ESSAYS ON EXCHANGE RATE, MONETARY AND FISCAL POLICIES IN DOLLARIZED ECONOMIES

BY LUIS V. PALACIOS-SALGUERO

A dissertation submitted to the

Graduate School—New Brunswick

Rutgers, The State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Economics

Written under the direction of

Roberto Chang

and approved by

New Brunswick, New Jersey

May, 2010

ABSTRACT OF THE DISSERTATION

ESSAYS ON EXCHANGE RATE, MONETARY AND FISCAL POLICIES IN DOLLARIZED ECONOMIES

by LUIS V. PALACIOS-SALGUERO

Dissertation Director: Roberto Chang

My dissertation has four chapters. I use dynamic stochastic general equilibrium (DSGE) models to study the welfare implications of exchange rate, monetary, and fiscal policies in de facto dollarized economies. Dollarization is a common phenomenon in emerging economies. In many of them economic agents hold liabilities in foreign currency while most income is earned in domestic currency. Thus, a sudden depreciation of the domestic currency may cause significant adverse effects on domestic agents' wealth and welfare. That is why governments try to design and implement macroeconomic policies that help reduce these adverse effects. My work aims at contributing to the design and implementation of these policies. In the first chapter, I study alternative exchange rate regimes in a dollarized economy. I develop a DSGE model and pursue Bayesian estimation using data from Singapore. The main conclusion is that the flexible exchange rate regime is better than the fixed exchange rate. In the second chapter, I work on an extension of my first chapter by introducing nontradable goods, which allows me to study a broader set of exchange rate regimes in a dollarized economy. I develop a DSGE model and pursue Bayesian estimation using data from Peru. The main conclusion is that a policy that pegs the domestic currency price of exports is better than a flexible exchange rate regime that targets the consumer price index, which in turn is better than the fixed exchange rate. The third chapter studies the optimal fiscal rule for a dollarized economy. Using a DSGE model with endogenous dollarization, I obtain

that an optimal fiscal rule should take into account deviations (from their steady state values) of the level of government debt, government spending, and inflation. The fourth chapter characterizes the optimal exchange rate policy in a dollarized economy using a method developed by Devereux and Sutherland (2007, 2008). The method allows me to use a DSGE model in order to compute the optimal currency composition of the portfolio of (foreign) liabilities in the long-run equilibrium and its dynamics. The main finding is that the flexible exchange rate is better than the fixed rate.

Acknowledgements

Many people have helped me with their comments and suggestions to make this dissertation successful, and I am really grateful to them. First of all, I would like to thank my parents, whose support during my years at school cannot be measured. I am also grateful to my brother and sisters for their love and support. And thank you to my wife too for her enormous patience and support. I would like to thank Dr. Roberto Chang for being my Committee Chair and helping me achieve one of the main goals of my life with his wise and rich advice. I also want to thank Drs. Michael Bordo, Bruce Mizrach, and Horacio Sapriza for all their comments and suggestions. Thanks once again to you all!

Dedication

To my parents, Nora and Luis, and my wife, Malena

Table of Contents

Chapter 1

Introduction

Since the early 1970s, most countries in the world have decided to let their currencies float. However, most of these countries actually have a managed floating exchange rate regime, that is, one in which the central bank intervenes in the foreign exchange market. As highlighted by Chang (2005) and other authors, the dollarization of liabilities explains why central banks are concerned with "undesired" fluctuations in the exchange rate and the potential balance sheet effects. Balance sheet effects refer to the adverse economic and financial impact on firms and individuals that follows a depreciation of the domestic currency, and these effects are especially strong in economies where a significant amount of debt is denominated in foreign currency while most income is earned in domestic currency. Since a depreciation of the domestic currency could be detrimental for highly-dollarized economies, governments evaluate alternative exchange rate regimes with respect to that of a pure floating regime. Recent adoptions of exchange rate regimes different from the flexible regime, as in Argentina and Ecuador, confirm the huge importance that the exchange rate policy has for a government's economic and political stability and viability in (de facto) dollarized economies.

Moreover, since emerging economies continuously face adverse external shocks (such as those to interest rate, oil price, and commodity prices), the shocks' propagation mechanisms and the economic conditions under which they occur must be studied with rigor in order to propose macroeconomic policies that make these economies less exposed to adverse shocks. This is especially important in today's world, where financial and trade linkages have become very strong, as evidenced by the worldwide effects of the current international economic crisis.

In the four chapters of my dissertation, I pursue research concerned with the design and implementation of optimal macroeconomic policies in small open economies with an emphasis on exchange rate, fiscal and monetary policies. Using modern quantitative and econometric methods and my knowledge of current international macroeconomic theory and practice I obtain results that should be interesting and useful for macroeconomists and policy-makers.

In the first chapter of my dissertation, I study the welfare implications of alternative exchange rate regimes in a small open economy with a high degree of dollarization. In particular, I develop a DSGE model and pursue Bayesian estimation using data from Singapore (a country that is highly engaged in international trade and finance and that has problems with currency substitution). The main conclusion is that the flexible exchange rate regime is better than the fixed exchange rate regime, in terms of providing a greater level of welfare than that provided by the latter. This result is consistent with the conventional wisdom (for instance, Friedman, Mundell, and Poole), which states that an open economy mainly affected by real shocks should have a flexible exchange rate.

In the second chapter, I work on an extension of my first chapter by introducing nontradable goods, which allows me to study the welfare implications of a broader set of exchange rate regimes in a small open economy with a high degree of dollarization. In particular, I develop a DSGE model and pursue Bayesian estimation using data from Peru (a country that has had problems with currency substitution for almost two decades). The main conclusion is that a flexible exchange rate regime where the nominal anchor is the domestic currency price of exports is better than a flexible exchange rate regime where the nominal anchor is the consumer price index, which in turn is better than the fixed exchange rate regime, where the ranking is based on the level of welfare associated with each exchange rate policy. This result is consistent with the contributions made by Frankel (2003 and 2005).

The third chapter studies the optimal fiscal policy rule for a de facto dollarized economy. Some authors have stated that monetary policy is not as effective in a dollarized economy as in an economy where this phenomenon is absent (Cespedes, Chang and Velasco, 2001). If this is true, how important is to characterize an optimal fiscal policy rule in a dollarized economy? In this paper I use a DSGE model for a small open economy with endogenous dollarization to evaluate alternative fiscal policy rules. The results indicate that an optimal fiscal rule should take into account deviations (from their corresponding steady state values) of the amount of government debt, government spending, and inflation in order to maximize the level welfare in the economy.

Finally, the fourth chapter characterizes the optimal exchange rate policy in a de facto dollarized economy using a state of the art method developed by Devereux and Sutherland (2007, 2008). The method allows me to use a DSGE model in order to compute the optimal currency composition of the portfolio of (foreign) liabilities of the economy in the long-run equilibrium as well as its dynamics. I find that (i) the flexible exchange rate is better than the fixed exchange rate, (ii) under a flexible exchange rate, the economy will optimally issue only debt in pesos while accumulate only assets in dollars, and (iii), under a fixed exchange rate, the economy will optimally issue only debt in dollars while accumulate only assets in pesos. Some of these findings are in line with the external borrowing behavior of some Asian economies before the 1997 Asian crisis.

Chapter 2

Endogenous Dollarization in a Small Open Economy: Fixed or Flexible Exchange Rate?

2.1 Introduction

To float or not to float? This seems to be one of the key macroeconomic questions that emerging economies have to answer. Since early 1970s most countries in the world have decided to let their currencies float. However, most of these countries actually have a managed floating exchange rate regime, that is, one in which the central bank will intervene the foreign exchange market in order to affect the domestic price of the foreign currency. As highlighted by Chang (2005) and other authors, the dollarization of liabilities explains why central banks are concerned with "undesired" fluctuations on the exchange rate[1] and the potential balance sheet effects. Balance sheet effects refer to the adverse economic and/or financial impact on firms and individuals that follows a depreciation of the domestic currency in economies in which a significant amount of debt is denominated in foreign currency while most income is generated in domestic currency[2]. Thus, since depreciation of the domestic currency could be particularly dangerous for highly-dollarized small open economies, governments evaluate alternative exchange rate regimes to that of a pure floating exchange. Recent adoptions of exchange rate regimes alternative to the flexible one, like in Argentina and Ecuador[3] confirm

---

[1]It is well understood and documented that economies become dollarized during episodes of high inflation. However, disinflations are not necessarily followed by dedollarization. In particular, Bolivia, Peru, Russia, Ukraine and other countries have remained highly dollarized long after the inflation rate was brought down to single digits. Peru is a remarkable case: During the last 16 years it has had a dollarization ratio greater than 50 percent even though during the last 12 years it has had a one-digit inflation rate.

[2]According to Ize and Levy-Yeyati (2003), many emerging economies facing dollarization have tried to eliminate it by implementing disinflationary policies, but most of them have been unsuccessful. They state that the main reason for that result is that dollarization levels can remain high if the expected volatility of the inflation rate is high in relation to the expected volatility of the real exchange rate.

[3]While Argentina had a currency board between 1991 and 2002, Ecuador and Salvador adopted official dollarization in 2000 and 2001, respectively.

the huge importance that the exchange rate regime has for governments' economic and political stability and viability (and for the economies themselves) in economies characterized by a high degree of dollarization. This paper contributes to the debate on optimal exchange rate regime for emerging economies by showing, with the help of a straightforward dynamic model, that the flexible exchange rate regime is the best policy, which is a result consistent with the conventional wisdom.

In previous papers, like in Ize and Levy-Yeyati (2003), the effect of dollarization on the economic performance of countries and other related issues have been studied using portfolio models and other similar approaches. In addition, some of these studies have assumed that the degree of dollarization is exogenously given, like in Moron and Castro (2003). This paper studies this problem using a novel approach: a dynamic stochastic general equilibrium model with endogenous dollarization. In this study, under two different alternative exchange rate regimes, I analyze how real exogenous shocks to a small open economy affect the optimal currency composition of its portfolio of liabilities, which is determined endogenously by the model, and thus how much the overall economy is ultimately affected. In order to do so, I develop a model of a small open economy with an incomplete menu of assets: domestic residents can only borrow internationally using short-term bonds denominated in domestic or foreign currency. In addition, the small open economy with an endogenous degree of dollarization is inhabited by households, firms and a government. Households live infinite periods and accumulate capital partly financed with the sale of one-period bonds denominated in both domestic and foreign currency. Uncertainty in my model is given by two shocks that follow independent exogenous processes: a technology shock to output A_t and a random level (volume) of domestic exports X_t[4].

Authors have identified characteristics of business cycles in emerging economies that distinguish them from business cycles in developed economies. A couple of these characteristics are as follows: (1) business cycles are more volatile in emerging economies, and (2) emerging economies are susceptible to additional sources of volatility, such as terms of trade fluctuations[5]. In addition, regarding the common features of emerging

[4]As explained below, domestic firms are assumed to have some monopolistic power in world markets and thus face a downward sloping demand curve; therefore, a shock to the level of exports will have an effect both on the terms of trade and in the quantity of exports.

[5]The literature on small open economies recognizes the terms of trade shocks as one of the most

economies, in many of them exports are characterized by a high concentration in a small number of commodities whose world prices are very volatile[6]. Also, their fiscal revenues tend to be largely dependent on the prices of the main export commodities, and so the stance of their public finances is vulnerable to major changes in the world prices of export goods. Incidentally, in my model, shocks to the level (volume) of exports will cause (ceteris paribus) a change in the terms of trade of the economy because domestic firms are assumed to have some monopolistic power in the (foreign) market for their goods[7].

Additionally, the model features convex portfolio adjustment costs for both peso and dollar bonds in order to induce stationarity of the equilibrium dynamics. This stationarity inducing technique has been used, among others, in recent papers by Neumeyer and Perri (2001) and Schmitt-Grohe and Uribe (2003). In my model, the cost of increasing liability holdings by one unit is greater than one because it includes the marginal cost of adjusting the size of the portfolio[8].

In order to compare the fixed and flexible exchange regimes' outcomes that result from exogenous shocks, I solve the model for the decentralized economy, that is, I solve the problems of both households and firms independently. All variables are in per capita terms (i.e., there is no population growth). Moreover, since a small open economy is analyzed, the domestic (dollar) interest rate equals the world (dollar) interest rate, which in turn is assumed to be exogenously given; this assumption greatly simplifies the analysis. I write a Matlab code in order to compute the impulse response functions, the moments for the endogenous variables in the model, the conditional welfare, and other relevant statistical information. My code is based on those provided by Schmitt-Grohe

---

relevant shocks affecting these economies. See, for instance, Mendoza (1995), Kose (2002), and Broda (2003). In particular, Mendoza (1995) finds that terms of trade disturbances explain 56 percent of aggregate output fluctuations in developing countries.

[6]According to UNCTAD, in 1995, 57 developing countries depended on three commodities for more than half of their exports.

[7]It is important to notice that during the current world economic crisis, many countries that rely heavily in international trade have been severely affected by the fall in world trade; in particular countries such as Hong Kong, Malaysia, Singapore, South Korea, Taiwan and Thailand are expected to experience a GDP fall of at least 4 percent in 2009 (The Economist, as of 08/15/09), a result partly explained by falling exports and terms of trade. Developed countries such as Japan and Germany have also been substantially affected by the current world crisis: current estimates for GDP growth in 2009 for both countries indicate a fall of at least 5.9 percent in this key macroeconomic indicator.

