Monetary Policy in a Small Open Economy with Endogenous Financial Dollarization

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Abstract

This paper analyses optimal monetary policy in a small open economy allowing for financial dollarization (FD). More importantly, we endogenise FD, making it dependent on the expected monetary policy. Contrary to the standard small open economy model, where central banks should control domestic (producer) prices and adopt a pure floating exchange rate regime, we find that some exchange rate control is optimal. The extent of this control increases with the level of domestic credit and the degree of openness, and decreases with the degree of rigidity in wages. We also show that introducing regulations preventing agents from making deposits and loans in foreign currency increases welfare but is not Pareto improving given that lenders are worse-off.

JEL Classification: E-52, F-41, F-36, G-11

Keywords: Optimal Monetary Policy, Exchange Rate Regime, Exchange Rate Volatility, Asset Substitution

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1 Introduction

Financial Dollarization (FD), defined as the holding by residents of a share of their assets and/or liabilities denominated in foreign currency, is a common and relevant characteristic of many economies, particularly in Latin America, Eastern Europe and some parts of Asia. Notwithstanding the recent growth in the literature on FD, the theoretical and empirical studies have concentrated only on explaining the drivers of financial dollarization (e.g. Ize and Levy-Yeyati (2003), Barajas and Morales (2003) and Basso, Calvo-Gonzalez, and Jurgilas (2007)) or providing empirical analysis on its consequences (e.g. Levy-Yeyati (2006) and Nicolo, Honohan, and Ize (2005)). An important question that has been widely neglected, namely, what is the optimal monetary policy for financially dollarized economies, is the focus of this paper. This lack of attention is surprising given that there does not seem to be a consistent relationship between level of openness, level of dollarization and monetary/exchange rate regime for countries were FD is prevalent (see Table 1).

This paper contributes to two strands of literature, the financial dollarization and the new open economy, laying out a small open economy model incorporating endogenous financial dollarization. Gali and Monacelli (2005) and Sutherland (2001) show that, in the absence of FD, central banks of small open economies should target producer prices, adopting a pure exchange rate floating regime. This policy generates high exchange rate volatility in order to offset nominal rigidities and stabilise the shocks\(^1\).

However, in a financially dollarized economy, the higher the exchange rate variance, the lower the expected welfare of borrowers. As a result, the central bank finds it optimal to exert some control over the exchange rate. The extent to which the monetary authority controls the exchange rate increases with the level of domestic credit and the degree of openness of the economy, and decreases with the degree of rigidity in wages. Therefore, our model provides a theoretical explanation for the so called “fear of floating” phenomenon - the empirical observation that although countries may announce they will allow the exchange rate to float, they in fact do not (Calvo and Reinhart 2002).

Following the recent empirical and theoretical work on the determinants of asset substitution, mentioned above, households select the optimal portfolio composition of local and foreign currency denominated assets. While maximising portfolio returns and minimising their variance, agents weight the trade-off between the forward looking variances of inflation and real exchange rate, determining the level of FD. Financial dollarization is endogenous since these forward looking variances are affected by the expected monetary policy. The level of FD, on the other hand, has an impact on welfare and hence will influence the monetary policy decision.

The closest contribution, within the financial dollarization literature, to

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\(^1\)This policy prescription does not necessarily hold for economies with incomplete pass-through (see Corsetti and Pesenti (2005)) and for economies facing sector specific shocks (see Tille (2002)).
our own is Chang and Velasco (2006). They develop a small closed econ-
omy model where (i) firms choose the composition of external debt given
the expected monetary policy, (ii) central bank sets monetary policy given
the debt composition. They found that both floating and fixed exchange
rate regimes can emerge as equilibrium outcomes, but the floating regime is
Pareto superior and hence is the equilibrium under commitment.

Despite giving the important step of incorporating endogenous variance
and covariances into the portfolio selection problem, Chang and Velasco
(2006) only consider the currency choice of external debt. However, in most
cases, countries can only borrow in foreign currency (see Eichengreen, Haus-
mann, and Panizza (2003)). Furthermore, in the economies where FD is pre-
dominant, both households and firms, decide to make deposits and loans in
foreign currency directly through the domestic banking system, aspect that
their modeling approach does not incorporate. Finally, they assume the
economy is fully open (households only consume foreign produced goods)
and they only consider fixed and pure floating exchange rate regimes.

Our model, building on the new keynesian open economy literature, gives
us the flexibility to investigate optimal monetary policy under different levels
of openness. More importantly, it does not restrict the central bank choice
to fixed and pure floating exchange rate regimes. That turns out to be very
important since the optimal monetary policy under our specification is to
target the consumer price index, implying a intermediate level of exchange
rate control.

The framework developed here also allows us to analyse the impact of
the implementation of a regulation preventing agents from holding foreign
currency denominated assets and liabilities. Such a policy, often used to
achieve de-dollarization, increases the economy’s welfare but is not Pareto
improving given that it benefits only borrowers; lenders are worse-off. Fi-
nally, we analyse the effects of increasing levels of net foreign liabilities in
the banking sector on welfare and optimal monetary policy. Foreign liabilities
are at their highest when the exchange rate volatility is controlled, leading
to lower levels of welfare. Hence, the central bank finds it optimal to let the
exchange rate float freely.

The remainder of the paper is divided into five sections. Section 2 intro-
duces the model and section 3 presents the equilibrium conditions. In
section 4, we show the main results of the paper, discussing optimal mon-
etary policy under endogenous FD. In this section we also analyse whether
the introduction of a regulation preventing agents from making deposits and
loans denominated in foreign currency is Pareto and/or welfare improving.
Section 5 discusses an extension to the model where banks have open access
to foreign funds. Section 6 concludes.
Table 1: Financially Dollarized Small Open Economies

<table>
<thead>
<tr>
<th>Country</th>
<th>Openness</th>
<th>Imports</th>
<th>Domestic Credit</th>
<th>Net Foreign Assets</th>
<th>Loan Dollarization</th>
<th>Deposit Dollarization</th>
<th>IMF de facto Exch. Rate Regime 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albania</td>
<td>63%</td>
<td>43%</td>
<td>0%</td>
<td>0.0%</td>
<td>68%</td>
<td>31%</td>
<td>Floating</td>
</tr>
<tr>
<td>Armenia</td>
<td>71%</td>
<td>45%</td>
<td>8%</td>
<td>1.1%</td>
<td>-91%</td>
<td>-8%</td>
<td>Fix Peg</td>
</tr>
<tr>
<td>Azerbaijan</td>
<td>165%</td>
<td>40%</td>
<td>7%</td>
<td>-0.5%</td>
<td>15%</td>
<td>17%</td>
<td>Crawling Peg</td>
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<tr>
<td>Belarus</td>
<td>132%</td>
<td>64%</td>
<td>21%</td>
<td>-0.1%</td>
<td>21%</td>
<td>-2%</td>
<td>Pegged within Horizontal Band</td>
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<tr>
<td>Bosnia and Her.</td>
<td>67%</td>
<td>53%</td>
<td>12%</td>
<td>0.0%</td>
<td>65%</td>
<td>17%</td>
<td>Managed Floating</td>
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<tr>
<td>Bulgaria</td>
<td>125%</td>
<td>68%</td>
<td>30%</td>
<td>4.8%</td>
<td>36%</td>
<td>33%</td>
<td>Fix Peg</td>
</tr>
<tr>
<td>Croatia</td>
<td>103%</td>
<td>56%</td>
<td>64%</td>
<td>9.2%</td>
<td>22%</td>
<td>31%</td>
<td>Managed Floating</td>
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<td>Czech Republic</td>
<td>135%</td>
<td>64%</td>
<td>46%</td>
<td>9.2%</td>
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<td>Estonia</td>
<td>102%</td>
<td>84%</td>
<td>54%</td>
<td>-14.0%</td>
<td>80%</td>
<td>30%</td>
<td>Currency Board</td>
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<td>Georgia</td>
<td>76%</td>
<td>46%</td>
<td>21%</td>
<td>0.6%</td>
<td>83%</td>
<td>94%</td>
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<td>Hungary</td>
<td>138%</td>
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<td>Israel</td>
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<td>Kazakhstan</td>
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<td>Latvia</td>
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<td>-16.6%</td>
<td>70%</td>
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<td>Lithuania</td>
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<td>59%</td>
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<td>55%</td>
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<td>Macedonia</td>
<td>97%</td>
<td>57%</td>
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<td>8.9%</td>
<td>54%</td>
<td>40%</td>
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<tr>
<td>Moldova</td>
<td>191%</td>
<td>120%</td>
<td>20%</td>
<td>-3.1%</td>
<td>76%</td>
<td>44%</td>
<td>Managed Floating</td>
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<tr>
<td>Poland</td>
<td>65%</td>
<td>36%</td>
<td>34%</td>
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<td>50%</td>
<td>17%</td>
<td>Pegged within Horizontal Band</td>
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<tr>
<td>Romania</td>
<td>76%</td>
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<td>Slovak Republic</td>
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<td>80%</td>
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<td>Slovenia</td>
<td>121%</td>
<td>61%</td>
<td>56%</td>
<td>-6.3%</td>
<td>27%</td>
<td>25%</td>
<td>Pegged within Horizontal Band</td>
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<tr>
<td>Turkey</td>
<td>31%</td>
<td>33%</td>
<td>60%</td>
<td>-0.6%</td>
<td>58%</td>
<td>35%</td>
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<td>Ukraine</td>
<td>110%</td>
<td>54%</td>
<td>31%</td>
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<td>Philippines</td>
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<td>Paraguay</td>
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<td>Peru</td>
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<tr>
<td>Uruguay</td>
<td>50%</td>
<td>25%</td>
<td>57%</td>
<td>6.7%</td>
<td>87%</td>
<td>92%</td>
<td>Managed Floating</td>
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</tbody>
</table>

Mean: 70.7% 41% 32.7% 2.2% 55.6% 35.3% 1.9% 35.0


Note: Openness = (Imports + exports)/GDP. Imports, Domestic Credit and Net Foreign Assets in the Banking Sector are shown as percentage of the GDP. Loan (deposit) dollarization is shown as percentage of total loans (deposits).
2 Model

We consider a two period small open economy model inhabited by two representative households, \( j = \{G, H\} \), a continuum of unions \( z = [0, 1] \), a representative firm, a representative bank, the central bank and the government. We assume there is perfect competition in the banking sector, hence, banks act only as intermediaries.

