rule:

$$\ln\left(\frac{1+i_t}{1+i}\right) = \alpha_{\pi_D} \ln\left(\frac{\pi_{D_t}}{\pi_D}\right), \tag{2.29}$$

where α_{π_D} is the weight placed by the authority on targeting domestic inflation π_{D_t}.

It was only in the first quarter of 2002 that *Bangko Sentral ng Pilipinas* (BSP), the Philippines' central bank, implemented inflation targeting. Prior to this period, BSP adhered a monetary targeting approach to monetary policy. It would be interesting then to examine the welfare cost/gain of giving up the previous monetary policy for the current one. Hence, monetary targeting takes its place in the set of alternative monetary rules and is modeled as equation (2.29) by replacing the variable π_D with M.

To mirror the behavior of the economy under flexible prices in the absence of other distortions, we include a rule that aims to target inflation rate in the non-traded goods prices. This monetary policy takes the liberty away from firms in the non-traded sector to adjust their prices in response to a shock. Also, nominal exchange rate targeting is included in the list of rules. However, since this model assumes incomplete pass through, it would be no surprise that strict exchange rate targeting would not bring about gains in welfare relative to the baseline policy.

This study also accommodates the proposal of Frankel (2005) of pegging the export price index (PEPI) as an appropriate monetary policy for small open economies. According to Frankel, pegging the export price index has the advantage over CPI targeting in that the former is more robust to terms of trade shocks. When the world price of exports deteriorates, such a monetary policy responds indirectly through a domestic currency depreciation; CPI targeting does not. On one hand, a rise in the price of the country's imports would also make a domestic currency depreciation desirable. Although neither of the two policies deliver the desired result, CPI targeting implies a contractionary monetary policy that leads to an appreciation of the domestic exchange rate against the dollar, whereas PEPI at least promises no appreciation of the exchange rate.

Lastly, a policy that does price-level targeting through the CPI completes our list of alternative monetary policies. Ball et al. (2005) and Gorodnichenko and

Shapiro (2007) are among those in the literature that provide evidence of the efficacy of such monetary policy. Price-level targeting has the advantage over inflation targeting in that the former gives room for the policymaker to make up for past mistakes. This regime is able to offset a temporary inflation shock by bringing back the price level to its target, whereas there is no such offset under inflation targeting. With inflation targeting, a temporary inflation shock leads to a permanent shift in the time path of the price level, making the price level increasingly difficult to predict as the forecast horizon increases. While the long-run predictability of the price level under this alternative policy is the source of its appeal, the same policy, however, has the propensity to raise the short-run variability of both inflation and output (Ambler, 2009).

2.4 Equilibrium and aggregation

Going back to the non-traded sector to integrate the optimal behavior of the overall set of identical firms leads to the following aggregate production technology and demands for capital and labor:

$$Y_{N_t} = A_N K_{N_t}^{\alpha} H_{N_t}^{1-\alpha} \tag{2.30}$$

$$R_{N_t} K_{N_t} = \alpha MC_{N_t} Y_{N_t} \tag{2.31}$$

$$W_{D_t} H_{N_t} = (1-\alpha) MC_{N_t} Y_{N_t}. \tag{2.32}$$

If we restrict attention to equilibria in which the nominal interest rate is strictly positive, as we do in this paper, then the cash-in-advance constraint faced by households will always be binding (Schmitt-Grohé and Uribe, 2007). Thus, the aggregate household demand for money satisfies

$$M_t = \nu P_{D_t} C_{D_t}. \tag{2.33}$$

The domestic labor market clearing condition states that

$$H_{D_t} = H_{N_t} + H_{X_t}. \tag{2.34}$$

Finally, the economy's current account equation is given by

$$(1 + i^*_{t-1}) S_t D_{t-1} + f_e S_t W_{F_t} H_{F_t} = P_{X_t} Y_{X_t} - S_t P^*_{M_t} T_{M_t} + S_t D_t + S_t Remit_t, \tag{2.35}$$

where the derivation can be followed in Appendix A.4. In the process of deriving (2.35) from (2.6), we assumed that $T_t = M_t - M_{t-1} + (1 + i_{t-1}) B_{t-1} - B_t$ and

$$\begin{aligned} Y_t = C_{D_t} + I_{N_t} + I_{X_t} + \frac{\psi_D}{2}(D_t - D)^2 + \frac{\psi_{P_M}}{2}\left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1\right)^2 \\ + \frac{\psi_{P_N}}{2}\left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1\right)^2 + \frac{\psi_{Rem}}{2}(Remit_t - Remit)^2. \end{aligned} \tag{2.36}$$

A stationary competitive equilibrium is a set of stationary stochastic processes $\{C_{D_t}$, C_{F_t}, H_{D_t}, H_{F_t}, D_t, B_t, M_t, I_{N_t}, I_{X_t}, $K_{N_{t+1}}$, $K_{X_{t+1}}$, $Remit_t$, λ_t, ζ_t, Q_{N_t}, Q_{X_t}, P_{D_t}, W_{D_t}, R_{N_t}, R_{X_t}, Y_{X_t}, Y_t, Y_{N_t}, P_{N_t}, T_{M_t}, P_{M_t}, S_t, H_{X_t}, H_{N_t}, MC_{N_t}, $i_t\}_{t=0}^{\infty}$ satisfying (2.3-2.5), (2.8-2.22), (2.24-2.36) given exogenous processes $\{i^*_t$, $P^*_{X_t}\}_{t=0}^{\infty}$ and initial conditions K_{N_0}, K_{X_0}, D_{-1}, i^*_{-1}, B_{-1}, i_{-1}, M_{-1}, $C_{F_{-1}}$, $C_{D_{-1}}$,

$P_{M_{-1}}$ and $P_{N_{-1}}$. Equilibrium under any of the monetary policy regimes discussed can be defined in a similar manner by replacing (2.29) with the appropriate monetary specification.

Other macroeconomic variables that are of interest in this paper are domestic inflation rate, π_{D_t}, non-traded goods inflation rate, π_{N_t}, gross domestic product, GDP_t, real interest rate, r_t, and the real exchange rate, RER_t. Gross rates of domestic and non-traded goods inflation are given by

$$\pi_{D_t} = \frac{P_{D_t}}{P_{D_{t-1}}},$$
$$\pi_{N_t} = \frac{P_{N_t}}{P_{N_{t-1}}}.$$

Following Schmitt-Grohé and Uribe (2001), gross domestic product is expressed as

$$GDP_t = \frac{P_{X_t} Y_{X_t} + P_{N_t} Y_{N_t}}{P_{D_t}},$$

which can be interpreted as the value of all goods produced within the economy in terms of domestic final goods. The real interest rate is defined as

$$r_t = i_t + 1 - \pi_{D_t}.$$

Lastly, we follow Galí and Monacelli (2005) in defining the bilateral real exchange rate as the ratio of the two countries price indices, expressed in the currency of the home economy, i.e.,

$$RER_t = \frac{S_t P_{F_t}}{P_{D_t}},$$

where we previously mentioned that $P_{F_t} = 1$.

Chapter 3

Welfare evaluation

Policy evaluations are carried out by comparing welfare costs across different monetary regimes. We follow the steps outlined by Schmitt-Grohé and Uribe (2007) in deriving a welfare cost measure.

Conditional welfare associated with an alternative monetary policy, denoted by a, is defined as

$$V_0^a = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U \left(\frac{(\widetilde{C}_{D_t}^a)^{1-\sigma_D}}{1-\sigma_D} + \frac{(\widetilde{C}_{F_t}^a)^{1-\sigma_F}}{1-\sigma_F} - \eta \frac{(H_{D_t}^a + H_{F_t}^a)^{1+\psi}}{1+\psi} \right),$$

where $\widetilde{C}_{Z_t}^a \equiv C_{Z_t}^a - \rho_Z C_{Z_{t-1}}^a$ and $H_{Z_t}^a$ are the contingent plans for consumption and labor under a particular policy. Similarly, we denote conditional welfare associated with the baseline monetary regime b by V_0^b.[8]

Conditional welfare cost then, denoted by ϵ^c, is defined as the fraction of

[8]We note that at time 0, the economy is in the nonstochastic steady state of a competitive equilibrium which is invariant across monetary regimes. This ensures that the economy begins from the same initial point for all possible policies considered.

regime b's consumption stream that a consumer would freely give up to be indifferent between the two regimes a and b. That is, ϵ^c can derived from the following equality:

$$V_0^a = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U \left(\frac{[(1-\epsilon^c)\widetilde{C}_{D_t}^b]^{1-\sigma}}{1-\sigma} + \frac{[(1-\epsilon^c)\widetilde{C}_{F_t}^b]^{1-\sigma}}{1-\sigma} - \eta \frac{(H_{D_t}^b + H_{F_t}^b)^{1+\psi}}{1+\psi} \right),$$

where we conveniently impose $\sigma = \sigma_D = \sigma_F$ to facilitate a tractable derivation of the welfare cost measure.

If we let $V_{H_0}^b = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\eta \frac{(H_{D_t}^b + H_{F_t}^b)^{1+\psi}}{1+\psi} \right)$, then the previous equation becomes

$$V_0^a = (1-\epsilon^c)^{1-\sigma} \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U \left(\frac{(\widetilde{C}_{D_t}^b)^{1-\sigma}}{1-\sigma} + \frac{(\widetilde{C}_{F_t}^b)^{1-\sigma}}{1-\sigma} \right) - V_{H_0}^b.$$

Yet, $\mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t U \left(\frac{(\widetilde{C}_{D_t}^b)^{1-\sigma}}{1-\sigma} + \frac{(\widetilde{C}_{F_t}^b)^{1-\sigma}}{1-\sigma} \right) = V_0^b + V_{H_0}^b$. As a result, we have a simplified expression for V_0^a:

$$V_0^a = (1-\epsilon^c)^{1-\sigma} (V_0^b + V_{H_0}^b) - V_{H_0}^b.$$

Solving for ϵ^c, we obtain

$$\epsilon^c = 1 - \left(\frac{V_0^a + V_{H_0}^b}{V_0^b + V_{H_0}^b} \right)^{\frac{1}{1-\sigma}}.$$

For a second-order approximation of the welfare cost measure, refer to Appendix B.

Chapter 4

Model calibration and solution

The equilibrium dynamics of the model is estimated through a second-order approximation to the equilibrium conditions around the nonstochastic steady state. The latest version of Dynare, a free software that runs in Matlab, is used to perform this routine. Since we are ultimately after welfare cost estimates in this study, it is necessary to do a second-order approximation to account for the volatility effects on the mean levels of welfare.

The model, with respect to a baseline monetary policy specification, is calibrated to match moments of some macroeconomic variables for Philippine data spanning the 2002:Q1-2009:Q3 period. Such a period is chosen because it is characterized by a homogeneous inflation targeting regime, which is believed to be of the flexible variety (Mariano and Villanueva, 2006). In particular, the baseline regime is modeled as a hybrid Taylor rule with the following specification:

$$\ln\left(\frac{1+i_t}{1+i}\right) = \alpha_i \ln\left(\frac{1+i_{t-1}}{1+i}\right) + \alpha_{\pi_D} \ln\left(\frac{\pi_{D_t}}{\pi_D}\right) + \alpha_S \ln\left(\frac{S_t}{S}\right) + \alpha_{GDP} \ln\left(\frac{GDP_t}{GDP}\right).$$

Variables without t subscripts stand for their corresponding nonstochastic steady state values. Together with the other parameters in the model, we search for parameter values to match simulated moments to empirical ones of some variables.

From the calibration exercise, the smoothing parameter α_i is set to 0.84, which agrees with the value for the optimized Taylor rule reported by Schmitt-Grohé and Uribe (2007). The parameters α_{π_D}, α_S and α_{GDP} are assigned values of 1.6, 0.2 and 0.7, respectively. These values are fairly consistent with the Bayesian estimates of Bautista (2009) for the Philippines using data for a similar period.

Table 4.1 presents a summary of the values assumed by the parameters in the model. We follow Devereux et al. (2006) in setting the world real interest rate at 6% so that at the quarterly level, $\beta = 0.985$. The intensity of habit formation, ϱ_D, takes on an upper bound to some emerging country estimates (see Uribe and Yue, 2006; Haider and Khan, 2008, for comparison). This habit persistence value must be consistent with a mid-range value for the intertemporal elasticity of substitution, $\sigma_D = \sigma_F$. Quarterly depreciation rate is set to $\delta = 0.025$ as in many papers (Christiano et al., 2005; Acosta et al., 2009; Devereux et al., 2006). α and γ take on values used by Devereux et al. (2006) which are inferred from Asian data. Likewise, ρ takes on a value of unity following (Devereux et al., 2006). The parameter λ is set so that steady state markup of prices over marginal cost in the non-traded sector is 10%, as practiced in the literature.

