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Liability Dollarization and Fear of Floating

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Abstract

This paper addresses the question of whether *fear of floating* in developing countries can be justified as optimal discretionary monetary policy in a dollarized economy where intermediate goods importers face Bernanke-type credit constraint. Exchange rate depreciation not only worsens the net-worth but also increases the financing amount of importer firms who borrow in foreign currency, hence exaggerating the borrowing finance premium. Besides, because of high exchange rate pass-through, fluctuations in the exchange rate also have strong impacts on domestic price levels and production. These effects, together, magnify the macroeconomic consequences of the economy that experiences external and domestic technology shocks. It can be shown that the fixed exchange rate regime dominates the inflation targeting regime in both the role of cushioning shocks and in welfare terms.

JEL Classification: F0, F4

Keywords: Liability Dollarizaion, Fear of Floating, Imported Goods.

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1 Introduction

There are two defining features in emerging and developing economies: (1) *Fear of Floating*, a phenomenon where authorities are reluctant to let their nominal exchange rate fluctuate and (2) Increasing uses of U.S dollar/strong currency in debt denomination instead of domestic currency, the so-called *Liability Dollarization* in these economies' finance system. This paper addresses the question whether the former phenomenon can be justified under increasingly liability dollarized economies.

Fear of Floating has been seen as prima facie phenomenon because most of all recent financial crises occurred under pegged exchange rate environments and rigidity in nominal exchange has been perceived as one of the main reasons. Calvo and Reinhart (2002), however, show that despite having experienced severe exchange rate crises, authorities in emerging economies have kept intervening to smooth exchange rate fluctuations and evidently there has not much variation in nominal exchange rate in these economies. In particular, they presents evidence showing that interest rate and reserve variability are significantly higher in emerging market economies than in developed economies like U.S and Japan and the probability that the monthly variation of the nominal exchange rate is in a narrow band of plus and minus 2.5% is more than 79% for all developing countries, [1] which is definitely higher than that in developed countries. Taking into account the fact that emerging economies often experience much more volatile shocks than developed counterpart, relatively little variation in nominal exchange rate in emerging economies is remarkable phenomenon.

On the other hand, liability dollarization belongs to another broad feature that has recently obtained popularity in emerging/developing economies: dollarization. In these countries, it has become increasingly popular that governments borrow in dollars, individuals can hold dollar denominated bank accounts, firms and households can borrow in dollars both domestically and from abroad. In particular, to quantitatively document dollarization, Reinhart, Rogoff, and Savastano (2003) (RRS, henceforth) build a com-

[1] In details, the probabilities are 79%, 87%, and 92% for those who claim to have freely floating exchange rate regime, managed floating, and limited floating, respectively. The probabilities for developed countries like U.S and Japan is 59% and 61%.

posite index of dollarization for large range of developing countries and show that that the frequency distribution of the composite dollarization index has shifted markedly to the right between 1980-85 and 1996-2001, indicating that the degree of dollarization in developing countries has risen significantly during these periods.[2] By exploring the data in further, RRS are able to show that by late 90s, more than half of 143 countries in their samples have at least 10% of broad money or of domestic public debt denominated or linked to foreign currency and one third of these 143 countries have more than 10% of external debts borrowed from private sector. They also find evidence suggesting that higher level of dollarization tends to increase the exchange rate pass-through, thereby reinforcing the fear of floating in highly dollarized economies.

This paper attempts to shed light on the relationship between the two aforementioned defining features in emerging economies, especially the question whether fear of floating can be justified as optimal discretionary monetary policy in dollarized economy with responses to external and domestic shocks. To this end, I consider a small open economy where intermediate goods importers face Bernanke type of credit constraint. Foreign intermediate goods are essentially required in final goods production to highlight the exchange rate pass-through into domestic consumption prices. To import foreign intermediate goods, firms have to borrow in foreign currency, which incorporates liability dollarization. Finally, the rates that domestic borrowers have to pay to foreign lenders depends on the their net-worth, which characterizes the *financial acceleration* of firm's balance-sheet, i.e., the higher rates borrowers have to pay for higher total debt over net-worth leverage.

In literature, Cespedes et al (2002) and Devereux, Lane, and Xu (2006) (henceforth DLX) have followed Bernanke et al (1999) (henceforth BGG) to take into account the credit constraints in investment financing for liability dollarized emerging economies.

[2]Concretely, RRS define a (partially) dollarized economy as one where households and firms hold a fraction of their portfolio (inclusive of money balances) in foreign currency assets and/or where the private and public sector have debts denominated in foreign currency. The composite index is defined as the (normalized) sum of bank deposits in foreign currency as a share of broad money, total external debt as a share of GNP, and domestic government debt denominated in (or linked to) a foreign currency as a share of total domestic government debt.

In particular, in their models, exchange rate fluctuations affect firms' real net worth positions and investments through balance sheet constraints, thereby having profound macroeconomic impacts. Both Cespedes et al and DLX compares the macroeconomic consequences and welfare of alternative monetary policies: inflation targeting and fixed exchange rate for the financial constrained small open economy under external shocks. Despite different settings, the two papers reach a quite similar conclusions: balance sheet constraints under the presence of liability dollarization is an important propagation channel, it can magnify the effects of external shocks, leading both real and financial volatility to be greater than in an economy without these constraints. However, even under financial imperfections and balance sheet constraints, inflation targeting or flexible exchange rate regime still dominates the fixed exchange rate regime in both the role of cushioning external shocks and in welfare terms.

Nonetheless, there is one common feature in Crespedes and DLX 's models that might limit the impact of exchange rate fluctuations to other macroeconomic variables. In particular, in these models, exchange rate fluctuations *only* affect the net worth of firms and through that channel determining the finance premium of foreign currency borrowing and then financing investment. In fact, most emerging economies and developing countries, most of which are often relatively less industrialized, have to rely heavily on imported intermediate goods for domestic productions. For example, according to Christiano et al (2006), in developing countries, less than 17% of imported goods is for consumption, the left is the intermediate goods and most of which are essential for the domestic productions. The heavy reliance of domestic productions on foreign intermediate goods implies a high exchange rate pass-through and high external exposure as mentioned above. Furthermore, due to limited cross-border enforcement especially for emerging countries where legal systems are still in needs of much improvement, it is likely that import firms are subject to the borrowing constraints. These insights motivate the consideration of the Bernanke type of credit constraints for import firms.[3] Since import firms need to borrow foreign currency to finance imported intermediate goods, exchange rate fluctuations affects not only the net worth of import firms but also the

[3] Both Crespedes et al and DLX consider the Bernanke type of credit constraint for entrepreneurs who borrow to finance capital investment

amount of financing. This very double-effect from exchange rate fluctuations leads to more profound impacts on the leverage of import firms, causing much more fluctuations in finance premium than those in Crespedes and DLX 'models. This feature and the high exchange rate pass-through via production are the innovations of this paper compared to DLX's paper but they are sufficient to overturn the results.

Also based on Christiano et al (2006) empirical findings that less than 17% of imported goods are consumption goods, this paper assumes that consumers in small open consume only domestically produced final goods, which in turn produced by domestic value-added goods and imported intermediate gooods. In other words, this is one sector economy. This small open economy is endowed with fixed amount of tradable goods, which domestic consumers do not consume. The tradable goods, however, can be exported to the rest of the world, where export goods price is determined and given to this small open economy.

Under aforementioned different specifications, this paper follows DLX to re-examine the macroeconomic consequences and welfare of alternative monetary policies: inflation targeting and fixed exchange rate [4] for the credit constrained small open economy in response to external shocks: world interest rate and term of trade shocks and (labor) productivity shock, which happens to be the main disturbances for emerging countries. This paper finds that " fear of floating" can be justified for highly dollarized economies under these shocks. The volatilities of output, consumptions are higher under the inflation targeting rule than under the fixed exchange rate rule. The welfare under fixed exchange rate regime also dominates that under the inflation targeting regime under wide range of parameter specifications.

The paper is organized as follows. Section 2 sets out the model. Section 3 discusses calibration and the solution of the model. Section 4 develops the main results including impulse responses, volatilities of macroeconomic variables, and welfare evaluation under alternative monetary policies. Some conclusions follow.

[4]We follow the setting of endogenous monetary policy as in DLX, and use the perturbation method from Schmitt-Grohe and Uribe's paper to solve the model to the second order approximation in order to calculate the welfare.