Households supply labour, the only production factor, to the representative firm and consume a composite of foreign and home traded goods. Good prices are perfectly flexible in both periods and wages are fully flexible in the first period. In order to introduce nominal rigidity we assume that a portion of the unions set second period wages in period one (before the shock) while the remaining unions set wages after the realisation of the shock.

The rest of the world consumption and prices are exogenously given. Furthermore, the only source of uncertainty is the rest of the world demand for domestically produced goods in period two\(^2\). Foreign prices \((P^* \_i)\) are normalised to one in both periods \(i = \{1, 2\}\). Finally, we assume that the central bank can commit and thus, monetary policy is set in period one.

Households

In the first period, households decide how much deposits and loans they wish to make\(^3\). Each representative household has a specific discount factor, \( \beta_H \) for household \( H \) and \( \beta_G < \beta_H \) for household \( G \). The relationship between the interest rate charged by banks and the households’ implicit interest rate \((1/\beta_j)\) determines whether household \( j = H, G \) decides to take a loan or make a deposit. In equilibrium, the impatient household \((G)\) takes a loan while the patient \((H)\) makes a deposit.

Households maximise their expected utility, given their disposal income (wages, profits and transfers), choosing the amount of deposits and loans in local and foreign currency, implicitly determining consumption in each period. Both local and foreign currency denominated assets are risky. While the first might fluctuate due to inflation, the second will fluctuate due to changes in inflation and in the nominal exchange rate, i.e due to real exchange rate changes.

Households in period one choose the demand for loans, the demand for deposits and the portfolio compositions, or the set \((D, L, \alpha_d, \alpha_l)\), where \( D = \) total deposits, \( L = \) total loans, \( \alpha_d = \) portion of deposits in foreign currency (deposit dollarization) and \( \alpha_l = \) portion of loans in foreign currency (loan dollarization)\(^4\).

\(^2\) Although we do not consider other shocks, a home demand shock, e.g. government expenditure shock, or a taste (preference) shock would lead to the same monetary policy response (see Sutherland (2001) for a small open economy model, similar to ours, with such shocks)

\(^3\) Though we have not assumed that firms make loans in period one, Basso, Calvo-Gonzalez, and Jurgilas (2007) show that the portfolio decision of risk neutral firms that can default in their loans is analogous to that of the household.

\(^4\) Throughout the paper we state that households demand loans and deposits, consid-
In order to simplify the exposition and the solution of the model each household is split into two units: (i) the investor and (ii) the fund manager.

The investor solves a certainty equivalent problem selecting \( D \) and \( L \), given the expected returns, the portfolio allocations \( (\alpha_d, \alpha_l) \), the first period disposal income, \( I_{1,j} \), and the expected disposable income in the second period, \( I_{2,j} \).

The expected returns are defined as \( E[R_d] = (1 - \alpha_d)R_d + \alpha_dR^*_d - E[P_2 - P_1] + \alpha_dE[S_2 - S_1] \) for deposits and \( E[R_l] = (1 - \alpha_l)R_l + \alpha_lR^*_l - E[P_2 - P_1] + \alpha_lE[S_2 - P_1] \) for loans, where \( S_i \) is the nominal exchange rate at period \( i = \{1, 2\} \), \( P_i \) the price index, \( R_d \) (\( R_l \)) the local currency deposit (loan) rate and \( R^*_d \) (\( R^*_l \)) the foreign currency deposit (loan) rate.

The investor’s \( j = \{H, G\} \) problem is

\[
\max_{\{C_{1,j}, C_{2,j}, D, L\}} \quad \frac{C_{1,j}^{1-1/\sigma}}{1 - 1/\sigma} - \delta \frac{\bar{N}_{1,j}^{1+1/\gamma}}{1 + 1/\gamma} + \beta \left[ \frac{C_{2,j}^{1-1/\sigma}}{1 - 1/\sigma} - \delta \frac{\bar{N}_{2,j}^{1+1/\gamma}}{1 + 1/\gamma} \right]
\]

Subject to

\[
C_{1,j} = I_{1,j} - D + L + wed_j \tag{1}
\]

\[
C_{2,j} = I_{2,j} + E[R_d]D - E[R_l]L \tag{2}
\]

\[
I_{1,j} = (1 - \tau)\frac{W_1}{P_1}N_{1,j} + \Pi_{1,j} + T_{1,j}
\]

\[
I_{2,j} = E\left[(1 - \tau)\frac{W_2}{P_2}N_{2,j} + \Pi_{2,j} + T_{2,j}\right] \tag{3}
\]

\[
N_{i,j} = \frac{N_i}{2}, \quad \Pi_{i,j} = \frac{\Pi_i}{2} \quad \text{for} \quad j = \{H, G\} \tag{4}
\]

The first two equations are the budget constraints for period one and two respectively. The following two give the disposal income in each period, where \( \tau \) is the tax/subsidy on labour income and \( T_{i,j} \) is a government transfer. \( \Pi_i \) is the firm profits in period \( i \). Finally, \( N_i \) is the total labour demand from the representative firm given by a composite index of all labour types \( z = [0, 1] \) (this is formally defined in the firm problem below). Hence, both households supply all types of labour, taking the wages set by unions as given and meeting the firm’s labour demand.

The variable \( wed_j \) represents a difference in wealth between household \( H \) and \( G \) in the first period, such that \( wed = wed_H = -wed_G \). When this wealth wedge is different from zero the size of the credit market is determined by two main elements: (i) the further apart the households’ discount factors are, the greater the credit market and (ii) the higher the period one wealth level of the patient household (\( H \)) relative to the impatient householdering that both are products that banks sell to households. However, deposit “demand” is upward sloping as it represents a supply of funds.

\(^5\)Note that the certainty equivalent assumption allow us to solve the investor problem independently of the portfolio composition decision. Hence, the variance of the return does not affect the total deposit and loan decisions (no precautionary motive). Combining both decisions would increase the complexity of the model without significantly changing the results. See Basso, Calvo-Gonzalez, and Jurgilas (2007) for details.
hold \((G)\), the deeper the credit market. An important empirical motivation to include this variable is the evidence presented by Lawrance (1991) that poorer households are more impatient.

Consumption in each period, for household \(j\), \(C_{i,j}\), is given by

\[
C_{i,j} = \frac{C_{i,P,j}^\omega C_{i,F,j}^{1-\omega}}{\omega^\omega (1-\omega)^{1-\omega}},
\]

a composite index of the consumption of home produced goods \(C_{i,P,j}\) and the consumption of foreign produced goods \(C_{i,F,j}\). \(\omega\) determines the bias towards home goods in the household consumption index and is regarded as a measure of the degree of openness of the economy. The higher \(\omega\), the lower the degree of openness of the economy.

Given the consumption index, the price index will be given by

\[
P_i = P_i^*_i S_i^{1-\omega} \quad i = \{1, 2\}. \tag{5}
\]

The form of the consumption index, with a unit elasticity of substitution between home and foreign goods, first introduced in an open economy setting by Corsetti and Pesenti (2001), ensures the current account is always in balance. That makes the international asset structure irrelevant, allowing tractable solutions to be obtained from models that take account of the uncertainty in macroeconomic variables as we do.\(^6\)

The second part of the household, the fund manager, allocates the deposits \((D)\) and loans \((L)\) determined by the investor into foreign currency denominated deposits and loans \((d^*, l^*)\) and local currency denominated deposits and loans \((d, l)\) to maximise the portfolio return in period two and minimise its variance, where

\[
D = d + d^*, \quad d = (1 - \alpha_d)D \quad \text{and} \quad d^* = \alpha_d D \\
L = l + l^*, \quad l = (1 - \alpha_l)L \quad \text{and} \quad l^* = \alpha_l L
\]

Hence, fund manager’s \(j = H, G\) problems are, respectively,

\[
\max_{\alpha_d} \quad E[\bar{R}_d] - q \frac{\text{VAR}[\bar{R}_d]}{2} \\
\max_{\alpha_l} \quad E[-\bar{R}_l] - q \frac{\text{VAR}[\bar{R}_l]}{2}
\]

The portfolio decision would then be given by

\[
\alpha_d = \frac{R_d^* - R_d + E[S_2 - S_1]}{q\text{VAR}[S_2]} + \frac{\text{COV}[P_2, S]}{\text{VAR}[S_2]} \tag{6}
\]
\[
\alpha_l = \frac{R_l - R_l^* - E[S_2 - S_1]}{q\text{VAR}[S_2]} + \frac{\text{COV}[P_2, S]}{\text{VAR}[S_2]} \tag{7}
\]

Where \(q\) represents how important the variance is relative to the expected

\(^6\)For a model where this assumption is relaxed see De Paoli (2004).
returns in the fund managers’ portfolio allocation. Thus, the higher the value of $q$, the lower the sensitivity of the interest rate differential onto the portfolio decision.

An alternative specification for the fund manager problem would be to maximise the expected value of consumption and minimise its variance. If this were to be the case, the households would attempt to maximise the portfolio return and minimise its variance plus adjust the portfolio to hedge against income fluctuations. Income fluctuations, however, result from economy’s aggregate shocks and therefore cannot be hedged from borrowing or lending internally. That way, the resulting portfolio allocations in equilibrium would be the same.

**Unions**

We assume there are two types of unions, $a$ and $b$. The labour market is populated by a continuum of unions $z \in [0, 1]$ for each labour type. Type $a$ unions set second period wages before the realisation of the shock (in period one), while type $b$ unions set second period wages after the realisation of the shock. The proportion of type $a$ unions in the labour market is $\kappa \in [0, 1]$, hence, this parameter determines the degree of wage rigidity in the economy.

