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This paper explores the idea that *fear of floating* can be justified as an optimal discretionary monetary policy in a dollarized emerging economy. Specifically, I consider a small open economy in which intermediate goods importers borrow in foreign currency and face a credit constraint. In this economy, exchange rate depreciation not only worsens importers' net-worth but also increases the financing amount in domestic currency, therefore exaggerating their borrowing finance premium. Besides, because of high exchange rate pass-through into import prices, fluctuations in the exchange rate also have strong impacts on domestic prices and production. These effects, together, magnify the macroeconomic consequences of the floating exchange rate policy in response to external shocks. The paper shows that the floating exchange rate regime is dominated by the fixed exchange rate regime in the role of cushioning shocks and in welfare terms.

Keywords: Liability Dollarization, Fear of Floating, Imported Goods
JEL classification: F0, F4

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1 Introduction

There are two distinguishing features in exchange rates and financial systems in emerging economies. They are: (i) the so-called *fear of floating*, a phenomenon where authorities are reluctant to let their nominal exchange rates fluctuate and (ii) *liability dollarization*, the increasing uses of the U.S dollar in debt denomination. This paper addresses the question of whether fear of floating can be justified an optimal discretionary monetary policy in a dollarized emerging economy.

Fear of floating seems to be a puzzling phenomenon since most exchange rate crises in emerging economies occurred in pegged exchange rate environments and nominal exchange rate rigidities have been perceived as one of main reasons. However, Calvo and Reinhart (2002) show that despite having experienced severe exchange rate crises, authorities in emerging economies have kept resisting exchange rate fluctuations and consequently there has not much variation in nominal exchange rates in these economies. In particular, Calvo and Reinhart (2002) present evidence that interest rate and reserve variabilities are significantly higher in emerging market economies than in their developed counterparts. The probability that the monthly variation of nominal exchange rates is in a narrow band of plus and minus 2.5% is more than 79% for all developing countries. [1] Given the fact that emerging economies often experience much more volatile shocks than their developed counterpart, relatively small variation in nominal exchange rates in emerging economies is remarkable.

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

[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%.

governments borrow in the U.S dollar, individuals can hold U.S dollar denominated bank accounts, firms and households can borrow in the U.S dollar both domestically and internationally. In particular, to quantitatively document dollarization, Reinhart, Rogoff, and Savastano (2003) (RRS, henceforth) build a composite index of dollarization for a wide range of developing countries so are able to show that that the frequency distribution of the composite dollarization index has shifted markedly to the right between 1980-85 and 1996-2001. The shift indicates that the degree of dollarization in developing countries has risen significantly during these periods.[2] By exploring the data 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 notable features, particularly the question of whether fear of floating can be justified as an optimal discretionary monetary policy in dollarized emerging economy in response to external shocks. To this end, I consider a small open economy in which intermediate goods importers borrow in foreign currencies and face credit constraints. Foreign intermediate goods are required for final goods production. In this economy, interest rates

[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.

that domestic borrowers pay to foreign lenders depend on the borrowers' net-worth, which characterizes the *financial acceleration*, i.e., the higher the leverage is the higher the interest rates borrowers have to pay.

It should be noted that this paper is not the first to address the relationship between dollarization and exchange rate policies. Cespedes et al. (2002) and Devereux et al (2006) (henceforth DLX) have followed Bernanke et al (1999) (henceforth BGG) to take into account credit constraints in investment financing for liability-dollarized emerging economies. In these models, exchange rate fluctuations affect firms' real net worth positions and investments through balance-sheet constraints, thereby having impacts on the macroeconomy. Despite different settings, the two papers reach quite similar conclusions: balance-sheet constraints in the presence of liability dollarization is an important propagation channel, it can magnify the effects of external shocks, leading both real and financial variables' volatility to be greater than in an economy without these constraints. However, even under financial imperfections and balance sheet constraints, the inflation targeting or the 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 a common feature in Crespedes and DLX that limits the impact of exchange rate fluctuations on other macroeconomic variables. In these models, exchange rate fluctuations *only* affect the net worth of firms and via this channel determine the finance premium of foreign currency borrowing. Emerging economies, most of which are relatively less industrialized, have to rely heavily on imported intermediate goods for domestic production. Christiano et al (2006), for example, shows that in developing countries, more than 80% of the import is intermediate goods for domestic production. The heavy reliance on foreign intermediate goods implies a high exchange rate pass-through and high external exposure. Moreover, because of limited cross-border enforcements particularlly for emerging countries, import firms are subject to borrowing constraints. As a result, when import firms borrow in foreign currencies to finance intermediate goods, exchange rate fluctuations affects not only the borrowers' net worth but also the financing amount. 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. The borrowing constraint imposed on import firms is the main departure from to DLX's paper.