[8]To be more specific, and as it will become more clear below, in my model households will have to pay a "fee" in terms of lost output if their transactions in the international financial market lead to deviations from some long-run (steady state) level.

and Uribe (2003, 2004a, 2004c).

Regarding the exchange rate regimes evaluated in this study, it is important to mention that Frankel (2003) suggests that pegging the export price (PEP) is a monetary regime that can be applied to countries that specialize in the production of a particular agricultural or mineral commodity. PEP proposes fixing the price of the single commodity in terms of local currency (here, pesos). It has been argued that PEP is not appropriate for countries where diversification of exports is an issue. For such countries the modified version, PEPI, developed by Frankel (2005), proposes fixing the price (in pesos) of a comprehensive index of export prices. According to Frankel (2005), in either version of the monetary regime (PEP or PEPI), one advantage is that the domestic currency depreciates automatically when the world market for the country's exports deteriorates. This depreciation will certainly help the economy reduce the negative effects of the weak exports market conditions (by stimulating domestic exports).

Furthermore, following the recommendations given by Kim et al. (2003), the exchange rate policies in my paper are evaluated in terms of conditional expected welfare instead of the unconditional one. Thus, the object that exchange rate policy aims to maximize in my study is the expectation of lifetime utility of the representative household conditional on a particular initial state of the economy (the non-stochastic steady state). In contrast, many existing normative evaluations of monetary policy rank policies based upon unconditional expectations of utility. As Kim et al. (2003) point out, unconditional welfare measures ignore the welfare effects of transitioning from a particular initial state to the stochastic steady state induced by the policy under consideration. By using conditional welfare, I highlight the fact that transitional dynamics matter for policy evaluation.

In the last part of the present study I pursue Bayesian analysis to estimate the parameters of my DSGE model. Bayesian methods have become a powerful tool to conduct empirical research. This approach allows a researcher to incorporate prior information to his evaluation of theoretical models with the use of observed data. Using the posterior distributions for parameters, a researcher can use his model to perform policy analysis or forecast the dynamics of macroeconomic variables. My work in this section is conducted with the help of DYNARE, a computational toolbox for the study of DSGE models.

Finally, the most important finding in my study is that the flexible exchange rate regime is the best policy in terms of providing a greater level of (conditional) welfare to the domestic economy than the one provided by the fixed exchange rate regime. What explains this key result is that the fixed exchange rate regime creates an additional costly burden for the economy: First, under this regime, in the market for peso bonds, only the quantity of peso bonds can be adjusted, not its price (the interest rate in pesos), and this adjustment is costly (due to the presence of quadratic portfolio adjustment costs). Secondly, since a fixed exchange rate makes the interest rate on peso bonds equal to that on dollar bonds, it follows that in practice the domestic economy will be able to issue only one type of bonds (which pays the interest rate on dollar bonds), and as it is well known, decreasing the number of assets traded internationally should reduce welfare (because it increases the degree of market incompleteness), as suggested by Benigno (2009). Thirdly, since under the fixed regime there is one less relative price (the interest rate in pesos), the rest of the variables of the model are forced to absorb the shocks, making the variables more volatile (that is, shocks are magnified), and thus increasing their associated uncertainty, which will in turn cause a loss of efficiency in the allocation of resources (both intratemporal and intertemporal); certainly, some of these variables are consumption and hours worked, which directly affect welfare. Therefore, as a result, following exogenous shocks to the economy, there will be a significant impact on consumption, hours worked, investment, the capital stock, output, and welfare.

The paper is structured as follows. The next section outlines the basic model, and section 3 discusses the calibration of the parameters of the model. Section 4 explains how the model is solved under each alternative exchange rate regime, discusses the resulting impulse response functions, and makes a comparison of the dynamics of the model and welfare effects under the alternative exchange rate regimes. Section 5 uses Bayesian estimation to evaluate the model for the economy of Singapore[9], a country whose exports of goods and services are greater than its GDP and that faces currency substitution issues. Finally, section 6 concludes.

[9]According to the World Development Indicators, ten countries export goods with a value greater than 90 percent of GDP. This group of countries includes Singapore, Malaysia, Hong Kong, Luxeamburg, and UAE. In addition, thirteen countries in the world import goods with a value greater than 90 percent of GDP. This second group of countries includes Singapore, Malaysia, Hong Kong, Luxeamburg, and Puerto Rico.

2.2 The Model

Consider a small open economy populated by a large number of identical households, monopolistically competitive firms and a government. I develop an infinite-horizon production economy with imperfectly competitive product markets and sticky prices.

2.2.1 The Household's Problem

Each household has preferences defined over processes of consumption and leisure and described by the utility function

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \right\} \tag{2.1}$$

where c_t denotes consumption, h_t denotes labor effort, $\beta \in (0,1)$ denotes the subjective discount factor, and E_t denotes the mathematical expectation operator conditional on information available in period t. The single period utility function U is assumed to be increasing in consumption, decreasing in effort, strictly concave, and twice continuously differentiable.

Households can hold physical capital, k_t. The law of motion of the capital stock k_t is given by

$$k_{t+1} = (1-\delta)k_t + i_t - \phi(k_{t+1}, k_t) \tag{2.2}$$

where $\delta \in (0,1)$ denotes the constant rate of depreciation of the capital stock, i_t is (gross) investment, and $\phi(k_{t+1} - k_t)$ is a measure of capital adjustment costs.

Capital adjustment costs have many explanations[10]. Changing the level of the capital stock in a firm creates disruption costs during the installation of any new or replacement capital, and costly learning must be incurred as the structure of production may have been changed. Moreover, installing new equipment or structures often involves delivery lags and time to install or build. The irreversibility of many projects caused by a lack of secondary markets for capital goods acts as another form of adjustment cost. It is assumed that $\phi(0) = \phi'(0) = 0$. Small open economy models typically include capital adjustment costs to avoid excessive investment volatility in response

[10]For further details see Hamermesh and Pfann (1996) and Cooper and Haltiwanger (2006).

to shocks to the domestic economy. Thus, I introduce capital adjustment costs, as in Schmitt-Grohe and Uribe (2006), to avoid the excess volatility of investment that typically arises in small open economy models.

Every period, in order to finance current consumption c_t, investment i_t and foreign debt repayment, domestic households can issue one-period bonds denominated in both domestic currency ("peso bonds" B_{t+1}) and foreign currency ("dollar bonds" B^*_{t+1}). The domestic economy borrows from the world financial market, represented by a continuum of risk-neutral lenders. A peso-bond is a promise to pay a principal plus an interest r^p_t in pesos after one period. In turn, dollar-bonds are promises to pay a principal plus an interest r_t in dollars after one period. Peso bonds and dollar bonds are sold for one peso and one dollar, respectively. The representative household's optimal borrowing decisions determine the degree of "dollarization" in the economy, which will be influenced by its expectations about equilibrium prices and the exchange rate.

The representative household's period-by-period (dollar) budget constraint is given by

$$\begin{aligned}\frac{B_{t+1}}{s_t} + B^*_{t+1} + \pi_t + \frac{w_t h_t}{s_t} + \frac{R_t k_t}{s_t} = c_t + i_t + \frac{(1+r^p_t)B_t}{s_t} + (1+r_t)B^*_t \\ + \frac{\psi_2}{2}(B^*_{t+1} - B^*)^2 + \frac{\psi_3}{2}(B_{t+1} - B)^2\end{aligned} \tag{2.3}$$

where the left hand side of the equality represents all the sources of income for the representative household, while the right hand side represents all the possible uses of that income. Both sides of the above expression are expressed in dollars. I assume that all domestic consumption and investment is made in only foreign goods, that the dollar price of foreign consumption and investment goods is equal to \$1, and that this dollar price does not change. That means that consumption c_t and (gross) investment i_t in the expression above represent, at the same time, quantities of goods and the dollar value of these components of aggregate demand. The nominal wage rate and the rental rate of capital are represented by w_t and R_t, respectively. Since free trade prevails and the law of one price holds, the peso price of imports is given by the exchange rate s_t (expressed in pesos per dollar); in other words, in my model s_t is not only the nominal exchange rate but also the aggregate level of prices in the domestic economy. This implies that the real wage rate and the real rental rate of capital in the domestic economy are given by $\frac{w_t}{s_t}$ and $\frac{R_t}{s_t}$, respectively.

I assume that there are portfolio adjustment costs associated with the issuance of debt, both in pesos and in dollars. In this model, stationarity is induced by assuming that agents face convex costs of holding liabilities in quantities different from some long-run level. Portfolio adjustment costs for the issuance of peso and dollar bonds are given, respectively, by the following expressions

$$\frac{\psi_3}{2}(B_{t+1} - B)^2$$

and

$$\frac{\psi_2}{2}(B^*_{t+1} - B^*)^2$$

where B and B^* are the steady state values of peso and dollar bonds, respectively. Clearly, in the steady state portfolio adjustment costs are zero.

I asume that, because of no arbitrage, the expected gross rate of return on peso bonds (the expected gross interest rate on peso bonds) $E_t\{1+r^p_{t+1}\}$ equals the expected peso gross rate of return on world assets, that is,

$$E_t\left\{1 + r^p_{t+1}\right\} = E_t\left\{(1 + r_{t+1})\left(\frac{s_{t+1}}{s_t}\right)\right\} \tag{2.4}$$

In addition, households are subject to a borrowing constraint that prevents them from engaging in Ponzi schemes.

Furthermore, I assume a GHH specification for the period utility function mentioned above following Mendoza (1991)[11]; in particular,

$$U(c_t, h_t) = \frac{\left(c_t - \frac{h_t^\omega}{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

where γ is the coefficient of relative risk aversion, and ω is equal to one plus the inverse of the intertemporal elasticity of substitution in labor supply.

Additionally, I assume a specific functional form for the implicit capital adjustment costs function mentioned above following Mendoza (1991); in particular,

---

[11]The benchmark utility function (GHH) is a generalized version of quasi-linear utility, first introduced into the real business cycle literature by Greenwood, Hercowitz and Huffman (1988). GHH preferences have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period.

$$\phi(k_{t+1},k_t)=\frac{\phi}{2}(k_{t+1}-k_t)^2$$

where ϕ is the capital adjustment cost parameter.

The household chooses the set of processes $\{c_t, h_t, k_{t+1}, i_t, B_{t+1}, B^*_{t+1}\}_{t=0}^{\infty}$ and some borrowing limit that prevents it from engaging in Ponzi-type schemes so as to maximize (2.1) subject to (2.2)-(2.4), taking as given the set of processes for $\{\pi_t, r^p_t, r_t, w_t, R_t, s_t\}_{t=0}^{\infty}$ and the initial conditions k_0, B_0, and B^*_0.

Let the multiplier on the flow budget constraint (2.3) be $\lambda_t\beta^t$. Then the first-order conditions of the household's maximization problem are (2.2) $-$ (2.4) holding with equality and

$$\lambda_t=\left(c_t-\frac{h_t^{\omega}}{\omega}\right)^{-\gamma} \tag{2.5}$$

$$\lambda_t\frac{w_t}{s_t}=\lambda_t h_t^{\omega-1} \tag{2.6}$$

$$\lambda_t\left[1+\phi(k_{t+1}-k_t)\right]=\beta E_t\left[\lambda_{t+1}\left(\frac{R_{t+1}}{s_{t+1}}+(1-\delta)+\phi(k_{t+2}-k_{t+1})\right)\right] \tag{2.7}$$

$$\lambda_t\left[\frac{1}{s_t}-\psi_3(B_{t+1}-B)\right]=\beta E_t\left[\lambda_{t+1}\left(\frac{1+r^p_{t+1}}{s_{t+1}}\right)\right] \tag{2.8}$$

$$\lambda_t\left[1-\psi_2(B^*_{t+1}-B^*)\right]=\beta E_t\left[\lambda_{t+1}(1+r_{t+1})\right] \tag{2.9}$$

The interpretation of the first order conditions above are as follows: Equation (2.5) defines the marginal utility of consumption. Equation (2.6) states that in equilibrium the representative household must be indifferent between enjoying an additional hour of leisure and enjoying the additional units of consumption that it will afford to buy by working one more hour. Equation (2.7) states that in equilibrium, the representative household must be indifferent between consuming an additional unit of good, and investing that additional unit and then consuming the goods that he could buy with the revenues from the investment, net of depreciation. Equation (2.8) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of peso bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more peso bond must equal the discounted value of the marginal utility of consumption lost from the repayment of the unit of peso bond. Equation (2.9) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of dollar bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more dollar bond must equal the discounted value of the marginal utility of consumption lost from the repayment of the unit of dollar bond, including the interest on that additional debt.

2.2.2 The Firms' Problem

Each firm is the monopolistic producer of one variety of final goods, all of which are sold abroad. The domestic firm's output is given by

$$\tilde{y}_t = A_t F(\tilde{k}_t, \tilde{h}_t) - \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*)$$

where the first element of the right hand side of the above expression corresponds to the production function of domestic firms, which have access to a constant returns to scale production technology, and the second term corresponds to the price adjustment costs funtion.

I follow Rotemberg (1982) and introduce sluggish price adjustment by assuming that the firm faces a resource cost that is quadratic in the inflation rate of the good it produces:

$$Price\ adjustment\ cost = \frac{\phi_2}{2}\left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*} - 1\right)^2$$

The parameter ϕ_2 measures the degree of price stickiness. The higher is ϕ_2 the more sluggish is the adjustment of nominal prices. If $\phi_2 = 0$, then prices are flexible. The assumption of quadratic adjustment costs implies that firms change their price every period in the presence of shocks, but will adjust only partially towards the optimal price the firm would set in the absence of adjustment costs. As with any type of quadratic adjustment cost, a firm prefers a sequence of small adjustments to very large adjustments in a given period.