Each union $z \in [0, 1]$ of type $a$ and $b$ maximises its members expected utility selecting wage $w_{i,m}(z)$ for $i = \{1,2\}$ and $m = \{a,b\}$. Although there are two households types ($G$ and $H$), both supply labour type $z$ to the representative firm and are, therefore, members of union $z$. That way, unions consider the aggregate variables (sum of both households) while measuring the members’ expected utility.\footnote{That would be equivalent to unions setting wages considering the representative member. An alternative, but more complex specification, would be to measure members’ utility as a weighted sum of the utility for each member. The main difference is that the dispersion of consumption between the members would affect the wage setting decision in this alternative specification.}

The union $z$ of type $m$ selects the second period wage as follows

$$\max_{w_{2,m}(z)} E \left[ \frac{C_2^{1-1/\sigma}}{1 - 1/\sigma} - \frac{\delta N_{2,m}(z)^{1+1/\gamma}}{1 + 1/\gamma} \right]$$

subject to

$$C_2 = (1 - \tau) \frac{w_{2,m}(z)}{P_2} N_{2,m}(z) + \Pi + \bar{R}_d - \bar{R}_l + T$$

$$N_{2,m}(z) = \left( \frac{w_{2,m}(z)}{W_{2,m}} \right)^{-\varphi} N_{2,m}$$

Where the last equation is the representative firm’s demand for labour $z$ of union type $m$ (see firm problem below).
The second period wage set by type a unions (before the shock) is

\[ w_{2,a}(z) = \delta \frac{1}{1 - \tau} \varphi \frac{E \left[ N_{2,a}(z)^{1+1/\gamma} \right]}{E \left[ P_2^{-1} C_2^{-1/\sigma} N_{2,a}(z) \right]} \quad \text{for} \quad z \in [0, 1] \quad (8) \]

The wage set for type b unions (after the shock) is

\[ w_{2,b}(z) = \delta \frac{1}{1 - \tau} \varphi \frac{P_2 C_2^{1/\sigma} N_{2,b}(z)^{1/\gamma}}{P_i} \quad \text{for} \quad z \in [0, 1] \quad (9) \]

We assume \( \tau \) is set such that \( \frac{1}{1 - \tau} \varphi = 1 \), thus taxes remove the monopoly distortion.

Given that wages are flexible in period one, labour supply is given by

\[ w_{1,a}(z) = \delta P_1 C_1^{1/\sigma} N_{1,a}(z)^{1/\gamma} \quad \text{for} \quad z \in [0, 1] \]

As all unions are equal, in equilibrium, \( w_{i,m}(z) = W_{i,m} \) for \( i = \{1, 2\} \) and \( m = \{a, b\} \).

**Representative Firm**

The firm decides labour demand \( (N_{i,m}(z)) \) to maximise real profits given wages \( (w_{i,m}(z)) \) for period \( i = \{1, 2\} \) and union type \( m = \{a, b\} \), thus

\[
\max_{\{N_{i,a}(z), N_{i,b}(z)\}} \frac{P_{P,i} Y_i}{P_i} - \frac{1}{P_i} \int_0^1 w_{i,a}(z) N_{i,a}(z) \, dz - \frac{1}{P_i} \int_0^1 w_{i,b}(z) N_{i,b}(z) \, dz \\
\]

Subject to

\[
Y_i = N_{i,\eta}, \quad 0 < \eta < 1 \\
N_i = \frac{N_{i,a} N_{i,b}^{1-\kappa}}{\kappa (1 - \kappa)^{1-\kappa}} \\
N_{i,a} = \left[ \int_0^1 N_{i,a}(z)^{\frac{\varphi - 1}{\varphi}} \, dz \right]^{\frac{\varphi}{\varphi - 1}} \quad \text{and} \quad N_{i,b} = \left[ \int_0^1 N_{i,b}(z)^{\frac{\varphi - 1}{\varphi}} \, dz \right]^{\frac{\varphi}{\varphi - 1}}.
\]

As standard, that would imply the following demand function for labour type \( z \) of union \( m = \{a, b\} \)

\[ N_{i,m}(z) = \left( \frac{w_{i,m}(z)}{W_{i,m}} \right)^{-\varphi} N_{i,m} \]

and the wage index \( W_{i,m} = \left[ \int_0^1 w_{i,m}(z)^{1-\varphi} \, dz \right]^{1/1-\varphi} \)

The total labour demand for type \( m = \{a, b\} \) union is given by

\[
N_{i,a} = \left( \frac{W_{i,a}}{W_i} \right)^{-1} N_i, \quad N_{i,b} = \left( \frac{W_{i,b}}{W_i} \right)^{-1} N_i \\
\]

where \( W_i = W_{i,a} W_{i,b}^{1-\kappa}. \)

---

\(^8\)Note that given the proportion of type a unions is \( \kappa \), the demand for labour for that union type is adjusted, otherwise one would have \( N_{i,a} = \left( \frac{w_{i,a}}{w_{i,b}} \right)^{-1} N_i \).
The demand for goods is given by \( \sum_j C_{i,j} + \frac{SC^*_i}{P_i} \), where \( C^*_i \) is the amount spent by the rest of the world on home produced goods in period \( i = 1, 2 \). In the first period foreign demand is fixed and equal to \( C^*_i \) and in the second, foreign demand is equal to \( C^*_i \), which is stochastic with mean \( \bar{C}^*_i \) and variance \( \Sigma \).

**Central Bank and Government**

The government taxes labour income and makes a transfer to each household such that \( \tau W_i P_i N_{i,j} = T_{i,j} \), for \( j = \{H, G\} \) and \( i = \{1, 2\} \).

The central bank maximises the weighted sum of the welfare of each agent.

The problem under commitment is

\[
\max_{\{\varepsilon\}} \sum_j \frac{1}{2} \left\{ \frac{C^{1-1/\sigma}_{1,j}}{1 - 1/\sigma} + \beta_j \left[ \frac{C^{1-1/\sigma}_{2,j}}{1 - 1/\sigma} \right] \right\} - \delta \left[ \frac{N^{1+1/\gamma}_{1}}{1 + 1/\gamma} + \frac{\beta_H + \beta_G N^{1+1/\gamma}_{2}}{2} \right]
\]

Subject to firms, unions and households behaving optimally and

\[ P^\varepsilon_{P,2} S^{1-\varepsilon}_2 = \bar{M} \tag{10} \]

where, \( \varepsilon \) is the monetary policy parameter and \( \bar{M} \) the monetary policy target, defined as \( \bar{M} = P^\varepsilon_{P,1} S^{1-\varepsilon}_1 \). Under this monetary policy set up the central bank can fix the producer prices (\( \varepsilon = 1 \)), the consumer price index (\( \varepsilon = \omega \)) or the nominal exchange rate (\( \varepsilon = 0 \)) to their period one level.\footnote{Although the monetary policy assumed here is ad-hoc an alternative model specification in which households derive utility from money balances produces the same qualitative results. See Srour (2002) for an example of such specification.}

### 3 Equilibrium

As it is standard we will solve the model backwards.

**Period 2**

Table 2 shows the solution for consumption, labour, the wage for type \( b \) unions, the nominal exchange rate, the producer price and the price index given the external demand shock, the monetary policy (\( \varepsilon \)) and the first period variables. The results are obtained by combining the households and firm first order conditions, the goods market clearing condition, the balance of payment equality and the wage setting equation for type \( b \) unions, see Appendix A for details.

The average rates on total deposits and loans are given by \( \bar{R}_d = (1 - \alpha_d) R_d + \alpha_d R^*_d - (P_2 - P_1) + \alpha_d (S_2 - S_1) \) and \( \bar{R}_l = (1 - \alpha_l) R_l + \alpha_l R^*_l - (P_2 - P_1) + \alpha_l (S_2 - P_1) \).
Table 2: Solution of the Main Model - Period 2

\[
C_{2,H} = \frac{1}{2} S_2 C^* \frac{1}{P_2} \frac{1}{1 - \omega} + \bar{R}_d D (11)
\]
\[
C_{2,G} = \frac{1}{2} S_2 C^* \frac{1}{P_2} \frac{1}{1 - \omega} - \bar{R}_l L (12)
\]
\[
N_{2,H} = \frac{1}{2} S_2 C^* \frac{1}{P_2} \frac{1}{1 - \omega} - \omega - \bar{R}_l L (13)
\]
\[
N_{2,G} = \frac{1}{2} S_2 C^* \frac{1}{P_2} \frac{1}{1 - \omega} - \omega + \bar{R}_l L (14)
\]
\[
W_{2,b} = \delta P_2 C_2^{1/\sigma} \left( \frac{S_2 C^*}{P_2} \frac{1}{1 - \omega} \right) (15)
\]
\[
S_2 = Z^{\phi_2} W_2^{\phi_2 (1 - \eta)} C^*(1 - \eta) \phi_2 (16)
\]
\[
P_{2,P} = Z^{\phi_2 - \phi_3} W_2^{\phi_2 - \phi_3 (1 - \eta)} C^* (1 - \eta) (1 - \eta) \phi_2 - \phi_3 (17)
\]
\[
P_2 = Z^{\phi_2 - \phi_3} W_2^{\phi_2 - \phi_3 (1 - \eta)} M^C (1 - \eta) (1 - \eta) \phi_2 - \phi_3 (18)
\]
\[
Z = \frac{W_2^{\phi_2 (1 - \eta)}}{M^{\eta (1 - \omega) (1 - \eta)}} (19)
\]
\[
M = \frac{P_{2,1}}{S_1^{1 - \varepsilon}} (20)
\]

For simplicity, let \( \kappa = 1 \) (full wage rigidity), then, by substituting the solution for the nominal exchange rate (15) and prices ((16) and (17)) into the solution for labour (13) and disposal income excluding loans and deposits \((I_{2,j})\) and setting \( \varepsilon \) equal to zero (fixed nominal exchange rate) and one (fixed producer prices), we get the following results.