2 The Model

2.1 Outline of the model

This is one sector model of a small open economy where final goods are produced using labor and imported intermediate goods. Domestic agents consume only domestically produced final goods,[5] they are, however, endowed with fixed amount of tradable goods, which can be exported to the rest of the world with exogenous prices.

The model has following particular characteristics: 1. Rigidity in prices;[6] 2. Credit constraint in foreign currency borrowing to account for *Balance-Sheet Effects* of liability dollarization, the increasingly defining characteristic of emerging economies; 3. Low substitutability between domestic value-added goods and imported intermediate goods, reflecting critical reliance of domestic productions on foreign intermediate goods in emerging economies.

There are four sets of domestic agents in the model: households, firms, importers, and the monetary authority, vs. one foreign "the rest of world" where foreign-currency prices of imported intermediate goods are set and lending rates of foreign fund are determined. The rest of the world also demands fixed amount of domestic endowment tradable goods, which domestic agents do not consume. Domestic households have access to international financial markets through two kind of non state contingent bonds. Financing contracts are set up between foreign bankers and domestic importer firms who need to borrow to finance foreign intermediate goods. Final goods firms hire labor from households, re-buy intermediate goods from importers, and sell goods to both domestic households and importers for consumption. Finally, the monetary authority sets domestic nominal interest rates as monetary policy instrument.

[5]This assumption is justified by empirical evidence that suggests in the majority of developing countries less than 17% of imported goods is for consumptions and other left are intermediate goods for domestic production.

[6]To allow effective monetary policy under New-Keynesian framework

2.2 Households

There is a continuum of households with unit measure. The representative household has preferences as follows:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} - \eta \frac{L_t^{1+\psi}}{1+\psi}\right) \tag{2.1}$$

where C_t is a composite consumption and L_t is labor supply . Composite consumption is a function of only domestically produced differentiated goods $C_t(i)$, $C_t = (\int_0^1 C_t(i)^{\frac{\rho-1}{\rho}} di)^{\frac{\rho}{\rho-1}}$, with $\rho > 1$. The implied consumer price index CPI is then $P_t = (\int_0^1 P_t(i)^{1-\rho} di)^{\frac{1}{1-\rho}}$, where $P_t(i)$ is the price of differentiated good i.

Households have access to financial markets with non state-contingent bonds in the form of both domestic and foreign currency denomination. Trade in foreign currency bonds is, however, subject to small portfolio adjustment costs, $\frac{\psi_D}{2}(D_{t+1} - \bar{D})^2$, [7] where $\bar{D}$ is an exogenous steady state level of net foreign debt and D_t is the amount of foreign debts. The household can borrow directly in terms of foreign currency at a given interest rate i_t^* , or in domestic currency assets at an interest rate i_t.

Each period, the representative household's revenue comes from profits Π_t from firms he owns, wages W_t from labor supply, incomes from exporting endowment goods $S_t P_{Xt}^* \bar{X}$, total debts he can borrow $S_t D_{t+1} + B_{t+1}$, less debt repayment from last period $(1 + i_t^*) S_t D_t + (1 + i_t) B_t$, as well as portfolio adjustment costs. Therefore, his budget constraint can be expressed as:

$$\begin{aligned} P_t C_t = & W_t L_t + \Pi_t + S_t D_{t+1} + B_{t+1} + S_t P_{Xt}^* \bar{X} \\ & - (1 + i_t^*) S_t D_t - (1 + i_t) B_t - P_t \frac{\psi_D}{2} (D_{t+1} - \bar{D})^2 \end{aligned} \tag{2.2}$$

Here S_t is the nominal exchange rate, P_{Xt}^* is price of export goods in foreign currency, D_t is outstanding amount of foreign currency debt and B_t is the stock of domestic currency debt, $\bar{X}$ is the endowment amount of export goods.

[7] As shown in Schitt-Grohe and Uribe (2003), portfolio adjustment cost induces stationarity in economy's net foreign assets.

The household will choose each differentiated goods to minimize expenditure conditional on total composite consumption. Demand for each differentiated goods is then:

$$C_t(i) = \Big(\frac{P_t(i)}{P_t}\Big)^{-\rho} C_t \tag{2.3}$$

The household optimal first order conditions can be obtained as:

$$\frac{1}{1+i^*_{t+1}}\left[1 - \frac{\psi_D P_t}{S_t}(D_{t+1} - \bar{D})\right] = \beta E_t\left\{\frac{C_t^\sigma P_t}{C_{t+1}^\sigma P_{t+1}}\frac{S_{t+1}}{S_t}\right\} \tag{2.4}$$

$$\frac{1}{1+i_{t+1}} = \beta E_t\left(\frac{C_t^\sigma P_t}{C_{t+1}^\sigma P_{t+1}}\right) \tag{2.5}$$

$$W_t = \eta L_t^\psi P_t C_t^\sigma \tag{2.6}$$

Equation 2.4 and 2.5 represent the Euler equation for the purchase of foreign and domestic currency bonds. Equation 2.6 is the labor supply equation.

2.3 Production Firms

Differentiated final goods $Y(i)$ is CES function of domestically produced value added $V(i)$ and imported intermediate goods $M(i)$.

$$Y_t(i) = \left[a^{\frac{1}{\epsilon}} V_t(i)^{\frac{\epsilon-1}{\epsilon}} + (1-a)^{\frac{1}{\epsilon}} M_t(i)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}} \tag{2.7}$$

Value added V_t is in turn produced using only labor

$$V_t(i) = A_{vt} L_t(i) \tag{2.8}$$

where A_{vt} is productivity.

Cost minimization implies:

$$V_t(i) = a\Big(\frac{W_t}{A_{vt} MC_t(i)}\Big)^{-\epsilon} Y(i) \tag{2.9}$$

$$M_t(i) = (1-a)\Big(\frac{Z_t}{MC_t(i)}\Big)^{-\epsilon} Y(i) \tag{2.10}$$

where W_t, Z_t, MC_t is nominal wage, domestic price of imported intermediate goods, and marginal cost, respectively.

2.4 Price setting

Firms in the final sector set their prices as monopolistic competitors with Rotemberg (1982) type of sticky prices. Each firm bears a small direct cost of price adjustment, therefore, firms will only adjust prices gradually in response to shocks to demand or marginal cost. Firms are owned by domestic households, therefore, firms will maximize its expected profit stream using the households discount factor. The discount factor is defined as follows

$$\Gamma_{t+1} = \beta \frac{P_t C_t^{\sigma}}{P_{t+1} C_{t+1}^{\sigma}}. \tag{2.11}$$

Using this, we can define the objective function of the final goods firm i as:

$$E_0 \sum_{t=0}^{\infty} \Gamma_t \big[P_t(i) Y_t(i) - MC_t Y_t(i) - \frac{\psi_P}{2} (\frac{P_t(i) - P_{t-1}(i)}{P_t(i)})^2 \big] \tag{2.12}$$

where $\Gamma_0 = 1$, and $Y_t(i) = (\frac{P_t(i)}{P_t})^{-\rho} Y_t$ represents total demand for firm i's product, and the third expression inside parentheses describes the cost of price change that is incurred by the firm.

Firm i chooses its price to maximise 2.12. Since all final goods firms are alike, after imposing symmetry, we may write the optimal price setting equation as:

$$\begin{aligned} P_t &= \frac{\rho}{\rho - 1} MC_t - \frac{\psi_P}{\rho - 1} \frac{P_t}{Y_t} \frac{P_t}{P_{t-1}} \left(\frac{P_t}{P_{t-1}} - 1 \right) \\ &\quad + \frac{\psi_P}{\rho - 1} E_t \left[\Gamma_{t+1} \frac{P_{t+1}}{Y_t} \frac{P_{t+1}}{P_t} \left(\frac{P_{t+1}}{P_t} - 1 \right) \right] \end{aligned} \tag{2.13}$$

Notice that when the parameter ψ_P is zero, firms simply set price as a markup over marginal cost. In general, however, the final goods price follows a dynamic adjustment process.