As pointed out by Rotemberg (1982), Barro (1972), and Mussa (1976), among others, changing prices is costly for two reasons: First, there is the administrative cost of changing the price lists, informing dealers, etc. Secondly, there is the implicit cost that results from the unfavourable reaction of customers to large prices changes. While the administrative cost is a fixed cost per price change, the second cost can be a different function of the magnitude of the price change; in particular, customers may well prefer small and recurrent price changes to occasional large ones. This is what is implicitly assumed by Rotemberg (1982), when he makes the costs to changing prices a function of the square of the price change.

The firm hires labor and capital from perfectly competitive domestic factor markets. Moreover, the foreign demand for the domestic good is of the form $X_t d(p_{i,t})$, where X_t denotes the level of foreign demand and $p_{i,t}$ denotes the relative (peso) price of the good in terms of the average (peso) price of domestic exports. The relative price $p_{i,t}$ is defined as $s_t \tilde{p}_t^* / p_t$; where s_t is the nominal exchange rate, $\tilde{p}_t^*$ is the dollar price of the good produced by the firm, and p_t is the average peso price of domestic exports. The demand function $d(.)$ is assumed to be decreasing and to satisfy $d(1) = 1$ and $d'(1) < -1$. The restrictions on $d(1)$ and $d'(1)$ are necessary for the existence of a symmetric equilibrium. The monopolist sets the dollar price of the good it supplies $\tilde{p}_t^*$ taking the level of aggregate demand X_t as given, and is constrained to satisfy demand at that price; that is,

$$A_t F(\tilde{k}_t, \tilde{h}_t) - \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*) \geq X_t d(p_{i,t}) \tag{2.10}$$

(Dollar) Profits are given by

$$\tilde{\pi}_t = \tilde{p}_t^* X_t d(p_{i,t}) - \frac{w_t \tilde{h}_t}{s_t} - \frac{R_t \tilde{k}_t}{s_t} \tag{2.11}$$

In addition, I assume a Cobb-Douglas specification for the implicit production function mentioned above following Mendoza (1991)[12]; in particular,

[12]The Cobb-Douglas production function is commonly used in economics partly because of its analytical tractability. As scholars have noted, by the end of the nineteenth century Wicksell and Pareto had already used this type of production function in their studies.

$$F(k_t, h_t) = k_t^{\alpha} h_t^{1-\alpha}$$

Each period, imperfectly competitive firms choose capital $\tilde{k}_t$, labor services $\tilde{h}_t$ and the dollar price of exports $\tilde{p}_t^*$, subject to demand and technological constraints (2.10), so as to maximize profits (2.11). Since the firm is owned by the representative household, it is natural to assume that the intertemporal marginal rate of substitution $\beta\frac{\lambda_{t+1}}{\lambda_t}$ can be used to discount future profits. Let the multiplier on the demand and supply equilibrium condition (2.10) be $\tilde{\mu}_t \beta^t \left(\frac{\lambda_{t+1}}{\lambda_t}\right) \tilde{p}_t^*$; then the firm will maximize the following expression:

$$\begin{aligned} L = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{t+1}}{\lambda_t} \left[\tilde{p}_t^* X_t d(p_{i,t}) - \frac{w_t \tilde{h}_t}{s_t} - \frac{R_t \tilde{k}_t}{s_t} \right] \right\} \\ + E_t \left\{ \sum_{t=0}^{\infty} \tilde{\mu}_t \beta^t \frac{\lambda_{t+1}}{\lambda_t} \tilde{p}_t^* \left[X_t d(p_{i,t}) - A_t F(\tilde{k}_t, \tilde{h}_t) + \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*) \right] \right\} \end{aligned} \tag{2.12}$$

taking as given the processes for $\{A_t, X_t, w_t, R_t, s_t, \lambda_t\}_{t=0}^{\infty}$.

As a result of the profit maximization process, input demands and export prices must satisfy the following efficiency conditions:

$$\frac{R_t}{s_t} = -\tilde{\mu}_t \tilde{p}_t^* A_t \alpha \tilde{k}_t^{\alpha-1} \tilde{h}_t^{1-\alpha} \tag{2.13}$$

$$\frac{w_t}{s_t} = -\tilde{\mu}_t \tilde{p}_t^* A_t \tilde{k}_t^{\alpha} (1-\alpha) \tilde{h}_t^{-\alpha} \tag{2.14}$$

$$\begin{aligned} X_t \left[d\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) + d'\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) \right] + \tilde{\mu}_t \left[X_t d'\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) + \tilde{p}_t^* \phi_2 \left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*} - 1\right) \left(\frac{1}{\tilde{p}_{t-1}^*}\right) \right] \\ + \tilde{\mu}_t \left[X_t d\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) - A_t \tilde{k}_t^{\alpha} \tilde{h}_t^{1-\alpha} + \frac{\phi_2}{2} \left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*} - 1\right)^2 \right] \\ = E_t \left\{ \tilde{\mu}_{t+1} \beta \left(\frac{\lambda_{t+1}}{\lambda_t}\right) \tilde{p}_{t+1}^* \phi_2 \left(\frac{\tilde{p}_{t+1}^*}{\tilde{p}_t^*} - 1\right) \left(\frac{\tilde{p}_{t+1}^*}{\tilde{p}_t^{*2}}\right) \right\} \end{aligned} \tag{2.15}$$

The interpretation of the first order conditions above are as follows: Equations (2.13) states that in equilibrium there is a wedge between the real rental rate of capital and the marginal productivity of capital, which is explained by the monopolistic power of the firms. Equation (2.14) states that in equilibrium there is a wedge between the real wage rate and the marginal productivity of labor, which is explained, again, by the presence of imperfectly competitive firms in the market. Equation (2.15) states that in equilibrium there is a wedge between marginal revenue and marginal cost as a result of the presence of price adjustment costs à la Rotemberg (1982).

Let me define the real marginal cost mc_t and real marginal revenue mr_t as follows:

$$mc_t = \frac{\frac{w_t}{s_t}}{p_t^* A_t \tilde{k}_t^{\alpha}(1-\alpha)\tilde{h}_t^{-\alpha}}$$

$$mr_t = \frac{s_t \tilde{p}_t^*}{p_t} + \frac{d\left(\frac{s_t \tilde{p}_t^*}{p_t}\right)}{d'\left(\frac{s_t \tilde{p}_t^*}{p_t}\right)}$$

2.2.3 Equilibrium

I restrict attention to symmetric equilibria where all firms charge the same price for the good they produce ($\tilde{p}_t^* = p_t^*$). As a result, I have that $p_{i,t} = 1$ for all t. It then follows from the fact that all firms face the same wage rate and rental rate of capital, the same shocks to technology and exports, and the same production technology, that they all hire the same amount of labor and capital; that is, $\tilde{h}_t = h_t$ and $\tilde{k}_t = k_t$. Let

$$\eta \equiv d'(1)$$

denote the equilibrium value of the elasticity of demand faced by the individual producers of goods. Then, in equilibrium, the expression for the marginal revenue mr_t above simplifies to

$$mr_t = 1 + \frac{1}{\eta}$$

Furthermore, the domestic goods market equilibrium condition[13] is given by

$$p_t y_t = s_t p_t^* X_t d\left(\frac{s_t p_t^*}{p_t}\right)$$

where s_t is the nominal exchange rate, expressed in number of units of domestic currency per unit of foreign currency, while $X_t d(.)$ is the quantity of domestic exports. As in Chang and Velasco (2004), I assume that domestic residents do not consume

[13]The value in pesos of domestic output equals the value in pesos of the quantity demanded of domestic output.

home goods, and thus the demand for home output comes from foreigners. This is a simplifying assumption and should not affect the main results of the paper. Since by assumption total domestic production y_t is exported

$$y_t = X_t d\left(\frac{s_t p_t^*}{p_t}\right)$$

I obtain the expected result that

$$p_t = s_t p_t^* \tag{2.16}$$

which states that the price in pesos of domestic exports p_t equals the product of the nominal exchange rate s_t times the dollar price of domestic exports p_t^*.

As I mentioned earlier, due to their monopolistic power, domestic firms set the dollar price of exports p_t^* in every period. Clearly, an increase in p_t^* can be interpreted as a positive change to the terms of trade in the economy. That is, ceteris paribus, a positive change in the price of domestic exports will increase the purchasing power of domestic agents in terms of foreign goods (imports).

Notice that my model does not make explicit the use of a monetary aggregate in the economy, although the domestic price level is a key variable in the model. It is possible to introduce money explicitly to my model, but the conclusions should not change. My model assumes that the monetary authority just supplies the amount of money that maintains the exchange rate s_t at its pegged value under the fixed exchange rate regime, and that maintains constant the peso price of domestic exports p_t under the flexible exchange rate regime[14].

The stochastic processes for the level of foreign aggregate demand for domestic goods X_t and the technology shock A_t are exogenously given by

$$logX_t = \tau logX_{t-1} + \epsilon_{X,t}, \quad \text{where} \quad \epsilon_{X,t} \sim N(0, \sigma_X^2) \tag{2.17}$$

$$logA_t = \rho logA_{t-1} + \epsilon_{A,t}, \quad \text{where} \quad \epsilon_{A,t} \sim N(0, \sigma_A^2) \tag{2.18}$$

where both $\epsilon_{X,t}$ and $\epsilon_{A,t}$ are white noise random variables.

[14]To be more precise, the flexible exchange rate regime in my model implies that the central bank pursues a price targeting/flexible rate policy, where the target is the peso price of domestic exports.

2.3 Calibration

I do calibrate the model for an average small open economy that has a high level of dollarization. Thus, some parameter values are picked from studies on the Canadian and Argentinian economies and some values are picked from the related literature, which will be mentioned below. The time unit is meant to be a year. The basic calibration and parameterization of the model is taken from Mendoza (1991). Mendoza calibrates the model to the Canadian economy[15]. Moreover, Mendoza argues that Canada is viewed as a typical small open economy because of the historical absence of capital controls and the high degree of integration of its financial markets with those of the United States. The parameter values that I will use in my simulation of the model are given in Table 2.1 below.

Table 2.1: Calibration

Symbol	Value	Description
α	0.32	Capital's share of income
β	0.9615	Subjective discount factor
γ	2	Coefficient of relative risk aversion
δ	0.1	Depreciation rate
η	-6	Price elasticity of demand for a specific export good variety
ψ_2	0.00074	Parameter of the portfolio adjustment cost function on dollar bonds
ψ_3	0.00074	Parameter of the portfolio adjustment cost function on peso bonds
ϕ	0.028	Parameter of the capital adjustment cost function
ϕ_2	0.028	Degree of price stickiness
ρ	0.42	Degree of autocorrelation for the technology shock
τ	0.56	Degree of autocorrelation for the exports shock
ω	1.455	One plus the inverse of the intertemporal elasticity of substitution in labor supply
σ_A	0.0129	Standard deviation of the technology shock error term
σ_X	0.0129	Standard deviation of the exports shock error term
r	0.04	World's real interest rate

In addition, following Schmitt-Grohe and Uribe (2003), I assign small values to the parameters ψ_2 and ψ_3[16], which help measure the portfolio adjustment costs that arise from choosing debt levels in dollars and pesos different from their corresponding steady state values. Also, I assign a value of 0.9615 to the discount factor β, since in the steady state the discount factor equals the inverse of the gross world interest rate.

[15]The data considered by Mendoza corresponds to annual observations for the period 1946-1985, expressed in per capita terms of the population older than 14 years, transformed into logarithms and detrended with a quadratic time trend.

[16]I have assumed that the values for these parameters are the same since, in principle, there is no reason to think that the values must be different.

Regarding the annual world interest rate in dollars r, I assign it a value of 4 percent. Moreover, I assign the value of 0.8 to both debts, which imply steady state values for the level of dollarization and the ratio of total debt to output equal to 65 percent and 1.19, respectively, which are consistent with empirical values for some small open economies[17]. The value of 0.1 assigned to the annual depreciation rate δ implies an average investment ratio of about 19 percent, which is close to the average value of 18.5 percent observed in Argentina between 1997 and 2007. I set the value of the parameter α, which determines the average capital share of income, at 0.32, a value commonly used in the related literature. In addition, I set the value of the price elasticity of demand on a specific good η equal to -6; this value implies a steady state value for the (value-added) markup of 0.20, which is a reasonable value[18].

2.4 Solving the Model

I assume that in period 0 the government chooses the exchange rate regime. The government is assumed to be endowed with a commitment technology that allows it to maintain throughout time the policy decision it makes in period 0. As a result, the announced policy enjoys full credibility on the part of the private sector; in other words, there is no time inconsistency problem in my model.

2.4.1 Flexible Exchange Rate Regime

In the model with flexible exchange rate regime, first, the government (central bank) fixes the value of the peso price of domestic exports p_t to its long-run (nonstochastic steady state) level p, following Frankel (2003), and then, after observing the realization of the exogenous shocks to technology and the level of exports, households and firms, taking p_t as given, solve their corresponding constrained optimization problems as explained above. Thus, under the flexible exchange rate regime, I have

$$p_t = p \tag{2.19}$$

[17]For instance, Argentina's public debt/GDP ratio averaged 1.13 between 2001 and 2004, its external debt/GDP ratio averaged 1.14 during the same period, and its dollarization ratio averaged 63.2 percent between 1997 and 2001, according to data reported by Moody's (Moody's Statistical Handbook, November 2006).