The parameter φ is set to 4, much higher than the unity value for Devereux et al. (2006). This implies that the Frisch elasticity of domestic labor supply is equal to 0.25. Such a value is consistent with the average estimates of uncompensated labor supply elasticities for men and women obtained by Evers et al. (2008) for a group of countries.[9] The authors find that the mean elasticities for men and women are 0.07 and 0.43, respectively. Moreover, $1/\varphi = 0.25$ is close to the simple average of two labor elasticity estimates obtained for the Philippines. Bautista (1973) concludes that Philippine manufacturing in 1961 is characterized by a unitary elasticity of labor supply. Dessing (2002), on one hand, examines a $1975-76$ data of rural households with low wage rates in the Philippines and arrives at a labor supply elasticity of -0.554. The author's paper also surveys a literature that shows positive labor supply elasticities at higher levels of income.

Due to the difficulty of quantifying the economic cost of emigration, the parameter f_e is calibrated so that the steady state hours worked in the home economy is 0.4, slightly higher than the steady state value of 0.2 for the case of the U.S. economy (Prescott, 1986). The slightly higher steady state work-hours reflects the observation of longer working hours in developing countries relative to the developed economies (Lee et al., 2007). It is not difficult to accept the calibrated value of f_e since, apart from the monetary costs of labor migration which include visa processing, transportation, initial monthly allowance, emigrants also face the non-monetized cost of leaving their families behind and adjusting to a

[9]This group refers to countries with available empirical estimates of labor supply elasticities (excluding those obtained through OLS estimation for they are known to be inconsistent). These are estimates pertaining to US, Sweden, Germany, France, Italy, Netherlands, UK, and Finland labor markets.

new environment. From equation (2.33), $\nu = S_M/S_C$, where S_M is the average ratio of M1 to GDP from 1988-1999 and S_C, the private consumption share of GDP for the same period. The ν value implies that households hold money balances equivalent to 45% of their quarterly consumption. On one hand, we treat ν^W as the ratio of the Philippine real wage rate to that of the US and use the year 2000 wage rate values of Ashenfelter and Jurajda (2001) who suggest to use the Big Mac index in comparing wage rates across countries (W_{F2000} = 2.59 whereas $W_{D_{2000}}$ = 0.46). Ideally, the ν^W parameter must also take account of the differences in the wage measurement and consumption basket, proxied by the nominal exchange rate. The degree of home bias, a, reflects the chunk of non-traded goods in the CPI. We could not find data directly corresponding to a and instead calculated the average share of tradables to GDP (1-a) for the period 1981-1999, using the sectoral classification of Gonzalez-Soriano (1990). The value for a obtained is comparable to the Thai average of 54% for the period 1980-1998.

Following Schmitt-Grohé and Uribe (2001), the value of ψ_I is chosen such that the simulated standard deviation of investment matches the observed one. In the same way, the value of ψ_{Rem} reflects the correspondence of the simulated standard deviation of remittances to the data. We further borrow the estimate of Schmitt-Grohé and Uribe (2003) for ψ_D.

The degree of price rigidity in the non-traded sector, governed by ψ_{P_N}, is set at 175 following Schmitt-Grohé and Uribe (2001) where they draw their choice of ψ_{P_N} from Sbordone's (2002) estimate of a linear new Keynesian Phillips curve using U.S. data. In a Calvo-Yun staggered pricing model, this value of ψ_{P_N} implies that firms change their price on average every 9 months, as pointed by Sbordone.

This is acceptable to the Philippine case as employment contracts for temporary employees are usually set to an average of 6 months. Meanwhile, the speed of exchange rate pass-through, ψ_{P_M}, is set at 30 to reflect studies that report a high (but not complete) degree of exchange rate pass-through into imported goods prices in the Philippines (see Webber, 1999; Sahminan, 2002; Devereux and Yetman, 2010).

We draw from the empirical estimates of Devereux et al. (2006) in pinning down the parameters associated to the processes of the two exogenous variables. The authors ran a quaterly VAR system over 1982:Q1 to 2003:Q3 for the US real interest rate and Asian aggregate terms of trade. They find that there is a low correlation between the residuals of the two variables and that terms of trade appears to be more persistent than interest rate. Specifically, world interest rate and terms of trade, $tot_t \equiv \frac{P^*_{X_t}}{P^*_{M_t}}$, are assumed to follow an AR(1) process of the form,

$$\ln\left(\frac{1+i^*_t}{1+i^*}\right) = z_1 \ln\left(\frac{1+i^*_{t-1}}{1+i^*}\right) + \epsilon_{i^*},$$

$$\ln\left(\frac{tot_t}{tot}\right) = z_2 \ln\left(\frac{tot_{t-1}}{tot}\right) + \epsilon_{tot},$$

where ϵ_{i^*} and ϵ_{tot} are the shocks associated to i^* and tot, respectively. Finally, to compute the long run allocations of the endogenous variables in the model, we impose the calibration restrictions that the steady state external debt is 59.66% of GDP and that nominal exchange rate at the steady state is equal to unity. The debt-to-GDP estimate is obtained from a simple average of annual Philippine data from 1970 to 2004.

Table 4.1: Calibrated parameters

Parameter	Value	Description
β	0.985	Discount factor (quarterly real interest rate is $(1-\beta)/\beta$)
$\varrho_D = \varrho_F$	0.404	Intensity of habit formation
$\sigma_D = \sigma_F$	2.8	Inverse elasticity of consumption
η	3	Disutility of labor
φ	4	Inverse elasticity of labor supply
f_e	0.40386	Cost of emigration per unit
ν^W	0.1776	Sets the relationship between W_{D_t} and W_{F_t}
ν	0.4499	Fraction of money held by domestic households
δ	0.025	Quarterly depreciation rate
$A_N = A_X$	1	Productivity parameters
α	0.3	Capital share in the non-traded sector
γ	0.7	Capital share in export sector
a	0.5868	Degree of home bias
A	1.9699	$A = \frac{1}{a^a(1-a)^{1-a}}$
ρ	1	Elasticity of substitution between Y_{N_t} and T_{M_t}
λ	11	Elasticity of substitution across non-traded goods variety
ψ_D	0.0007	Portfolio adjustment cost parameter
ψ_I	4.44	Investment adjustment cost parameter
ψ_{Rem}	0.03284	Remittance adjustment cost parameter
ψ_{P_N}	175	Price adjustment cost, non-traded sector
ψ_{P_M}	30	Degree of exchange rate pass-through
α_i	0.84	Coefficient of interest rate smoothing
α_{π_D}	1.6	Coefficient of inflation
α_S	0.2	Coefficient of nominal exchange rate
α_{GDP}	0.7	Coefficient of output
z_1	0.46	Persistence of world interest rate
z_2	0.77	Persistence of terms of trade
$\sigma_{\epsilon_{i^*}}$	0.0122	Standard deviation of world interest rate shock
$\sigma_{\epsilon_{tot}}$	0.0130	Standard deviation of terms of trade shock
ρ_{i^*, P_X^*}	0.042	Correlation between world interest rate and terms of trade

Chapter 5

Results and discussion

We first compare the comovements implied by the model to those observed in the Philippine data. We then examine how this model with labor mobility and remittances differ from a model bereft of these features. After doing so, the model's response to various monetary policy regimes are examined and the welfare costs presented.

5.1 Theoretical and empirical moments of some macroeconomic variables

A comparison of the actual and simulated comovements of some macroeconomic variables is presented in Table 5.1. Although the model overestimates the volatility of output and greatly underestimates the volatilities of the real exchange rate and overseas labor, it captures reasonably well the volatilities of consumption and

Table 5.1: Actual and predicted comovements (Sample: 2002:Q1-2009Q3)

	GDP_t	C_{D_t}	I_t	π_t	$\frac{tb_t}{GDP_t}$	rer_t	$Remit_t$	H_{D_t}	H_{F_t}	rW_{D_t}
% Std. dev.										
Philippine data	1.00	0.64	6.49	0.95	3.15	3.79	7.37	0.80	7.95	2.53
Model	2.97	0.63	6.49	0.32	0.89	0.41	7.37	0.42	0.42	3.56
Corr. with GDP										
Philippine data	1.00	0.67	0.66	0.27	0.65	-0.16	-0.22	0.11	-0.21	0.13
Model	1.00	0.56	0.31	0.13	0.16	-0.35	-0.35	0.52	-0.47	0.55

Notes: Data are obtained from the CEIC database and depending on the series, are sourced from various national and international institutions. The national income accounts data are from the National Statistical Coordination Board (NSCB). GDP_t is gross domestic product, C_{D_t} and I_t are the GDP shares of private consumption expenditures and gross capital formation, respectively, and tb_t is net exports. All these aforementioned series are in their 1985 prices. The gross rate of inflation, π_t, is computed from the consumer price index (CPI) in 2005 prices, the series of which originates from the International Monetary Fund (IMF). Domestic employment series (H_{D_t}) also comes from IMF. Data for overseas Filipino workers (H_{D_t}) is provided by the Philippine Overseas Employment Administration (POEA). The real exchange rate series, rer_t, is calculated as US Producer Price Index (PPI) multiplied by average-of-period nominal exchange rate and divided by the Philippine CPI. PPI, also in 2005 prices, is from IMF. Empirical $Remit_t$ is estimated as remittances in US dollar multiplied by end-of-period nominal exchange rate and divided by the CPI. The remittances and exchange rate series are from Bangko Sentral ng Pilipinas. Finally, the domestic real wage series, rW_{D_t}, is wages in the manufacturing sector (data from LABORSTA, an ILO database) divided by the CPI. All series handled are seasonally-adjusted with X-11 in EViews. The series appearing in Table 2 are logged (except for $\frac{tb_t}{GDP_t}$, which was HP-filtered immediately) and detrended using the HP filter, also in EViews.

to some extent, inflation, domestic labor and the domestic real wage. Moreover, it correctly implies that consumption, investment, inflation, trade-balance-to-GDP ratio, domestic employment and real wage are positively correlated with GDP, whereas real exchange rate, remittances and labor outflow are counter-cyclical with GDP. We can, thus, say that the model succeeds qualitatively in replicating the key cyclical characteristics of these macroeconomic aggregates observable from the data.

Moreover, the model's variance decomposition analysis reveals that 30.32% of the fluctuations in GDP is due to the external interest rate shock whereas 69.68% can be attributed to shocks coming from the terms of trade. These figures are consistent with the findings of Mendoza (1995) and Uribe and Yue (2006).

5.2 The baseline model in response to the two shock processes

This section discusses the model's responses to transitory shocks to the US real interest rate and terms of trade and establishes the importance of incorporating exchange rate pass-through and the two features of labor migration and remittances to the standard small open economy model.

Figures 5.1 and 5.2 show the impulse responses of the models to a 1% shock to the external real interest rate. Figure 5.1 compares the impulse response functions of the baseline model (with incomplete pass-through and labor migration) to those of a model with labor migration but complete pass-through. Figure 5.2 presents a comparison of the baseline model with the standard small open economy model without labor mobility and migrant transfers.