2.5 Importers

This section follows closely with BGG and DLX's paper, except we consider the case for import firms (henceforth, importers) and further details are in the Appendix. As mentioned by BGG, etc, imperfections of financial market make borrowing more costly for borrower than financing project out of internal resources and borrowing premium depends on borrower's network relative to total required borrowing. In particular,

In order to finance intermediate goods import, importers borrow foreign currency from foreign lenders. Each importer faces an idiosyncratic shock $\omega \in (0, \infty)$, drawn from a distribution $F(\omega)$, with probability density function (pdf) $f(\omega)$, and expected value $E(\omega) = 1$. Shock ω is observed by the importer, but can only be observed by the lender through monitoring that incurs extra cost. The borrowing arrangement between lenders and importer is then constrained by the presence of private information. The optimal contract is a debt contract specified by a given amount of lending and a state-dependent threshold level of shock $\bar{\omega}$. If the importer reports shock exceeding the threshold, hen a fixed payment $\bar{\omega}$ times the return from importing is made to the lender, and no monitoring takes place. But if reported shock falls short of the threshold, then the lender monitors, incurring a monitoring cost μ times the value of the project, and receives the full residual amount of the importing project.

An importer j, at the end of period t, plans to import M^j_{t+1} units of intermediate goods must pay nominal price $S_t P^*_{Mt} M^j_{t+1}$ to foreign exporter. Here, P^*_{Mt} is the price of imported intermediate goods, which is given to him at time t. If the importer begins with nominal net worth in domestic currency given by NW_{t+1}, then he needs to borrow in foreign currency an amount given by

$$D^j_{Mt+1} = \frac{1}{S_t}(S_t P^*_{Mt} M^j_{t+1} - NW^j_{t+1}) \tag{2.14}$$

The total expected return on the import project is $E_t(R_{Mt+1} S_t P^*_{Mt} M_{t+1})$, where R_{Mt+1} is the return rate from importing and will be defined below.

The optimal contract specifies a cut-off value of the importer's shock, $\bar{\omega}_{t+1}$, and an amount of importing intermediate goods, M_{t+1}. Under this contract structure, the importer receives an expected share $A(\bar{\omega}_{t+1})$ of the total return on importing project and the lender receives share $B(\bar{\omega}_{t+1})$. In sum, $A(\bar{\omega}_{t+1}) + B(\bar{\omega}_{t+1}) + \phi_{t+1} = 1$, where ϕ_{t+1} represents the expected cost of monitoring.[8]

[8] $A(\bar{\omega})$, $B(\bar{\omega})$, and ϕ_N may be written as follows: $A(\bar{\omega}) = \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega$, $B(\bar{\omega}) =$

As shown in the Appendix, the first order conditions for the optimal contract can be expressed by the following two equations:

$$\frac{E_t\left\{R_{Mt+1}\left[B(\bar{\omega}_{t+1})\frac{A'(\bar{\omega}_{t+1})}{B'(\bar{\omega}_{t+1})}-A(\bar{\omega}_{t+1})\right]\right\}}{E_t\left[\frac{A'(\bar{\omega}_{t+1})}{B'(\bar{\omega}_{t+1})}\frac{S_{t+1}}{S_t}\right]}=1+i^*_{t+1} \tag{2.15}$$

$$\frac{R_{Mt+1}S_t}{S_{t+1}}B(\bar{\omega}_{t+1})=(1+i^*_{t+1})(1-\frac{NW_{t+1}}{S_tP^*_{Mt}M_{t+1}}) \tag{2.16}$$

Equation (2.15) represents the relationship between the expected return from import project, LHS and the opportunity cost of funds for lender, RHS. In the absence of private information or with zero monitoring costs, the expected return would equal the opportunity cost of funds for the lender. Nonetheless, the presence of moral hazard in the lending environment generally imposes an *external finance premium*, so that $E_t(R_{Mt+1}) \geq (1+i^*_{t+1})E_t\frac{S_{t+1}}{S_t}$ and the extent of this premium depends on the value of $\bar{\omega}$. The key characteristic of the BGG *financial acceleration* framework is that the borrowing premium is related to the borrowing amount. This relationship is reflected through the participation constraint equation for the lender (2.16). The smaller is the importers net worth NW_{t+1} relative to total required amount $S_tP^*_{Mt}M_{t+1}$, the more the importer must borrow.

Moreover, equations (2.15) and (2.16) may then be used to show that the external finance premium $\frac{E(R_{Mt+1})}{(1+i^*_{t+1})E\frac{S_{t+1}}{S_t}}$ is increasing in the *leverage ratio* $\frac{S_tP^*_{Mt}M_{t+1}}{NW_{t+1}}$.[9] A fall in importer's net worth or an increase in the amount of money to be financed or both will directly reduce the amount of importing intermediate goods by raising the external finance premium. In other words, financial acceleration implies that the more the importer borrows or the less net-worth he has or both then importer has to bear higher cost of borrowing. The distinguishing feature of this paper compared to literature especially when applied for emerging market is that a nominal exchange rate depreciation leads to both a fall in importer's net worth and a rise in the amount of required financing, thereby *accelerating* the finance premium more than those analyzed in literature.

$\bar{\omega}\int_{\bar{\omega}}^{\infty}f(\omega)d\omega+(1-\mu)\int_0^{\bar{\omega}}\omega f(\omega)d\omega$, $\phi_{Nt}=\mu\int_0^{\bar{\omega}}\omega f(\omega)d\omega$. It is straightforward to show that $A'(\bar{\omega})\leq 0$, and $B'(\bar{\omega})\geq 0$.

[9] See BGG, Appendix

Following Carlstrom and Fuerst (1997) and BGG, we design the importers so that they are always constrained by the need to borrow or financial acceleration always takes place. A simple way to allow for this is to assume that a fraction of the existing stock of importers randomly die each period so that importers don't build up wealth to the extent that the borrowing constraint is non-binding and at the same time a fraction of importers arrives to replacing these exiting ones.

At the beginning of each period, a non-defaulting importer j receives the return from importing project $R_{Mt}S_{t-1}P^*_{Mt-1}M_t(j)(\omega_t(j)-\bar{\omega}_t)$. Importers, then, die at any time period with probability $(1-\nu)$ and consume (all their net-worth) only in the period in which they die. Therefore, at any given period, a fraction $(1-\nu)$ of the return from importing project is consumed away. Since shocks on importers are i.i.d., the functional forms used here allow for aggregation, so that the average return from importing in each sector is $R_{Mt}S_{t-1}P^*_{Mt-1}M_tA(\bar{\omega}_t)$. The consumption for the importer, therefore, can be expressed as:

$$PC^m_t = (1-\nu)R_{Mt}S_{t-1}P^*_{Mt-1}M_tA(\bar{\omega}_t) \tag{2.17}$$

Since importers do not supply labor, their aggregate net worth is equal to:

$$NW_{t+1} \;=\; \nu R_{Mt}S_{t-1}P^*_{Mt-1}M_tA(\bar{\omega}_t) \tag{2.18}$$

where C^m_t is the consumption level of importers when they die.

Using the definition of $A(\bar{\omega})$ and the lender's participation constraint equation, we rewrite importer's net-worth as:

$$NW_{t+1} = \;\nu(1-\phi_t)R_{Mt}S_{t-1}P^*_{Mt-1}M_t - \nu(1+i^*_t)\tfrac{S_t}{S_{t-1}}(S_{t-1}P^*_{Mt-1}M_t - NW_t) \tag{2.19}$$

Notice that an depreciation of current exchange rate reduces the importer's net worth by raising the value of existing foreign currency liabilities.

To conclude this section, we define the return from importing project. Importers sell their imported intermediate goods directly to final goods firms. Therefore, gross nominal return rate from importing is,

$$R_{Mt}S_{t-1}P^*_{Mt-1} = Z_t \tag{2.20}$$

2.6 Monetary Policy Rules

The monetary authority utilizes domestic interest rate as the monetary instrument. The general form of the interest rate rule used can be expressed as

$$1 + i_{t+1} = \left(\frac{P_t}{P_{t-1}} \frac{1}{\bar{\pi}} \right)^{\mu_\pi} \left(\frac{S_t}{\bar{S}} \right)^{\mu_S} (1 + \bar{i}) \tag{2.21}$$

The parameter μ_π allows the monetary authority to control the CPI inflation rate around the desired target of $\bar{\pi}$ whereas μ_S controls the degree to which interest rates attempt to control fluctuations in the exchange rate around a target level of $\bar{S}$. We will compare the properties of alternative exchange rate regimes under two main different assumptions regarding the values of these policy coefficients.