Table 3: Stabilization of Shocks

<table>
<thead>
<tr>
<th></th>
<th>Fixed Exchange Rate</th>
<th>Fixed Producer Prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Income</td>
<td>( Z^{\omega} ) \left( \frac{1}{(1 - \omega) M^\eta} \right) C^* (1 - \eta)</td>
<td>( Z^{\omega} ) \left( \frac{1}{(1 - \omega) M^\eta} \right) C^* (1 - \omega)</td>
</tr>
<tr>
<td>Labour</td>
<td>( Z^{-\omega} ) \left( \frac{1}{(1 - \omega) M^\eta} \right) C^*</td>
<td>( Z^{-\omega} ) \left( \frac{1}{(1 - \omega) M^\eta} \right) C^*</td>
</tr>
</tbody>
</table>

Hence, as the central bank moves \( \varepsilon \) from zero to one it will manage to stabilize the foreign shock more effectively, i.e. reduce the variability of labour and income, given the variance of the shock (the exponent of \( C^* \) is closer to zero). Moreover, when the central bank controls producer prices it actually makes labour independent from the shock, reducing its variance to zero.
Period 1

The following approximations are used in order to find the first period equilibrium conditions, presented next. Note that this second order approximation is similar to the solution methodology introduced by Obstfeld and Rogoff (2000) where shocks are assumed to be log-normal. Thus, for any generic function \( f(x) \), its expectation is equal to the function evaluated at the mean value of \( x \) plus a variance adjustment.

\[
E[f(x)] \approx f(E[x]) + \frac{f''(E[x])}{2} \text{VAR}[x]
\]

\[
\text{VAR}[f(x)] \approx f'(E[x])^2 \text{VAR}[x].
\]

The relevant first period variables to solve for the equilibrium of this economy are the wages, the deposits and loans, the rates of interest and the portfolio allocations.

Using the results in table 2 and the unions first order condition (8) gives

\[
W_{1}^{1-\Xi_1} = \frac{\gamma^{\Xi_4} E[C^*_{\Xi_2}]}{E[C^*_{\Xi_3}]} \approx \frac{\gamma^{\Xi_4} C^*_{\Xi_1} + \Xi_2(\Xi_2 - 1)C^*_{\Xi_2} - 2 \Sigma}{\gamma^{\Xi_4} C^*_{\Xi_1} + \Xi_3(\Xi_3 - 1)C^*_{\Xi_3} - 2 \Sigma}
\]

where \( \gamma, \Xi_1, \Xi_2, \Xi_3, \Xi_4 \) are functions of the structural parameters of the model (see Appendix A for details).

An important variable driving the results discussed in section 4 is the wage risk premium (WRP) defined as the difference between the wage set by households and the wage that would be set under certainty when \( C^* = C^* \).

Formally,

\[
\text{WRP} = \left( \frac{\gamma^{\Xi_4} E[C^*_{\Xi_2}]}{E[C^*_{\Xi_3}]} \right)^{\frac{1}{1-\Xi_1}} - \left( \frac{\gamma^{\Xi_4} C^*_{\Xi_1}}{C^*_{\Xi_2}} \right)^{\frac{1}{1-\Xi_1}}
\]

The investor part of the households, who decides \( L \) and \( D \), sets

\[
D = \frac{I_1 - I_2 (\bar{R})^{-\sigma} \beta_H^{-\sigma}}{1 + (\bar{R})^{1-\sigma} \beta_H^{1-\sigma}}
\]

\[
L = \frac{I_2 (\bar{R})^{-\sigma} \beta_G^{-\sigma} - I_1}{1 + (\bar{R})^{1-\sigma} \beta_G^{1-\sigma}}
\]

Where \( I_{1,j} = I_1 = \frac{S_1 C^*}{2(1-\omega)} \) (see Appendix A for details). The expected disposable income \( I_2 \) is given by

\[
I_{2,j} = I_2 = E \left[ \frac{1}{2} S_2 C^* \frac{1}{P_2} \frac{1}{1-\omega} \right] = \frac{1}{2} \frac{Z^{\phi_1}}{1-\omega} E \left[ W_{2,b}^{\phi_1(1-\kappa)} C^*(1-\eta)\phi_1 + 1 \right]
\]
Note that the total deposits and loan choices are only affected by the aggregate level of income in each period and the discount factors.

Perfect competition in the banking sector implies that \( L = D \) and

\[
R^*_d - R_d + E[S_2] - S_1 = R_l - R^*_l - E[S_2] - S_1 = R^* - R + E[S_2] - S_1 = 0 \tag{25}
\]

\[
\bar{R} = (1 - \alpha)R + \alpha R^* - E[P_2] + P_1 + \alpha(E[S_2] - S_1) \tag{26}
\]

The portfolio allocation is given by

\[
\alpha = \alpha_d = \alpha_l = \max \left[ \frac{\text{COV}[P_2,S]}{\text{VAR}[S]}, 0 \right]
\]

\[
\approx \max \left\{ \Psi \left[ 1 - \frac{\phi_1}{\phi_2} \right], 0 \right\} \tag{27}
\]

where \( \Psi \) is a function of the wage set by type \( a \) unions, the mean of the shock \( C^* \) and the structural parameters of the model (See Appendix A for details). The max term is needed since the portfolio allocation must not be smaller than zero\(^{11}\). The term inside the square brackets, which effectively controls the sign of the covariance, using the definitions of \( \phi_1 \) and \( \phi_2 \), is equal to \( 1 - \frac{\epsilon}{\phi_2} \). Thus, when the central bank changes \( \epsilon \) from zero to one, the covariance will move from minus infinity to roughly \( 1 - \omega \), being zero when \( \epsilon = \omega \) (CPI targeting). Thus, perhaps surprisingly, given an external shock, the higher the control over the exchange rate relative to producer prices, the lower the financial dollarization (FD). As Ize and Levy-Yeyati (2003) point it out, the main driver of FD is the exchange rate pass-through. In our model, exchange rate pass-through is at its highest when producer prices are fixed and the consumer price index moves with the nominal exchange rate. Also note that the covariance, and therefore the portfolio allocation, is undefined when \( \epsilon = 0 \); in this case both assets have the same riskness profile.

4 Optimal Monetary Policy

Using the equilibrium conditions, (11)-(27), derived in the previous section, we are now able to evaluate the economy’s welfare as a function of the monetary policy parameter \( \epsilon \), and the structural parameters of the model. The details of the welfare function \( U(\epsilon) \) incorporating the equilibrium conditions can be found in Appendix B.

The optimal monetary policy can, therefore, be characterised as the value of \( \epsilon \) that maximises the welfare function \( U(\epsilon) \). As we cannot obtain clear analytical results we run numerical simulations under different sets of structural parameter values to compute welfare for all values of \( \epsilon \in [0,1] \).

In order to do so, we need to set values for the main parameters of the

\(^{10}\)The expected nominal exchange rate \( E[S_2] \) and the expected price index \( E[P_2] \) are calculated using the same approximation.

\(^{11}\)Portfolio shares must also be smaller than 1, but this limit is never binding in the main model.
model. A discussion on the sensitivity of these parameters is presented at
the end of this section. $\beta_H$ is set to 0.99 such that given a lower value for
$\beta_G$, the credit market exists. The intertemporal elasticity of substitution
($\sigma$) is set to 0.7, a rough average for the values used in different studies (for
instance De Paoli (2004) sets it to be equal to 1 while Chari, Kehoe, and
McGrattan (2002) set it equal to 0.2). $\eta$ is set to 0.65, given that the share
of labour income is roughly 65%\footnote{The model does not explicitly include capital, though one can assume it to be fixed in the short term.}. Following Rotemberg and Woodford
(1997) we set $\gamma = 2$. We set $\delta$ such that labour is around 0.7. Finally we
set $C^* = 0.5$ and $\Sigma = 0.05$.

Note that we have not set values for the other four main parameters of the
model, namely, $\omega$, $\kappa$, $\beta_G$ and the initial wealth wedge between households ($wed$). These parameter values will be specified for each of the welfare
analysis presented here as openness (controlled by the first), degree of wage
rigidity (controlled by the second) and the level of domestic credit (controlled
by the third and fourth) are the key drivers of the results.

Figure 1 shows the results of the welfare and its main components when $\kappa = 1$, implying full wage rigidity (all unions set second period wages before
the shock), $\omega = 0.6$ implying a ratio of import over output of around 40%,$\beta_G = 0.4$ and $wed = 0$.

As shown in figure 1(a), welfare is maximised when $\varepsilon = 1$, that is when
the central bank chooses to target domestic (producer) prices and leaves the
nominal exchange rates to float freely.

Firstly, as noted by Corsetti and Pesenti (2001), among others, the central bank, while targeting producer prices, can influence the terms of trade in
a way beneficial to domestic consumers, hence the utility from consumption
increases with $\varepsilon$ (figures 1(b) and 1(c)).
Secondly, as noted by Sutherland (2001), a small open economy benefits from reducing the risk premium on wages (WRP). In our model, when $\varepsilon = 1$ labour is independent of the shock, thus, the risk premium is zero. Therefore, despite the fact that expected labour demand increases in $\varepsilon$, the positive impact of lower variance makes the welfare loss smaller in $\varepsilon$ (figure 1(d)).

As noted by Gali and Monacelli (2005) and Sutherland (2001), either fixing the nominal exchange rate or controlling the consumer price index ($\varepsilon = \omega$), leads to excess smoothness in the nominal exchange rate resulting in a deviation from the first best allocation (without nominal rigidities). Therefore, controlling producer prices leads to higher, but optimal, volatility of the exchange rate. As indicated by Gali and Monacelli (2005) the consumer price index (CPI) targeting is a hybrid regime between domestic price targeting and fixed exchange rate regime.

**Deeper Credit Markets**

Under the optimal monetary policy ($\varepsilon = 1$), financial dollarization is at its highest (figure 1(f)), given that the exchange rate pass-through is also at its highest. Nonetheless, the introduction of credit markets and endogenous financial dollarization into the standard small open economy model does not significantly affect welfare.