A quick glance at the graphs in Figures 5.1 and 5.2 would tell us that the three models generally respond to the shock in the same way. The difference lies in the degree of their responses. Overall, households, now with more costly access to foreign loans and facing a depreciation of the nominal exchange rate, scrimp on domestic consumption and investment, thereby reducing demand for non-traded goods. The fall in demand, consequently, leads to a decline in the domestic price index, which implies a depreciation of the real exchange rate. (For the full pass-through case, the sudden surge in the nominal exchange rate pulls up import prices in the domestic market which leads to an initial upward tick in domestic CPI and inflation.) With its increased competitiveness in the world market, the export sector expands resulting to further trade surplus. The baseline monetary policy that is a hybrid of domestic inflation, exchange rate and output targeting responds to the shock by preventing this real exchange rate depreciation and deviation of output from its steady state level. While the fixed exchange rate prevents the depreciation of the exchange rate by design, the CPI inflation targeting does so by stabilizing the exchange rate to prevent inflation to gear away from the target. In the case of a complete exchange rate pass-through to imported goods prices, a policy maker cannot stabilize inflation without largely stabilizing the exchange rate. And so the nominal interest rate has to rise by a significant amount. Thus, such monetary policy actually ensures that almost the full impact (only slightly cushioned by the weight on output in the monetary rule) of the external interest rate shock is passed through to the domestic economy. The eventual rise in the real interest rate cripples the economy as manifested by the drop in GDP and the fall in domestic employment. This result implies that the expansion of the export sector is unable to compensate for the contraction in the non-traded sector so as to raise aggregate output. On one hand, the presence of incomplete pass-through makes it possible for the monetary authority to control inflation without worrying much on the depreciation of the nominal exchange rate. And so the monetary authority need not raise the nominal interest rate by as much as in the complete pass-through case. As presented in Figure 1, there is greater real exchange rate depreciation and a smaller increase in the domestic real interest rate for the delayed pass through case. The presence of delayed pass through then shields the economy from a further drop in GDP and domestic employment. The increase in trade balance is less in this case as the domestic economy's absorption picks up and exports are less as households' resources are channeled to the non-traded sector.

The presence of labor mobility and remittances also alter the degree of the response of the model's variables. Figure 5.2 contrasts the baseline model to the model without these features, all other things equal. Following the flow earlier, the rise in the domestic real exchange rate enhances migrant transfers to the home economy, thereby faintly relieving households from a decline in total absorption. This household response is supported by a smaller fall in the demand for consumption and investment goods resulting to a domestic deflation. Nominal exchange rate further increases as households' consumption basket includes imported goods. Despite the improved competitiveness of the traded sector, output in this sector slightly falls compared to the no labor mobility case as more household workers supply labor to the foreign market where real wages are higher. Since the economy is still sensitive to the surge in the nominal exchange rate to a certain degree (despite the presence of delayed pass through), the monetary authority responds by jacking up interest rates. Despite a lower rise in the real interest rate, GDP drops by a greater amount and aggregate domestic employment plummets further while foreign-bound labor increases.[10] The drop in GDP tells us that migrant transfers are unable to cushion the negative impact of the shock on the domestic economy as labor moves out of the domestic market resulting to a smaller aggregate output. For example, as much as the export sector wants to take advantage of the exchange rate depreciation by producing more, it is constrained by the labor supply in the local economy. Still in Figure 5.2, the domestic real wage cannot be too low since domestic firms now have to compete with foreign firms in the labor market. In this model, the exodus of migrant workers sinks the foreign real wages by a degree greater than the decline in domestic real wages. This is one limitation of the model - by imposing a relationship between domestic and foreign real wages, the latter becomes determined by the domestic household's foreign labor supply, which should not ideally be the case. This weakness can possibly be remedied by making the foreign wage exogenous and one way to do so is to model it as a productivity shock from the external economy. Despite the large drop in foreign real wages, remittances increase as migrant workers cut down on their consumption having realized that their wage earnings have increased value in the home country as a result of the real exchange rate depreciation.

Figures 5.3 and 5.4 present the responses of some variables from an unanticipated temporary shock to the terms of trade. Focusing attention on Figure 3, the

[10]The opposing responses of the two types of labor is mainly due to the high substitutability of the two by model design. It would be interesting as well to incorporate a parameter governing the substitutability of domestic and foreign labor so as to examine their responses from a shock.

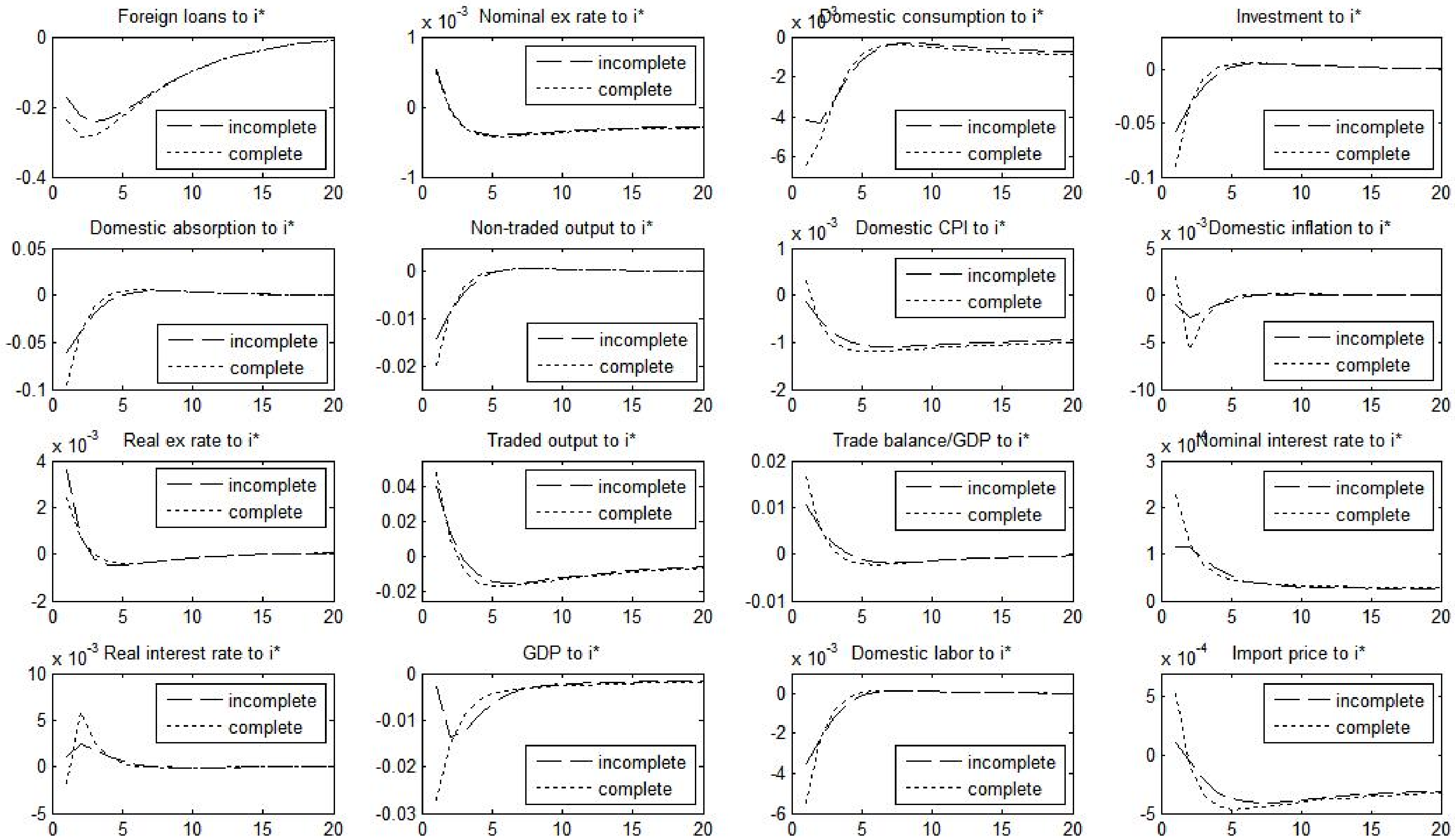

Figure 5.1: Impulse response to i^*: Complete vs. incomplete pass through for a model with labor mobility and remittances

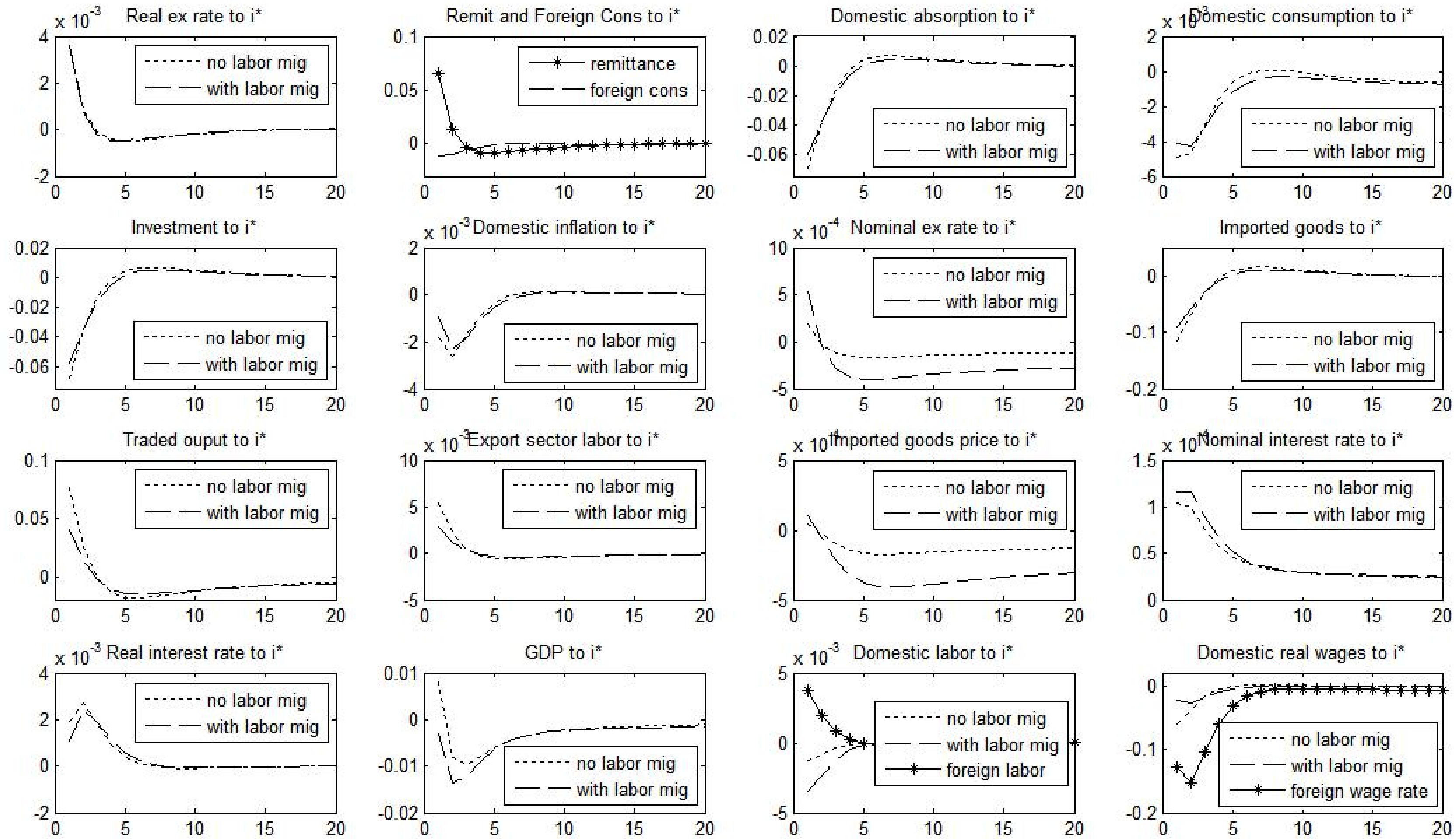

Figure 5.2: Impulse response to i^*: A comparison of the baseline model with a model without labor mobility and remittances.