2.7 Equilibrium

Every period, each final goods market must clear. Using the symmetry between goods we obtain:

$$Y_t = C_t + C_t^M + \frac{\psi_D}{2}(D_{t+1} - \bar{D})^2 + \frac{\psi_P}{2}(\frac{P_t}{P_{t-1}} - 1)^2 + \frac{Z_t M_t}{P_t}\phi_t \tag{2.22}$$

Equation (2.22) means demand for final goods comes from household consumptions, importer consumptions, portfolio adjustment costs, costs of price adjustment, and costs of monitoring loans.

The aggregate balance of payments condition for the economy may be derived by adding the budget constraint of the household and importer. Combining with final goods market clearing, we may write it as

$$S_t P_{Mt}^* M_{t+1} + S_t(1 + {i_t}^*)[D_t + D_{Mt}] = S_t P_{Xt}^* \bar{X} + S_t[D_{t+1} + D_{Mt+1}] \tag{2.23}$$

This just says that total paying to the world, which comprise of amount of importing and debt payments, must equal total receipts, which are the amount of exporting, plus new net foreign borrowing.

3 Calibration and Solution

The benchmark parameter choices for the model are described in Table 1. Following literature, this paper sets the inter-temporal elasticity of substitution in consumption to 0.5 or $\sigma = 2$. ψ is set to 1, implying the unity elasticity of labor supply, which is common in empirical literature.[10]

The elasticity of substitution between varieties of final goods determines the average price-cost mark-up, hence, this paper follows standard estimates from the literature in setting a 10 percent mark-up, so that $\rho = 11$.

One important thing in this paper is that we consider relatively low substitutability between domestic value-added intermediate goods and the imported intermediate goods in the production of final goods. Since developing countries often have to import intermediate goods like machines, oil, etc, which is essential to productions but they have limited technology to produce for themselves, we follow Christiano et al (2007) and others to choose the elasticity of substitution between imported intermediate goods and value added intermediate goods less than unity, $\epsilon = 0.5$. [11]

We also assume that the small economy starts out in a steady state with zero consumption growth, therefore, the world interest rate must equal the rate of time preference. We set the world interest rate equal to 6 percent annually, an approximate number used in the macro-RBC literature, so that at the quarterly level, this implies a value of 0.985 for the discount factor. We set $\bar{D}$ so that steady state total debt [12] is 40 percent of GDP, approximately that for East Asian economies in the late 1990's.

We set a so that the share of imported intermediate goods in production is 40 percent, implying a is equal to 0.6. This is consistent with the estimates given for intermediate imports as a fraction of GDP in Christiano et al (2006) for Thailand.

[10]For example, Christiano, Eichenbaum, and Evans (1997) and set elasticity of labor supply to other values different from unity does not change the paper's conclusions but the implied volatility of key macroeconomic variables.

[11]In other paper by Christiano et al (2004), when labor appears in production of value-added, they even allow no substitutability between value-added good and imported intermediate goods but this model does not include capital so we keep relatively high value of ϵ

[12]Which include the debt of importer

With respect to the costs of portfolio adjustment, we follow the estimate of Schmitt-Grohe and Uribe (2003) to set $\psi_D = .0007$.

To calibrate the degree of nominal rigidity in the model, we set the parameter governing the cost of price adjustment, ψ_P so that, if the model were interpreted as being governed by the dynamics of the standard Calvo price, adjustment process, all prices would adjust on average after 4 quarters. To match this degree of price adjustment requires a value of $\psi_P = 120$.

We choose a steady state risk spread of 350 basis points, which is higher than DLX and BGG but might be consistent with developing countries. We follow BGG to set leverage level to 2 and bankruptcy cost parameter μ equal to 0.12. Given the other parameters chosen, the implied savings rate of entrepreneurs is equal to 0.93.

This paper considers three types of shock: a) shocks to the world interest rate, b) productivity in domestically produced value-added, and c) shocks to intermediate goods prices. In the model, a) is represented by shocks to i_t^*, b) is represented by shocks to A_v, and c) is represented by shocks to $\frac{P_{Mt}^*}{P_{Xt}^*}$.

The general form of the interest rule 2.21 allows for a variety of different types of monetary policy stances. This paper focuses analysis to two types of rules. The first rule is a CPI targeting rule (CPI rule), whereby the monetary authority targets the stability of domestic consumer price index so that he sets $\mu_\pi \to \infty$. Secondly, we analyze a simple fixed exchange rate $\mu_S \to \infty$, whereby the monetary authorities adjust interest rates so as to keep the nominal exchange rate from fluctuating.

The model is, then, solved numerically using a second order approximation to the dynamic stochastic system, where the approximation is done around the non-stochastic steady state by perturbation method. Since we later proceed to compare alternative monetary rules in terms of welfare,[13] it is necessary to use a second order approximation. For example, as demonstrated by Kim and Kim (2002), in a simple two-agent economy, a welfare comparison based on an evaluation of the utility function using a linear/first order approximation to the policy function may yield the spurious result such that welfare is higher under autarky than under full risk sharing, which is apparently wrong.

[13]Welfare in this economy is represented by the expected utility of households and importers.

Woodford (2003) also shows that a second order accurate representation of expected utility can be obtained only through a second order representation of the underlying dynamic system, except in special cases.

4 Dynamics under Alternative Monetary Rules

We now examine the impacts of shocks under the two alternative monetary rules. This paper assumes that all shocks are described as AR(1) processes and adopt the VAR results of DLX's paper for US interest rate, a proxy for world interest rate, with persistence 0.46 and the standard deviation of 0.0122 and (log) term of trade shocks with persistence 0.77 and standard deviation 0.013. Finally, we follow Faia and Monacelli (2006) to assume that the (labor) log productivity follows as:

$$log(A_{vt+1}) = \rho^a log(A_{vt}) + \epsilon^a_{t+1} \tag{4.24}$$

where $\rho^a = 0.9$ and ϵ^a_{t+1} is an i.i.d shocks with standard deviation 0.01.

4.1 Impulse Responses

Figure 1 presents the effects of a persistent shock to the world interest rate under the two alternative monetary regimes. Under the CPI targeting rule where exchange rate is free to float, nominal exchange rate depreciates then gradually appreciates after a rise in world interest rate as usual. The depreciation in nominal exchange rate, however, not only raises the domestic price of imported intermediate goods but also increases the leverage of importer, thereby raising the finance premium or the cost of external borrowing. These things combine to account for a sharp decrease in the level of imported intermediate goods, reducing output under the CPI targeting from second period after shock.

By contrast, after a rise in the cost of external borrowing, the monetary authority under fixed exchange rate regime raises nominal interest rate to defend its nominal exchange rate, which makes the consumptions/output fall and leisure increase on impact. However, due to the fixed exchange rate, the domestic currency prices of imported intermediate goods remains the same, which helps to stabilize the importers' net-worth and mitigates the impact on the finance premium of external borrowing. Consequently, imported intermediate goods level decreases with limited amount, hence, relatively less impact on output.

Figure 2 presents the impulse responses with respect to an increase in term of trade shock, i.e., an increase in intermediate imported goods price relative to export goods price. The difference between CPI rule and fixed exchange rate rule is that the former allow nominal exchange rate to fluctuate to keep balance payment whereas the latter attempts to fix it. The consequences are clear from the impulse response of key macroeconomic variables like output, consumption, and imported intermediate goods. Fluctuations in nominal exchange rate tends to amplify the impact of term of trade because of high exchange rate pass-through to domestic production and sensitive finance premium. Nonetheless, since the fixed exchange rate regime relies on the production of domestic value-added to adjust according to the term of trade shock, labor is more volatile under this monetary rule.

Finally, Figure 3 presents the effects of a persistent shock to the (domestic) labor productivity under the two alternative monetary regimes. An improvement in productivity of value-added leads to increasing in initial output, falling in (marginal) cost. Under CPI rule, to keep price stable, the monetary lower interest rate to simulate consumption to meet increased output. A cut in interest rate leads to sharp depreciation in nominal exchange rate on impact and gradual appreciation afterward. The depreciation of exchange rate by the same logic mentioned above will offset the demand of imported intermediates, preventing output from further extension. Moreover, although the real wage rate under CPI rule increases, income effects and impact from exchange rate on output lead to an increase in leisure or decrease in labor supply. On the other hand, under fixed exchange rate rule, the monetary authority keeps interest rate unchanged to fix nominal exchange rate and allows price to adjust. Relatively high interest rate prevents output/consumption from large increase but encourages leisure consumption on impact of shock. Decreasing in price also discourages demand in labor and intermediate goods, offsetting the impacts of shock in labor productivity. However, as usual, fixed exchange rate rule relatively increases the volatility of employment.