Under aforementioned different specifications, this paper follows DLX to re-examine the macroeconomic consequences and compare welfare of alternative monetary policies: the inflation targeting regime and the fixed exchange rate regime [3] in response to external shocks. This paper finds that fear of floating can be justified in highly dollarized economies. The volatilities of output, consumptions, and imported goods are higher under the inflation targeting rule than under the fixed exchange rate rule. The welfare of the fixed exchange rate regime also dominates that for the inflation targeting regime in a wide range of parameter specifications.

There are several other papers addressing fear of floating. Lahiri and Vegh (2001) incorporate three key frictions into their model: an output cost of nominal exchange rate fluctuations, an output cost of higher interest rates to defend the currency, and a fixed cost of intervention. The model then predicts a non-monotonic relationship between the nominal exchange rate and the size of the shock. For large shocks, which are identified for developing countries, the output costs resulting from exchange rate fluctuations become too large relative to the cost of intervening. Therefore, monetary authorities find it optimal to stabilize the exchange rate. My research differs with this

[3] I 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.

paper in several aspects. First, I incorporate stochastic environment and financial constraints and its endogenous propagation mechanism via the financial acceleration to the macroeconomy while Lahiri and Vegh (2001) do not. Second, I address the external shocks, particularly the terms of trade shock while the paper addresses monetary shocks.

My paper shares a key aspect with the paper by Devereux and Poon (2004): Intermediate good importers in developing countries face endogenous borrowing constraints so exchange rate adjustments might become destabilizing. The difference is that Devereux and Poon (2004) assume a collateral borrowing constraint like Kiyotaki and Moore (1997). In their model, the constraint is *not always binding*; it binds only when shocks are negative and large so the model might be more suitable to address monetary policies in crises. By contrast, I follow the BGG framework in which exchange rate fluctuations always have impacts on the borrowers' leverage, hence on the financial premium, regardless of the scale and direction of shocks.

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.

2 The Model

2.1 Model Outline

This is one sector model of a small open economy where final goods are domestically produced using labor and imported intermediate goods. Domestic agents consume only domestically produced final goods,[4] they are, however, endowed with a fixed amount of tradable goods, which can be exported to the rest of the world with exogenous prices.

The model has following characteristics: (i) rigidities in prices,[5] (ii) credit constraints in foreign currency borrowing to highlight *balance-sheet effects* of liability dollarization, (iii) imperfect substitutability between domestic value-added goods and imported intermediate goods to capture the reliance of domestic production on foreign intermediate goods.

There are four sets of domestic agents in the model: households, firms, importers, and the monetary authority, vs. "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 domestically endowed tradable goods, which domestic agents do not consume. Domestic households have access to international financial markets through two kinds of non-state-contingent bonds. Financing contracts are set up between foreign bankers and domestic importer firms who need to borrow to finance imported 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 a monetary policy instrument.

[4]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.

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

2.2 Households

There is a continuum of households of measure one. The representative household maximizes its expected life-time utility which is given 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 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, $\frac{\psi_D}{2}(D_{t+1} - \bar{D})^2$, [6] 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 final goods firms' profits Π_t, the supply of labor with wages W_t, 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:

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

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

Here S_t is the nominal exchange rate, P^*_{Xt} is the price of export goods in foreign currency, D_t is the 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.

The household chooses each differentiated goods to minimize expenditure conditional on total composite consumption. Demand for each differentiated goods then can be derived as follows:

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

The household's first order conditions can be expressed as:

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

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

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

Equations 2.4 and 2.5 represent the Euler equations 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 a 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 input as follows:

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

where A_{vt} is the productivity shock.

Cost minimizing behavior of final goods firm i implies that:

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

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

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

2.4 Price Setting

Firms in the final sector set their prices as monopolistic competitors. I assume that each firm bears a small direct cost of price adjustment as in Rotemberg (1982), therefore, firms will only adjust prices gradually in response to demand or the marginal cost shocks. Firms are owned by domestic households, hence firms will maximize their expected profit stream using 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 follows:

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

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 the parentheses are the costs of price changes.

Firm i chooses its price to maximize (2.12). Because all final goods firms are alike, after imposing symmetry, the optimal price setting equation can be expressed as:

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

Notice that when the parameter ψ_P is zero, the final good price is just a markup over the marginal cost. Otherwise, the price follows a dynamic adjustment process.

2.5 Importers

In this section, I follows closely BGG and DLX to describe credit constraints of import firms (henceforth, importers).[7] As mentioned by BGG and others, financial market imperfections make external borrowing more costly than financing project out of internal resources and the borrowing premium depends on borrower's network relative to total required borrowing.