[18]Basu and Fernald (1997) estimate gross-output markup of about 1.1. They show that their estimates are consistent with values for the value-added markup of up to 0.25.

It is important to mention that Frankel (2003) suggests that pegging the export price (PEP) is a monetary regime that can be applied to countries that are specialized in the production of a particular agricultural or mineral commodity. PEP proposes fixing the price of the single commodity in terms of local currency (here, pesos). It has been objected that PEP is inappropriate for countries where diversification of exports is an issue. For such countries the modified version, PEPI, developed by Frankel (2005), proposes fixing the price of a comprehensive index of export prices. According to Frankel (2005), in either version of the monetary regime (PEP or PEPI), one advantage is that the currency depreciates automatically when the world market for the country's exports deteriorates.

2.4.1.1 The First Order Conditions

I am now ready to define an equilibrium. A competitive equilibrium is a set of plans for $\{c_t, h_t, i_t, k_{t+1}, B_{t+1},\ B^*_{t+1}, \lambda_t, \mu_t, p^*_t, w_t,\ R_t, s_t, r^p_t, r_t\}$ satisfying (2.2) - (2.4), (2.10) - (2.11), (2.16) - (2.19), some non-Ponzi game condition, and the following conditions

$$\lambda_t = \left(c_t - \frac{h_t^\omega}{\omega}\right)^{-\gamma} \tag{2.20}$$

$$\lambda_t \frac{w_t}{s_t} = \lambda_t h_t^{\omega-1} \tag{2.21}$$

$$\lambda_t \left[1 + \phi(k_{t+1} - k_t)\right] = \beta E_t \left[\lambda_{t+1}\left(\frac{R_{t+1}}{s_{t+1}} + (1-\delta) + \phi(k_{t+2} - k_{t+1})\right)\right] \tag{2.22}$$

$$\lambda_t \left[\frac{1}{s_t} - \psi_3(B_{t+1} - B)\right] = \beta E_t \left[\lambda_{t+1}\left(\frac{1 + r^p_{t+1}}{s_{t+1}}\right)\right] \tag{2.23}$$

$$\lambda_t \left[1 - \psi_2(B^*_{t+1} - B^*)\right] = \beta E_t \left[\lambda_{t+1}(1 + r_{t+1})\right] \tag{2.24}$$

$$\frac{R_t}{s_t} = -\mu_t p^*_t A_t \alpha k_t^{\alpha-1} h_t^{1-\alpha} \tag{2.25}$$

$$\frac{w_t}{s_t} = -\mu_t p^*_t A_t k_t^{\alpha}(1-\alpha) h^{-\alpha} \tag{2.26}$$

$$X_t\eta\left[\left(1+\frac{1}{\eta}\right)-(-\mu_t)\right]+\mu_t p_t^*\phi_2\left(\frac{p_t^*}{p_{t-1}^*}-1\right)\left(\frac{1}{p_{t-1}^*}\right)$$
$$+\mu_t\left[X_t-A_tk_t^{\alpha}h_t^{1-\alpha}+\frac{\phi_2}{2}\left(\frac{p_t^*}{p_{t-1}^*}-1\right)^2\right]$$
$$=E_t\left\{\mu_{t+1}\beta\left(\frac{\lambda_{t+1}}{\lambda_t}\right)p_{t+1}^*\phi_2\left(\frac{p_{t+1}^*}{p_t^*}-1\right)\left(\frac{p_{t+1}^*}{p_t^{*2}}\right)\right\} \tag{2.27}$$

given the fixed value of the peso price of domestic exports p, exogenous processes $\{A_t, X_t\}$ and initial conditions $A_0, X_0, k_0, B_0, B_0^*, p*_{-1}$.

Incidentally, I compute the level of dollarization for the economy (LD_t) and the ratio of total (foreign) debt to output (RTD_t) for each period in order to make a better analysis of the impact of the different exogenous shocks to the economy. These two indicators are defined as follows:

$$LD_t = 1-\frac{\frac{B_{t+1}}{s_t}}{\frac{B_{t+1}}{s_t}+B_{t+1}^*} \tag{2.28}$$

$$RTD_t = \frac{\frac{B_{t+1}}{s_t}+B_{t+1}^*}{p_t^* y_t} \tag{2.29}$$

2.4.1.2 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value; that is $\epsilon_X = 0$ and $\epsilon_A = 0$, which implies values for the level of domestic exports and the productivity factor of $X = 1$ and $A = 1$, respectively. In addition,

$$B = \bar{B}$$

$$B^* = \bar{B^*}$$

$$p^* = \left(\frac{X^{\frac{(1-\alpha)(\omega-1)}{\omega}}}{[-\mu(1-\alpha)]^{\frac{1-\alpha}{\omega}}\left[\frac{-\mu\alpha}{\frac{1}{\beta}-(1-\delta)}\right]^{\alpha}}\right)^{\frac{1}{\frac{1-\alpha}{\omega}+\alpha}}$$

$$k = \frac{-\mu\alpha p^* X}{\frac{1}{\beta}-(1-\delta)}$$

$$h = [p^*(-\mu)(1-\alpha)X]^{\frac{1}{\omega}}$$

$$s = \frac{p}{p^*}$$

$$r^p = r$$

$$y = Ak^{\alpha}h^{(1-\alpha)} = X$$

$$w = h^{\omega-1}s$$

$$R = -\mu\alpha\left(\frac{X}{k}\right)p$$

$$\mu = -\left(\frac{1+\eta}{\eta}\right)$$

$$\lambda = \left(c - \frac{h^{\omega}}{\omega}\right)^{-\gamma}$$

$$\pi = p^*X\left(-\frac{1}{\eta}\right)$$

$$c = p^*X - r\left(B^* + \frac{B}{s}\right) - \delta k$$

$$i = \delta k$$

2.4.1.3 Effects on the Economy of a Positive Technology Shock

Table 2.2 below summarizes the main impact effects on the economy that result from a positive technology shock.

Table 2.2: Flexible Exchange Rate: Impact Effects

Shock	y	c	i	h	k_{t+1}	B_{t+1}	B^*_{t+1}	s	p^*	π
A_t	0	−	−	−	−	+	+	+	−	−

Following a positive technology shock, consumption, hours and investment fall, while output stays the same. The reason for output not to change is that, in equilibrium, it is equal to total exports, as can be seen in Equation (2.10) above, and total exports are exogenous in my model. Even though the technology shock does not affect total output (and thus the level of exports), it causes a deterioration of the terms of trade and, thus, a decrease in welfare; that is, following a positive technology shock the domestic economy will experience "immiserizing growth"[19]. Moreover, since the positive technology shock makes the economy more productive but domestic exports stay the same (as they are

[19]Bhagwati (1958) suggests that under some conditions economic growth could cause a welfare loss for the economy. In particular, if growth is export biased it may lead to a deterioration of the terms of trade, which may dominate the gains from growth and thus cause a net welfare loss for the domestic economy.

exogenous), less resources (both capital and labor) are required to produce the same level of output. As less capital is now necessary for production, households reduce investment immediately. However, since firms cannot reduce immediately the current level of the stock of capital (which has to be fully used in equilibrium), much less labor is hired. As workers work less hours, less wage income flows into the households, which in turn will reduce consumption. Moreover, as firms adjust the stock of capital, they incur in costly capital adjustment costs, which make the positive technology shock even more costly for the economy (resulting in a greater loss of welfare). The combined net effect of the falls in both consumption and hours worked[20] explains the fall in the level of utility of the representive household, and thus the fall in welfare.

Regarding the impact effect on debt and its dynamics, since the economy becomes poorer (because of the deterioration of the terms of trade, which follows an increase in the peso price of imports, caused by the impact depreciation of the domestic currency), it will borrow more money in the foreign market (in order to smooth consumption), both in pesos and in dollars (the debt-to-GDP ratio increases). However, the economy will borrow more dollars than pesos as the economy expects the domestic currency to appreciate in the (near) future (that is, the dollarization ratio increases on impact). The nominal exchange rate increases on impact because the fall in the dollar price of exports (caused by the now-more-productive domestic firms, which have to reduce their dollar prices in order to avoid losing part of their share of the market to its competitors) has an immediate negative effect on the inflow of dollars to the economy; thus, as dollars become “scarce” in the domestic economy, the peso price of dollars (the nominal exchange rate) jumps up on impact. However, domestic agents know that eventually the exchange rate has to return to its (lower) long-run equilibrium value, which means that an appreciation of the peso is expected. Moreover, the interest rate on peso bonds falls on impact as domestic agents expect the peso to appreciate in the (near) future. In addition, following the impact increase in the peso price of imports (caused by the impact depreciation of the peso), both the real wage and the real rental rate of capital fall (which makes domestic households poorer). As time goes by, the adverse effects of the shock to the economy will decrease (and eventually vanish): the

[20]The negative effects of the drop in consumption on welfare dominates the positive effects of the increase in leasure on welfare.

terms of trade and (dollar) export revenues will recover, the economy will borrow less, the peso will appreciate, the interest rate on peso bonds will increase, consumption, hours worked and the capital stock will increase, and the rest of the variables will eventually reach their long-run equilibrium values. Figure (6.1) in the Appendix shows the impulse response functions to output, consumption, hours, investment, debt and other key variables associated with a positive technology shock to the economy.

2.4.1.4 Effects on the Economy of a Positive Shock to Exports

Table 2.3 below summarizes the impact effects on the economy that result from a positive shock to exports.

Table 2.3: Flexible Exchange Rate: Impact Effects

Shock	y	c	i	h	k_{t+1}	B_{t+1}	B^*_{t+1}	s	p^*	π
X_t	$+$	$+$	$+$	$+$	$+$	$-$	$-$	$-$	$+$	$+$

Following a positive shock to exports, output, consumption, hours and investment increase on impact. The greater demand for exports allows the economy to expand immediately in order to satisfy it. Not only will the economy produce more, but it will also charge a greater dollar price for its exports, and thus (as it will be explained below) the terms of trade will improve. And as domestic production (and exports) increases, export revenues go up. Moreover, the greater production will demand the use of more resources (both capital and labor). As more capital is now required for production, households increase investment immediately. However, since firms cannot adjust immediately the current level of the stock of capital (which has to be fully used in equilibrium), much more labor is hired. As workers work more hours, more wage income flows into the households, which in turn will increase consumption. The combined net effect of the increase in both consumption and hours worked[21] explains the increase in the level of utility of the representive household, and thus the increase in welfare.

Regarding the impact effect on debt and its dynamics, since the economy becomes richer (because of the improvement of the terms of trade, which follows a drop in the peso price of imports, caused by the impact appreciation of the domestic currency) it

[21] The positive effects of the increase in consumption on welfare dominates the adverse effects of the decrease in leasure on welfare.

will borrow less money in the foreign market (which helps to smooth consumption), both in pesos and in dollars (the debt-to-GDP ratio falls). However, the economy will borrow less dollars than pesos as households expect the domestic currency to depreciate in the (near) future (that is, the dollarization ratio falls on impact). The nominal exchange rate decreases on impact because the increase in both the level and the dollar price of exports (caused by the shock) has an immediate positive effect on the inflow of dollars to the economy; thus, as dollars become "abundant" in the domestic economy, the peso price of dollars (the nominal exchange rate) jumps down on impact. However, domestic agents know that eventually the exchange rate has to return to its (higher) long-run equilibrium value, which means that a depreciation of the peso is expected. Moreover, the interest rate on peso bonds increases on impact as domestic agents expect the peso to depreciate in the (near) future. In addition, following the impact fall in the peso price of imports (caused by the impact appreciation of the peso), both the real wage and the real rental rate of capital increase (which makes domestic households richer). As time goes by, the positive effects of the shock to the economy will decrease (and eventually vanish): the terms of trade and export revenues will drop, the economy will borrow more, the peso will depreciate, the interest rate on peso bonds will decrease, consumption, hours worked and the capital stock will decrease, and the rest of the variables will eventually reach their long-run equilibrium values. Figure (6.2) in the Appendix shows the impulse response functions to output, consumption, hours, investment, debt and other key variables associated with a positive shock to exports.

2.4.2 Fixed Exchange Rate Regime

In the model with fixed exchange rate regime, first, the government (central bank) fixes the value of the exchange rate s_t to its long-run (nonstochastic steady state) level s, and then, after observing the realization of the exogenous shocks to technology and the level (volume) of exports, households and firms, taking s_t as given, solve their corresponding contrained optimization problems, as explained above. Thus, under the fixed exchange rate regime, I have

$$s_t = s \tag{2.30}$$

2.4.2.1 The First Order Conditions

A competitive equilibrium is a set of plans for $\{c_t, h_t, i_t, k_{t+1}, B_{t+1}, B^*_{t+1}, \lambda_t, \mu_t, p^*_t, w_t, R_t, p_t, r^p_t, r_t\}$ satisfying (2.2) - (2.4), (2.10) - (2.11), (2.16) - (2.18), (2.30), some non-Ponzi game condition, and conditions (2.20) - (2.27) stated in section 2.4.1.1 above, given the fixed value of the exchange rate s, exogenous processes $\{A_t, X_t\}$ and initial conditions $A_0, X_0, k_0, B_0, B^*_0, p*_{-1}$.

2.4.2.2 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value; that is $\epsilon_X = 0$ and $\epsilon_A = 0$, which implies values for the level of domestic exports and the productivity factor of $X = 1$ and $A = 1$, respectively. In addition, the steady state values for the rest of endogenous variables in the model are the same as the ones stated in section 4.1.2 above.