4.2 Welfare Evaluation of Alternative Monetary Policy Rules

Table 2 compares the implied standard deviations of key macroeconomic variables under two alternative monetary rules when the model is driven by the three aforementioned shock processes. It is shown that volatilities of output, consumptions, and imported intermediate goods are higher under the CPI targeting than that under the fixed exchange rate. However, the labor under the fixed exchange rate rule is more volatile than that under CPI targeting rule, which is consistent with the theoretical model. The economy under fixed exchange rate rule relies on the domestic factor, here is labor, to adjust in response to shocks whereas under CPI rule, it relies on the exchange rate adjustment to absorb shocks. However, under high exchange rate pass-through, (liability) dollarized economy is very sensitive to exchange rate fluctuations, therefore, output, consumption, and intermediate goods become more volatile than under standard case. High volatility in these key macroeconomic variables might rationalize the styled-facts that emerging economies are reluctant to float their exchange rate or the 'fear of floating'.

We then proceed to compute welfare of each monetary policy regime. The solution method produces a second order accurate measure of expected utility. This paper follows DLX to modify the way taking into account the welfare of importers. The welfare of households, as usual, can be measured as:

$$E_0 \sum_{t}^{\infty} \beta^t U(C_t, N_t) \tag{4.25}$$

Since importers are risk neutral, obtain utility only from final goods consumption, and consume at any time period with probability $1 - \nu$, we can express the utility of importers with unit measure in total as

$$E_0 \sum_{t}^{\infty} \beta^t C_t^m \tag{4.26}$$

given the assumption that the monetary authority discounts the utility of future entrepreneurs at the same rate that private households discount future utility.

The last column of Table 2 shows the implied welfare results: The welfare of economy under fixed exchange rate regime is higher than that under the CPI targeting. These results are consistent with above implied volatility of key macroeconomic variables and therefore confirm the "fear of floating" phenomenon.

Finally, we exclude the domestic labor productivity shock to consider only the external shock as in DLX's paper, the same implied conclusions about volatility and welfare hold.

5 Conclusions

This paper considers a small open highly dollarized economy importing intermediate goods from the world under the financial constraints. The obtained conclusions are consistent with the "fear of floating", i.e., floating exchange rate leads to more volatile in emerging countries' productions and consumption and therefore lower welfare than fixing their exchange rate under external world shocks and productivity shocks under wide range of parameter specifications.

However, we have not conducted any concrete empirical work to support the low substitutability assumption between domestic value-added goods and imported intermediate goods (though it seems reasonable) and further research also need to be done to document the AR(1) assumption in log labor productivity in the paper.

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Figure 1: **Impulse Response to i^*:**