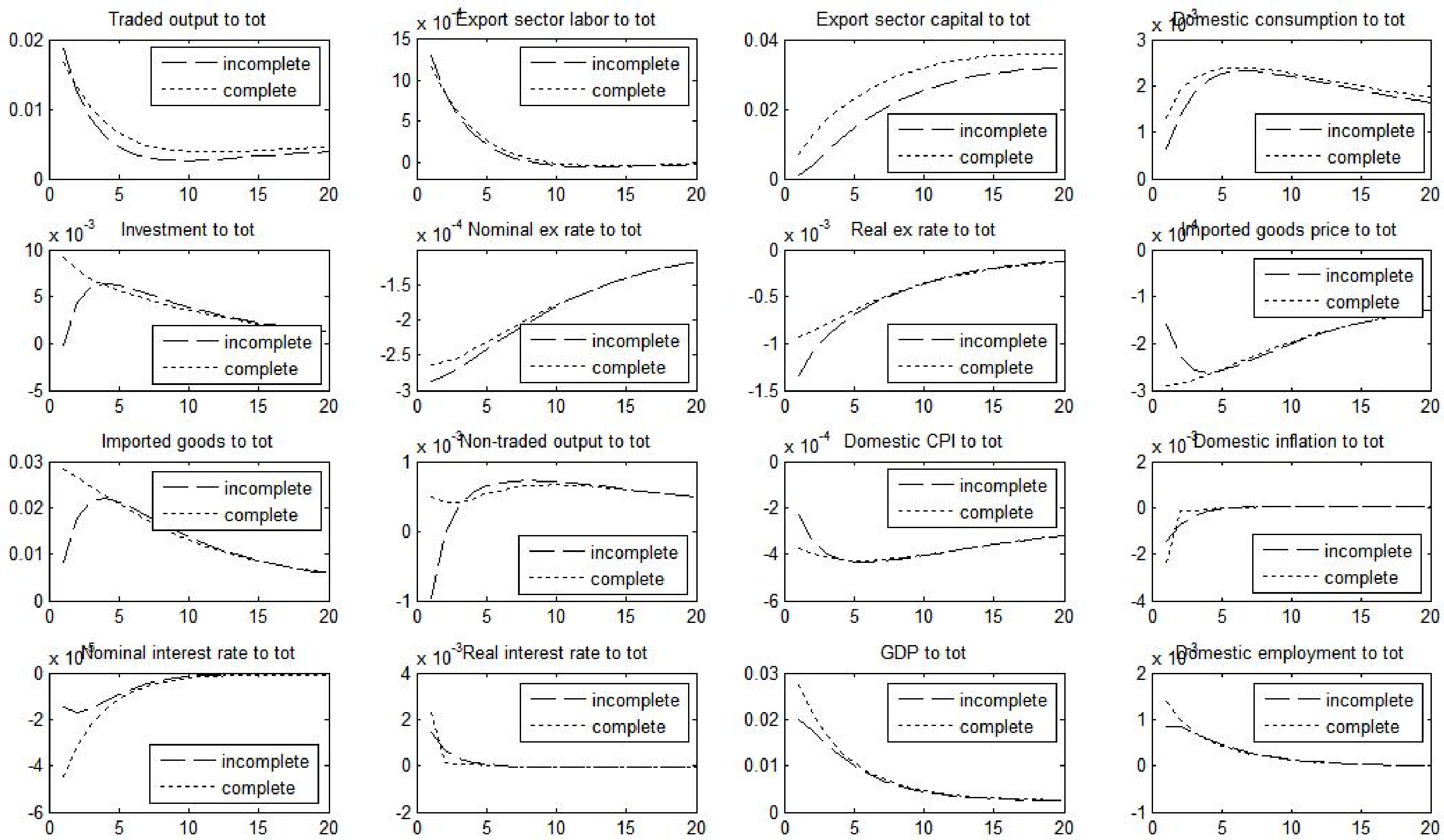

Figure 5.3: Impulse response to tot: Complete vs. incomplete pass through for a model with labor mobility and remittances

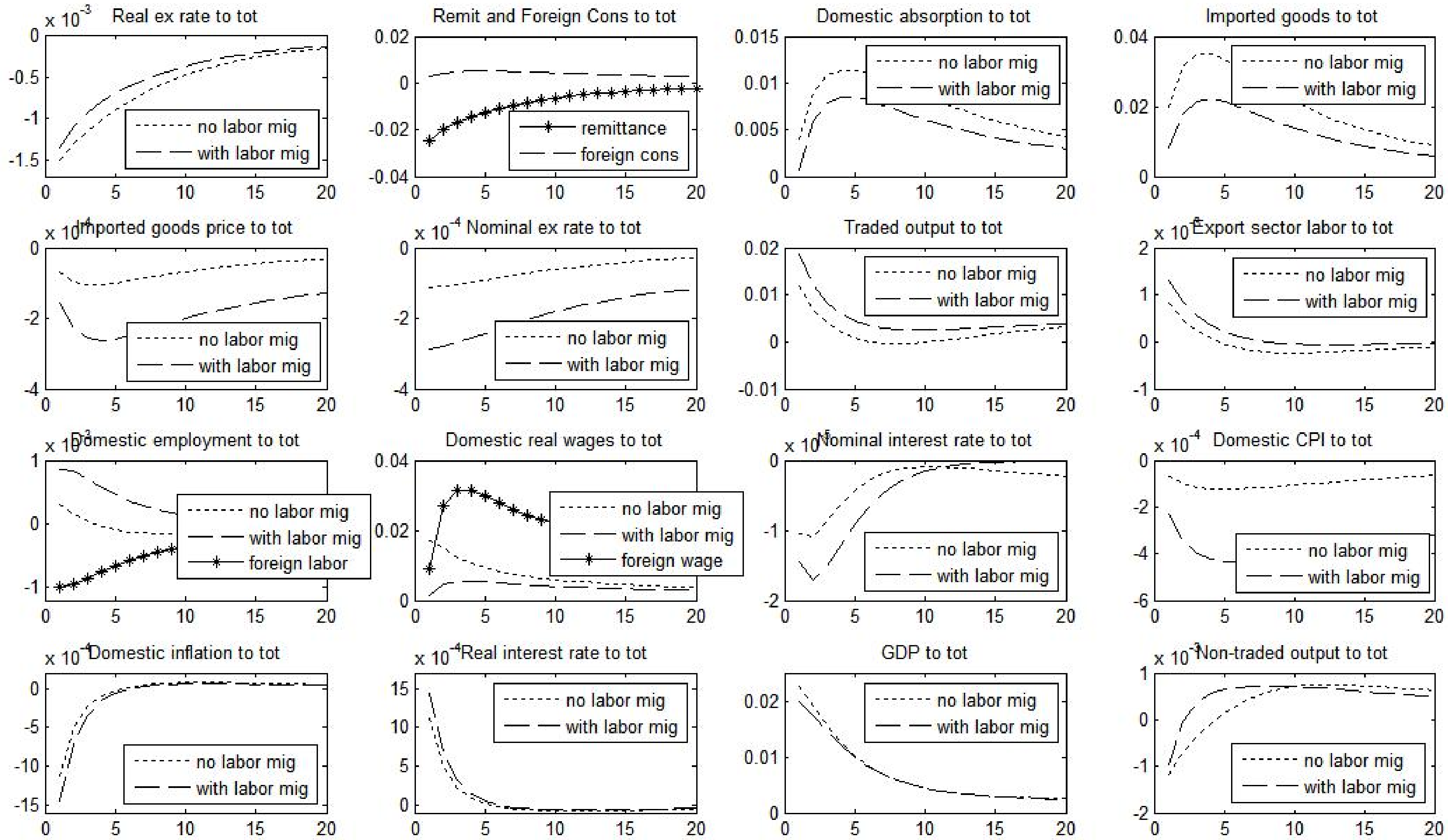

Figure 5.4: Impulse response to tot: A comparison of the baseline model with a model without labor mobility and remittances.

terms of trade shock, serving as a positive productivity shock to the export sector, increases tradable output and the sector's demand for inputs. Thus, this income effect induces domestic households to increase their consumption and investment expenditures. With the increased inflow of dollars to the economy, the nominal exchange rate appreciates. In the case of incomplete pass through, the fall in the nominal exchange rate leads to an instantaneous drop in import prices, but not as much as in complete pass-through. This leads to households buying more imported and lesser non-traded goods, as opposed to the complete pass-through case. The fall in import prices pulls down the domestic CPI resulting to a deflation. The monetary authority comes into the picture by decreasing nominal interest rates to stabilize inflation and the nominal exchange rate. The real interest rate shoots up brought about by the drop in inflation. Expectedly, GDP and domestic employment grow in both cases with the expansion of the producing sectors. For the incomplete pass-through, GDP is mainly driven by the growth in the export sector.

Figure 5.4 shows that the appreciation of the real exchange rate dampens the incentive of migrant workers to send their earnings back to the home country and instead spend their income on consumption. This leads to a smaller increase in household absorption that includes imported goods. The decline in the demand for imported goods pulls down the nominal exchange rate whereas the real exchange rate appreciates by a smaller degree under labor mobility due to the smaller increase in the demand for imported goods. Output in the export sector further increases with labor mobility as workers choose to stay in the home country due to increased domestic productivity. In turn, the outflow of workers decreases, partly due to the lower nominal exchange rate. The increased domestic supply of workers leads to a lower domestic real wage. On the other hand, foreign wage has to increase by a large amount to attract more workers. The nominal interest rate drops more significantly with labor mobility due to the decline in the nominal exchange rate and domestic prices. Finally, GDP rises less with labor migration due to a decrease in absorption coming from a drop in remittances.

Comparing the responses of GDP and inflation to the two shocks in Figures 5.2 and 5.4, we observe that the presence of labor mobility makes GDP more vulnerable while domestic inflation less before a real interest rate shock, given a hybrid flexible inflation targeting regime. Conversely, GDP is less and inflation more sensitive in the same model before a negative terms of trade shock.

How relevant are the labor migration and remittance dynamics of the model to the Philippine economy? Tan (2006) attributes this significant outflow of Filipino labor to, among others, the economy's poor performance, the country's market-based educational system, and the reduction in migration-related risks through the presence of government-established institutions that protect the rights of the workers in the destination country. There have also been a number of microeconometric studies on labor migration and remittances that focus on the Philippines. For instance, Choi and Yang (2007) are able to show that migrant transfers are motivated by changes in Philippine households' income using rainfall shocks as instrumental variables for income changes. Their results imply that remittances serve as insurance for the recipient households, thereby explaining the negative relationship between GDP and remittances in Table 2. Moreover, Yang (2008) obtains an estimate of 0.60 for the elasticity of Philippine-peso remittances with respect to the exchange rate. Indeed, a depreciation of the peso against the migrant's currency leads to increases in overseas remittances to the Philippines. At the macro level, while remittances may drive macroeconomic growth by boosting national disposable income, they may also bring harm to the economy as inflows of migrant transfers can fuel inflation, lead to an appreciation of the real exchange rate that places the traded sector to a disadvantage, and reduce labor market participation rates (Catrinescu et al., 2009). In the case of the Philippines, Rodriguez and Tiongson (2001) find that labor emigration reduces the labor supply of non-migrant relatives, which translates into lower earnings from the local labor market. Acosta et al. (2009) also support their findings using data for El Salvador and add that remittance flows, whether altruistically motivated or not, are channeled more towards non-tradables by the recipient households providing an incentive for the non-traded sector to expand, thereby reallocating labor away from the tradable sector - a phenomenon known as the Dutch disease.

The figures have demonstrated that the presence of labor mobility and its consequent migrant transfers generate a different set of economic decision-making dynamics from the standard small open economy model. Moreover, since the results obtained from this section may be conditional on the baseline monetary policy, it is fitting to explore other monetary rules that can possibly cushion the impact of these external shocks onto an economy where labor mobility and remittances are important driving forces behind output growth.

5.3 Comparison of alternative monetary rules

Table 5.2 presents the welfare cost figures associated to the different monetary rules in the face of the external shocks. Four of the six alternative monetary regimes in Table 5.2 reveal to cause a gain in welfare relative to the baseline policy of a hybrid flexible inflation targeting. For instance, households have to augment their current stream of consumption under the baseline policy by 0.039 percent to experience the same level of welfare with monetary targeting. Stated in another way, households are willing to give up 0.035 percent of their consumption stream under the non-traded price inflation targeting to see the baseline policy implemented. On the other hand, the same households have to let go of 0.100 percent of the nonstochastic steady state baseline consumption to experience export price targeting as the prevailing monetary policy rule. Thus, positive welfare cost values imply that households are worse off under the associated regimes. The intuition behind these results can be inferred from a comparison of the impulse responses of the models as presented in Figures 5.5 and 5.6.