This lack of relevance is due to the rather small credit market depth, defined as the ratio of total loans to output, obtained under this parameter specification. While the credit market depth in the simulation is around 8% (figure 1(e)), the data on market depth for most economies listed in Table 1 is considerably higher than that (average of 43.8%). Therefore, in order to increase the credit market depth, we introduce a wealth wedge between borrowers and lenders in period one and reduce $\beta_G$. The results are shown in figure 2.

![Figure 2: Welfare under higher levels of credit ($\kappa = 1, \omega = 0.6$)](image)

When a wealth wedge of 0.3 is introduced (one third of the economy's

---

13Note that the discount factors for the impatient household here are considerably lower than the ones observed in empirical studies (e.g. Lawrance (1991)). Given that, in our model, only households make loans, such low values are needed to obtain a credit market depth that matches the data.
income), then domestic credit jumps to around 25% of the output and it is now optimal to control (although rather timidly) the nominal exchange rate setting $\varepsilon = 0.95$. Further increasing credit market depth to around 29%, reducing $\beta_L$ to 0.1, makes optimal to set $\varepsilon = 0.86$. Note that setting $\varepsilon = 0.6$ would imply controlling the consumer price index.

Exerting some control over exchange rate becomes optimal since when the monetary authority sets $\varepsilon = 1$, controlling producer prices, the nominal exchange rate exhibits higher variance. This leads to a sharp increase in the nominal exchange rate risk premium$^{14}$. Given that the borrower increases the share of foreign currency denominated loans as $\varepsilon$ approaches one, the expected loan payment in period two also increases sharply with $\varepsilon$. Therefore, the borrower’s expected utility from consumption decreases when $\varepsilon > \omega = 0.6$ (see figure 3).

![Figure 3: Borrower’s Utility - high levels of credit ($\beta_G = 0.4$, $wed = 0.3$, $\kappa = 1$)](image)

**Level of Openness**

Another important parameter that we kept constant so far is the level of openness of the economy. Although we set the ratio of imports over GDP to roughly 40% ($\omega = 0.6$) in our model, the data from the main emerging markets economies show it can be considerably higher than that. The average for the countries in table 1 is 55%. Figure 4 shows how welfare changes with monetary policy for $\omega = 0.3$ under low and high levels of credit. The decrease in the optimal $\varepsilon$ for economies with deeper credit markets, i.e. the increase in exchange rate control, is even stronger in this case. This is so since financial dollarization is higher and the consumption basket is heavily biased towards foreign goods. It is in fact optimal to target the consumer price index (CPI) and not domestic (producer) prices for highly open economies with domestic credit of around 25-30% (CPI targeting is achieved when $\varepsilon = \omega = 0.3$).

$^{14}$The exchange rate premium (ERP) is defined as the difference between the expected nominal exchange rate and the nominal exchange rate evaluated when the shock is equal to its mean value. Formally $ERP = Z^\omega E[C^\omega (1-\eta)^2 ] - Z^\omega E[C^\omega (1-\eta)^2 ]$. 

Variable Levels of Nominal Rigidity

The analysis done so far only considered full wage rigidity, $\kappa = 1$. Assuming a portion $\kappa < 1$ of the unions in the labour market set wages one period in advance and the remaining unions set wages after the shock is realised we are able to investigate the effects of different levels of nominal rigidity on the optimal monetary policy.

Figure 5 shows the welfare for different levels of $\kappa$ (the other parameter are set as follows: $\omega = 0.6$, $\beta_G = 0.4$ and $wed = 0.3$). The central bank finds it optimal to exert greater control over the nominal exchange rate, the lower the rigidity of nominal wages. The driver for this result is the effects of the the variance of labour on the disutility of labour. The lower the proportion of unions that cannot adjust wages in the second period, the smaller the relevance of reducing the variance of labour to the economy’s welfare and hence the smaller the gain from controlling producer prices.

If half of the unions are allowed to change wages at period two ($\kappa = 0.5$) and domestic credit is around 25-30% then the central bank targets the consumer price index ($\varepsilon = \omega$) instead of the producer price index, $\varepsilon = 1$ (see figure 5(c)). Moving $\varepsilon$ from 1 to $\omega$ leads to a decrease in the exchange rate pass-through and a decrease in FD, reducing the potential utility loss of borrowers due to the exchange rate premium.

Although the CPI targeting is a hybrid regime between the fixed ex-
change rate and domestic price targeting, the evolution of welfare when monetary policy moves from fixed exchange rate towards CPI targeting ($0 < \varepsilon < \omega$) and from CPI towards domestic price targeting ($\omega < \varepsilon < 1$) is essentially different. The difference comes from the effect of the level of financial dollarization and the variance of nominal exchange rate on the welfare of borrowers, since FD only occurs after $\varepsilon > \omega$.

4.1 Impact of Regulation on Foreign Currency Denominated Assets

A common regulatory policy used to promote de-dollarization or control FD is to prevent or prohibit agents from making deposits and loans denominated in foreign currency. This type of policy is currently in place in Brazil. The framework developed in this paper can be employed to analyse the welfare consequences of implementing such a policy.

In order to do so, we solve the model excluding the portfolio equation (27), and setting $\alpha = 0$. Although the economy’s welfare increases, only borrowers benefit from the change, lenders are worse-off, thus the policy implementation is not Pareto improving. The main drivers of this result are: (i) the variance of the total income of lenders is increasing in $\varepsilon$ due to inefficient portfolio allocation and (ii) since without FD the exchange rate premium bears no impact on the expected loan payment, this payment does not rise as sharply as before. Figure 6 shows the results (unconnected dotted line shows the equilibrium after the implementation of the policy). The other parameter for these simulations are $\omega = 0.6$, $\beta_G = 0.4$, $\kappa = 1$ and $wed = 0.3$.

![Graphs](a) Welfare (b) Lender’s Utility (c) Borrower’s Utility

Figure 6: Welfare effects of Policy preventing Financial Dollarization

Note that under the new policy the difference between the evolution of welfare when moving monetary policy from the regime with fixed exchange rate towards consumer price targeting ($0 < \varepsilon < \omega$) and from CPI towards producer price targeting ($\omega < \varepsilon < 1$) does not exist (no kink at $\varepsilon = \omega$). CPI becomes again a simple hybrid regime between these two extreme policies.

4.2 Sensitivity Analysis

Changing the other parameters of the model does not alter the qualitative answers of the model.
Higher (lower) values of $\gamma$ make the households more (less) averse to the volatility of labour and therefore strengthen (weaken) the welfare gain from controlling producer prices. Lower (higher) values for $\eta$ lead to more (less) labour demand given an external demand shock and hence will strengthen (weaken) the welfare gain from controlling producer prices.

Lower (higher) $\sigma$ increases (decreases) the risk aversion, leading to lower (higher) levels of credit and higher (lower) welfare losses due to the variance of consumption. These effects tend to strengthen (weaken) the welfare gain from controlling producer prices. Finally, a decrease (increase) in $\Sigma$ strengthens (weakens) the welfare gain from controlling producer prices, because its impact on the exchange rate risk premium is stronger than the impact on the variance of labour.

5 Welfare under Monopolistic Competition in the Banking Sector with access to Foreign Funds

Central and Eastern European economies have observed sharp increases in foreign liabilities in the banking sector; the average of net liabilities in the banking sector for these economies is around 3% of the GDP (see table 1). Moreover, Basso, Calvo-Gonzalez, and Jurgilas (2007) show that this process has been an important driver of financial dollarization in this economies. Hence, in this section, we incorporate monopolistic competition in the banking sector, including a continuum of banks $h = [0, 1]$, and allow them to borrow from abroad at an exogenously set interest rate ($R^*$). For simplicity we set $\kappa = 1$, assuming full wage rigidity. In order to facilitate the exposition of the model we also include a deposit and loan CES aggregator.

Deposits and Loan Aggregator

The aggregator sells deposit and loan indexes to households and buys individual banks’ deposits and loans from each bank in order to minimise the cost for loans$^{15}$ and maximise the gains for deposits$^{16}$. We assume perfect competition so the aggregator makes no profits.

Note that the aggregator selects deposits and loans indexes, which are a composite of all banks deposits and loans given a constant elasticity of substitution ($\theta_b$). That way the banking sector will be characterised by monopolistic competition. The details of the aggregator’s problem are shown in Appendix C.

Banks

---

15 The household promises to pay an interest rate for the loans ($l$), thus the aggregator wants to pay as little as possible for the individual loans made in each bank $h$.
16 The aggregator promises to pay a deposit rate to the household, thus he/she will want to maximise the deposit rate on each individual deposit or minimise the present value of each deposit.
Each bank $h$ chooses deposit and loan interest rates for foreign and local currency ($rd^*_h$, $rl^*_h$, $rd_h$, $rl_h$) and the amount of funds ($F$) denominated in foreign currency to maximise its expected second period real profits.

Increasing foreign bank penetration in the banking system is directly related with increasing capability of the banking sector to acquire funds (foreign liability) from abroad. Although we do not explicitly model foreign ownership, allowing banks to borrow funds implicitly accounts for this important characteristic of many emerging market financial intermediation sectors.

Banks are assumed to have balanced currency positions, thus loans must be equal to funds plus deposits for each currency. Given prudential regulations limiting net open foreign exchange positions, this assumption is not unreasonable.

Bank $h$ real profit maximisation is given by

$$
\max_{\{rl_h, rl^*_h, rd_h, rd^*_h, F\}} E \left[ (rl_h - (P_2 - P_1) - 1) l_h \\
+ (rl^*_h - (P_2 - P_1) + (S_2 - S_1) - 1) l^*_h \\
- (rd_h - (P_2 - P_1) - 1) d_h \\
- (rd^*_h - (P_2 - P_1) + (S_2 - S_1) - 1) d^*_h - \frac{S_2(FR^*)}{P_2} - \Delta \right]
$$

subject to demand functions from the aggregator (details in Appendix C) and

$$
l_h = d_h \\
l^*_h = d^*_h + \frac{S_1 F}{P_1}
$$

where $R^*$ is the exogenously given interest rate banks must pay to borrow $F$ and $\Delta$ is a government lump-sum tax on bank’s profits that is transferred to the households\textsuperscript{17}.