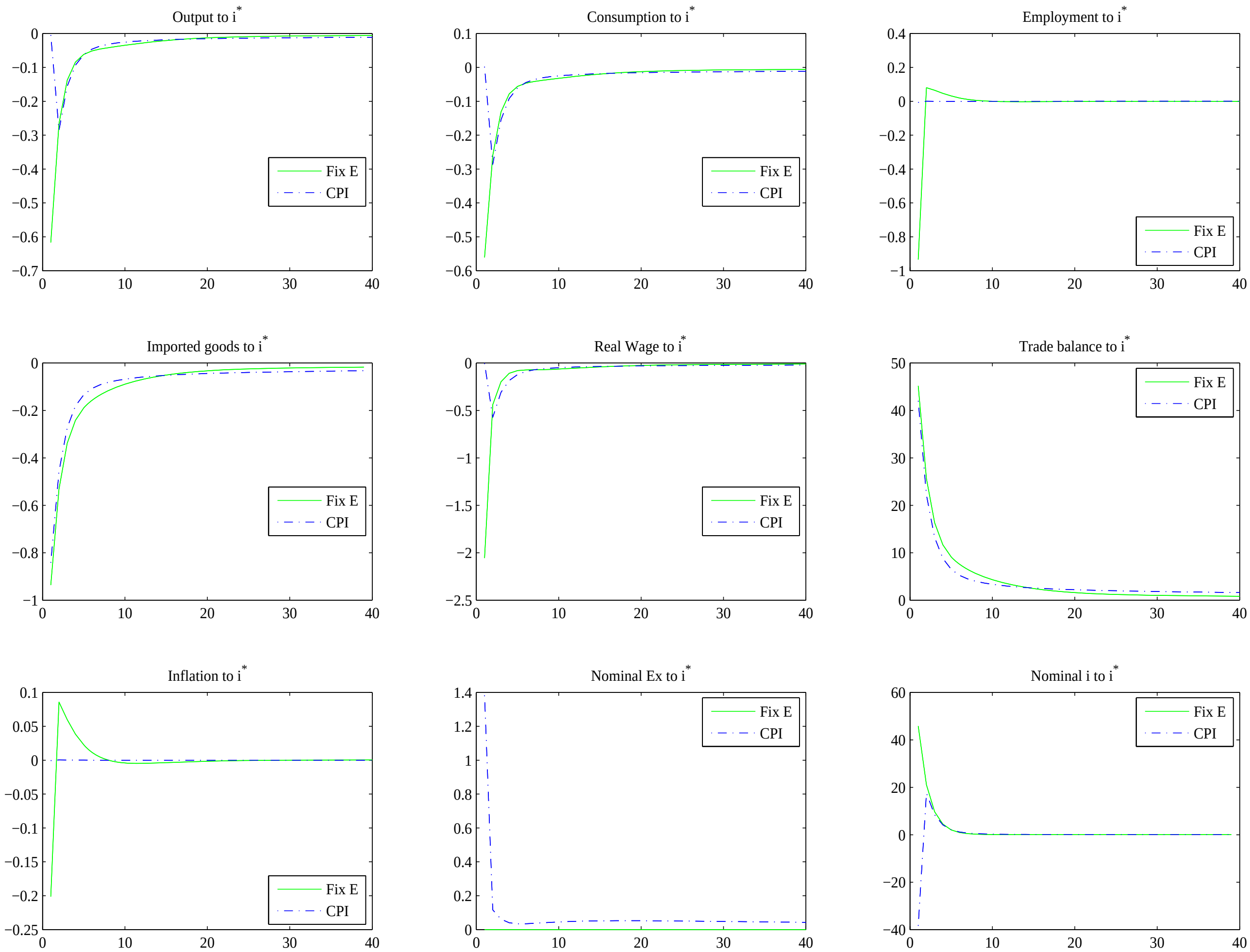

Figure 2: **Impulse Response to Term of Trade** $\frac{P^*_{Mt}}{P^*_{Xt}}$

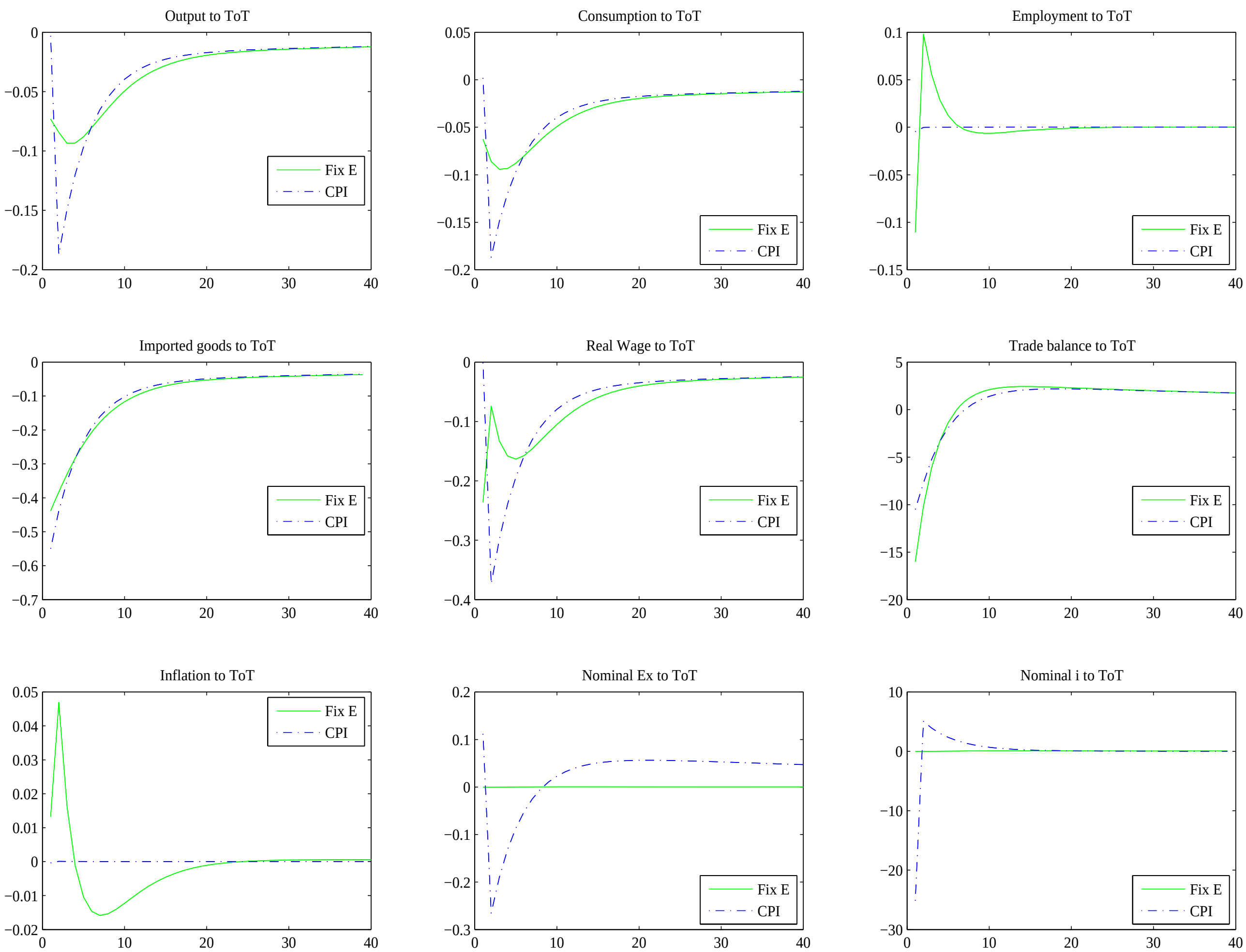

Figure 3: **Impulse Response to technology shock** A_v

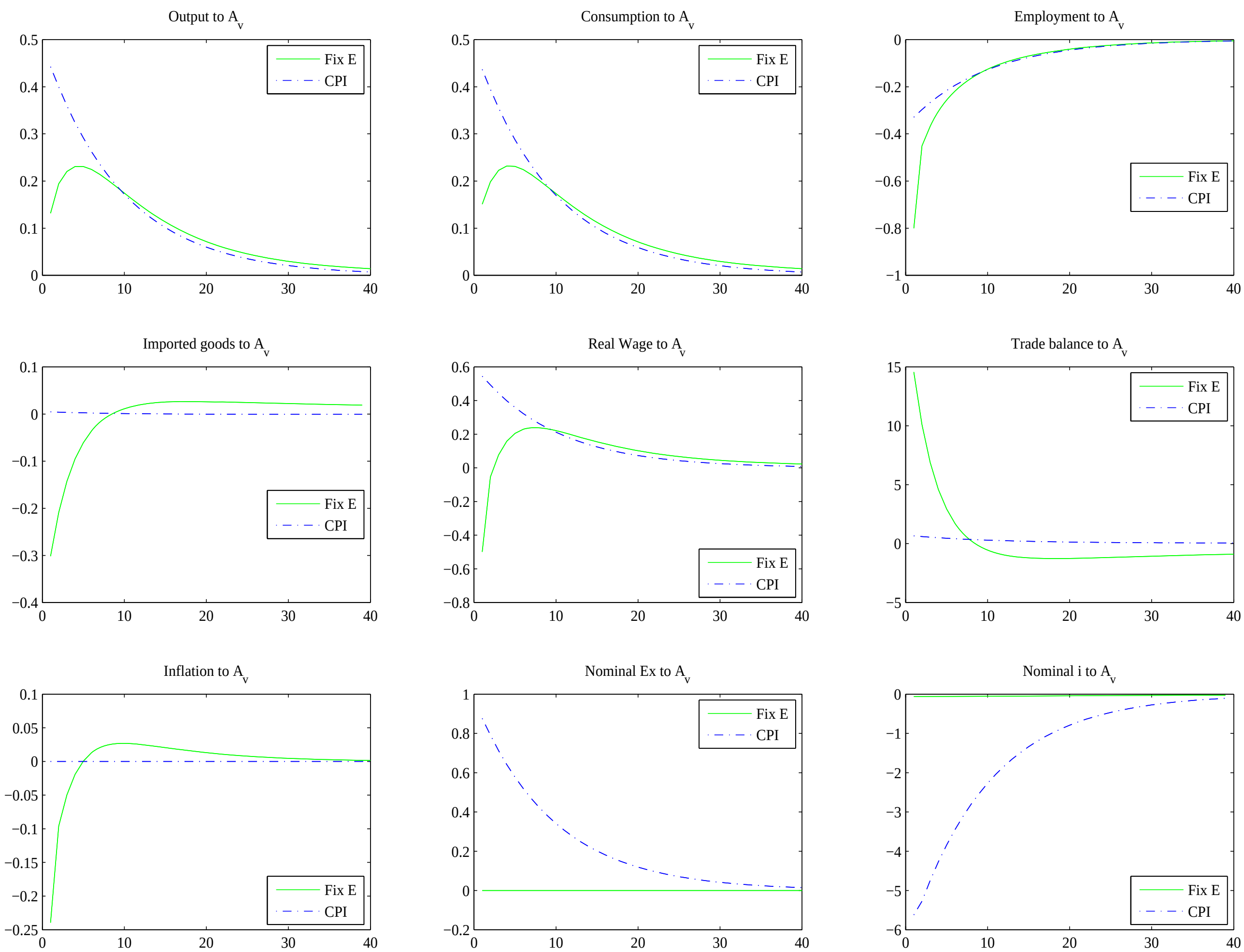

Table 1: **Calibration of the Model**

Parameter	Value	Description
σ	2	Inverse of elasticity of substitution in consumption
β	0.985	Discount factor (quarterly real interest rate is $\frac{1-\beta}{\beta}$)
ϵ	0.5	Elasticity of substitution between value added goods and import goods in production
ρ	11	Elasticity of substitution between varieties
η	1.0	Coefficient on labor in utility
ψ	1.0	Inverse elasticity of labor supply
δ	0.025	Quarterly rate of capital depreciation
a	0.6	Share on value added goods in production
ψ_P	120	Price adjustment cost
ψ_D	0.0007	Bond adjustment cost
σ_ω	0.5	Standard error of the technology shock of importers
μ	0.12	Coefficient of monitoring cost for lenders
ν	0.93	Aggregate saving rate of importers

Table 2: Standard Deviations

	Output	Cons	Intermediate	Labor	Real ER	Real IR	Inflation	Nom.ER	Nom. IR	Exp. Utility
Fix. ER	0.84	0.84	1.28	1.18	1.39	0.19	0.29	0	0.01	-69.05
CPI	1.1	1.1	1.29	0.76	2.15	0.37	0	2.23	0.37	-70.00
$Fix.ER^e$	0.36	0.36	1.20	0.21	0.58	0.058	0.08	0	0.001	-69.02
CPI^e	0.44	0.44	1.29	0.007	0.73	0.34	0	0.073	0.34	-69.07

[b] Note: CPI refers to a monetary rule which keeps the CPI inflation rate fixed, and FER refers to a monetary rule which keeps the nominal exchange rate fixed. Variables are Output, Consumption, Labor, Intermediate goods, Real Exchange Rate, Real Interest Rate,Inflation, Nominal Exchange Rate, Nominal Interest Rate, Expected Utility. $Fix.ER^e$, CPI^e are results excluding domestic labor shocks

Technical Appendix of

"Liability Dollarization and Fear of Floating"

1 Equilibrium

In this appendix, I sum up all equations that describe equilibrium conditions and are used to solve the model.