2.4.2.3 Effects on the Economy of a Positive Technology Shock

Table 2.4 below summarizes the impact effects on the economy that result from a positive technology shock.

Table 2.4: Fixed Exchange Rate: Impact Effects

Shock	y	c	i	h	k_{t+1}	B_{t+1}	B^*_{t+1}	p	p^*	π
A_t	0	$-$	$-$	$-$	$-$	$+$	$+$	$-$	$-$	$-$

Following a positive technology shock, consumption, hours and investment fall, while output stays the same. Even though the technology shock does not affect total output (and thus the level of exports), it will make the dollar price of exports fall and thus cause a deterioration of the domestic terms of trade and a fall in export revenues. Thus, following a technology shock the domestic economy will experience "immiserizing growth". Moreover, since the positive technology shock makes the economy more productive but domestic exports stay the same, less resources are required to produce the same level of output. As less capital is now necessary for production, households reduce investment immediately. However, since firms cannot reduce immediately the current level of the stock of capital, much less labor is hired. As workers work less hours, less wage income flows into the households, which in turn will reduce consumption. Moreover, as firms adjust the stock of capital, they incur in costly capital adjustment costs, which make the positive technology shock even more costly for the economy. The combined net effect of the falls in both consumption and hours worked explains the fall in the level of utility of the representive household, and thus the fall in welfare.

Regarding the impact effect on debt and its dynamics, since the economy becomes poorer (because of the deterioration of the terms of trade, which follows a fall in the peso price of exports, caused by the drop in their dollar price), it will borrow more money in the foreign market (in order to smooth consumption), both in pesos and in dollars (the debt-to-GDP ratio increases). Under fixed exchange rate, domestic agents are in principle indifferent between issuing peso debt and dollar debt (since the government guarantees the exchange between pesos and dollars at the fixed exchange rate); the only concern they have about how much debt they should issue in one currency or the other is the one associated with the quadratic portfolio adjustment costs: Domestic agents have to increase (or decrease when necessary) the amount of both debts "proportionately" so that the total quadratic cost does not increase unnecessarily. The fact that an increase in the dollarization ratio is observed on impact (smaller than the one that occurs under the flexible exchange rate regime) is the result of the particular specification that I have assumed for the portfolio adjustment costs (and not the result of households' decisions based on what they expect to happen in the future with the exchange rate, which is the case under the flexible exchange rate regime). In addition, following the deterioration of export revenues, both the real wage and the real rental rate of capital fall (since there is less money to compensate the factors of production for their services). As time goes by, the adverse effects of the shock to the economy will decrease (and eventually vanish): the terms of trade and profits will recover, the economy will borrow less, consumption, hours worked and the capital stock will increase, and the rest of the variables will eventually reach their long-run equilibrium values. Figure (6.3) in the Appendix shows the impulse response functions to output, consumption, hours, investment, debt and other key variables associated with a positive technology shock to the economy.

2.4.2.4 Effects on the Economy of a Positive Shock to Exports

Table 2.5 summarizes the impact effects on the economy that result from a positive shock to exports.

Table 2.5: Fixed Exchange Rate: Impact Effects

Shock	y	c	i	h	k_{t+1}	B_{t+1}	B^*_{t+1}	p	p^*	π
X_t	+	+	+	+	+	−	−	+	+	+

Following a positive shock to exports, output, consumption, hours and investment increase on impact. The greater demand for exports allows the economy to expand immediately in order to satisfy it. Not only will the economy produce more, but it will also charge a greater dollar price for its goods, and thus (as it will be explained below) the terms of trade will improve. As the dollar price for exports and domestic production increase, export revenues increase and profits go up. Moreover, the greater production will demand the use of more resources (both capital and labor). As more capital is now required for production, households increase investment immediately. However, since firms cannot adjust immediately the current level of the stock of capital, much more labor is hired. As workers work more hours, more wage income flows into the households, which in turn will increase consumption. The combined net effect of the increase in both consumption and hours worked explains the increase in the level of utility of the representive household, and thus the increase in welfare.

Regarding the impact effect on debt and its dynamics, since the economy becomes richer it will borrow less money in the foreign market (in order to smooth consumption), both in pesos and in dollars (the debt-to-GDP ratio falls). As mentioned previously, under fixed exchange rate, domestic agents are in principle indifferent between issuing peso debt and dollar debt; the only concern they have about how much debt they should issue in one currency or the other is the one associated with the quadratic portfolio adjustment costs. The fact that a fall in the dollarization ratio is observed on impact (smaller than the one that occurs under the flexible exchange rate regime) is the result of the particular specification that I have assumed for the portfolio adjustment costs. In addition, following the increase of export revenues, both the real wage and the real rental rate of capital increase (since there is more money to compensate the factors of production for their services). As time goes by, the positive effects of the shock to the economy will decrease (and eventually vanish): the terms of trade and profits will drop, the economy will borrow more, consumption, hours worked and the capital stock will decrease, and the rest of the variables will eventually reach their long-run equilibrium values. Figure (6.4) in the Appendix show the impulse response functions to output, consumption, hours, investment, debt and other key variables associated with a positive shock to exports.

2.4.3 Comparing Moments under Alternative Exchange Rate Regimes

Table 2.6 below shows the second moments for some variables of interest.

Table 2.6: Comparing Moments

		Flexible			Fixed		
Shock	Variable	σ_x	$\rho_{xt,xt-1}$	$\rho_{xt,GDPt}$	σ_x	$\rho_{xt,xt-1}$	$\rho_{xt,GDPt}$
A_t	y_t	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	c_t	1.6994	0.4460	n.a.	2.1674	0.6413	n.a.
	i_t	5.5182	-0.1576	n.a.	5.5304	-0.1572	n.a.
	h_t	1.9882	0.2988	n.a.	1.9880	0.2983	n.a.
	k_{t+1}	0.6151	0.5584	n.a.	0.6223	0.5668	n.a.
	B_{t+1}	7.2425	0.9988	n.a.	14.8554	0.9992	n.a.
	B^*_{t+1}	13.9724	0.9988	n.a.	28.6650	0.9992	n.a.
	s_t	2.8744	0.3031	n.a.	n.a.	n.a.	n.a.
	p_t	n.a.	n.a.	n.a.	2.8741	0.3026	n.a.
X_t	y_t	1.5570	0.5600	1	1.5570	0.5600	1
	c_t	2.1092	0.6515	0.8041	2.3961	0.7220	0.7312
	i_t	7.3139	-0.0717	0.6331	7.3219	-0.0715	0.6340
	h_t	2.0772	0.4052	0.9839	2.0770	0.4049	0.9837
	k_{t+1}	0.9464	0.6738	0.9864	0.9506	0.6760	0.9845
	B_{t+1}	12.9508	0.9992	-0.0368	17.0044	0.9994	-0.0575
	B^*_{t+1}	24.9848	0.9992	-0.0368	32.8050	0.9994	-0.0575
	s_t	1.5075	0.2466	-0.9358	n.a.	n.a.	n.a.
	p_t	n.a.	n.a.	n.a.	3.0685	0.3612	0.8336

In all cases investment is more volatile than both consumption and output, and consumption is more volatile than output. The last result is a well-known stylized fact for small open economies, which has been explained mainly by their inability to smooth consumption fully, which is in turn due to their limited access to well developed financial markets (that is why I assume asset market incompleteness in this model).

Furthermore, under both exchange rate regimes, following a shock to exports, consumption, hours and investment are procyclical, while debt in both pesos and dollars are countercyclical. In addition, both current debt and next-period capital show significant positive levels of autocorrelation, which is partly explained by the presence of portfolio and capital adjustment costs.

Moreover, consumption, investment, next-period capital, and both debts are more volatile under a fixed exchange rate regime than under a flexible exchange rate regime, while hours are almost as volatile under flexible exchange rate as under fixed exchange rate regime. These results help to explain why the conditional welfare associated with the flexible exchange rate regime is greater than the one related to the fixed exchange: The volatility of the economic variables play an important role in the computation of the conditional welfare, as shown below.

2.4.4 The Welfare Measure

2.4.4.1 Conditional Welfare

In this study, I evaluate the welfare consequences of alternative exchange rate regimes. I depart from the usual practice of identifying the welfare measure with the unconditional expectation of lifetime utility because using unconditional expectations of welfare amounts to not taking into account the transitional dynamics leading to the stochastic steady state[22]. The conventional choice of unconditional expectation is usually due to its merit of computational simplicity. Following Schmitt-Grohe and Uribe (2004b), I assume that in the initial state all state variables are in their non-stochastic steady states, and that the exchange rate policies are evaluated by the conditional expectations of the discounted lifetime utility[23]. Because the deterministic steady state is the same across both exchange rate regimes I consider, my choice of computing expected welfare conditional on the initial state being the nonstochastic steady state ensures that the economy begins from the same initial point under all possible policies. Therefore, my strategy will deliver the constrained optimal exchange rate regime associated with a particular initial state of the economy. An additional advantage in this choice of

[22]According to Kim and Levin (2005), using a criterion of which the discount factor is set to unity is also equivalent to maximizing the unconditional welfare, since no discounting implies that only the events in the far future matter for welfare evaluations. Although it is inconsistent with private agents' behavior, the unconditional welfare criterion has been used since it is easy to compare different policy rules. Under this criterion, the transitional dynamics become irrelevant and the comparison does not depend on the initial conditions of the economy.

[23]It is of interest to investigate the robustness of my results with respect to alternative initial conditions. For, in principle, the welfare ranking of the alternative polices will depend upon the assumed value for (or distribution of) the initial state vector. For further discussion of this issue, see Kim et al. (2003) and Schmitt-Grohe and Uribe (2004c).

the initial state is that it can significantly simplify my welfare calculations: all terms containing state variables vanish in my approximation of expected lifetime utility.

To understand how the conditional expectation is calculated, here I follow the steps made by Wang (2006), who uses perturbation methods to solve his model. Let V_t be the conditional expectation of lifetime utility at time t

$$V_t \equiv E_t \left\{ \sum_{s-t}^{\infty} \beta^{s-t} U(c_s, h_s) \right\} \tag{2.31}$$

To find a second-order approximation of V_t, I can define V_t as a new control variable in my model. From equation (2.31), I can obtain that V_t follows a law of motion as in equation (2.32) below

$$V_t - \beta E_t\{V_{t+1}\} = U(c_t, h_t) \tag{2.32}$$

I can put equation (2.32) into my system of nonlinear dynamic equations (in 2.4.1.1 or 2.4.2.1, depending on the exchange rate regime) and find a second-order approximation of the solution to this control variable using my Matlab code, which is based on the ones developed by Schmitt-Grohe and Uribe's (2004c)[24]. The code implements a second-order perturbation method to solve the DSGE model. As it is well known, standard perturbation methods provide a Taylor expansion of the policy functions that characterize the equilibrium of the economy in terms of the state variables of the model and a perturbation parameter.

$$\begin{aligned} V_t = g(X_t, \sigma) \approx g(\bar{X}, 0) + (X_t - \bar{X})' g_x(\bar{X}, 0) + g_\sigma(\bar{X}, 0)\sigma \\ + \frac{1}{2}(X_t - \bar{X})' g_{xx}(\bar{X}, 0)(X_t - \bar{X}) + \frac{1}{2} g_{\sigma\sigma}(\bar{X}, 0)\sigma^2 \\ +(X_t - \bar{X})' g_{x\sigma}(\bar{X}, 0)\sigma \end{aligned} \tag{2.33}$$

Here X_t is the vector of state variables in my model, $\bar{X}$ is the deterministic steady-state of the state vector, and σ is a parameter scaling the standard deviation of the exogenous shocks. As stated by Fernandez-Villaverde and Rubio-Ramirez (2005), the fundamental idea of the perturbation methods is to set the perturbation parameter σ equal to zero (so that the model can be solved analytically) and to exploit the implicit function theorem in order to solve for the unknown coefficients in the Taylor-series expansion in a recursive fashion.

[24]Their Matlab programs for the second-order approximation method are available at Uribe's website.

Let $V \equiv g(\bar{X}, 0)$ be the non-stochastic steady state lifetime utility. Then, using equation (2.32) I obtain

$$V = \frac{U(\bar{c}, \bar{h})}{1-\beta} \tag{2.34}$$

I have supposed that at time t, all state variables are in the non-stochastic steady state, therefore $X_t = \bar{X}$. This helps me eliminate all terms containing $X_t - \bar{X}$. Furthermore, from Theorem 1 of Schmitt-Grohe and Uribe (2004c), I know $g_\sigma(\bar{X}, 0) = 0$ and $g_{x\sigma}(\bar{X}, 0) = 0$. Now I can obtain a second-order approximation of V_t in a very simple form

$$V_t = V + \frac{1}{2} g_{\sigma\sigma}(\bar{X}, 0)\sigma^2 \tag{2.35}$$

Clearly, if the initial state of the economy is the non-stochastic steady state, the calculation of conditional welfare is greatly simplified.