Let us direct our attention to a deterioration in demand brought about by a real world interest rate hike. It is apparent from Figure 5.5 that the top five monetary policies generate different responses in non-traded goods prices, non-traded inflation, CPI, CPI inflation, and money holdings. The fall in non-traded output places an overall downward pressure on its price except for the case of non-traded inflation targeting, where the price slightly increases. This is so because of the 10 percent mark-up placed on the price over the marginal cost. Correspondingly, the slight increase in non-traded sector inflation causes the monetary authority to raise the nominal interest. Despite the fall in demand for imported goods, prices for these goods increase due to the depreciation of the nominal exchange. And so we see that except for the case of the baseline policy, domestic CPI and inflation go up. The biggest increase in the CPI inflation, however, comes from non-traded inflation targeting case. And so the high inflation rate works as a disadvantage to this monetary policy despite the large increase in GDP. Price-level and inflation targeting policies, on the other hand, raise the nominal interest rate more than non-traded inflation and money targeting do and this further causes a slump in income that ultimately leads to a fall in total output. Meanwhile, the increase in domestic prices pulls up money demand and with a policy of monetary targeting, raises the nominal interest rate. At the end of the day, despite the decrease in demand brought about by the domestic interest rate hike, total output increases as pulled up by the expansion of the traded sector. And even if GDP rises less under monetary targeting relative to non-traded inflation targeting, the initial surge in inflation is also lower for monetary targeting. And so explains why monetary targeting is welfare-superior to the other monetary rules. It is important to note, however, that without the price rigidity in the non-traded and import sectors, monetary targeting might not prevail the winner in this horserace and overall results might vary. Devereux et al. (2006) have shown that under complete pass-through, non-traded inflation targeting turns out to be the best monetary policy rule over inflation and exchange rate targeting, whereas inflation targeting is best under incomplete pass-through.

The welfare ranking obtained here is similar to that of Berger and Wagner (2006) for a two-country sticky price model exposed to productivity and cost-push shocks. If the two shocks are equally volatile, they find that monetary tar-

Table 5.2: Welfare cost comparisons for the model with labor mobility and remittances

Monetary policy rule	Specification				Welfare costs		% Std. dev.						
	α_i	α_{π_D}	α_S	α_{GDP}	ϵ^c x 100	ϵ^u x 100	σ_{π_D}	σ_i	σ_{GDP}	σ_I	σ_{H_D}	σ_{H_F}	σ_{Rem}
Baseline policy	0.84	1.60	0.20	0.70	0.0000	0.0000	0.32	0.01	2.97	6.49	0.42	0.42	7.37
Alternative simple monetary rules													
Money peg	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{M_t}{M}\right)$				-0.0389	-0.0170	0.21	0.21	3.18	4.95	0.31	0.36	8.05
Non-traded price inflation targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{\pi_{N_t}}{\pi_N}\right)$				-0.0348	-0.0143	0.31	0.14	3.07	3.70	0.18	0.27	8.99
(CPI) price-level targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{P_{D_t}}{P_D}\right)$				-0.0328	-0.0149	0.11	0.33	3.39	6.36	0.45	0.45	7.07
inflation targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{\pi_{D_t}}{\pi_D}\right)$				-0.0279	-0.0129	0.18	0.55	3.33	6.48	0.48	0.46	7.01
Exchange rate targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{S_t}{S}\right)$				0.0710	0.0336	0.26	1.01	5.95	12.01	1.04	0.81	3.53
Export price targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{P_{X_t}}{P_X}\right)$				0.1001	0.0490	0.45	1.06	4.83	12.62	1.05	0.80	5.76

Notes: The policy coefficients are restricted to lie in the interval $[0, 3]$ as in Schmitt-Grohé and Uribe (2007). Conditional and unconditional welfare costs are defined as the percentage decrease in the baseline optimal consumption process necessary to make the welfare levels of the baseline and alternative monetary policies identical. Thus, a negative figure indicates a welfare gain in that the associated policy brings about higher welfare compared to the baseline policy.

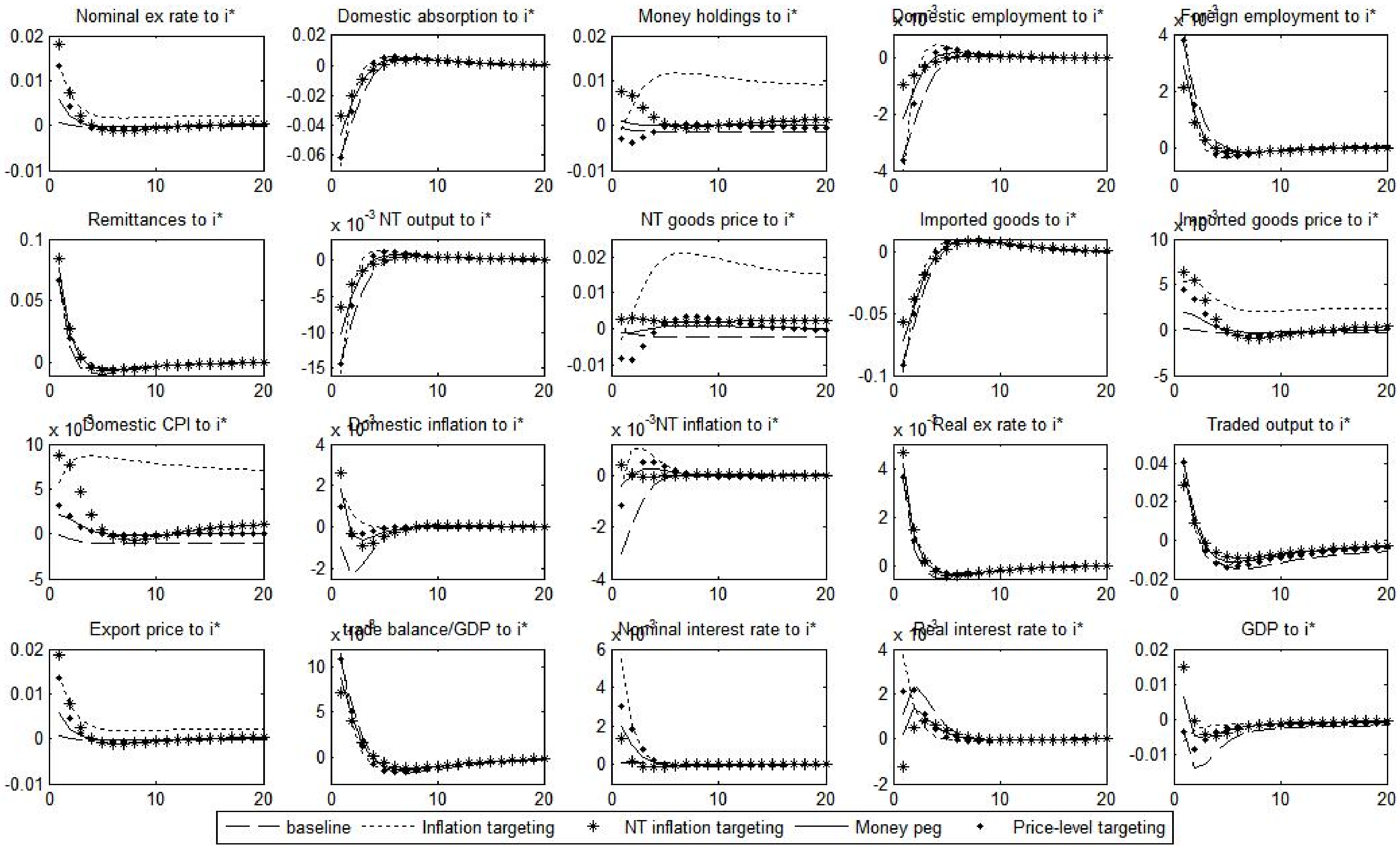

Figure 5.5: Impulse response to i^*: Comparing the top four monetary policies to the baseline policy

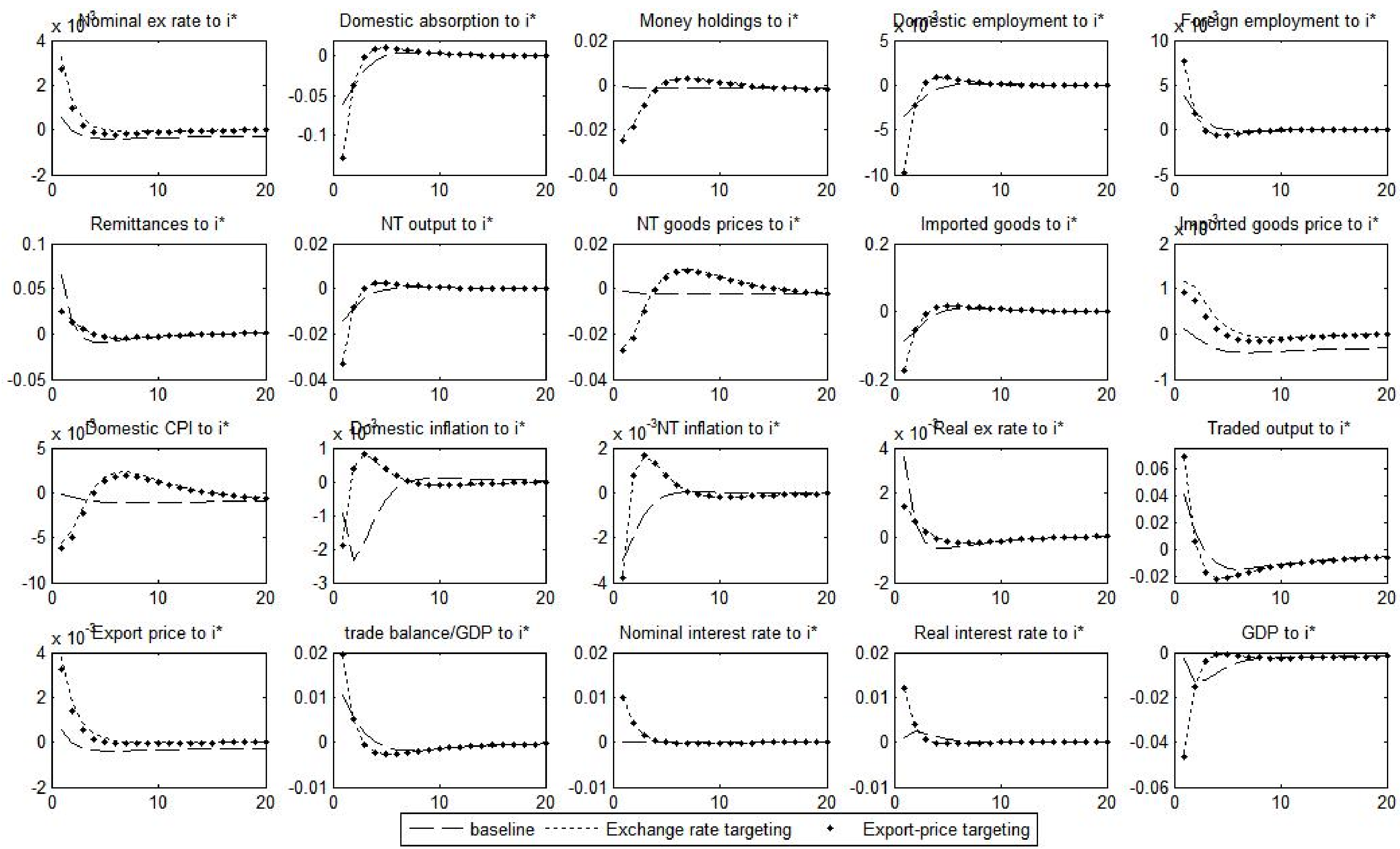

Figure 5.6: Impulse response to i^*: Comparing the 2 weakest policies to the baseline policy.