1.1 Households

Household's budget constraint is described by equation (**??**) in the text. The household optimality conditions for labor supply, domestic bond demand, and foreign bond demand are as follows:

$$W_t = \eta L_t^{\psi} P_t C_t^{\sigma} \tag{1.1}$$

$$\frac{1}{1+i_{t+1}} = \beta E_t \left(\frac{C_t^{\sigma} P_t}{C_{t+1}^{\sigma} P_{t+1}} \right) \tag{1.2}$$

$$\frac{1}{1+i_{t+1}^{*}} \left[1 - \frac{\psi_D P_t}{S_t} (D_{t+1} - \bar{D}) \right] = \beta E_t \left(\frac{C_t^{\sigma} P_t}{C_{t+1}^{\sigma} P_{t+1}} \frac{S_{t+1}}{S_t} \right) \tag{1.3}$$

1.2 Production Firms

After imposing symmetry condition, the optimal conditions from production firms can be written as:

$$Y_t = \left[a^{\frac{1}{\epsilon}} V_t^{\frac{\epsilon-1}{\epsilon}} + (1-a)^{\frac{1}{\epsilon}} M_t^{\frac{\epsilon-1}{\epsilon}} \right]^{\frac{\epsilon}{\epsilon-1}} \tag{1.4}$$

$$V_t = A_{vt} L_t \tag{1.5}$$

$$V_t = a \Big(\frac{W_t}{A_{vt} M C_t} \Big)^{-\epsilon} Y \tag{1.6}$$

$$M_t = (1-a) \Big(\frac{Z_t}{M C_t} \Big)^{-\epsilon} Y \tag{1.7}$$

The price setting condition:

$$
\begin{aligned}
P_t &= \frac{\rho}{\rho-1}MC_t - \frac{\psi_P}{\rho-1}\frac{P_t}{Y_t}\frac{P_t}{P_{t-1}}\left(\frac{P_t}{P_{t-1}}-1\right) \\
&+\frac{\psi_P}{\rho-1}E_t\left[\Gamma_{t+1}\frac{P_{t+1}}{Y_t}\frac{P_{t+1}}{P_t}\left(\frac{P_{t+1}}{P_t}-1\right)\right]
\end{aligned} \tag{1.8}
$$

1.3 The importer's problem:

The details of the optimal contract are derived below. Here we outline the specification of the importer's behavior for the solution of the model. Each period, importer borrows in foreign currency an amount:

$$
D_{Mt+1} = \frac{1}{S_t}(S_t P^*_{Mt} M_{t+1} - NW_{t+1}) \tag{1.9}
$$

The first order conditions for the optimal contract are:

$$
\frac{E_t\left\{R_{Mt+1}\left[B(\bar{\omega}_{t+1})\frac{A'(\bar{\omega}_{t+1})}{B'(\bar{\omega}_{t+1})} - A(\bar{\omega}_{t+1})\right]\right\}}{E_t\left[\frac{A'(\bar{\omega}_{t+1})}{B'(\bar{\omega}_{t+1})}\frac{S_{t+1}}{S_t}\right]} = 1 + i^*_{t+1} \tag{1.10}
$$

$$
\frac{R_{Mt+1}S_t}{S_{t+1}}B(\bar{\omega}_{t+1}) = (1+i^*_{t+1})(1-\frac{NW_{t+1}}{S_t P^*_{Mt} M_{t+1}}) \tag{1.11}
$$

$A(\cdot)$ is defined as the expected fraction of the return on capital accruing to the entrepreneur as part of the optimal contract. We may write is as:

$$
A(\bar{\omega}) = \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega)d\omega
$$

As shown later on this Appendix:

$$
A(\bar{\omega}) = \frac{1}{2}erfc\left(\frac{\ln(\bar{\omega}) - \frac{\sigma^2_\omega}{2}}{\sqrt{2}\sigma_\omega}\right) - \frac{\bar{\omega}}{2}erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma^2_\omega}{2}}{\sqrt{2}\sigma_\omega}\right)
$$

where $erfc(z) = \frac{2}{\sqrt{\pi}}\int_z^\infty e^{-t^2}dt$ is the "complementary error function".

Likewise the return to the lender, net of monitoring costs, is

$$
B(\cdot) = \bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega)d\omega + (1-\mu)\int_0^{\bar{\omega}} \omega f(\omega)d\omega
$$

Also be shown later on:

$$B(\bar{\omega}) = \frac{\bar{\omega}}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) + (1-\mu)\frac{1}{2}\left[1 + erf\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right)\right]$$

where $erf(z) = \frac{2}{\sqrt{\pi}} \int_0^z e^{-t^2} dt$ is the "error function".

We define ϕ_t as the fraction of the return from importing that is wasted in monitoring:

$$\phi_t = \mu \int_0^{\bar{\omega_t}} \omega f(\omega) d\omega$$

The case when ω_t^i is log-normally distributed with $E(ln\omega) = -\frac{\sigma_\omega^2}{2}$ and $Var(ln\omega) = \sigma_\omega^2$ is described in detail below.

Importer's consumption:

$$PC_t^m = (1-\nu) R_{Mt} S_{t-1} P_{Mt-1}^* M_t A(\bar{\omega}_t) \tag{1.12}$$

and aggregate net worth is:

$$NW_{t+1} = \nu(1-\phi_t) R_{Mt} S_{t-1} P_{Mt-1}^* M_t - \nu(1+i_t^*) \tfrac{S_t}{S_{t-1}} (S_{t-1} P_{Mt-1}^* M_t - NW_t) \tag{1.13}$$

Finally, the nominal return rate from importing:

$$R_{Mt} S_{t-1} P_{Mt-1}^* = Z_t \tag{1.14}$$

1.4 Monetary Policy Rules

$$1 + i_{t+1} = \left(\frac{P_t}{P_{t-1}} \frac{1}{\bar{\pi}}\right)^{\mu_\pi} \left(\frac{S_t}{\bar{S}}\right)^{\mu_S} (1 + \bar{i}) \tag{1.15}$$

1.5 Equilibrium

Final goods market must clearing conditions:

$$Y_t = C_t + C_t^M + \frac{\psi_D}{2}(D_{t+1} - \bar{D})^2 + \frac{\psi_P}{2}(\frac{P_t}{P_{t-1}} - 1)^2 + \frac{Z_t M_t}{P_t} \phi_t \tag{1.16}$$

The aggregate balance of payments condition:

$$S_t P_{Mt}^* M_{t+1} + S_t (1 + {i_t}^*)[D_t + D_{Mt}] = S_t P_{Xt}^* X + S_t [D_{t+1} + D_{Mt+1}] \tag{1.17}$$

The equilibrium of this economy is a collection of 18 sequences of allocation:

$(W_t, L_t, P_t, i_t, C_t, C_t^M, D_{t+1}, D_{Mt+1}, S_t, M_t, Y_t, MC_t, R_{Mt}, \bar{\omega}_t, Z_t, NW_{t+1}, V_t, X_t)$ satisfying the equilibrium conditions 1.1-1.18. I use perturbation method from Schmitt-Grohe and Uribe to solve this system of equations.

2 The derivation of the external finance premium

I this section, I derive the external finance premium used in the text. I closely follow the model of BGG and DLX.

At the end of period t a continuum of importers indexed by j need to finance the import of $S_t P_{Mt}^* M_{t+1}^j$ that will be re-sold to domestic producers in period $t+1$. Importers are subject to idiosyncratic shocks so that if one unit of funds in terms of domestic currency is invested by importer j, then the return is given by $\omega^j R_{Mt+1}$, where R_{Mt+1} is the gross return of importer, and ω^j follows a log-normal distribution with with mean $-\frac{\sigma_\omega^2}{2}$ and variance σ_ω^2 and is distributed i.i.d. across importers and time.