In particular, in order to finance intermediate goods imports, importers need to borrow in 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 costs. The borrowing arrangement between lenders and importers 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, then a fixed payment $\bar{\omega}$ times the return on the import project is made to the lender, and there is no monitoring. But if reported shock is lower than the threshold, then the

[7]See the Appendix for further details.

lender pays monitoring costs μ times the value of the project to monitor and receives the full residual amount of the import 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 foreigners. 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 imported 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 the import project and the lender receives a 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]

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

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

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

Equation (2.15) represents the relationship between the expected return from the import project (LHS) and the opportunity cost of funds for lender

[8] $A(\bar{\omega})$, $B(\bar{\omega})$, and ϕ_N may be written as follows: $A(\bar{\omega}) = \int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega - \bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega) d\omega$, $B(\bar{\omega}) = \bar{\omega}\int_{\bar{\omega}}^{\infty} f(\omega) d\omega + (1-\mu)\int_0^{\bar{\omega}} \omega f(\omega) d\omega$, $\phi_t = \mu \int_0^{\bar{\omega}} \omega f(\omega) d\omega$. It is straightforward to show that $A'(\bar{\omega}) \leq 0$, and $B'(\bar{\omega}) \geq 0$.

(RHS). Without private information(hence, no monitoring costs), the expected return would equal the opportunity cost of funds for the lender. However, the presence of moral hazard in the lending environment imposes an *external finance premium*, so that the return $E_t(R_{Mt+1})$ will be greater than the opportunity cost $(1+i^*_{t+1})E_t\frac{S_{t+1}}{S_t}$ 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, hence the higher the share $B(\bar{\omega}_{t+1})$ for the lender.

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 the importer's net worth or an increase in the financing amount or both will directly reduce the amount of imported 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 a higher cost of borrowing. The novel feature of this paper compared to the literature, is that a nominal exchange rate depreciation leads to both a fall in importers' net-worth and a rise in the financing amount, thereby *accelerating* the finance premium more than those analyzed in literature.

Following Carlstrom and Fuerst (1997) and BGG, I design the importers so that they are always constrained by the need to borrow so that financial acceleration always takes place. This can be obtained by assuming 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 replace

[9] See BGG, Appendix

these exiting ones.

At the beginning of each period, a non-defaulting importer j receives the return on the import 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 on the import project is consumed away. Since shocks on importers are i.i.d., the functional forms here can be aggregated so that the average return on import is $R_{Mt}S_{t-1}P^*_{Mt-1}M_tA(\bar{\omega}_t)$. The consumption for the importer, therefore, can be expressed as:

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

where C^m_t is the consumption level of importers when they die. And importers' aggregate net worth is equal to:

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

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

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

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 on the import project. Importers sell their imported intermediate goods directly to final goods firms. Therefore, the 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 uses 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 level 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 $\bar{S}$. I 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. After imposing 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 households' consumption, importers' consumption, portfolio adjustment costs, costs of price adjustment, and costs of monitoring loans.

The aggregate balance of payments condition for this small open economy can be derived by adding the budget constraint of the household and the importer and can be expressed as follows:

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

Equation 1.16 indicates that total expenditures, 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 I 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 rely on imported intermediate goods, which are essential to domestic production but they have limited resources to produce for themselves, I 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, $\epsilon = 0.9$. [11]

I also assume that this small open economy starts out in a steady state with zero consumption growth, therefore, the world interest rate must equal the rate of time preference. I 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. I set $\bar{D}$ so that steady state total debt [12] is 40 percent of GDP, approximately

[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 another 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 I set a higher value of ϵ

[12]Which include the debt of importer

that for East Asian economies in the late 1990's. The amount of tradable endowment $\bar{X}$ is chosen such that in steady state export is equal to 40% of GDP, which is also in the range of literature.

I set parameter a in the domestic production function 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.

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

To calibrate the degree of nominal rigidity in the model, I 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 $\psi_P = 120$.

I choose a steady state risk spread of 350 basis points, which is higher than DLX and BGG but might be consistent with developing countries. I 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.

In this paper, I consider two types of shock as in DLX: a) shocks to the world interest rate, b) shocks to (inverse) terms of trade. In the model, a) is represented by shocks to i_t^*, b) 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 on 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, I 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 I later proceed to compare the two 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. 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 Analysis

I now examine impacts of external shocks under the two alternative monetary rules. I assume that all shocks can be described as AR(1) processes and adopt the VAR results of DLX for the US interest rate, a proxy for the 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. There is negligible correlation between innovations between the world interest rate and terms of trade.

4.1 Impulse Responses

Figure 1 presents impulse responses in response to a negative terms of trade shock, i.e., an increase in the imported intermediate goods price relative to

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

Table 1: Model Calibration

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	0.9	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
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 deviation of importers' technology shocks
μ	0.12	Coefficient of monitoring cost for lenders
ν	0.93	Aggregate saving rate of importers

the export goods price. A key difference between the CPI rule and the fixed exchange rate rule is that the former attempts to stabilize final good prices and allows the exchange rate to fluctuate whereas the latter attempts to fix the exchange rate.