2.4.4.2 The Conditional Welfare Cost Measure

As the results on conditional welfare will show below, in my model one exchage rate policy dominates the other. In addition to that result, here I derive an expression that allows me to quantify the difference on welfare between the two exchange rate regimes. The algorithm stated below gives the percentage of the consumption of the "composite good"[25] stream associated with the flexible exchange rate that households are willing to give to be as well off under the flexible exchange rate as under the fixed exchange rate. Let c_t^A be the contingent plan for the consumption of the composite good associated with the flexible exchange rate regime and c_t^B be the contingent plan for consumption of the composite good associated with the fixed exchange rate. Then I can define the welfare cost of the flexible exchange rate regime rather than the fixed exchange rate regime as the value of λ^c such that

---

[25] By "composite good" I mean the combination of consumption and leisure that directly affects the level of period utility and thus welfare. In my model the composite good is given by $(c - \frac{h^\omega}{\omega})$. Even though it is traditional to measure welfare cost in terms of units of consumption goods, I argue that it is also valid to measure the welfare cost in terms of the particular combination of consumption goods and leisure (according to the particular utility function used) since this combination has a direct impact on the level of utility and thus on welfare in the economy.

$$V_t^B \equiv E_t \left\{ \sum_{t=0}^{\infty} \beta^t U\left((1-\lambda_c)c_t^A\right) \right\} \tag{2.36}$$

where c_t^A represents the value of the composite good in period t under the flexible exchange rate.

Remember that in my model, period utility (as a function of the composite good) under the flexible exchange rate is given by

$$U(c_t^A) = \frac{{c_t^A}^{1-\gamma} - 1}{1-\gamma} \tag{2.37}$$

Now notice that

$$U\left((1-\lambda_c)c_t^A\right) = (1-\lambda_c)^{1-\gamma} \left(\frac{{c_t^A}^{1-\gamma} - 1}{1-\gamma} \right) + \frac{(1-\lambda_c)^{1-\gamma} - 1}{1-\gamma} \tag{2.38}$$

Then it follows that

$$V_t^B = (1-\lambda_c)^{1-\gamma} V_t^A + \frac{(1-\lambda_c)^{1-\gamma} - 1}{(1-\gamma)(1-\beta)} \tag{2.39}$$

Now I use $V_t^A = g^A(x_t, \sigma)$ and $V_t^B = g^B(x_t, \sigma)$ to restate the above expression:

$$g^B(x_t, \sigma) = (1-\lambda_c)^{1-\gamma} g^A(x_t, \sigma) + \frac{(1-\lambda_c)^{1-\gamma} - 1}{(1-\gamma)(1-\beta)} \tag{2.40}$$

It follows that

$$\lambda_c = \Lambda(x_t, \sigma) \tag{2.41}$$

I want to find a second-order accurate approximation of Equations (2.39) and (2.40) around $(x_t, \sigma) = (\bar{x}, 0)$. After totally differentiating both expressions, evaluating both of them at $(x_t, \sigma) = (\bar{x}, 0)$ and applying a set of results found by Schmitt-Grohe and Uribe (2003), I obtain that the conditional welfare cost measure is given by

$$\lambda_c \approx \left[\frac{1-\beta}{\left(c - \frac{h^\omega}{\omega}\right)^{1-\gamma}} \right] \left(V_{\sigma\sigma}^A(\bar{x}, 0) - V_{\sigma\sigma}^B(\bar{x}, 0) \right) \frac{\sigma^2}{2} \tag{2.42}$$

The welfare cost λ_cx100 indicates the percentage of the consumption (of the composite good) stream associated with the flexible exchange rate that households are willing to give up to be as well off as under the fixed exchange rate regime.

2.4.4.3 Conditional Welfare Results

Table 2.7 below shows the results regarding the conditional welfare computed under alternative exchange rate regimes.

Table 2.7: Conditional Welfare

	C.W. Value
Flexible Rate	-38.3563
Fixed Rate	-38.3815
Welfare Cost	0.020%

From this table, it is clear that the conditional welfare associated with the flexible exchange rate regime is greater than that related to the fixed one. Therefore, the best exchange rate policy is the flexible one (alternatively, the flexible exchange rate dominates the fixed exchange rate). The result of the welfare cost (0.020%) is (as expected) consistent with the result from the direct conditional welfare comparison. Since the welfare cost is strictly positive[26], the welfare analysis clearly shows that the flexible exchange rate is superior to the fixed exchange rate. What explains this key result is that the fixed exchange rate regime creates an additional costly burden for the economy: First, under this regime, in the market for peso bonds, only the quantity of peso bonds can be adjusted, not its price (the interest rate in pesos r_t^p), and this adjustment is costly (due to the presence of quadratic portfolio adjustment costs). Secondly, since a fixed exchange rate makes the interest rate on peso bonds equal to that on dollar bonds, it follows that in practice the domestic economy will be able to issue only one type of bonds (which pays the interest rate on dollar bonds), and as it is well known, decreasing the number of assets traded internationally should reduce welfare (because it increases the degree of market incompleteness), as suggested by Benigno (2009)[27]. Thirdly, since under the fixed regime there is one less relative price (the interest rate in pesos), the rest of the variables of the model are forced to absorb the shocks, making

[26]It is a common result in the literature on welfare cost measurement that the computed values are small.

[27]In addition, one of the fundamental principles of modern portfolio theory states that, in order to obtain the best possible combination of risk and return on a portfolio of assets, an investor should add to his portfolio an asset whose return is not perfectly positively correlated to the return of any asset that composes the portfolio. Now, notice that in my model, under the flexible exchange rate, the interest rate on peso bonds is not correlated with the interest rate on dollar bonds, which is assumed to be constant.

the variables more volatile (that is, shocks are magnified), and thus increasing their associated uncertainty, which will in turn cause a loss of efficiency in the allocation of resources (both intratemporal and intertemporal); certainly, some of these variables are consumption and hours worked, which directly affect welfare. Overall, under the fixed exchange rate regime, following exogenous shocks to the economy, there will be a significant impact on consumption, hours, investment, the capital stock, output, and welfare.

2.4.5 Sensitivity Analysis

2.4.5.1 Alternative Preference Specification

My previous welfare analysis focused in GHH preferences, a preference specification that implies that the labor supply is unaffected by variations on household wealth. This type of preferences is commonplace in models of the small open economy. Nevertherless, it is of interest to investigate the extent to which the results reported above are robust to the introduction of preferences implying a wealth effect in labor supply. To this end, I consider a period utility function of the form

$$U(c_t, h_t) = \frac{\left[c_t^{\omega}(1-h_t)^{1-\omega}\right]^{1-\gamma} - 1}{1-\gamma}$$

Under these preferences, the marginal rate of substitution between consumption and leisure is given by

$$-\frac{U_h(c_t, h_t)}{U_c(c_t, h_t)} = \frac{1-\omega}{\omega}\frac{c_t}{1-h_t}$$

This marginal rate of substitution depends on the level of consumption, whereas the one implied by GHH preferences does not. I set the parameter ω at a value equal to 0.22 following Schmitt-Grohe and Uribe (2003).

The result regarding the welfare effects under the two alternative regimes is shown in Table 2.8 below.

Clearly, with this alternative period utility function specification, the flexible exchange rate regime is still superior to the fixed regime[28]: On one hand, the conditional

[28] The welfare cost λ_c under this specification for the utility function is given by $\lambda_c =$

Table 2.8: Conditional Welfare

	C.W. Value
Flexible Rate	10.4249
Fixed Rate	10.4175
Welfare Cost	0.023%

welfare under the flexible exchange rate regime is greater than that under fixed exchange rate regime; and, on the other hand, the welfare cost is strictly positive (0.023%).

2.5 Bayesian estimation using data from Singapore

Bayesian methods have become a powerful tool to conduct empirical research. This approach allows a researcher to incorporate prior information to his evaluation of theoretical models with the use of observed data. Using the posterior distributions for parameters, a researcher can use his model to perform policy analysis or forecast the dynamics of macroeconomic variables. In this section I pursue Bayesian analysis to estimate the parameters of the model under each of the exchange rate regimes using DYNARE and assuming GHH preferences.

Singapore is an East Asian developed economy that exports and imports goods and services in an amount greater than its total domestic production, that has had a managed floating exchange rate regime since early 1980's, and that has faced problems with currency substitution in the last years. Moreover, the current world economic crisis has been hitting its economy significantly: current estimates for its 2009 annual rate of growth indicate an economic contraction as large as 6.0 percent[29]. Certainly, the demand for its export goods from its main trade partners (including the US, Japan, Malaysia, and Hong Kong) has declined substantially. Regarding the degree of dollarization in Singapore, currency substitution has been a problem for a number of years, which explains in part why there was a debate in the country in the late 1990's about adopting official dollarization.

$\frac{1-\beta}{\omega\left[c^{\omega}(1-h)^{1-\omega}\right]^{1-\gamma}}(V^A_{\sigma\sigma} - V^B_{\sigma\sigma})\frac{\sigma^2}{2}$. In this opportunity, the welfare cost is measured in terms of units of consumption goods and not in terms of the "composite good". The particular specification for the utility function allows me to derive the relevant formula and compute the welfare cost in a more classic style.

[29] Figure reported in "The Economist" magazine, September 2009

2.5.1 The Data

The annual data on consumption, GDP, GDP deflator and population for Singapore (for the period 1960-2008) was obtained from the International Financial Statistics (IFS) website. The data on nominal consumption and nominal GDP was deflated using the GDP deflator, divided by the size of the population (in order to express the magnitudes in per capita terms since this is a representative-agent model), and detrended using the Hodrick and Prescott (1980, 1997) filter (the HP-filter hereafter)[30]. Incidentally, since I work with annual data, I used a smoothing parameter equal to 6.25 to apply the HP filter, which is the value proposed by Ravn and Uhlig (2002)[31]. Finally, the resulting GDP and consumption series were normalized such that the GDP series has a mean equal to one, and the mean of consumption series keeps its relative importance with respect to that of GDP (as the real per capita series for these two variables indicate).

2.5.2 Prior densities

The choice of my prior densities is based on the previously discussed calibration and also draws on the related literature. Both innovations's standard deviations have inverted-gamma distributions with mean equal to 0.02 and standard deviation equal to 1. The persistence parameters in the two AR(1) processes for the shocks are beta-distributed with mean equal to 0.5 and standard deviation equal to 0.15. The prior on the parameter α, which measures the capital's share of income, follows a normal distribution with mean equal to 0.32 and standard deviation equal to 0.1. The values for the size of the debt in both currencies in the steady state are beta distributed; the mean of the peso-debt is equal to 0.14 and that of the dollar-debt is equal to 0.076. The standard deviation of the peso debt is equal to 0.05, and that of the dollar debt is equal to 0.02. Both the capital adjustment cost and the price adjustment cost parameters follow a beta distribution with a mean equal to 0.028 and a standard deviation equal to 0.01. Both portfolio adjustment costs parameters follow a beta distribution with a mean equal to 0.00074 and a standard deviation equal to 0.0001. The CRRA parameter is normally distributed with mean equal to 2 and standard deviation equal to 0.5. The parameter

[30]The HP-filter was actually applied to the natural logarithms of the series.

[31]In contrast, a value of 100 for yearly data has been commonly used in the business cycle literature.

associated with the intertemporal elasticity of substitution in labor supply is normally distributed with mean equal to 1.455 and standard deviation equal to 0.5. The rate of depreciation has a beta distribution with mean equal to 0.1 and standard deviation equal to 0.03. The price elasticity of demand for a specific export good variety has a normal distribution with mean equal to -6 and standard deviation equal to 1.

2.5.3 Analysis of posterior estimates

Posterior densities result from 20,000 replications. As can be seen in Figures (6.5) - (6.6) in the Appendix, the posterior densities obtained from applying the Bayesian estimation using the model that assumes a flexible exchange rate regime are very similar to those obtained from applying the estimation using the model that assumes a fixed exchange rate regime. The analysis of the posterior estimates will be based on the results from the model that assumes a fixed exchange rate regime and concentrate in those results that deserve some especial attention.

The main results are summarized in Table (2.9) below. The persistence parameter of the technology process has a posterior mean equal to 0.44 and that related to the shock to exports has a posterior mean equal to 0.33, that is, the technology shock is more persistent than the shock to exports. These results are consistent with the results obtained from the forecast error variance decomposition (shown below): Even though the evolution of exports and the terms of trade in small open economies is key to explain their macroeconomic dynamics, the technology shock is still the main driving force of business cycles regarding both magnitude and persistence. With respect to the size of the debt in both domestic and foreign currency, their posterior means are consistent with a degree of dollarization of 50 percent, which is a reasonable value if one considers the share of foreign currency deposits in total deposits in Singapore's banking system[32]. With regards to the size of the total foreign debt (measured in dollars)[33], its (implied) posterior mean of 0.15 is consistent with an external debt to GDP ratio of 14.0

[32]According to the Monetary Authority of Singapore (its central bank), at the end of 2005 total deposits of non-bank customers in the domestic banking unit (which are largely S$-denominated deposits) were greater than $220 billion. In addition, foreign currency deposits in Singapore's banking system were about $270 billion.