\textbf{5.1 Equilibrium}

The key differences between the main model and the model with monopolistic competitive banks with access to foreign funds are: (1) the balance of payments equality has to accommodate the capital gain in the first period and the capital loss in the second period and (2) loans are not necessarily equal to deposits and rates of deposits and loans are not going to be equal.

Period two decision variables are now given by Table 4 (see Appendix A for details).

\textsuperscript{17}The introduction of a tax does not affect the qualitative results of the model but greatly simplifies it allowing analytical solutions to second period variables to be obtained.
Table 4: Solution - Period 2

\[
C_{2,H} = \frac{1}{2} \frac{S_2 \Lambda_2}{P_2} \frac{1}{1 - \omega} + \bar{R}_d D + \Delta/2 \tag{28}
\]

\[
C_{2,G} = \frac{1}{2} \frac{S_2 \Lambda_2}{P_2} \frac{1}{1 - \omega} - \bar{R}_l L + \Delta/2 \tag{29}
\]

\[
\Delta = \bar{R}_l L - \bar{R}_d D - \frac{S_2 FR^*}{P_2} \tag{30}
\]

\[
N_{2,H} = N_{2,G} = \frac{1}{2} \left( \frac{S_2 \Lambda_2}{P_{P,2}} \frac{1}{1 - \omega} \right)^{1/\eta} \tag{31}
\]

\[
S_2 = Z\phi_2 \Lambda_2 (1 - \frac{\phi_2}{\eta}) \tag{32}
\]

\[
P_{P,2} = Z\phi_2 - \phi_3 M \Lambda_2 (1 - \frac{\phi_2}{\eta}) \tag{33}
\]

\[
P_2 = Z\phi_2 - \phi_1 M \Lambda_2 (1 - \frac{\phi_2}{\eta}) \tag{34}
\]

where

\[
\Lambda_2 = C^* - \omega FR^* \tag{35}
\]

\[
Z = \frac{W_2^{\eta}}{M \eta^*(1 - \omega)^{(1 - \eta)}} \tag{36}
\]

The definitions of \(M, \phi_1, \phi_2\) and \(\phi_3\) remain the same.

The wage setting is not as straightforward because total consumption \(C_2\) is not equal to the sum of the disposal incomes of both households, but equal to \(\frac{S_2 \Lambda_2}{P_2(1 - \omega)} - \frac{S_2 FR^*}{P_2}\). Wage setting is given by

\[
W_2^{1-\eta \psi_1} = \Upsilon \frac{E\left[ \Lambda_2^{\Psi_1} \right]}{E\left[ \Lambda_2^{\Psi_3} \Omega_1^{1/\sigma} \right]} \tag{37}
\]

where

\[
\Psi_3 = (1 - \eta) \left( -\phi_2 + \frac{\phi_3}{\eta} - \phi_1 \right) + \frac{1}{\eta}
\]

\[
\Omega_1 = \Lambda_2^{(1 - \eta) \phi_1 + 1} - \Lambda_2^{(1 - \eta) \phi_2 + 1} FR^* \tag{38}
\]

The definitions of \(\Upsilon, \psi_1\) and \(\Psi_1\) remain the same (see Appendix A for details). Second order approximations to both expectations are done to obtain the final wage setting equation.

The other main first period variables, namely, the deposits and loans, the rates of interest and the portfolio allocations are obtained solving the system of equations presented in table 5. The system includes the first order conditions for the households, fund managers and banks problems.\(^{18}\)

---

\(^{18}\)Note that the banking sector clearing condition is also incorporated (see Appendix C).
Table 5: Solution - Period 1

\[(I_1 - D)^{-1/\sigma} = \beta_H \tilde{R}_d(I_2 + \tilde{R}_dD)^{-1/\sigma}\]
\[(I_1 + L)^{-1/\sigma} = \beta_G \tilde{R}_l(I_2 + \tilde{R}_lL)^{-1/\sigma}\]
\[\alpha_d = \frac{R^*_d - \tilde{R}_d + E[S_2 - S_1]}{q \text{VAR}[S_2]} + \frac{\text{COV}[P_2, S]}{\text{VAR}[S_2]}\]
\[\alpha_l = \frac{R^*_l - \tilde{R}_l - E[S_2 - S_1]}{q \text{VAR}[S_2]} + \frac{\text{COV}[P_2, S]}{\text{VAR}[S_2]}\]
\[D \alpha_d + FS_1 = L \alpha_l\]
\[D(1 - \alpha_d) = L(1 - \alpha_l)\]
\[R_d(1 + \theta_b) = R_l(\theta_b - 1)\]
\[R^*_d(1 + \theta_b) = R^*_l(\theta_b - 1)\]
\[R^*E[S_2] \theta_b = R^*_l(\theta_b - 1) + (E[S_2] - E[P_2])\theta_b\]

Where \(I_1 = \frac{S_1 \Lambda_1}{2(1-\omega)}\) (see Appendix A for details). The expected disposable income \(I_2\) is given by

\[I_{2,j} = I_2 = E\left[\frac{1}{2} S_2 C^*_2 \frac{1}{1 - \omega}\right] + E[\Delta/2]\]
\[= \frac{1}{2} \left(\frac{Z_{\phi_1}}{1 - \omega}\right) E \left[\Lambda_2^{(1-\eta)\phi_1 + 1}\right]\]
\[+ \frac{1}{2} \left(LE[\tilde{R}_d] - DE[\tilde{R}_d] - \frac{FZ_{\phi_1}}{M^\omega} E \left[\Lambda_2^{(1-\eta)\phi_1}\right]\right)\]

5.2 Welfare Analysis

Given the new equilibrium conditions presented above we can now analyse the impact of allowing banks to bring funds from abroad at a given interest rate on welfare and optimal monetary policy. The remaining parameter values used in these simulations are \(R^* = 1\), \(\theta_b = 20\) (implying a banking spread of around 15%) and \(q = 50\). Lower (higher) levels of \(q\) reinforce (weaken) the impact of interest rate differential onto the portfolio decision\(^{19}\).

Figure 7 shows the results for \(\omega = 0.6\) (low level of openness) and figure 8 shows the results for high level of openness \(\omega = 0.3\) (in subfigures (d) the upper curve denotes credit dollarization and lower curve deposit dollarization).

\(^{19}\)Recall that \(q\) is the weight of the variance relative to the expected returns on the fund manager portfolio decision. This is not used in the main model because there the expected returns on both assets are equal (no expected interest rate differential).
In both cases welfare is maximised when the central bank targets the producer prices. The main driver of this result is the behaviour of loan payments. In the main model, loan payments increase sharply as $\varepsilon$ increases, leading to lower welfare for borrowers. In the specification here, loan payments are closely linked with the level of funds borrowed from abroad ($F$). As $\varepsilon$ increases from zero to one, loan payments increase sharply as $F$ increases and then decrease as $F$ decreases. Thus the exchange rate premium effect on loan payments observed before is now offset by the decrease in $F$.

![Figure 7: Extension 2 - Low Openness ($\omega = 0.6$)](image)

For a high level of openness, $F$ is considerably high, even for low values of $\varepsilon$, resulting in high levels of credit dollarization. This link seems to hold in the data (with the exception of Bulgaria) as countries that control exchange rate and are relatively more open tend to have higher levels of foreign liabilities and dollarization (see table 1).

Foreign liabilities in the banking sector are at their highest when $\varepsilon = \omega$, i.e. when the central bank targets the CPI. This indicates that less control over the exchange rate compared to CPI will lead to a decrease in $F$ and a decrease in the mismatch between credit and deposit dollarization.

Some important caveats are in order. Firstly, we modeled a two period economy, thus all funds borrowed at period one must be paid at period two. Due to this unrealistic assumption, when funds ($F$) are high, agents must supply high levels of labour at period two, depressing welfare. Secondly, in our framework, as the central bank exerts more control on the exchange rate ($\varepsilon \to 0$), the pass-through becomes strongly negative and banks do not borrow any funds from abroad ($F = 0$). Finally, our framework does not allow us to analyse foreign liability dynamics for fixed exchange rate regimes and currency boards. In this two cases, other variables, such as the possibility of abandonment of the peg, foreign currency exposures of wages and remittances determine the portfolio decision.
6 Conclusion

This paper analyses monetary policy in a small open economy incorporating a very important feature that is present in most emerging economies, namely, financial dollarization. Given that variances are crucial for the determination of asset allocation, we employ a methodology, similar to the one introduced by Obstfeld and Rogoff (2000), that take explicit account of economic uncertainty and its impact on macroeconomic variables.

Our framework shows that if domestic credit is low, and hence financial dollarization has a limited macroeconomic impact, monetary policy in a small open economy is isomorphic to close economies, prescribing a domestic price targeting. Such policy stabilises the external shock reducing the variance of labour and income. This result matches the general conclusion of small open economy models, e.g. Sutherland (2001) and Gali and Monacelli (2005).

However, for higher levels of domestic credit (still below the ones observed empirically), intermediary levels of wage rigidity, and for levels of openness below the ones observed in the data, the optimal monetary policy is to control the consumer price index, thus, exerting some control over the exchange rate volatility. Under producer price control, exchange rate volatility is at its highest leading to a high exchange rate premium. Given that the financial dollarization level is also at its highest, a high exchange rate premium makes the borrowers worse off, reducing welfare.

Therefore, the theoretical model presented here shows that the “fear of floating” observed in many emerging economies is in fact an optimal response of the central bank when agents are allowed to accumulate domestic liabilities in foreign currency. Although Chang and Velasco (2006) also present a framework with this feature, they only model the currency choice of external debt. Firstly, for most if not all developing small open economies, the international credit market is only available in foreign currency (“original sin”). Furthermore, as Honig (2005) points out domestic liability dollarization plays a central role in producing a “fear of floating”.