In particular, under the CPI targeting rule, the monetary authority adjusts the domestic interest rate (hence, the exchange rate) so that final goods firms don't have incentives to change the price level. In other words, the monetary authority adjusts the monetary instrument so that the marginal cost of final good production stays unchanged in response to shocks. On impact of the terms of trade shock, since the cost of imported intermediate goods is already determined from the previous period, the monetary authority has to adjust the domestic interest rate so that labor costs (the wage rate) remains unchanged. Consequently, labor supply, consumption, and output remain unchanged on impact under the CPI rule. Nevertheless, the negative terms of trade shock will raise the cost of imported goods from the next period, therefore induce decreases in domestic production and consumption. Since households tend to smooth consumption, the interest rate has to be decreased significantly on impact so that households keep the same level of consumption in the first period and then gradually reduce it afterward. As a result, the exchange rate depreciates on impact of the negative shock. The depreciation of the exchange rate under the CPI rule, combined with an increase in the imported goods price, strongly hits on the import sector by not only increasing the domestic price of imported good prices but also worsening the importers' net-worth hence raising the borrowing risk premium. Consequently, from the second period after the shock, the exchange rate has to appreciate significantly to offset both the initial depreciation and an increase in imported goods prices. Therefore, the domestic interest rate has to be increased accordingly from the second period, which then contributes to significant drops in consumption, output, and imported goods.

By contrast, under the fixed exchange rate regime, final good prices increase in response to the negative terms of trade shock and households consume less consumption goods and more leisure (the substitution effect). The responses of other variables under the fixed exchange rate rule are straightforward. It is shown by the figure that consumption, output, and imported intermediate goods are more volatile under the CPI rule while employment is more fluctuating under the fixed exchange rate rule.

Figure 2 presents the impulse responses in response to a positive world interest rate shock. [14] In response to the shock, the monetary authority raises the domestic interest rate to fight against the depreciation of the exchange rate under the fixed exchange rate regime. An increase in the dosmestic interest rate leads to decreases in consumption, output, hence in imported goods. By contrast, the exchange rate depreciates on impact under the CPI rule, which makes imported intermediate goods more costly. The financial acceleration applies so that the drop in the imported goods is as profound as that in the fixed exchange rate regime. Nonetheless, the impacts of the world interest rate on real variables are small and there are not clear differences under the two alternative monetary rules.

Table 2 compares the implied standard deviations of key macroeconomic variables under the two alternative monetary rules when the model is driven by the two aforementioned shocks. It is shown that volatilities of output, consumptions, and imported intermediate goods are higher under the CPI targeting rule than that under the fixed exchange rate. However, labor input under the fixed exchange rate rule is more volatile than that under the CPI targeting rule. The reason goes as follows. Monetary policies under the CPI rule aim to stabilize the marginal cost of final good production, which consists of labor costs and imported intermediate good costs. Since the latter is determined from the previous period the monetary authority adjusts

[14] I scale up the IRs by 100 times.

the domestic interest rate to stabilize the labor cost, which lead to a relatively stable labor market under the CPI rule. However, as explained above, exchange rate fluctuations under the CPI rule with the presence of a high exchange rate pass-through and liability dollarization have strong impacts on output, consumption, and intermediate goods. High volatility in these key macroeconomic variables may explain the stylized-fact that emerging economies are reluctant to let their exchange rates fluctuate or the so-called "fear of floating".

4.2 Welfare Evaluation

Finally, I evaluate welfare of the economy under each monetary policy regime. The solution method produces a second order accurate measure of expected utility. I follow DLX to modify the way taking into account the welfare of importers. The welfare of households, as usual, can be measured as follows:

$$E_0 \sum_{t}^{\infty} \beta^t U(C_t, N_t) \tag{4.24}$$

Since importers are risk neutral, gain 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:

$$E_0 \sum_{t}^{\infty} \beta^t C_t^m \tag{4.25}$$

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

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

Figure 1: **IRs: Terms of Trade Shock** $\frac{P^*_{Mt}}{P^*_{Xt}}$

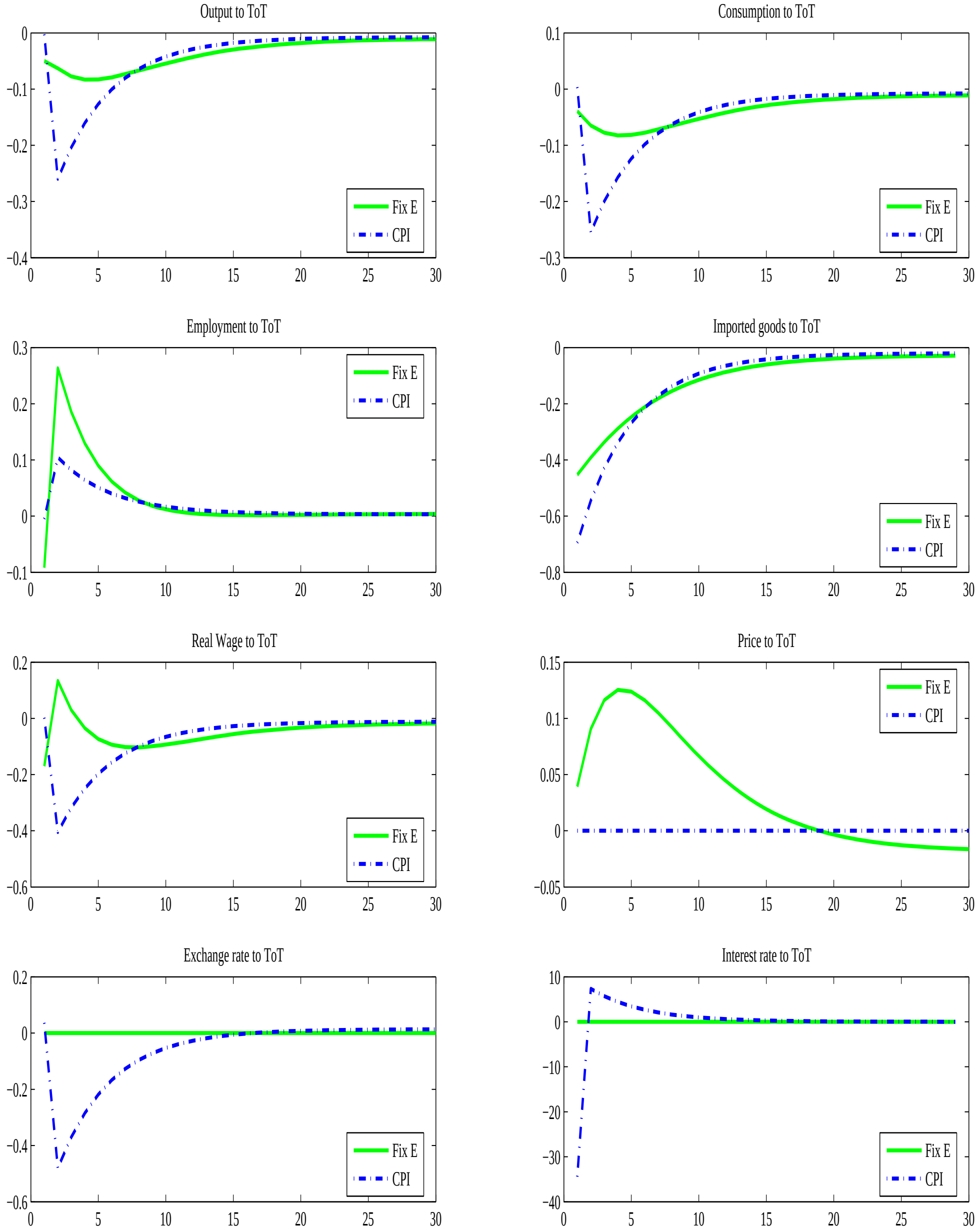

Figure 2: **IRs: World Interest Rate Shock i^*:**

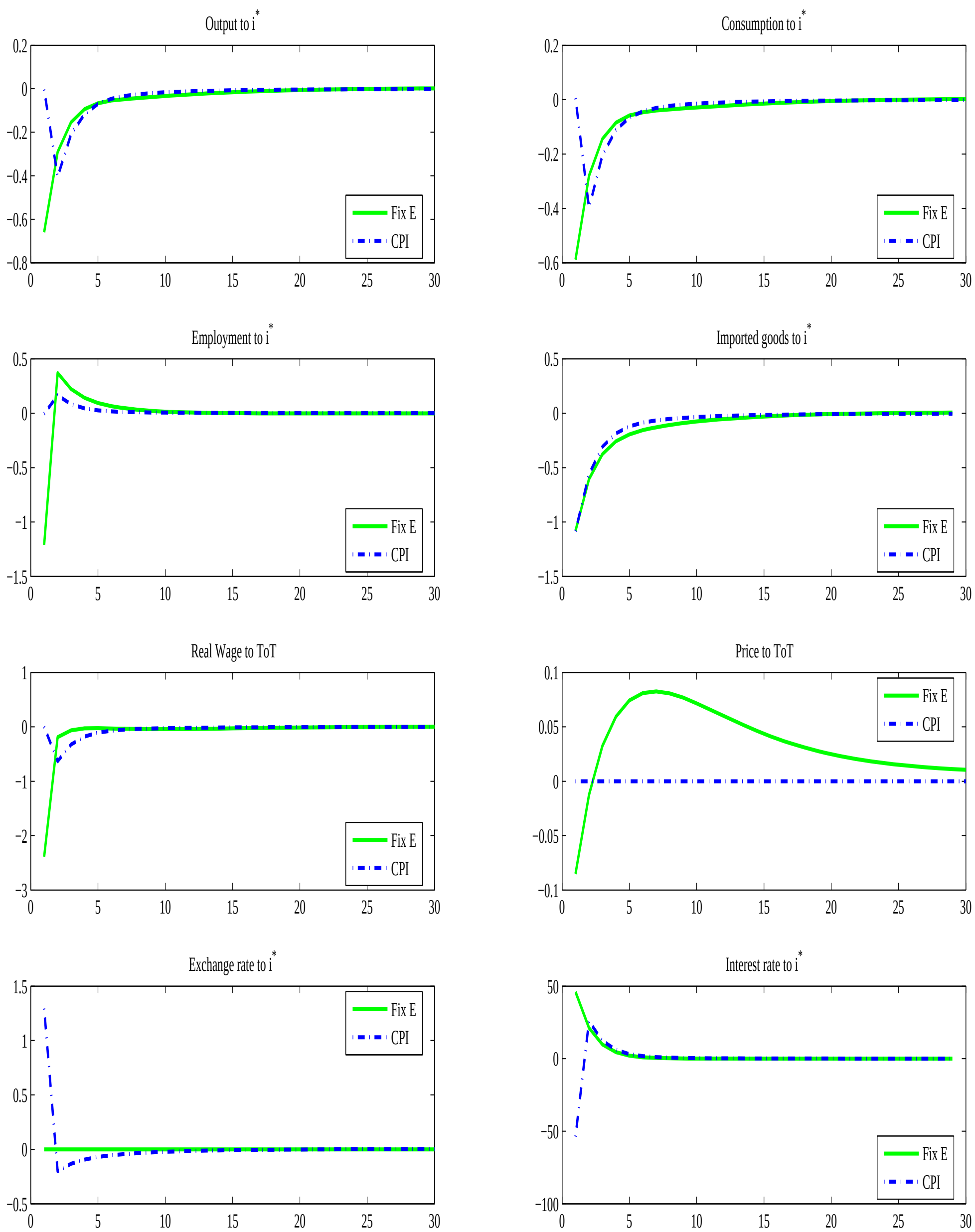

Table 2: Standard Deviations

	Output	Cons	Intermediate	Labor	Inflation	Nom.ER	Nom. IR	Exp. Utility
Fix. ER	0.46	0.46	1.47	0.51	0.10	0	0.01	-140.36
CPI	0.61	0.60	1.62	0.25	0	1.08	0.47	-144.96

[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.

5 Conclusions

This paper considers a small open highly dollarized economy borrowing in foreign currencies to import intermediate goods and facing borrowing constraints. The paper quantitatively shows that “fear of floating” can be justified as a discretionary optimal monetary policy because floating the exchange rate leads to relatively more volatile domestic production, consumption, and import, therefore lowering welfare in response to external world shocks.

References

[1] Bernanke, B., Gertler, M., and Gilchrist, S. (1999), "The Financial Accelerator in a Quantitative Business Cycle Model," in John Taylor and Michael Woodford, eds, Handbook of Macroeconomics, Volume 1c, Amsterdam: North Holland, 1341-1393.

[2] Calvo, Guillermo A. and Carmen M. Reinhart (2002), “Fear of Floating.” *Quarterly Journal of Economics* 117(2), pp. 379-408.