Table 5.3: Welfare cost comparisons for the model ***without*** labor mobility and remittances

Monetary policy rule	Specification				Welfare costs		% Std. dev.				
	α_i	α_{π_D}	α_S	α_{GDP}	ϵ^c x 100	ϵ^u x 100	σ_{π_D}	σ_i	σ_{GDP}	σ_I	σ_{H_D}
Baseline policy	0.84	1.60	0.20	0.70	0.0000	0.0000	0.34	0.01	3.14	7.38	0.15
Alternative simple monetary rules											
Money peg	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{M_t}{M}\right)$				-0.0571	-0.0276	0.20	0.20	3.46	5.74	0.08
Non-traded price inflation targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{\pi_{N_t}}{\pi_N}\right)$				-0.0512	-0.0246	0.39	0.10	3.68	4.28	0.06
(CPI) price-level targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{P_{D_t}}{P_D}\right)$				-0.0481	-0.0232	0.10	0.29	3.37	6.72	0.14
inflation targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{\pi_{D_t}}{\pi_D}\right)$				-0.0435	-0.0212	0.14	0.45	3.27	6.92	0.16
Exchange rate targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{S_t}{S}\right)$				0.1346	0.0657	0.45	0.99	4.45	12.65	0.50
Export price targeting	$\ln\left(\frac{1+i_t}{1+i}\right) = 3\ln\left(\frac{P_{X_t}}{P_X}\right)$				0.1450	0.0723	0.58	1.04	2.92	13.15	0.50

Notes: The policy coefficients are restricted to lie in the interval $[0, 3]$ as in Schmitt-Grohé and Uribe (2007). Conditional and unconditional welfare costs are defined as the percentage decrease in the baseline optimal consumption process necessary to make the welfare levels of the baseline and alternative monetary policies identical. Thus, a negative figure indicates a welfare gain in that the associated policy brings about higher welfare compared to the baseline policy.

geting dominates CPI and producer price targeting for varying degrees of price flexibility. The reason is that these two shocks affect intermediate goods output and prices in their model and a policy that stabilizes a combination of both would prove to be welfare-dominant. These authors also find that monetary targeting prevails to be the best simple rule if cost-push shocks predominate but is defeated by CPI targeting when productivity shocks are more dominant. As discussed by Sutherland (2004), policies that give room for price movements to stabilize output would dominate in the presence of cost-push shocks. In this model, however, price stability, to some extent, is made possible through price rigidity under a monetary targeting regime and monetary targeting is what causes relative stability in output. In addition, Senay and Sutherland (2007) find that monetary targeting is welfare superior to a fixed exchange rate when there is a low degree of elasticity of substitution between non-traded and imported goods. Yet, price targeting welfare-dominates exchange rate and monetary targeting. They use a model similar to that of Berger and Wagner (2006) but choose foreign money shocks to drive the dynamics of the model.

We turn to Figure 5.6 for an explanation of the exchange rate and export price targeting cases. For a fixed exchange rate regime, the initial increase in the nominal exchange rate is countered by a rise in the nominal interest rate. And so, household income further deteriorates causing a contraction in the non-traded and import sectors. Moreover, the expansion of the export sector is unable to compensate for the contraction in the non-traded sector such that aggregate output collapses to a much lower level compared to the baseline policy. Likewise, pegging the export price requires the monetary authority to raise the policy rate by about the same degree as in the fixed-exchange rate case and also leads to a fall in GDP by about the same level.

How does the ranking differ from one coming from a standard small open economy model without labor mobility and remittances? It can be deduced from Table 5.3 that the welfare ranking remains the same with the standard model.

Chapter 6

Conclusion

This study has extended the sticky-price small open economy set-up (without entrepreneurs) of Devereux et al. (2006) to allow for international labor emigration of households, thereby making remittances endogenously determined in the model. With the baseline monetary policy of a Taylor-rule type inflation targeting with a small weight on the nominal exchange rate, the simulated moments of some macroeconomic aggregates are broadly consistent with the moments of Philippine data for the inflation-targeting period 2002:Q1-2009:Q3. Moreover, variance decomposition analysis of the model reveal results that fairly agree with those in the literature. A comparison of the impulse response functions of the new set-up with the standard model reveal that the presence of labor mobility and migrant transfers in the economy generates different dynamics from the set-up without these features. We find that, under the baseline monetary policy, additional remittance income of domestic households leads to a decline in output in the face of an external real interest rate hike. On the other hand, labor outflow and its associated overseas workers' monetary transfers to the domestic household shields the entire economy from a further drop in GDP brought about by an adverse terms-of-trade shock. Finally, the calibrated model is used as a theoretical framework to search for monetary policies that are appropriate to this environment with highly mobile labor. We find that a flexible exchange rate regime in the form of either monetary targeting, non-traded inflation, price-level or inflation targeting brings welfare gains to the economy relative to the baseline monetary policy. In contrast, fixed exchange rate regimes will make the economy worse off relative to the same baseline policy. A ranking of the welfare costs reveals that monetary targeting is welfare-superior to any other policy. It is hypothesized, however, that this result is highly dependent on the sources of shocks to the system. For instance, adding domestic productivity shocks might alter the welfare ranking of the monetary rules. Moreover, changing the cash-in-advance constraint motivation of holding money to one with transactions cost and placing a shock on money velocity may allow us to examine the impact of monetary targeting on the economy in the event of a velocity shock. Finally, the welfare ranking of these various monetary policies is preserved even if one deals with the conventional small open economy model (one without labor migration and remittances).

The welfare-dominance of monetary targeting, if only for a small margin, somehow confirms Lim's 2008 theory that the Philippines' shift from monetary to inflation targeting in 2002 has not really brought in a significant positive impact on the real economy. There is a need then for BSP to further research on ways to improve the current monetary policy framework.

The model is only an initial attempt to study the impact of labor migration and remittance dynamics on a small open economy dynamic general equilibrium framework. It can be further improved by making foreign wages completely exogenous so that foreign wages remain unaffected by the inflow of foreign workers into the foreign economy. Moreover, including cost-push shocks in the model would allow us to verify whether inflation in the Philippines is a cost-push phenomenon, as stressed by Lim (2008), or not. Also, instead of simply manually matching the simulated moments to empirical ones, some parameter values may be determined by minimizing a measure of the distance between the model and empirical impulse response functions, as practiced in Christiano et al. (2005), to bring the model closer to the data. Lastly, it remains a challenge to estimate the welfare gain from labor migration and remittances as the utility functions of the model with labor migration differ from the model without such channels.

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Appendices

Appendix A

Model equations

A.1 Solution to the household's problem

The household's problem can be summarized by maximizing the following Lagrangean:

$$
\begin{aligned}
\mathcal{L} = \mathbf{E}_0 \sum_{t=0}^{\infty} \beta^t \Bigg\{ & \frac{(C_{D_t} - \varrho_D C_{D_{t-1}})^{1-\sigma_D}}{1-\sigma_D} + \frac{(C_{F_t} - \varrho_F C_{F_{t-1}})^{1-\sigma_F}}{1-\sigma_F} \\
& - \eta \frac{(H_{D_t} + H_{F_t})^{1+\psi}}{1+\psi} + \lambda_{F_t} \left(W_{F_t} H_{F_t} - C_{F_t} - Remit_t \right) \\
& + \lambda_{D_t} Q_{N_t} \left\{ \left[\frac{I_{N_t}}{K_{N_t}} - \frac{\psi_I}{2} \left(\frac{I_{N_t}}{K_{N_t}} - \delta \right)^2 \right] K_{N_t} + (1-\delta) K_{N_t} - K_{N_{t+1}} \right\} \\
& + \lambda_{D_t} Q_{X_t} \left\{ \left[\frac{I_{X_t}}{K_{X_t}} - \frac{\psi_I}{2} \left(\frac{I_{X_t}}{K_{X_t}} - \delta \right)^2 \right] K_{X_t} + (1-\delta) K_{X_t} - K_{X_{t+1}} \right\} \\
& + \lambda_{D_t} \Bigg[W_{D_t} H_{D_t} + R_{N_t} K_{N_t} + R_{X_t} K_{X_t} + M_{t-1} + S_t D_t + B_t \\
& + S_t Remit_t + T_t + \Pi_t - P_{D_t}(C_{D_t} + I_{N_t} + I_{X_t}) - M_t - S_t f_e W_{F_t} H_{F_t} \\
& - (1 + i^*_{t-1}) S_t D_{t-1} - (1 + i_{t-1}) B_{t-1} - \frac{\psi_D}{2} P_{D_t} (D_t - D)^2 \\
& - \frac{\psi_{REM}}{2} P_{D_t} (Remit_t - Remit)^2 \Bigg] + \lambda_{D_t} \zeta_t (M_t - \nu P_{D_t} C_{D_t}) \Bigg\}.
\end{aligned}
$$

The associated first order conditions are:

$$
\begin{aligned}
&C_{D_t}: \quad (C_{D_t} - \varrho_D C_{D_{t-1}})^{-\sigma_D} = \lambda_{D_t} P_{D_t}(1+\nu\zeta_t) \\
&H_{D_t}: \quad \eta(H_{D_t} + H_{F_t})^{\varphi} = \lambda_{D_t} W_{D_t} \\
&C_{F_t}: \quad (C_{F_t} - \varrho_F C_{F_{t-1}})^{-\sigma_F} = \lambda_{F_t} \\
&H_{F_t}: \quad \eta(H_{D_t} + H_{F_t})^{\varphi} = W_{F_t}(\lambda_{F_t} - \lambda_{D_t} S_t f_e) \\
&Remit_t: \quad \lambda_{F_t} = \lambda_{D_t}(S_t - \psi_{REM} P_{D_t}(Remit_t - Remit)) \\
&\text{assumption}: W_{F_t} = \frac{1}{\nu^W}\frac{W_{D_t}}{P_{D_t}} \\
&B_t: \quad \lambda_{D_t} = \beta(1+i_t)\mathbf{E}_t\lambda_{D_{t+1}} \\
&D_t: \quad \lambda_{D_t}(S_t - \psi_D P_{D_t}(D_t - D)) = \beta(1+i_t^*)\mathbf{E}_t S_{t+1}\lambda_{D_{t+1}} \\
&M_t: \quad \beta\mathbf{E}_t\lambda_{D_{t+1}} = \lambda_{D_t}(1-\zeta_t) \\
&I_{N_t}: \quad Q_{N_t}\left[1 - \psi_I\left(\frac{I_{N_t}}{K_{N_t}} - \delta\right)\right] = P_{D_t} \\
&I_{X_t}: \quad Q_{X_t}\left[1 - \psi_I\left(\frac{I_{X_t}}{K_{X_t}} - \delta\right)\right] = P_{D_t} \\
&K_{N_{t+1}}: \quad Q_{N_t} = \beta\mathbf{E}_t\frac{\lambda_{D_{t+1}}}{\lambda_{D_t}}\left\{R_{N_{t+1}} + Q_{N_{t+1}}\left[(1-\delta) - \frac{\psi_I}{2}\left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}} - \delta\right)^2\right.\right. \\
&\qquad\qquad \left.\left. + \psi_I\left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}} - \delta\right)\left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}}\right)\right]\right\} \\
&K_{X_{t+1}}: \quad Q_{X_t} = \beta\mathbf{E}_t\frac{\lambda_{D_{t+1}}}{\lambda_{D_t}}\left\{R_{X_{t+1}} + Q_{X_{t+1}}\left[(1-\delta) - \frac{\psi_I}{2}\left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}} - \delta\right)^2\right.\right. \\
&\qquad\qquad \left.\left. + \psi_I\left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}} - \delta\right)\left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}}\right)\right]\right\}
\end{aligned}
$$

A.2 Optimal allocation of consumption expenditures

The optimal non-traded and imported goods consumption bundle can be determined by minimizing the following expression

$$
P_{N_t}C_{N_t} + P_{M_t}C_{M_t} + \lambda_t\left(\overline{C}_D - \left[a^{\frac{1}{\rho}}C_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}}C_{M_t}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}\right)
$$

around C_{N_t} and C_{M_t} at every period, where λ is the lagrange multiplier. Correspondingly, the two first-order conditions

$$C_{N_t}: \quad P_{N_t} = \lambda_t a^{\frac{1}{\rho}} \left(\frac{C_{N_t}}{C_{D_t}}\right)^{-\frac{1}{\rho}}$$
$$C_{M_t}: \quad P_{M_t} = \lambda_t (1-a)^{\frac{1}{\rho}} \left(\frac{C_{M_t}}{C_{D_t}}\right)^{-\frac{1}{\rho}}$$

can be combined to arrive at the following expression

$$C_{M_t} = \frac{1-a}{a}\left(\frac{P_{M_t}}{P_{N_t}}\right)^{-\rho} C_{N_t}. \tag{A.1}$$

The above form can then be substituted into $C_{D_t} = \left[a^{\frac{1}{\rho}} C_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}} C_{M_t}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$ to result to the household's optimal demand for non-traded goods:

$$C_{N_t} = a\left(\frac{P_{N_t}}{P_{D_t}}\right)^{-\rho} C_{D_t}, \tag{A.2}$$

while taking into account that $P_{D_t} = \left[a P_{N_t}^{1-\rho} + (1-a) P_{M_t}^{1-\rho}\right]^{\frac{1}{1-\rho}}$. The optimal demand for imported goods,

$$C_{M_t} = (1-a)\left(\frac{P_{M_t}}{P_{D_t}}\right)^{-\rho} C_{D_t},$$

can be derived by plugging in (A.2) into (A.1).