Another relevant policy question investigated here is the welfare impact of introducing a regulation to prevent agents from making deposits and loans in foreign currency. This regulation is actually in place in some countries. We find that the introduction of such a policy leads to an increase in welfare, although it is not Pareto improving as lenders are worse-off.

Finally, we analyse the welfare impact of monetary policy when banks can borrow funds from abroad freely. We find that credit dollarization rises sharply as funds increase. We also find that the optimal monetary policy is to control producer prices due to the fact that when the exchange rate is controlled foreign liabilities are at their highest, leading to lower levels of welfare.

Although the model presented here embeds many important characteristic of small open economies, we have assumed unitary intertemporal elasticity of substitution, implying no trade imbalances. We also restricted our analysis to monetary policy responses to an external demand shock. Finally,
an important feature driving the results of the analysis on the impacts of foreign liabilities in the banking sector is the fact that we only consider a two period economy.

Hence, an important topic of future research is to incorporate different shocks, adopt a more flexible consumption index, and extend our framework to an infinity horizon economy. The extended framework would then provide a more realistic representation of the monetary policy trade-offs faced by small open economies.

References


Appendix A

**Equilibrium Solution - Main Model**
The firm’s first order conditions and goods market clearing condition are (time subscripts have been omitted for simplicity):

\[
\frac{W}{P} = \frac{P}{P} \frac{Y}{\eta N} \quad (A.1)
\]

\[
\Pi = (1 - \eta) \frac{P}{P} Y \quad (A.2)
\]

\[
Y = C_{P,H} + C_{P,G} + \frac{SC^*}{P} \quad (A.3)
\]

\[
Y = N^\eta \quad (A.4)
\]

Using (A.4) into (A.1) gives

\[
\Pi = \frac{1}{\eta} W Y^{(1 - \eta)/\eta} \quad (A.5)
\]

The Household first order conditions and the balance of payment condition are the budget constraint (2), the price index (5) and

\[
C_{P,H} = \frac{P S^{1-\omega} C_H}{P}, \quad C_{F,H} = \frac{P S^{1-\omega}(1 - \omega) C_H}{S} \quad (A.6)
\]

\[
C_{P,G} = \frac{P S^{1-\omega} C_G}{P}, \quad C_{F,G} = \frac{P S^{1-\omega}(1 - \omega) C_G}{S} \quad (A.7)
\]

\[
C^* = C_{F,G} + C_{F,H} \quad (A.8)
\]

Using (A.6), (A.7) and (A.8) into (A.3) gives

\[
Y = \frac{SC^*}{\Pi} \frac{1}{1 - \omega} \quad (A.9)
\]

Using (A.1), (A.2) and (A.9) into (2) and using (A.9) into (A.4) gives equations (11) - (13) into the main text.

Using (A.9) into (A.5) gives

\[
\Pi = \frac{W^{\eta}}{\eta^\eta} \left[ \frac{SC^*}{1 - \omega} \right]^{1 - \eta} \quad (A.10)
\]

Combining the result with the monetary policy rule (10), the wage index \(W = W^\kappa W_{b}^{1 - \kappa}\) and the price index (5) give equations (15)-(20) into the main text (time subscripts should be replaced).

The period two wage set by type \(b\) unions, using the solutions for \(P_{2}, C_{2}\) and \(N_{2}\) in table 2 is given by

\[
W_{b} = \delta P_{2} C_{2}^{1/\sigma} N_{b}^{1/\gamma} = \delta P_{2} C_{2}^{1/\sigma} \left( \frac{W_{2} N_{2}}{W_{b}} \right)^{1/\gamma} = Q_{a}(C^*)^{\psi_{2}} \quad (A.11)
\]

where
\[ Q_a = Y W_a \frac{1}{\psi_3} \]

\[ \psi_1 = \left( \phi_2 + \frac{\phi_3}{\gamma \eta} + \phi_1 \left( \frac{1}{\sigma} - 1 \right) \right) \]

\[ \psi_2 = \frac{(1 - \eta)\psi_1 + 1/\sigma + 1/(\gamma \eta)}{\psi_3} \]

\[ \psi_3 = 1 - (1 - \kappa)(\eta \psi_1 + 1/\gamma) + 1/\gamma \]

\[ \Upsilon = \frac{\delta}{(1 - \omega)^{1/(\sigma + 1/\gamma)}} \left[ \frac{1}{\eta \eta (1 - \omega)^{1 - \eta}} \right] \psi_1 \]

Given that prices are flexible in the first period, then one can set \( P_1 = 1 \), and use the same first order conditions stated above (adjusting for the time subscript) to find that \( C_1 = C_{1,H} + C_{1,G} = I_1 = \frac{S_1 C^*}{(1 - \omega)} \). Using the price index one finds that \( P_{P,1} = S_1^{\bar{\omega}} \). Using this result into the equivalent equation (A.10) for period one and the first period wage setting equation we find the solution for the nominal exchange rate, stated below.

\[ S_1 = \frac{\delta}{\eta} \frac{\psi_3}{\psi_3} \left( \frac{1}{\omega \eta} \right) \frac{C^*}{1 - \omega} \]

Labour at period one is given by

\[ N_1 = \frac{\delta}{\eta} \frac{\psi_3}{\psi_3} \left( \frac{1}{\omega \eta} \right) \frac{C^*}{1 - \omega} \]

The second period wage set by type a union (before the shock) is given by

\[ W_{2,a}^{1-\Xi_1} = \Upsilon \frac{E \left[ W_{2,b}^{(1-\kappa)\phi_3 + 1/\gamma} C^* \Upsilon_1 \right]}{E \left[ C^* \Xi_2 \right]} \frac{E \left[ C^* \Xi_1 \right]}{E \left[ C^* \Xi_1 \right]} \]

where

\[ \Upsilon_1 = ((1 - \eta)\phi_3 + 1) (1 + 1/\gamma) (1/\eta) \]

\[ \Upsilon_2 = (1 - \eta) \left( \phi_2 + \frac{\phi_3}{\eta} - \phi_1 \left( \frac{1}{\sigma} - 1 \right) \right) - \frac{1}{\sigma} + \frac{1}{\eta} \]

\[ \Xi_1 = \kappa(\eta \psi_1 + 1/\gamma) \left( 1 + (1 - \kappa)(\eta \psi_1 + 1/\gamma) \right) - 1/\gamma \]

\[ \Xi_2 = \psi_1 + \psi_2 (1 - \kappa) (\phi_3 + 1) (1 + 1/\gamma) \]

\[ \Xi_3 = \psi_2 + \psi_2 (1 - \kappa) (\eta (\phi_1 (1 - 1/\sigma) - \phi_2 + \phi_3/\eta) + 1) \]

In order to set total loans and deposits households must know their
expected income in the second period $I_{2,j}$. That is given by

$$
I_{2,j} = I_2 = E \left[ \frac{1}{2} S_2 C^* \frac{1}{1 - \omega} \right] = \frac{1}{2} Z^{\phi_1} \frac{1}{1 - \omega} E \left[ W_{,b}^{\phi_1 (1 - \kappa)} C^{*(1 - \eta) \phi_1 + \hat{A}} \right]
$$

$$
\approx \frac{1}{2} Z^{\phi_1} Q_1^{n(1 - \kappa) \phi_1} \frac{1}{1 - \omega} \left[ C_2 \Xi_5 + \Xi_5 (\Xi_5 - 1) C_2 \Xi_5 - 2 \Sigma \right] \frac{2}{2}
$$

(A.14)

where $\Xi_5 = (1 - \eta) \phi_1 + 1 + \psi_2 \eta (1 - \kappa) \phi_1$.

Finally in order to obtain the portfolio allocations we need to calculate the $\text{COV}(P_2, S_2)$ and the $\text{VAR}(S_2)$. Using (A.11), (15) and (17) we get

$$
\text{COV}(P_2, S_2) = Z^{2\phi_2 - \phi_1} Q_1^{n(1 - \kappa) (2\phi_2 - \phi_1)} M^* \text{COV}(C^{*x}, C^{*y})
$$

$$
= Z^{2\phi_2 - \phi_1} Q_1^{n(1 - \kappa) (2\phi_2 - \phi_1)} M^* (E(C^{*x} y) - E(C^{*x} E(C^{*y}))
$$

Where $x = (1 - \eta)(\phi_2 - \phi_1) + \psi_2 \eta (1 - \kappa)(\phi_2 - \psi_1)$ and $y = (1 - \eta)(\phi_2) + \psi_2 \eta (1 - \kappa) \phi_2$.

Using a second order approximation to the expectations and excluding the terms with order higher than $\text{VAR}(C^*) = \Sigma$ we obtain

$$
\text{COV}(P_2, S_2) = Z^{2\phi_2 - \phi_1} Q_1^{n(1 - \kappa) (2\phi_2 - \phi_1)} M^* C^x y \Sigma \left( y^2 \right)
$$

The variance of the nominal exchange rate is given by $\text{VAR}(S_2) = Z^{2\phi_2} Q_1^{n(1 - \kappa) (2\phi_2)} C^x \Sigma \left( y^2 \right)$.

The ratio of these two results gives the solution for the term used into the portfolio solution ((27)) in the main text.

$$
\frac{\text{COV}[P_2, S]}{\text{VAR}[S]} \approx \Psi \left[ 1 - \frac{\phi_1}{\phi_2} \right]
$$

where $\Psi = Z^{-\phi_1} Q_1^{n(1 - \kappa) \phi_1} M^* C^x - \phi_1 \phi_1 (1 - \eta) + \psi_2 (1 - \kappa) \eta$.

**Monopolistic Competition in the Banking Sector: Equilibrium Solution**

Replacing equation (A.8) with $C^* = C_{2,F,G} + C_{2,F,H} + FR^*$ and following the same steps as done above one gets the equations shown in table 4 in the main text.

The price index in period one is again normalised such that $P_1 = 1$. The balance of payment in period one changes to $\hat{C}^* = C_{1,F,G} + C_{1,F,H} - F$, and using the other first order conditions (adjusting for the time subscript) we find that $I_1 = W_1 N_1 + \Pi_1 = \frac{S_1 A_1}{(1 - \omega)}$ and $C_1 = C_{1,H} + C_{1,G} = \frac{S_1 (C^* + \omega F)}{1 - \omega} + S_1 F = \frac{S_1 A_1}{1 - \omega} + S_1 F$.