[3] Carlstrom, Charles and Timothy Fuerst (1997) "Agency Costs, Net Worth, and Business Cycle Fluctuations", *American Economic Review*

[4] Céspedes, Luis Felipe, Roberto Chang and Andrés Velasco (2002b), “Balance Sheets and Exchange Rate Policy.” Volume 94, Number 4, 1 September 2004 , pp. 1183-1193: *American Economic Review.*

[5] Christiano, Larry, Martin Eichenbaum and Charles Evans (1997), "Sticky Price and Limited Participation Models of Money: A Comparison", *European Economic Review* 41, 1201-1249.

[6] Christiano, Braggion and Roldos(2006), "Optimal Monetary Policy in a Sudden Stop ", *Journal of Economic Theory*, 119, 1-245.

[7] Christiano, Larry, Christopher Gust and Jorge Roldos (2007), "Monetary Policy in a Financial Crisis ", *NBER working paper*, 13254.

[8] Devereux, M., D. Poon (2004) "A simple model optimal monetary policy with financial constraints," mimeo.

[9] Devereux, Michael, Philip Lane and Juanyi Xu (2006) "Exchange Rates and Monetary Policy in Emerging Market Economies", *The Economic Journal* 116 (April), 478-506.

[10] Kim, J., Kim, S.H. 2002. "Spurious welfare reversals in international business cycle models". Journal of International Economics.

[11] Lahiri A., C. Vegh, " Living with the fear of floating: An optimal policy perspective, " NBER Working Paper 8391.

[12] Reinhart, Carmen, Kenneth S. Rogoff, and Miguel A. Savastano, "Addicted to Dollars", Working Paper 10015.

[13] Rotemberg, Julio (1982) "Monopolistic Price Adjustment and Aggregate Output", *Review of Economic Studies*, 49, 517-531.