The realization of ω^j can be observed by the importer but not by the lender. Lenders, however, can discover the true realization at a cost ϕ times the total return from importing. Since both lenders and importer are risk neutral, standard results establish that the optimal contract between importer and lender is a debt contract, where the importer pays a fixed amount $\bar{\omega^j} R_{Mt+1} S_t P_{Mt}^* M_{t+1}^j$ to the lender if $\omega^j > \bar{\omega^j}$. If $\omega^j < \bar{\omega^j}$, the lender proceed to monitor the project, the importer gets nothing, and the lender receives the full amount of import net of monitoring costs. Therefore, the expected return to the importer can be expressed as:

$$R_{Mt+1} S_t P_{Mt}^* M_{t+1}^j \left[\int_{\bar{\omega}_{t+1}^i}^{\infty} \omega^i f(\omega) d\omega - \bar{\omega}_{t+1}^i \int_{\bar{\omega}_{t+1}^i}^{\infty} f(\omega) d\omega \right] \equiv R_{Mt+1} S_t P_{Mt}^* M_{t+1}^j A(\bar{\omega}_{t+1}^j) \tag{2.18}$$

The expected return to the lender is then given by:

$$R_{Mt+1} S_t P_{Mt}^* M_{t+1}^j \left[\bar{\omega}_{t+1}^i \int_{\bar{\omega}_{t+1}^j}^{\infty} f(\omega) d\omega + (1-\mu) \int_0^{\bar{\omega}_t^j} \omega_{t+1}^j f(\omega) d\omega \right] \equiv R_{Mt+1} S_t P_{Mt}^* M_{t+1}^j B(\bar{\omega}_{t+1}^j) \tag{2.19}$$

The lender should receive a return at least equal to the world opportunity cost, given by $R^*_{t+1} = 1 + i^*_{t+1}$. Therefore, the participation constraint of the lender in terms of the foreign currency can be written as:

$$\frac{R_{Mt+1} S_t P^*_{Mt} M^j_{t+1} B(\bar{\omega}^j_{t+1})}{S_{t+1}} = \frac{(R_{Mt+1} S_t P^*_{Mt} M^j_{t+1} - NW^j_{t+1})}{S_t} \tag{2.20}$$

An optimal contract chooses the threshold value $\bar{\omega}^i_{t+1}$ and M^j_{t+1} to solve the following problem:

$$\max E_t \left(R_{Mt+1} S_t P^*_{Mt} M^j_{t+1} A(\omega^{\bar{i}}_{Nt+1}) \right) \tag{2.21}$$

subject to the participation constraint 2.20.

The two first order condition implied by the contract is then:

$$E_t \left[R_{Mt+1} S_t P^*_{Mt} A(\bar{\omega}^j_{t+1}) \right] + E_t \left[\lambda_{t+1} \frac{R_{Mt+1} S_t P^*_{Mt} A(\bar{\omega}^j_{t+1})}{S_{t+1}} - \lambda_{t+1} \frac{R^*_{t+1} S_t P^*_{Mt}}{S_t} \right] = 0 \tag{2.22}$$

$$\lambda_{t+1}(\theta) = -\frac{\pi(\theta) A'(\bar{\omega}^i_{t+1}(\theta)) S_{t+1}(\theta)}{B'(\omega^{\bar{i}}_{t+1}(\theta))} \tag{2.23}$$

where $\theta \in \Theta$ is a state of the world, $\pi(\theta)$ is the probability of state θ and λ_{t+1} is the Lagrange multiplier associated with the participation constraint. Substitute 2.23 into 2.22, we get:

$$E_t \left(R_{Mt+1} \left[\frac{A'(\omega^{\bar{i}}_{t+1})}{B'(\omega^{\bar{j}}_{t+1})} B(\omega^{\bar{j}}_{t+1}) - A(\omega^{\bar{j}}_{t+1}) \right] \right) = E_t \left[\frac{A'(\omega^{\bar{j}}_{t+1})}{B'(\omega^{\bar{j}}_{t+1})} \frac{S_{t+1}}{S_t} R^*_{t+1} \right] \tag{2.24}$$

Since ω^i is i.i.d across entrepreneurs, every importer actually faces the same financial contract, so we could drop the superscript i. Rearranging 2.24 to get (1.10) in the text.

The importers are assumed to die at any time period with probability $(1-\nu)$. Thus, at any given period, a fraction $(1-\nu)$ of importers' wealth is consumed. So the consumption of importers is given by 1.12. And the net worth NW_{t+1} is given by:

$$NW_{t+1} = \nu R_{Mt+1} S_t P^*_{Mt} M^j_{t+1} A(\bar{\omega}_t) \tag{2.25}$$

Use the fact that $B(\bar{\omega}) = 1 - A(\bar{\omega}) - \mu \int_0^{\bar{\omega}} \omega f(\omega) d\omega$ and imposing the participation constraint, we get 1.13.

3 Derivation of $A(\cdot)$, $A'(\cdot)$, $B(\cdot)$ and $B'(\cdot)$

This derivation follows closely that on the Appendix of DLX's paper.

By definitions:

$$A(\bar{\omega}) = \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega \tag{3.26}$$

$$B(\bar{\omega}) = \bar{\omega} \int_{\bar{\omega}}^{\infty} f(\omega) d\omega + (1-\mu) \int_{0}^{\bar{\omega}} \omega f(\omega) d\omega \tag{3.27}$$

Since ω_t^i is log-normally distributed with mean $-\frac{\sigma_\omega^2}{2}$ and variance σ_ω^2, we know that

$$E(\omega) = \int_{-\infty}^{\infty} \omega f(\omega) d\omega = 1 \tag{3.28}$$

where the density function $f(\omega)$ is given by:

$$f(\omega) = \frac{1}{\sigma_\omega \omega \sqrt{2\pi}} \exp\left\{ -\frac{(\ln \omega + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} \tag{3.29}$$

Therefore,

$$\begin{aligned}
\int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega &= \int_{\ln \bar{\omega}}^{\infty} \frac{1}{\sigma_\omega \sqrt{2\pi}} \exp\left\{ -\frac{(y + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} \exp(y) dy \\
&= \int_{\ln \bar{\omega}}^{\infty} \frac{1}{\sigma_\omega \sqrt{2\pi}} \exp\left\{ -\frac{(y - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} dy \\
&= \frac{1}{\sqrt{\pi}} \int_{\ln \bar{\omega}}^{\infty} \exp\left\{ -\frac{(y - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} d(\frac{y - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}) \\
&= \frac{1}{2} erfc \left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega} \right)
\end{aligned} \tag{3.30}$$

where $erfc(z) = \frac{2}{\sqrt{\pi}} \int_z^{\infty} e^{-t^2} dt$ is the *complementary error function.*

Similarly,

$$\begin{aligned}
\bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega)d\omega &= \bar{\omega}\int_{\bar{\omega}}^{\infty} \frac{1}{\sigma_\omega \omega\sqrt{2\pi}} \exp\left\{-\frac{(\ln\omega + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right\} d\omega \\
&= \bar{\omega}\int_{\bar{\omega}}^{\infty} \frac{1}{\sigma_\omega \sqrt{2\pi}} \exp\left\{-\frac{(\ln\omega + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right\} d\ln\omega \\
&= \bar{\omega}\int_{\ln\bar{\omega}}^{\infty} \frac{1}{\sqrt{\pi}} \exp\left\{-\frac{(\ln\omega + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right\} d(\frac{\ln\omega + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}) \\
&= \frac{\bar{\omega}}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) \qquad (3.31)
\end{aligned}$$

As results:

$$A(\bar{\omega}) = \frac{1}{2} erfc\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) - \frac{\bar{\omega}}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) \qquad (3.32)$$

At the same time,

$$\begin{aligned}
\int_0^{\bar{\omega}} \omega f(\omega)d\omega &= \frac{1}{\sqrt{\pi}}\int_{-\infty}^{\ln\bar{\omega}} \exp\left\{-\frac{(y - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right\} d(\frac{y - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}) \\
&= \frac{1}{2}\left[1 + erf\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right)\right] \qquad (3.33)
\end{aligned}$$

$$B(\bar{\omega}) = \frac{\bar{\omega}}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) + (1-\mu)\frac{1}{2}\left[1 + erf\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right)\right] \qquad (3.34)$$

where $erf(z) = \frac{2}{\sqrt{\pi}}\int_0^z e^{-t^2}dt$ is the *error function*.

Next, since:

$$A'(\bar{\omega}) = -\frac{1}{\sqrt{2\pi}\sigma_\omega}\left[\frac{1}{\bar{\omega}}\exp\left(-\frac{(\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) - \exp\left(-\frac{(\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right)\right] - \frac{1}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) \qquad (3.35)$$

However,

$$\begin{aligned}
\frac{1}{\bar{\omega}}\exp\left(-\frac{(\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) &= \exp[-\ln(\bar{\omega})]\exp\left(-\frac{(\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) \\
&= \exp\left(-\frac{(\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) \qquad (3.36)
\end{aligned}$$

Therefore,

$$A'(\bar{\omega}) = -\frac{1}{2} erfc \left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega} \right) \tag{3.37}$$

Note that $E(\omega) = 1$, so $B(\bar{\omega}) = 1 - A(\bar{\omega}) - \mu \int_0^{\bar{\omega}} \omega f(\omega) d\omega$, thus

$$B'(\bar{\omega}) = -A'(\bar{\omega}) - \frac{\mu}{\sqrt{2\pi}\sigma_\omega} \exp \left(-\frac{(\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right) \tag{3.38}$$