A.3 Solution to the firms' problems

A.3.1 Export sector

The firms in this sector have to determine their optimal demands for capital and labor inputs by maximizing profits. That is, their problem can be restated as

$$\max_{\{K_{X_t}, H_{X_t}\}_{t=0}^{\infty}} \quad P_{X_t} Y_{X_t} - R_{X_t} K_{X_t} - W_{D_t} H_{X_t} \quad \text{s.t.} \quad Y_{X_t} = A_X K_{X_t}^{\gamma} H_{X_t}^{1-\gamma},$$

which when solved will yield (2.20) and (2.21).

A.3.2 Non-traded sector

Each firm i faces the problem of minimizing

$$\mathcal{L} = R_{N_t}K_{N_t}(i) + W_{D_t}H_{N_t}(i) + MC_{N_t}(i)\left[\overline{Y_N(i)} - A_N K_{N_t}(i)^{\alpha} H_{N_t}(i)^{1-\alpha}\right]$$

over $K_{N_t}(i)$ and $H_{N_t}(i)$ for every t. Solving this problem results to

$$\begin{aligned} R_{N_t}K_{N_t}(i) &= \alpha MC_{N_t}(i)Y_{N_t}(i) \\ W_{D_t}H_{N_t}(i) &= (1-\alpha)MC_{N_t}(i)Y_{N_t}(i). \end{aligned}$$

Equation (2.23) can be derived by following the steps demonstrated in section A.2.

To determine the price level, firm i has to maximize the following expression over $P_{N_{t+k}}(i)$ for every k:

$$\begin{aligned} \mathbf{E}_t \sum_{k=0}^{\infty} \Gamma_{t,t+k} \Bigg\{ & P_{N_{t+k}}(i) \left(\frac{P_{N_{t+k}}(i)}{P_{N_{t+k}}}\right)^{-\lambda} Y_{N_{t+k}} - MC_{N_{t+k}}(i) \left(\frac{P_{N_{t+k}}(i)}{P_{N_{t+k}}}\right)^{-\lambda} Y_{N_{t+k}} \\ & - \; P_{D_{t+k}} \frac{\psi_{P_N}}{2} \left(\frac{P_{N_{t+k}}(i)}{P_{N_{t+k-1}}(i)} - 1\right)^2 \Bigg\} \end{aligned}$$

Hence, for $k = 0$ (also applies to any other value of k), the first-order condition appears as

$$\begin{aligned} \Gamma_{t,t} \Bigg\{ & (1-\lambda) \left(\frac{P_{N_t}(i)}{P_{N_t}}\right)^{-\lambda} Y_{N_t} + \lambda MC_{N_t}(i) \frac{P_{N_t}(i)^{-\lambda-1}}{P_{N_t}^{-\lambda}} Y_{N_t} \\ & - P_{D_t}\psi_{P_N} \left(\frac{P_{N_t}(i)}{P_{N_{t-1}}(i)} - 1\right) \frac{1}{P_{N_{t-1}}} \Bigg\} \\ = & \; - \mathbf{E}_t \Gamma_{t,t+1} P_{D_{t+1}} \psi_{P_N} \left(\frac{P_{N_{t+1}}(i)}{P_{N_t}(i)} - 1\right) \left(\frac{P_{N_{t+1}}(i)}{P_{N_t}(i)^2}\right). \end{aligned}$$

Imposing $P_{N_t}(i) = P_{N_t}$ and multiplying both sides of the equation by P_{N_t} and $\frac{1}{\Gamma_{t,t}}$, the previous equation transforms into

$$\begin{aligned} P_{N_t}(1-\lambda)Y_{N_t} + \lambda MC_{N_t}Y_{N_t} - P_{D_t}\psi_{P_N} \left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1\right) \frac{P_{N_t}}{P_{N_{t-1}}} \\ = \; - \psi_{P_N} \mathbf{E}_t \frac{\Gamma_{t,t+1}}{\Gamma_{t,t}} P_{D_{t+1}} \left(\frac{P_{N_{t+1}}}{P_{N_t}} - 1\right) \frac{P_{N_{t+1}}}{P_{N_t}}. \end{aligned}$$

Finally solving for P_{N_t} results into equation (2.24).

A.3.3 Import sector

Similar to the firms in the non-traded sector, firms in the import sector solve the following problem:

$$\max_{\{P_{M_{t+k}}\}} \mathbf{E}_t \sum_{k=0}^{\infty} \Gamma_{t,t+k} \Bigg\{ P_{M_{t+k}}(i) T_{M_{t+k}}(i) - S_{t+k} P_{M_{t+k}}(i) T_{M_{t+k}}(i) - P_{D_{t+k}} \frac{\psi_{P_M}}{2} \left(\frac{P_{M_{t+k}}(i)}{P_{M_{t+k-1}}(i)} - 1 \right)^2 \Bigg\}$$

$$\text{s.t.} \quad T_{M_{t+k}}(i) = \left(\frac{P_{M_{t+k}}(i)}{P_{M_{t+k}}} \right)^{-\lambda} T_{M_{t+k}}$$

P_{M_t} as expressed in equation (2.25) can be derived accordingly.

A.3.4 Household absorption sector

Identical firms in this sector solve the problem,

$$\max_{\{Y_{N_t}, T_{M_t}\}_{t=0}^{\infty}} \quad P_{D_t} \left[a^{\frac{1}{\rho}} Y_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}} T_{M_t}^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}} - P_{N_t} Y_{N_t} - P_{M_t} T_{M_t},$$

to yield equations (2.27) and (2.28).

A.4 Deriving the current account equation

The derivation of the current account equation in (2.35) starts from (2.6). Taking into account the labor market clearing condition in (2.34), the balanced budget condition: $T_t = M_t - M_{t-1} + (1 + i_{t-1}) B_{t-1} - B_t$, and dividends $\Pi_t = \Pi_{N_t} + \Pi_{M_t}$, where $\Pi_{N_t} = P_{N_t} Y_{N_t} - R_{N_t} K_{N_t} - W_{D_t} H_{N_t} - P_{D_t} \frac{\psi_{P_N}}{2} \left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1 \right)^2$ and $\Pi_{M_t} =$

$P_{M_t}T_{M_t} - S_tP^*_{M_t}T_{M_t} - P_{D_t}\frac{\psi_{P_M}}{2}\left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1\right)^2$, (2.35) transforms into

$$\begin{aligned} P_{D_t}(C_{D_t} + I_{N_t} + I_{X_t}) + (1 + i^*_{t-1})S_tD_{t-1} + P_{D_t}\frac{\psi_D}{2}(D_t - D)^2 + f_eS_tW_{F_t}H_{F_t} \\ = W_{D_t}H_{X_t} + R_{X_t}K_{X_t} + P_{N_t}Y_{N_t} - P_{D_t}\frac{\psi_{P_N}}{2}\left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1\right)^2 + P_{M_t}T_{M_t} \\ - \; S_tP^*_{M_t}T_{M_t} - P_{D_t}\frac{\psi_{P_M}}{2}\left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1\right)^2 + S_tD_t + S_tRemit_t. \end{aligned}$$

Recognizing the zero-profit conditions for the exporting and household absorption sectors, $P_{X_t}Y_{X_t} = R_{X_t}K_{X_t} + W_{D_t}H_{X_t}$ and $P_{D_t}Y_t = P_{N_t}Y_{N_t} + P_{M_t}T_{M_t}$, the above expression further simplifies to

$$\begin{aligned} P_{D_t}\Bigg(C_{D_t} + I_{N_t} + I_{X_t} + \frac{\psi_D}{2}(D_t - D)^2 + \frac{\psi_{P_N}}{2}\left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1\right)^2 \\ + \frac{\psi_{P_M}}{2}\left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1\right)^2\Bigg) + (1 + i^*_{t-1})S_tD_{t-1} + f_eS_tW_{F_t}H_{F_t} \\ = \; P_{X_t}Y_{X_t} + P_{D_t}Y_t - S_tP^*_{M_t}T_{M_t} + S_tD_t + S_tRemit_t. \end{aligned}$$

Yet, it is assumed that $Y_t = C_{D_t} + I_{N_t} + I_{X_t} + \frac{\psi_D}{2}(D_t - D)^2 + \frac{\psi_{P_N}}{2}\left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1\right)^2 + \frac{\psi_{P_M}}{2}\left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1\right)^2$. And so, the current account expression takes the form in (2.35).

A.5 Cobb-Douglas function as a special form of the CES function

Suppose $Y_t = \left[a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\right]^{\frac{\rho}{\rho-1}}$. If $\rho = 1$, as assumed in this paper, then $Y_t = AY^a_{N_t}T^{1-a}_{M_t}$, where $A = \frac{1}{a^a(1-a)^{1-a}}$.

Proof:

$$\ln Y_t = \frac{\rho}{\rho-1}\ln\left[a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\right]$$

$$\lim_{\rho\to 1}\ln Y_t = \lim_{\rho\to 1}\frac{\ln\left[a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\right]}{\frac{\rho-1}{\rho}}$$

By L'Hôpital's rule,

$$\lim_{\rho\to 1}\ln Y_t = \lim_{\rho\to 1}\frac{\frac{-\frac{1}{\rho^2}a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}}\ln a+\frac{1}{\rho^2}a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}}\ln Y_{N_t}-\frac{1}{\rho^2}(1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\ln(1-a)+\frac{1}{\rho^2}(1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\ln T_{M_t}}{a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}}+(1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}}}{\frac{1}{\rho^2}}$$

$$= \lim_{\rho\to 1}\frac{-a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}}\ln a + a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}}\ln Y_{N_t} - (1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\ln(1-a) + (1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}\ln T_{M_t}}{a^{\frac{1}{\rho}}Y_{N_t}^{\frac{\rho-1}{\rho}} + (1-a)^{\frac{1}{\rho}}T_{M_t}^{\frac{\rho-1}{\rho}}}$$

$$= \frac{-a\ln a + a\ln Y_{N_t} - (1-a)\ln(1-a) + (1-a)\ln T_{M_t}}{a+1-a}$$

$$= -\ln a^a + \ln Y_{N_t}^a - \ln(1-a)^{1-a} + \ln T_{M_t}^{1-a}$$

$$= -(\ln a^a + \ln(1-a)^{1-a}) + (\ln Y_{N_t}^a + \ln T_{M_t}^{1-a})$$

$$= -\ln a^a(1-a)^{1-a} + \ln Y_{N_t}^a T_{M_t}^{1-a}$$

$$\lim_{\rho\to 1}\ln Y_t = \ln\frac{Y_{N_t}^a T_{M_t}^{1-a}}{a^a(1-a)^{1-a}}$$

And so, $\quad Y_t = AY_{N_t}^a T_{M_t}^{1-a}, \quad$ where $\quad A = \dfrac{1}{a^a(1-a)^{1-a}}.$

Appendix B

Second-order expansion of the welfare cost measure

A second-order approximation of V_0^a, V_0^b and $V_{H_0}^b$ yields equilibrium values for these variables that are functions of the initial state vector x_0 and the parameter σ_ϵ scaling the standard deviation of the exogenous shocks. And so, if we state $V_0^a = V^{ac}(x_0, \sigma_\epsilon)$, $V_0^b = V^{bc}(x_0, \sigma_\epsilon)$ and $V_{H_0}^b = V^{bHc}(x_0, \sigma_\epsilon)$, the conditional welfare cost measure, ϵ^c, can be re-written as

$$\epsilon^c = 1 - \left(\frac{V^{ac}(x_0, \sigma_\epsilon) + V^{bHc}(x_0, \sigma_\epsilon)}{V^{bc}(x_0, \sigma_\epsilon) + V^{bHc}(x_0, \sigma_\epsilon)} \right)^{\frac{1}{1-\sigma}}.$$

Inherently, ϵ^c is a function of x_0 and σ_ϵ, i.e., $\epsilon^c = \Lambda^c(x_0, \sigma_\epsilon)$. Taking a second-order expansion of Λ^c around σ_ϵ and evaluating the resulting expression at $\sigma_\epsilon = 0$ finally leads to the following conditional welfare cost measure

$$\epsilon^c \approx \frac{V^{bc}_{\sigma_\epsilon \sigma_\epsilon}(x, 0) - V^{ac}_{\sigma_\epsilon \sigma_\epsilon}(x, 0)}{(1-\sigma)(V^{bc}(x, 0) + V^{bHc}(x, 0))} \frac{\sigma_\epsilon^2}{2},$$

where x denotes the nonstochastic steady state vector that is the same for both policies a and b (the steps are outlined in Schmitt-Grohé and Uribe (2007)).*

*Since welfare is characterized conditional on the deterministic steady state vector, only the first and second order derivatives of Λ^c with respect to σ_ϵ are considered. Moreover, in deriving the welfare cost measure, we acknowledge that $V^{ac}_{\sigma_\epsilon} = V^{bc}_{\sigma_\epsilon} = V^{bHc}_{\sigma_\epsilon} = 0$, as derived by Schmitt-Grohé and Uribe (2004).