[14] Schmitt-Grohe, Stephanie and Martin Uribe (2004a) Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function, *Journal of Economic Dynamics and Control*, 28, 755-775.

[15] Schmitt-Grohe, Stephanie, and Martin Uribe (2003) "Closing Small Open Economy Models" *Journal of International Economics*, 61, 163-85.

[16] Woodford, Michael (2003), *Interest and Prices: Foundations of a Theory of Monetary Policy* . Princeton University Press.

Technical Appendix of

"Liability Dollarization and Fear of Floating"

1 Equilibrium

1.1 Households

The representative household's budget constraint is described as 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 the symmetry condition, the optimality of production firms can be written as:

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

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

$$V_t = a \left(\frac{W_t}{A_{vt} MC_t} \right)^{-\epsilon} Y \tag{1.6}$$

$$M_t = (1-a) \left(\frac{Z_t}{MC_t} \right)^{-\epsilon} Y \tag{1.7}$$

The price setting condition:

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

1.3 The importer's problem:

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

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

The first order conditions for the optimal contract are:

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

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

$A(\cdot)$ 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:

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

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

Likewise the share of returns 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.

The 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 the aggregate net-worth is:

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

Finally, the nominal return rate from importing:

$$R_{Mt} S_{t-1} P_{Mt-1}^* = Z_t \tag{1.13}$$

1.4 Monetary Policy Rules

$$1 + i_{t+1} = \left(\frac{P_t}{P_{t-1}} \frac{1}{\bar{\pi}}\right)^{\mu_\pi} \left(\frac{S_t}{\bar{S}}\right)^{\mu_S} (1 + \bar{i}) \tag{1.14}$$

1.5 Equilibrium

Final goods market must clearing conditions:

$$Y_t = C_t + C_t^M + \frac{\psi_D}{2}(D_{t+1} - \bar{D})^2 + \frac{\psi_P}{2}(\frac{P_t}{P_{t-1}} - 1)^2 + \frac{Z_t M_t}{P_t}\phi_t \tag{1.15}$$

The aggregate balance of payments condition:

$$S_t P^*_{Mt} M_{t+1} + S_t(1+i_t{}^*)[D_t + D_{Mt}] = S_t P^*_{Xt} X + S_t[D_{t+1} + D_{Mt+1}] \quad (1.16)$$

The equilibrium 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 Derivation of the external finance premium

In 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 $S_t P^*_{Mt} M^j_{t+1}$ 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 importers but not by lenders. Lenders, however, can discover the true realization at a cost ϕ times the total return from importing. Since both lenders and importers are risk neutral, standard results establish that the optimal contract between an importer and a lender is a debt contract, where the importer pays a fixed amount $\bar{\omega}^j R_{Mt+1} S_t P^*_{Mt} M^j_{t+1}$ 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:

$$R_{Mt+1}S_tP^*_{Mt}M^j_{t+1}\left[\int_{\bar{\omega}^j_{t+1}}^{\infty}\omega^j f(\omega)d\omega - \bar{\omega}^j_{t+1}\int_{\bar{\omega}^j_{t+1}}^{\infty} f(\omega)d\omega\right]$$
$$\equiv R_{Mt+1}S_tP^*_{Mt}M^j_{t+1}A(\bar{\omega}^j_{t+1}) \tag{2.17}$$

The expected return to the lender is then given by:

$$R_{Mt+1}S_tP^*_{Mt}M^j_{t+1}\left[\bar{\omega}^j_{t+1}\int_{\bar{\omega}^j_{t+1}}^{\infty} f(\omega)d\omega + (1-\mu)\int_0^{\bar{\omega}^j_t}\omega^j_{t+1}f(\omega)d\omega\right]$$
$$\equiv R_{Mt+1}S_tP^*_{Mt}M^j_{t+1}B(\bar{\omega}^j_{t+1}) \tag{2.18}$$

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:

$$\frac{R_{Mt+1}S_tP^*_{Mt}M^j_{t+1}B(\bar{\omega}^j_{t+1})}{S_{t+1}} = \frac{R^*_{t+1}(R_{Mt+1}S_tP^*_{Mt}M^j_{t+1} - NW^j_{t+1})}{S_t} \tag{2.19}$$

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

$$\max E_t\left(R_{Mt+1}S_tP^*_{Mt}M^j_{t+1}A(\omega^{\bar{i}}_{Nt+1})\right) \tag{2.20}$$

subject to the participation constraint (2.19).