Using the price index one finds that $P_{P,1} = \frac{S_1^{n-1}}{S_1^{n-1}}$. Finally using this result into the equivalent equation (A.10) for period one and the first period wage setting equation we find the solution for the nominal exchange rate, stated below.
The average and variance of the shock (\(\omega\)) are such that (22), (23) and (26) hold.

Labour in period one is given by

\[
S_1 = \frac{\delta}{\eta} \frac{\eta \omega^\gamma}{(\sigma-\gamma-\sigma(1+\gamma)} A_1 \frac{[1-(1-\eta)\omega+(\omega-1)\sigma(\omega)]}{[\eta\omega(\sigma-1-\sigma(1+\gamma))]} \cdot \frac{1-(1-\eta)\omega}{1-\omega}\frac{C^* + F^{\eta\omega(\sigma-1-\sigma(1+\gamma))}}{1-\omega}
\]

\[
N_1 = \frac{\delta}{\eta} \frac{\eta \omega^\gamma}{(\sigma-\gamma-\sigma(1+\gamma)} A_1 \frac{[1-(1-\eta)\omega+(\omega-1)\sigma(\omega)]}{[\eta\omega(\sigma-1-\sigma(1+\gamma))]} \cdot \frac{1-(1-\eta)\omega}{1-\omega}\frac{C^* + F^{\eta\omega(\sigma-1-\sigma(1+\gamma))}}{1-\omega}
\]

**Appendix B**

**The Welfare Functions**

The economy’s welfare can be divided into five parts, the utility from consumption for both households in each period and the disutility of labour. Using the basic model equilibrium conditions (11)-(27) the economy’s welfare can be written as

\[
U(\varepsilon) = E[(A_1 + A_2) + (A_3 + A_4) - A_5]
\]

where

\[
A_1 = \frac{(S_1 \tilde{C}^*_1 - D + wed)^{1-1/\sigma}}{2(1-1/\sigma)},
\]

\[
A_2 = \frac{\beta H}{2(1-1/\sigma)} \left[ \frac{1}{2} \frac{Z_{\phi_1 \eta \phi_1(1-\kappa)}}{W_{2,b}} + \omega C^*(1-\eta)\phi_1 + 1 \right]^{1-1/\sigma} + D((1-\alpha)R + \alpha R^* - P_2 + 1 + \alpha(S_2 - S_1))^{1-1/\sigma},
\]

\[
A_3 = \frac{(S_1 \tilde{C}^*_1 + L - wed)^{1-1/\sigma}}{2(1-1/\sigma)},
\]

\[
A_4 = \frac{\beta G}{2(1-1/\sigma)} \left[ \frac{1}{2} \frac{Z_{\phi_1 \eta \phi_1(1-\kappa)}}{W_{2,b}} + \omega C^*(1-\eta)\phi_1 + 1 \right]^{1-1/\sigma},
\]

\[
A_5 = \frac{\delta N_1^{1+1/\gamma}}{1+1/\gamma} + \frac{\beta H + \beta G}{2} \frac{\delta}{1+1/\gamma} \left( \frac{Z_{\phi_2 W_{2,b} \psi_2}^{\eta \phi_3(1-\kappa)}}{M^{\eta \phi_3(1-\kappa)}} \right)^{1+1/\gamma},
\]

\[
S_2 = Z_{\phi_2 C^*(1-\eta)\phi_2},
\]

\[
P_2 = Z_{\phi_2 - \phi_1} M^{\omega} C^*(1-\eta)(\phi_2 - \phi_1),
\]

\[
W_{2,b} = Q_d C^* \psi_2,
\]

and

\[
Z = \frac{W_{2,b}^{\gamma}}{M^{\eta \phi(1-\kappa)(1-\eta)}}.\]

Finally, \(W_2\) is given by (21) and \(L, D, R\) and \(R^*\) are such that (22), (23) and (26) hold.

In order to obtain a solution for the expected welfare dependent only on the average and variance of the shock (\(C^*\)), a second order approximation
of the welfare equation is considered

The terms $A_1$ and $A_3$ do not depend on the shock ($C^*$) but only on its expected value, thus we only need to obtain an approximation for $E[A_2]$, $E[A_4]$ and $E[A_5]$.

$$E[A_2] = \frac{\beta H}{1 - 1/\sigma} E[f(C^*)^{1-1/\sigma}]$$
$$\approx \frac{\beta H}{1 - 1/\sigma} \left[ f(\bar{C}^*)^{1-1/\sigma} + \frac{\Sigma \partial^2 f(C^*)^{1-1/\sigma}}{\partial C^2}\bigg|_{C^* = \bar{C}^*} \right]$$

$$f(C^*) = \begin{bmatrix} \frac{1}{2} Z_{\phi_1 \phi_1 (1-\kappa)} \end{bmatrix}^{1-1/\sigma}$
$$+ D((1 - \alpha)R + \alpha R^* - P_2 + 1 + \alpha(S_2 - S_1))^{1-1/\sigma}$$

The same approximation is done for $E[A_4]$. $E[A_5]$ is given by

$$E[A_5] = \frac{\delta}{1 + 1/\gamma} N_1^{1+1/\gamma} + \frac{\delta(\beta H + \beta G)}{2(1 - 1/\gamma)} \left( Z_{\phi_1} Q_{a \phi_3 (1-\kappa)} \right)^{1+1/\eta}$$
$$E \left[ (C^* \psi_2 \eta \phi_3 (1-\kappa) + ((1 - \eta) \phi_3 + 1))^{1+1/\eta} \right]$$

where the last term expectation can be approximated to

$$\approx \bar{C}^* \zeta + \frac{\Sigma}{2} \zeta (\zeta - 1) \left[ \bar{C}^* \zeta^{-2} \right]$$

For $\zeta = (\psi_2 \eta \phi_3 (1-\kappa) + ((1 - \eta) \phi_3 + 1))^{(1+1/\gamma)}$.

The approximation for $E[A_2]$ and $E[A_5]$ in the model with monopolistic competition in the banking sector is done in a similar fashion. Note that the two main differences are that the main variables are now non-linear functions of $\Lambda_2 = C^* + \omega FR^*$, which in turn is an affine function of $C^*$. Secondly, one must now include the transfer from the government due to the tax on bank’s profits ($\Delta$).

**Appendix C**

**Deposits and Loans Aggregator**

The problems that the aggregator faces and her respective first order conditions are given below.

**Local Currency Deposits**

$$\min_{\{d_h\}} \left[ \int_0^1 \frac{1}{r} d_h dh \right]$$
subject to total deposits in local currency, which is a CES index of all deposits in each bank $h \in [0,1]$

$$d = \left[ \int_0^1 (d_h)^{\frac{\theta_b-1}{\theta_b}} dh \right]^{\frac{\theta_b}{\theta_b-1}}$$

That implies the following demand for local currency deposits from bank $h (d_h)$:

$$d_h = \left[ \frac{R_d}{rd_h} \right]^{-\theta_b} d$$ \hspace{1cm} (A.16)

where $rd_h$ is the deposit rate given by bank $h$ and the local currency deposit rate index $R_d$ is defined as

$$\frac{1}{R_d} = \left[ \int_0^1 \left( \frac{1}{rd_h} \right)^{\frac{1-\theta_b}{\theta_b}} dh \right]^{\frac{1}{1-\theta_b}}.$$ 

Note that profits are indeed zero since $\int_0^1 \frac{1}{rd_h} dh = \frac{1}{R_d} d$.

**Local Currency Loans**

$$\min_{\{l_h\}} \left[ \int_0^1 rhl_h dh \right]$$

subject to total loans in local currency which is a CES index of all loans done in each bank $h \in [0,1]$

$$l = \left[ \int_0^1 (l_h)^{\frac{\theta_b-1}{\theta_b}} dh \right]^{\frac{\theta_b}{\theta_b-1}}$$

That implies the following demand for local currency loans from bank $h (l_h)$:

$$l_h = \left[ \frac{rl_h}{R_l} \right]^{-\theta_b} l$$ \hspace{1cm} (A.17)

where $rl_h$ is the loan rate set by bank $h$ and the local currency loan rate index $R_l$ is defined as

$$R_l = \left[ \int_0^1 (rl_h)^{1-\theta_b} dh \right]^{\frac{1}{1-\theta_b}}.$$ 

Note that, again, profits are zero since $\int_0^1 rl_h l_h dh = R_l$. 
Similarly for foreign currency loans and deposits:

\[ d^*_h = \left[ \frac{R^*_d}{r d^*_h} \right]^{-\theta_b} d^* \quad (A.18) \]

where

\[ \frac{1}{R^*_d} = \left[ \int_0^1 \left( \frac{1}{r d^*_h} \right)^{1-\theta_b} dh \right]^{\frac{1}{1-\theta_b}} \]

\[ l^*_h = \left[ \frac{r l^*_h}{R^*_l} \right]^{-\theta_b} l^* \quad (A.19) \]

where

\[ R^*_l = \left[ \int_0^1 (r l^*_h)^{1-\theta_b} dh \right]^{\frac{1}{1-\theta_b}} \]

where \( r d^*_h \) and \( r l^*_h \) are bank \( h \)'s foreign currency deposit and loan rates and \( d^*_h \) and \( l^*_h \) are the demand for bank \( h \)'s foreign currency deposits and loans. \( R^*_d \) and \( R^*_l \) are the respective interest rate indexes.

The sufficient condition for the bank market to clear is that the rate indexes hold. Given all banks are equal this implies that bank’s \( h \) rates and rate indexes are equal\(^{20}\).

\(^{20}\)One can easily show that ensuring that the rate indexes hold, together with the individual bank demand equations used as constraints to bank \( h \)'s problem guarantees that the equations for \( d, d^*, l, l^* \) used in the aggregator problem hold.