Appendix C

Complete set of equilibrium conditions

1. $Remit_t = W_{F_t} H_{F_t} - C_{F_t}$
2. $W_{F_t} = \frac{1}{\nu^W} \frac{W_{D_t}}{P_{D_t}}$
3. $K_{N_{t+1}} = \left[\frac{I_{N_t}}{K_{N_t}} - \frac{\psi_I}{2} \left(\frac{I_{N_t}}{K_{N_t}} - \delta \right)^2 \right] K_{N_t} + (1-\delta) K_{N_t}$
4. $K_{X_{t+1}} = \left[\frac{I_{X_t}}{K_{X_t}} - \frac{\psi_I}{2} \left(\frac{I_{X_t}}{K_{X_t}} - \delta \right)^2 \right] K_{X_t} + (1-\delta) K_{X_t}$
5. $\lambda_{D_t} = \frac{(C_{D_t} - \varrho_D C_{D_{t-1}})^{-\sigma_D}}{P_{D_t}(1+\nu\zeta_t)}$
6. $\eta(H_{D_t} + H_{F_t})^{\varphi} = \lambda_{D_t} W_{D_t}$
7. $(C_{F_t} - \varrho_F C_{F_{t-1}})^{-\sigma_F} = \lambda_{D_t}[S_t - P_{D_t}\psi_{Rem}(Remit_t - Remit)]$
8. $\eta(H_{D_t} + H_{F_t})^{\varphi} = \lambda_{D_t} W_{F_t}[S_t(1-f_e) - P_{D_t}\psi_{Rem}(Remit_t - Remit)]$
9. $S_t \lambda_{D_t} \left[1 - \frac{P_{D_t}\psi_D(D_t - D)}{S_t} \right] = \beta(1+i_t^*)\mathbf{E}_t \lambda_{D_{t+1}} S_{t+1}$
10. $\lambda_{D_t} = \beta(1+i_t)\mathbf{E}_t \lambda_{D_{t+1}}$
11. $\frac{1}{1-\zeta_t} = 1 + i_t$
12. $Q_{N_t} \left[1 - \psi_I \left(\frac{I_{N_t}}{K_{N_t}} - \delta \right) \right] = P_{D_t}$
13. $Q_{X_t} \left[1 - \psi_I \left(\frac{I_{X_t}}{K_{X_t}} - \delta \right) \right] = P_{D_t}$

14. $Q_{N_t} = \beta \mathbf{E}_t \frac{\lambda_{D_{t+1}}}{\lambda_{D_t}} \Bigg\{ R_{N_{t+1}} + Q_{N_{t+1}} \Bigg[(1-\delta)$
$- \frac{\psi_I}{2} \left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}} - \delta \right)^2 + \psi_I \left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}} - \delta \right) \left(\frac{I_{N_{t+1}}}{K_{N_{t+1}}} \right) \Bigg] \Bigg\}$

15. $Q_{X_t} = \beta \mathbf{E}_t \frac{\lambda_{D_{t+1}}}{\lambda_{D_t}} \Bigg\{ R_{X_{t+1}} + Q_{X_{t+1}} \Bigg[(1-\delta)$
$- \frac{\psi_I}{2} \left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}} - \delta \right)^2 + \psi_I \left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}} - \delta \right) \left(\frac{I_{X_{t+1}}}{K_{X_{t+1}}} \right) \Bigg] \Bigg\}$

16. $Y_{X_t} = A_X K_{X_t}^{\gamma} H_{X_t}^{1-\gamma}$

17. $R_{X_t} K_{X_t} = \gamma P_{X_t} Y_{X_t}$

18. $W_{D_t} H_{X_t} = (1-\gamma) P_{X_t} Y_{X_t}$

19. $P_{X_t} = S_t P_{X_t}^{*}$

20. $P_{N_t} = \frac{\lambda}{\lambda-1} MC_{N_t} - \frac{\psi_{P_N}}{\lambda-1} \frac{P_{D_t}}{Y_{N_t}} \frac{P_{N_t}}{P_{N_{t-1}}} \left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1 \right)$
$+ \frac{\psi_{P_N}}{\lambda-1} \mathbf{E}_t \left[\frac{\Gamma_{t,t+1}}{\Gamma_{t,t}} \frac{P_{D_{t+1}}}{Y_{N_t}} \frac{P_{N_{t+1}}}{P_{N_t}} \left(\frac{P_{N_{t+1}}}{P_{N_t}} - 1 \right) \right]$

21. $P_{M_t} = \frac{\lambda}{\lambda-1} S_t P_{M_t}^{*} - \frac{\psi_{P_M}}{\lambda-1} \frac{P_{D_t}}{T_{M_t}} \frac{P_{M_t}}{P_{M_{t-1}}} \left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1 \right)$
$+ \frac{\psi_{P_M}}{\lambda-1} \mathbf{E}_t \left[\frac{\Gamma_{t,t+1}}{\Gamma_{t,t}} \frac{P_{D_{t+1}}}{T_{M_t}} \frac{P_{M_{t+1}}}{P_{M_t}} \left(\frac{P_{M_{t+1}}}{P_{M_t}} - 1 \right) \right]$

22. $Y_t = A Y_{N_t}^{a} T_{M_t}^{1-a}, \quad A = \frac{1}{a^a (1-a)^{1-a}}$

23. $Y_{N_t} = a \left(\frac{P_{N_t}}{P_{D_t}} \right)^{-1} Y_t$

24. $T_{M_t} = (1-a) \left(\frac{P_{M_t}}{P_{D_t}} \right)^{-1} Y_t$

25. $\ln \left(\frac{1+i_t}{1+i} \right) = \alpha_{\pi_D} \ln \left(\frac{\pi_{D_t}}{\pi_D} \right)$

26. $Y_{N_t} = A_N K_{N_t}^{\alpha} H_{N_t}^{1-\alpha}$

27. $R_{N_t} K_{N_t} = \alpha MC_{N_t} Y_{N_t}$

28. $W_{D_t} H_{N_t} = (1-\alpha) MC_{N_t} Y_{N_t}$

29. $M_t = \nu P_{D_t} C_{D_t}$

30. $H_{D_t} = H_{N_t} + H_{X_t}$

31. $(1+i^*_{t-1})S_t D_{t-1} + f_e S_t W_{F_t} H_{F_t} = P_{X_t} Y_{X_t} - S_t P^*_{M_t} T_{M_t} + S_t D_t + S_t Remit_t$

32. $Y_t = C_{D_t} + I_{N_t} + I_{X_t} + \frac{\psi_D}{2}(D_t - D)^2 + \frac{\psi_{P_M}}{2}\left(\frac{P_{M_t}}{P_{M_{t-1}}} - 1\right)^2$
$+ \frac{\psi_{P_N}}{2}\left(\frac{P_{N_t}}{P_{N_{t-1}}} - 1\right)^2 + \frac{\psi_{Rem}}{2}(Remit_t - Remit)^2$

Appendix D

Steady state expressions

1. $Remit = W_F H_F - C_F$
2. $W_F = \frac{1}{\nu^W} \frac{W_D}{P_D}$
3. $I_N = \delta K_N$
4. $I_X = \delta K_X$
5. $\lambda_D P_D (1 + \nu\zeta) = [C_D(1 - \rho_D)]^{-\sigma_D}$
6. $\eta(H_D + H_F)^{\varphi} = \lambda_D W_D$
7. $[C_F(1 - \rho_F)]^{-\sigma_F} = \lambda_D S$
8. $\eta(H_D + H_F)^{\varphi} = \lambda_D W_F S(1 - f_e)$
9. $1 = \beta(1 + i^*)$
10. $i = i^*$
11. $\frac{1}{1-\zeta} = 1 + i$
12. $Q_N = P_D$
13. $Q_X = Q_N$
14. $R_N = Q_N \left(\frac{1-\beta(1-\delta)}{\beta} \right)$
15. $R_X = R_N$
16. $Y_X = A_X K_X^{\gamma} H_X^{1-\gamma}$

17. $R_X K_X = \gamma P_X Y_X$

18. $W_D H_X = (1-\gamma) P_X Y_X$

19. $P_X = S P_X^*$

20. $P_N = \frac{\lambda}{\lambda - 1} MC_N$

21. $P_M = \frac{\lambda}{\lambda - 1} S$

22. $Y = A Y_N^a T_M^{1-a}$

23. $Y_N = a \left(\frac{P_N}{P_D} \right)^{-1} Y$

24. $T_M = (1-a) \left(\frac{P_M}{P_D} \right)^{-1} Y$

25. $Y_N = A_N K_N^{\alpha} H_N^{1-\alpha}$

26. $R_N K_N = \alpha MC_N Y_N$

27. $W_D H_N = (1-\alpha) MC_N Y_N$

28. $M = \nu P_D C_D$

29. $H_D = H_N + H_X$

30. $i^* SD + f_e S W_F H_F = P_X Y_X - S T_M + S Remit$

31. $Y = C_D + I_N + I_X$
    Additional equation for GDP:

32. $GDP = \frac{P_N Y_N + P_X Y_X}{P_D}$

Appendix E

Solving for the steady state solutions

Given some parameter values, we solve for the steady state values of 35 unknowns given 31 equations and 4 calibration restrictions. The unknowns are $Remit$, W_F, H_F, C_F, I_N, K_N, I_X, K_X, H_D, P_D, ζ, W_D, C_D, S, f_e, i, i^*, Q_N, R_N, Q_X, R_X, Y_X, H_X, P_X, P_X^*, P_N, MC_N, P_M, Y, Y_N, T_M, H_N, M, D, and GDP. The equations are enumerated below.

1. $Remit = W_F H_F - C_F$
2. $W_F = \frac{1}{\nu^W}\frac{W_D}{P_D}$
3. $I_N = \delta K_N$
4. $I_X = \delta K_X$
5. $\eta(H_D + H_F)^{\varphi} P_D(1+\nu\zeta) = W_D[C_D(1-\rho_D)]^{-\sigma_D}$
6. $[C_F(1-\rho_F)]^{-\sigma_F} P_D(1+\nu\zeta) = S[C_D(1-\rho_D)]^{-\sigma_D}$
7. $S = \nu^W P_D(1-f_e)$
8. $1 = \beta(1+i^*)$
9. $i = i^*$
10. $\frac{1}{1-\zeta} = 1 + i$
11. $Q_N = P_D$
12. $Q_X = Q_N$
13. $R_N = Q_N\left(\frac{1-\beta(1-\delta)}{\beta}\right)$

14. $R_X = R_N$

15. $Y_X = A_X K_X^{\gamma} H_X^{1-\gamma}$

16. $R_X K_X = \gamma P_X Y_X$

17. $W_D H_X = (1-\gamma) P_X Y_X$

18. $P_X = S P_X^*$

19. $P_N = \frac{\lambda}{\lambda - 1} MC_N$

20. $P_M = \frac{\lambda}{\lambda - 1} S$

21. $Y = A Y_N^a T_M^{1-a}$

22. $Y_N = a \left(\frac{P_N}{P_D} \right)^{-1} Y$

23. $T_M = (1-a) \left(\frac{P_M}{P_D} \right)^{-1} Y$

24. $Y_N = A_N K_N^{\alpha} H_N^{1-\alpha}$

25. $R_N K_N = \alpha MC_N Y_N$

26. $W_D H_N = (1-\alpha) MC_N Y_N$

27. $M = \nu P_D C_D$

28. $H_D = H_N + H_X$

29. $i^* SD + f_e S W_F H_F = P_X Y_X - S T_M + S Remit$

30. $Y = C_D + I_N + I_X$

31. $GDP = \frac{P_N Y_N + P_X Y_X}{P_D}$

The following are the calibration restrictions:

1. Debt-to-GDP ratio, $\frac{SD}{P_D GDP}$, is set to a period average of 59.66%.
2. Steady state work-hours, H_D, is set to 0.4.
3. Nominal exchange rate, S, is set to unity.
4. Terms of trade denominated in US dollars, P_X^*, is also assumed to be equal to 1.