[33]Total foreign debt is the sum of the dollar debt and the peso debt. The peso debt was converted into dollars using the steady state value of the exchange rate).

percent, which is a reasonable value for Singapore[34]. The capital's share of income has a posterior mean of 0.39, which is significantly higher than those in developed economies. Still, this estimated value is reasonable for Singapore: According to the document "The Income Approach to Gross Domestic Product", elaborated by the Ministry of Trade and Industry of Singapore, in 1997 the shares of profits, remuneration and indirect taxes in Singapore's GDP were 47.5, 42.7 and 10.3, respectively, while these shares in the USA were 34.5, 58.2 and 7.3, respectively. If one considers the "share of profits in GDP" as a proxy for the capital's share of income, then one could see the estimated value of 0.39 as being relatively consistent with what the government of Singapore's official statistics show. Regarding, the innovations's standard deviations, the estimates indicate a reasonable level of volatility in both technology and exports' shocks (close to 0.01 in both cases), and that the volatility of the technology shock is slightly smaller than that of the exports shock. Incidentally, even though Singapore is a dynamic economy, it has experienced economic contractions with regularity: It experienced recessions in 1985-1986, 2001, 2003 and 2009, and its GDP barely increased in 1998. Regarding the depreciation rate, its posterior mean is about 0.06, which is smaller than the standard value of 0.1 used in the literature; however, this value of 0.06 is consistent with the posterior mean of the capital's share of income (0.39) previously discussed, in the sense that in a (developed) country where capital plays a key role in the generation of output and income, a relatively low rate of depreciation contributes to the stock of capital's accumulation and maintenance. Regarding the estimated posterior means for the rest of parameters that have been estimated, the results indicate that the priors are plausible.

Therefore, the analysis of the posterior estimates allows me to conclude that the Bayesian estimation of the model, which uses data from Singapore, shows that the values of the fundamental parameters of the model used in the first part of this study (the analysis of a calibrated model) are plausible, which makes those results sound.

---

[34]According to the CIA World Factbook, this ratio is currently 14.1 percent of GDP. In addition, according to the OECD, between 1998 and 2002 this ratio fluctuated between 14 and 23 percent of GDP. However, it is important to mention that the Asian Development Bank reports figures according to which the ratio of external debt to GDP is significantly higher.

Table 2.9: Estimation Results

para-meter	prior mean	FIXED E.R. post. mean	FIXED E.R. confidence interval		FLEXIBLE E.R. post. mean	FLEXIBLE E.R. confidence interval		prior dist.	prior σ
α	0.32	0.3924	0.3336	0.466	0.3918	0.327	0.4576	norm	0.1
B	0.14	0.1376	0.0587	0.2071	0.1413	0.0652	0.2268	beta	0.05
B^*	0.076	0.0755	0.0445	0.1079	0.0744	0.043	0.1027	beta	0.02
ϕ	0.028	0.0281	0.0123	0.0416	0.0276	0.0121	0.0427	beta	0.01
ϕ_2	0.028	0.0279	0.0126	0.045	0.0272	0.0113	0.0419	beta	0.01
ρ	0.5	0.437	0.2421	0.6367	0.4239	0.2282	0.6295	beta	0.15
τ	0.5	0.3281	0.1708	0.4759	0.3344	0.183	0.4809	beta	0.15
ψ_2	0.001	0.0007	0.0006	0.0009	0.0007	0.0006	0.0009	beta	0.0001
ψ_3	0.001	0.0007	0.0006	0.0009	0.0007	0.0006	0.0009	beta	0.0001
γ	2	2.0193	1.2681	2.7767	2.0163	1.3034	2.7992	norm	0.5
ω	1.455	1.5869	0.9931	2.0222	1.5946	1.0331	2.1359	norm	0.5
δ	0.1	0.0587	0.0274	0.0834	0.0591	0.0284	0.0868	beta	0.03
η	-6	-5.2547	-6.9446	-3.6378	-5.2321	-6.8631	-3.2849	norm	1
σ_A	0.02	0.0098	0.0081	0.0115	0.0098	0.008	0.0116	invg	1
σ_X	0.02	0.01	0.0084	0.0115	0.01	0.0082	0.0115	invg	1

2.5.4 Optimal Exchange Rate Policy for Singapore using Bayesian estimates

Here I present and briefly discuss the results from the comparison of the welfare implications of the two alternatives exchange rate regimes for Singapore. To compute the welfare measures I used as values for the fundamental parameters of the model the posterior estimates for their means, which are shown in Table (2.9) in the previous section[35].

Table 2.10: Conditional Welfare

	C.W. Value
Flexible Rate	-41.2735
Fixed Rate	-41.3533
Welfare Cost	0.059%

It can be seen from the results shown in Table (2.10) above that the flexible exchange rate policy is the best monetary regime for Singapore, a country heavily engaged in international trade and that faces some problems with currency substitution. It follows that it is recommended for Singapore to have a flexible exchange rate regime. Incidentally, since 1981 Singapore has had a managed floating system, and presently

[35]In particular, I used the posterior means that result from the Bayesian estimation of the model under the fixed exchange rate regime, which are very similar to those obtained from the estimation of the model under the flexible exchange rate regime. The reader should remember that the previous Bayesian estimation was conducted with the model that assumes GHH preferences.

the Monetary Authority of Singapore (the central bank) manages the Singapore dollar against a basket of currencies of its main trading partners and competitors.

2.5.5 Forecast Error Variance Decomposition

The results obtained from this part of the analysis (see Table (2.11) below) show that in my model the shock to exports explains all the volatility of output and the level of exports, which is what one should expect to happen in an economy that is heavily engaged in international trade, such as Singapore, which actually exports goods and services for an amount greater than its total domestic production. Regarding the technology shock, more than 58 percent of the volatility of consumption, hours worked and profits is explained by this shock, and more than 69 percent of the volatility of investment and the stock of capital is also explained by this shock. Overall, the technology shock is the main driving force in this small open economy, but the shock to exports plays also an important role in determining the dynamics of its macroeconomic variables.

Table 2.11: Variance Decomposition (%)

Variables	FIXED E.R.		FLEXIBLE E.R.	
	σ_A	σ_X	σ_A	σ_X
A_t	100	0	100	0
B_{t+1}	61.95	38.05	59.81	40.19
B^*_{t+1}	61.95	38.05	59.81	40.19
c_t	61.3	38.7	59.82	40.18
R_t	58.73	41.27	23.51	76.49
h_t	59.49	40.51	59.31	40.69
i_t	71.39	28.61	69.31	30.69
k_t	74.84	25.16	72.27	27.73
λ_t	62.05	37.95	59.9	40.1
μ_t	75.25	24.75	75.46	24.54
p_t	79.86	20.14	n.a.	n.a.
p^*_t	79.86	20.14	79.68	20.32
π_t	58.93	41.07	58.72	41.28
R^p_t	n.a.	n.a.	73.71	26.29
s_t	n.a.	n.a.	79.68	20.32
V_t	62.05	37.95	59.9	40.1
w_t	59.49	40.51	91.01	8.99
X_t	0	100	0	100
y_t	0	100	0	100

2.6 Conclusions

In this paper I use a novel approach to study the welfare implications of alternative exchange rate regimes in a small open economy with a high degree of dollarization: a dynamic stochastic general equilibrium model with endogenous dollarization. In my model infinitely-lived households finance consumption, investment and debt repayment by issuance of short-term bonds denominated in both domestic (pesos) and foreign currency (dollars). Thus, the optimal currency composition of households' portfolios of liabilities is adjusted every period in response to the economy's performance. In turn, imperfectly competitive domestic firms set the dollar price of exports every period taking into account current technology and demand conditions. The economy can be affected by two shocks that follow independent stochastic processes, a technology shock and a (level of) exports shock. Finally, the government chooses the exchange rate regime (fixed or flexible), and then defends the nominal anchor (the pegged value of the exchange rate or the peso price of domestic exports, depending on the chosen regime). The most important finding in my study is that the flexible exchange rate regime is the best policy in terms of providing a greater level of (conditional) welfare to the domestic economy than that provided by the fixed exchange rate regime. What explains this key result is that the fixed exchange rate regime creates an additional costly burden for the economy: First, under this regime, in the market for peso bonds, only the quantity of peso bonds can be adjusted, not its price (the interest rate in pesos r_t^p), and this adjustment is costly (due to the presence of quadratic portfolio adjustment costs). Secondly, since a fixed exchange rate makes the interest rate on peso bonds equal to that on dollar bonds, it follows that in practice the domestic economy will be able to issue only one type of bonds (which pays the interest rate on dollar bonds), and as it is well known, decreasing the number of assets traded internationally should reduce welfare (because it increases the degree of market incompleteness), as suggested by Benigno (2009). Thirdly, since under the fixed regime there is one less relative price (the interest rate in pesos), the rest of the variables of the model are forced to absorb the shocks, making the variables more volatile (that is, shocks are magnified), and thus increasing their associated uncertainty, which will in turn cause a loss of efficiency in the allocation of resources (both intratemporal and intertemporal); certainly, some of these variables are consumption and hours worked, which directly affect welfare. Overall, under the fixed exchange rate regime, following exogenous shocks to the economy, there will be a significant impact on consumption, hours, investment, the capital stock, output, and welfare.

The main result in my paper is consistent with the conventional wisdom, which states that for economies mainly affected by real shocks, it is recommended to have a flexible exchange rate regime. Another important result is that the model replicates some stylized facts for emerging economies. In particular, regarding volatility, consumption is more volatile than output, investment is more volatile than consumption, and capital is less volatile than output; regarding comovements, consumption, investment, hours, and capital are all procyclical. Moreover, another important finding is that the main result of my model is consistent with the contributions made by Frankel (2003, 2005): for an emerging economy that is actively engaged in international trade, pegging the peso price of domestic exports PEP is a desirable exchange rate regime (in my model, the flexible exchange rate regime assumes that the nominal anchor is the peso price of domestic exports). Furthermore, the results of my model are robust, since a change in the utility function (from one that implies that the labor supply is unaffected by variations on household wealth to one that implies a wealth effect in labor supply) does not affect the ranking of the exchange rate regimes: the flexible exchange is the best policy. Finally, the Bayesian estimation of the model (which uses data from Singapore) shows that (i) the values of the fundamental parameters of the model used in the first part of this study (the analysis of a calibrated model) are plausible, which makes those results sound, and (ii) a fixed exchange rate regime is not recommended for Singapore (which actually has had a a managed floating system since 1981).

Chapter 3

Endogenous Dollarization and Optimal Exchange Rate Policy: The Role of Non-tradable Goods

3.1 Introduction

The current international economic and financial crisis has had a number of adverse effects on all countries around the world. Some of them have been a significant outflow of capital, a depreciation of the domestic currency, a fall of exports, and a contraction of the economy. In particular, countries such as Argentina, Brazil and Mexico have experienced a significant depreciation of their respective currencies since the outset of the present world crisis.

And given the still high level of uncertainty (especially regarding the pace of the economic recovery in the short and medium term) in the world economy and its particular implications on the volatility of the exchange rate, emerging economies have to address a key question: To float or not to float? Following the abandonment of the Bretton Woods accord, most countries in the world have decided to let their currencies float. However, most of these countries actually have a managed floating exchange rate regime, that is, one in which the central bank will intervene the foreign exchange market in order to affect the domestic price of the foreign currency. As highlighted by Chang (2005) and other authors, the dollarization of liabilities explains why central banks are concerned with "undesired" fluctuations on the exchange rate[1] and the potential balance sheet effects. Balance sheet effects refer to the adverse economic and/or financial impact on firms and individuals that follows a depreciation of the domestic currency in economies in which a significant amount of debt is denominated in foreign

[1]It is well understood and documented that economies become dollarized during episodes of high inflation. However, disinflations are not necessarily followed by dedollarization. In particular, Argentina, Bolivia, Peru, Russia, Ukraine and other countries have remained highly dollarized long after the inflation rate was brought down to single digits. Peru is a remarkable case: During the last 16 years it has had a dollarization ration greater than 45 percent even though during the last 12 years it has had a one-digit inflation rate.

currency while most income is generated in domestic currency[2]. Thus, since depreciation of the domestic currency could be particularly dangerous for highly-dollarized small open economies, governments evaluate alternative exchange rate regimes to that of a pure floating exchange. Recent adoptions of exchange rate regimes alternative to the flexible one, like in Argentina and Ecuador[3] confirm the huge importance that the exchange rate regime has for governments' economic and political stability and viability (and for the economies themselves) in economies characterized by a high degree of dollarization. This paper contributes to the debate on optimal exchange rate regime for emergent economies by showing, with the help of a straightforward dynamic model, that the flexible exchange rate regime that pegs the domestic-currency price of exports is the best policy, which is a result consistent with the conventional wisdom.

In previous papers, like in Ize and Levy-Yeyati (2003), the effect of dollarization on the economic performance of countries and other related issues have been studied using portfolio models and other similar approaches. In addition, some of these studies have assumed that the degree of dollarization is exogenously given, like in Moron and Castro (2003). This paper studies this problem using an alternative approach: The stochastic dynamic general equilibrium model. In this study, under three different alternative exchange rate regimes, I analyze how real exogenous shocks to a small open economy affect the optimal currency composition of its portfolio of liabilities, which is determined endogenously by the model, and thus how much the overall economy is ultimately affected. In order to do so, I build a model of a small open economy with an incomplete menu of assets: domestic residents can only borrow internationally using short-term bonds denominated in domestic currency (here pesos) or foreign currency (here dollars). In addition, the small open economy with an endogenous degree of dollarization is inhabited by households, firms and a government. Households live infinite periods and accumulate capital partly financed with the sale of one-period bonds denominated in both domestic currency (here pesos) and foreign currency (here dollars). Uncertainty in my model is given by two shocks that follow independent

[2]According to Ize and Levy-Yeyati (2003), many emergent economies facing dollarization have tried to eliminate it by implementing disinflationary policies, but most of them have been unsuccessful. They state that the main reason for that result is that dollarization levels can remain high if the expected volatility of the inflation rate is high in relation to the expected volatility of the real exchange rate.

[3]While Argentina had a currency board between 1991 to 2002, Ecuador and Salvador adopted official dollarization in 2000 and 2001, respectively.

exogenous processes: A technology shock to output A_t and a random level (volume) of domestic exports X_t[4].