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

$$E_t\left[R_{Mt+1}S_tP^*_{Mt}A(\bar{\omega}^j_{t+1})\right] + E_t\left[\lambda_{t+1}\frac{R_{Mt+1}S_tP^*_{Mt}B(\bar{\omega}^j_{t+1})}{S_{t+1}} - \lambda_{t+1}\frac{R^*_{t+1}S_tP^*_{Mt}}{S_t}\right] = 0 \tag{2.21}$$

$$\lambda_{t+1}(\theta) = \frac{\pi(\theta)A'(\bar{\omega}^j_{t+1}(\theta))S_{t+1}(\theta)}{B'(\omega^{\bar{i}}_{t+1}(\theta))} \tag{2.22}$$

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 2.22 into 2.21, we get:

$$E_t\left(R_{Mt+1}\left[\frac{A'(\omega_{t+1}^{\bar{j}})}{B'(\omega_{t+1}^{\bar{j}})}B(\omega_{t+1}^{\bar{j}})-A(\omega_{t+1}^{\bar{j}})\right]\right)=E_t\left[\frac{A'(\omega_{t+1}^{\bar{j}})}{B'(\omega_{t+1}^{\bar{j}})}\frac{S_{t+1}}{S_t}R_{t+1}^{*}\right] \tag{2.23}$$

Since ω^j is i.i.d across entrepreneurs, every importer actually faces the same financial contract, so we could drop the superscript j. Rearranging 2.23 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' net-worth is consumed. So the consumption of importers is given by 1.12. And the net worth NW_{t+1} is given by:

$$NW_{t+1}=\nu R_{Mt+1}S_tP_{Mt}^{*}M_{t+1}^{j}A(\bar{\omega}_t) \tag{2.24}$$

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 **??**.

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:

$$A(\bar{\omega})=\int_{\bar{\omega}}^{\infty}\omega f(\omega)d\omega-\bar{\omega}\int_{\bar{\omega}}^{\infty}f(\omega)d\omega \tag{3.25}$$

$$B(\bar{\omega})=\bar{\omega}\int_{\bar{\omega}}^{\infty}f(\omega)d\omega+(1-\mu)\int_0^{\bar{\omega}}\omega f(\omega)d\omega \tag{3.26}$$

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

$$E(\omega)=\int_{-\infty}^{\infty}\omega f(\omega)d\omega=1 \tag{3.27}$$

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

$$f(\omega)=\frac{1}{\sigma_\omega\omega\sqrt{2\pi}}\exp\left\{-\frac{(\ln\omega+\frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right\} \tag{3.28}$$

Therefore,

$$\begin{aligned}
\int_{\bar{\omega}}^{\infty} \omega f(\omega) d\omega &= \int_{\ln \bar{\omega}}^{\infty} \frac{1}{\sigma_\omega \sqrt{2\pi}} \exp\left\{ -\frac{(y + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} \exp(y) dy \\
&= \int_{\ln \bar{\omega}}^{\infty} \frac{1}{\sigma_\omega \sqrt{2\pi}} \exp\left\{ -\frac{(y - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} dy \\
&= \frac{1}{\sqrt{\pi}} \int_{\ln \bar{\omega}}^{\infty} \exp\left\{ -\frac{(y - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} d(\frac{y - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}) \\
&= \frac{1}{2} erfc\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega} \right) \qquad (3.29)
\end{aligned}$$

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

Similarly,

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

As results:

$$A(\bar{\omega}) = \frac{1}{2} erfc\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega} \right) - \frac{\bar{\omega}}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega} \right) \qquad (3.31)$$

At the same time,

$$\begin{aligned}
\int_0^{\bar{\omega}} \omega f(\omega) d\omega &= \frac{1}{\sqrt{\pi}} \int_{-\infty}^{\ln \bar{\omega}} \exp\left\{ -\frac{(y - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2} \right\} d(\frac{y - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}) \\
&= \frac{1}{2} \left[1 + erf\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega} \right) \right] \qquad (3.32)
\end{aligned}$$

$$B(\bar{\omega}) = \frac{\bar{\omega}}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) + (1-\mu)\frac{1}{2}\left[1 + erf\left(\frac{\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right)\right] \quad (3.33)$$

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

Next, since:

$$A'(\bar{\omega}) = -\frac{1}{\sqrt{2\pi}\sigma_\omega}\left[\frac{1}{\bar{\omega}} \exp\left(-\frac{(\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) - \exp\left(-\frac{(\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right)\right] - \frac{1}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) \quad (3.34)$$

However,

$$\begin{aligned} \frac{1}{\bar{\omega}} \exp\left(-\frac{(\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) &= \exp[-\ln(\bar{\omega})] \exp\left(-\frac{(\ln(\bar{\omega}) - \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) \\ &= \exp\left(-\frac{(\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) \quad (3.35) \end{aligned}$$

Therefore,

$$A'(\bar{\omega}) = -\frac{1}{2} erfc\left(\frac{\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2}}{\sqrt{2}\sigma_\omega}\right) \quad (3.36)$$

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

$$B'(\bar{\omega}) = -A'(\bar{\omega}) - \frac{\mu}{\sqrt{2\pi}\sigma_\omega} \exp\left(-\frac{(\ln(\bar{\omega}) + \frac{\sigma_\omega^2}{2})^2}{2\sigma_\omega^2}\right) \quad (3.37)$$