Authors have identified characteristics of business cycles in emerging economies that distinguish them from business cycles in industrialized economies. A couple of these characteristics are as follows: (1) business cycles are more volatile in emerging economies, and (2) emerging economies are susceptible to additional sources of volatility, such as terms of trade fluctuations[5]. In many emerging economies, exports are characterized by a high concentration in a small number of commodities whose world prices are very volatile[6]. Also, their fiscal revenues tend to be largely dependent on the prices of the main export commodities, and so the stance of their public finances is vulnerable to major changes in the world prices of export goods. In my model, shocks to the level (volume) of exports will cause (ceteris paribus) a change in the terms of trade of the economy because domestic export firms are assumed to have some monopolistic power in the (foreign) market for their goods.

Additionally, the model features convex portfolio adjustment costs for both peso and dollar bonds in order to induce stationarity of the equilibrium dynamics. This stationarity inducing technique has been used, among others, in recent papers by Neumeyer and Perri (2001) and Schmitt-Grohe and Uribe (2003). In this model, the cost of increasing asset holdings by one unit is greater than one because it includes the marginal cost of adjusting the size of the portfolio[7].

In order to compare the three exchange regimes' outcomes that result from exogenous shocks, I solve the model for the decentralized economy, that is, I solve the problems of both households and firms independently. All variables are in per capita

---

[4]As explained below, domestic firms are assumed to have some monopolistic power in world markets and thus face a downward sloping demand curve; therefore, a shock to the level of exports will have an effect on the terms of trade.

[5]The literature on small open economies recognizes the terms of trade shocks as one of the most relevant shocks affecting these economies. See, for instance, Mendoza (1995), Kose (2002), and Broda (2003). Mendoza (1995) finds that terms of trade disturbances explain 56 percent of aggregate output fluctuations in developing countries.

[6]According to UNCTAD, in 1995, 57 developing countries depended on three commodities for more than half of their exports.

[7]To be more specific, and as will become more clear below, in my model households will have to pay a "fee" in terms of lost output if their transactions in the international asset market lead to deviations from some long-run (steady state) level.

terms (i.e., there is no population growth). Moreover, since a small open economy is analyzed, the domestic (dollar) interest rate equals the world (dollar) interest rate, which in turn is assumed to be exogenously given. This assumption greatly simplifies the analysis. I write a Matlab code in order to compute the impulse response functions, the moments for the endogenous variables in the model, the conditional welfare, and other relevant statistical information. The code is based on those provided by Schmitt-Grohe and Uribe (2003, 2004a, 2004c).

It is important to mention that Frankel (2003) suggests that pegging the export price (PEP) is a monetary regime that can be applied to countries that are specialized in the production of a particular agricultural or mineral commodity. PEP proposes fixing the price of the single commodity in terms of local currency (here, pesos). It has been objected that PEP is inappropriate for countries where diversification of exports is an issue. For such countries the modified version, PEPI, developed by Frankel (2005), proposes fixing the price of a comprehensive index of export prices. According to Frankel (2005), in either version of the monetary regime (PEP or PEPI), one advantage is that the domestic currency depreciates automatically when the world market for the country's exports deteriorates. This depreciation will certainly help the economy reduce the negative effects of the weak exports market conditions.

In the model that is developed in this paper, a nontraded sector produces differentiated goods that will be part of the consumption basket of the representative agent of the economy (the other part of the basket is composed of differentiated imported goods). A number of studies introduce nontradable goods into a model in order to measure the contribution of the relative price of nontradable to tradable goods to the volatility of the real exchange rate, which is a key determinant of the level of competitiveness of an economy (see for instance Burstein, Eichembaun and Rebelo, 2005). The introduction of nontradables into this model will allow me to compare the fixed exchange rate regime and the monetary regime suggested by Frankel (2003 and 2005) to the traditional flexible exchange rate regime, in which the nominal anchor is the consumer price index.

Furthermore, following the recommendations given by Kim et al. (2003), the exchange rate policies in my paper are evaluated in terms of conditional expected welfare instead of the unconditional one. Thus, the object that exchange rate policy aims to maximize in my study is the expectation of lifetime utility of the representative household conditional on a particular initial state of the economy. In contrast, many existing normative evaluations of monetary policy rank policies based upon unconditional expectations of utility. As Kim et al. (2003) point out, unconditional welfare measures ignore the welfare effects of transitioning from a particular initial state to the stochastic steady state induced by the policy under consideration. By using conditional welfare, I highlight the fact that transitional dynamics matter for policy evaluation.

In the last part of the present study I pursue Bayesian analysis using data from Peru to estimate the parameters of my DSGE model. As previously mentioned, Peru has experienced a very high level of dollarization for more than 16 years; the persistency of this problem makes Peru a very good candidate to pursue an empirical analisys of optimal exchange rate policies with my model. Incidentally, Bayesian methods have become a powerful tool to conduct empirical research. This approach allows a researcher to incorporate prior information to his evaluation of theoretical models with the use of observed data. Using the posterior distributions for parameters, a researcher can use his model to perform policy analysis or forecast the dynamics of macroeconomic variables. My work in this section is conducted with the help of DYNARE, a computational toolbox for the study of DSGE models.

Finally, the most important finding in my study is that pegging the peso price of exports is the best policy in terms of providing a greater level of (conditional) welfare to the domestic economy than the ones provided by the fixed exchange rate regime and the flexible exchange rate regime that has the CPI as nominal anchor. One of the key reasons behind this result is that the fixed exchange rate regime creates an additional costly burden to the economy: under this regime, in the market for peso bonds, only the quantity of peso bonds can be adjusted, not its price (the interest rate in pesos), and this adjustment is costly. As a result, following exogenous shocks to the economy, there will be a significant impact on investment, the capital stock, output, and welfare. Regarding the reasons behind the result that pegging the peso price of exports is a better regime than CPI targeting, the main reason is that an exogenous adverse shock to the price of imports creates an upward pressure on the CPI, which is neutralized by a contractionary monetary policy (under CPI targeting), which in turn affects the level of welfare. This policy response is absent under pegging the peso price of exports, the policy recommended by Frankel (2003, 2005). It is also worth mentioning that the Bayesian analysis of my model allows me to conclude that the best monetary regime for Peru is pegging the peso price of exports, since this regime delivers the greatest level of welfare.

The paper is structured as follows. The next section outlines the basic model, and section 3 discusses the calibration of the parameters of the model. Section 4 explains how the model is solved under each alternative exchange rate regime, discusses the resulting impulse response functions, and makes a comparison of the dynamics of the model and welfare effects under the alternative exchange rate regimes. Section 5 uses Bayesian estimation to evaluate the model for the Peruvian economy, a country that has had a degree of dollarization above 45 percent for more than 16 years. Finally, section 6 concludes.

3.2 The Model

Consider a small open economy populated by a large number of identical households, monopolistically competitive firms and a government. There are two sectors of production in the domestic economy: The non-tradable sector and the exports sector. In addition, there are imports firms with monopolistic power. I develop an infinite-horizon production economy with imperfectly competitive product markets and sticky prices.

3.2.1 The Household's Problem

Each household has preferences defined over processes of consumption and leisure and described by the utility function

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \right\} \tag{3.1}$$

where c_t denotes a composite consumption index to be defined below, h_t denotes labor effort, $\beta \in (0, 1)$ denotes the subjective discount factor, and E_t denotes the mathematical expectation operator conditional on information available in period t. The single period utility function U is assumed to be increasing in consumption, decreasing in effort, strictly concave, and twice continuously differentiable.

The composite consumption index c_t is a CES function of consumption of non-traded goods $c_{N,t}$ and imported goods $c_{M,t}$:

$$c_t = \left[a^{\frac{1}{\theta}} c_{N,t}^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} c_{M,t}^{\frac{\theta-1}{\theta}} \right]^{\frac{\theta}{\theta-1}}$$

where $a \in (0,1)$ denotes the share of non-tradable goods in the consumption basket, and $\theta > 0$ is the elasticity of substitution between non-tradables and imported goods.

Note that the consumer price index (CPI) p_t associated with the consumption basket c_t is given by[8]

$$p_t = \left[a p_{N,t}^{1-\theta} + (1-a) p_{M,t}^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{3.2}$$

where $p_{N,t}$ and $p_{M,t}$ represent the prices of non-tradable goods and imported goods, respectively.

The demands for $c_{N,t}$ and $c_{M,t}$ by domestic households (derived by maximizing the level of the consumption composite index subject to a given level of total expenditure) are therefore given by

$$c_{N,t} = a \left(\frac{p_{N,t}}{p_t} \right)^{-\theta} c_t \tag{3.3}$$

$$c_{M,t} = (1-a) \left(\frac{p_{M,t}}{p_t} \right)^{-\theta} c_t \tag{3.4}$$

Moreover, the consumption index for non-tradable and imported goods is given by

$$c_{N,t} = \left(\int_0^1 c_{N,t}(i)^{\frac{\lambda_n - 1}{\lambda_n}} di \right)^{\frac{\lambda_n}{\lambda_n - 1}} \tag{3.5}$$

$$c_{M,t} = \left(\int_0^1 c_{M,t}(i)^{\frac{\lambda_m - 1}{\lambda_m}} di \right)^{\frac{\lambda_m}{\lambda_m - 1}} \tag{3.6}$$

where $c_{N,t}(i)$ and $c_{M,t}(i)$ denote the consumption of each individual differentiated non-tradable and imported good, respectively, and $\lambda_n > 1$ and $\lambda_m > 1$ represent the elasticities of substitution among varieties of the non-traded and imported goods, respectively.

Besides, each firm i in the monopolistically competitive market for non-traded and imported goods will face individual demand functions for the goods they produce[9], which are given by

$$c_{N,t}(i) = \left(\frac{p_{N,t}(i)}{p_{N,t}} \right)^{-\lambda_n} c_{N,t} \tag{3.7}$$

[8] This is the resulting cost-minimizing price of a unit of the consumption composite good.

[9] These demand functions result from households' maximization of the level of consumption subject to a given level of expenditure.

$$c_{M,t}(i) = \left(\frac{p_{M,t}(i)}{p_{M,t}}\right)^{-\lambda_m} c_{M,t} \tag{3.8}$$

where $p_{N,t}(i)$ and $p_{M,t}(i)$ denote the price of each individual differentiated non-tradable and imported good, respectively.

Moreover, the prices of non-tradable and imported goods are given by an aggregator of the individual prices that each of the firms i will be able to charge according to its monopolistic power in its respective market:

$$p_{N,t} = \left(\int_0^1 p_{N,t}(i)^{1-\lambda_n} di\right)^{\frac{1}{1-\lambda_n}} \tag{3.9}$$

$$p_{M,t} = \left(\int_0^1 p_{M,t}(i)^{1-\lambda_m} di\right)^{\frac{1}{1-\lambda_m}} \tag{3.10}$$

For simplicity, I will assume that the two previous elasticities of substitution are equal to some value λ_D, that is, $\lambda_n = \lambda_m = \lambda_D$.

Continuing with the analysis of the household's problem, each household can hold physical capital, k_t, whose law of motion is given by

$$k_{t+1} = (1-\delta)k_t + i_t - \phi(k_{t+1}, k_t) \tag{3.11}$$

where $\delta \in (0,1)$ denotes the constant rate of depreciation of the capital stock, i_t is (gross) investment, and $\phi(k_{t+1} - k_t)$ is a measure of capital adjustment costs.

Capital adjustment costs have many explanations. Changing the level of capital services at a business generates disruption costs during installation of any new or replacement capital and costly learning must be incurred as the structure of production may have been changed. Moreover, installing new equipment or structures often involves delivery lags and time to install or build. The irreversibility of many projects caused by a lack of secondary markets for capital goods acts as another form of adjustment cost. It is assumed that $\phi(0) = \phi'(0) = 0$. Small open economy models typically include capital adjustment costs to avoid excessive investment volatility in response to shocks to the domestic economy. Thus, I introduce capital adjustment costs, as in Schmitt-Grohe and Uribe (2006), to avoid the excess volatility of investment that typically arises in small open economy models.

Every period, in order to finance current consumption c_t, investment i_t and foreign debt repayment, domestic households can issue one-period bonds denominated in both domestic currency ("peso bonds" B_{t+1}) and foreign currency ("dollar bonds" B^*_{t+1}). The domestic economy borrows from the world financial market, represented by a continuum of risk-neutral lenders. A peso-bond is a promise to pay a principal plus an interest r^p_t in pesos after one period[10]. In turn, dollar-bonds are promises to pay a principal plus an interest r_t in dollars after one period. Peso bonds and dollar bonds are sold for one peso and one dollar, respectively. The representative household's optimal borrowing decisions determine the degree of "dollarization" in the economy, which will be influenced by his expectations about equilibrium prices and the exchange rate.

The representative household's period-by-period (dollar) budget constraint is given by

$$\begin{aligned}\frac{B_{t+1}}{s_t} + B^*_{t+1} + \pi_t + \frac{w_t h_t}{s_t} + \frac{R_t k_t}{s_t} &= \frac{p_t}{s_t}(c_t + i_t) + \frac{R^p_t B_t}{s_t} + R^*_t B^*_t \\ &+ \frac{p_t}{s_t}\frac{\psi_2}{2}(B^*_{t+1} - B^*)^2 + \frac{p_t}{s_t}\frac{\psi_3}{2}(B_{t+1} - B)^2\end{aligned} \tag{3.12}$$

where the left hand side of the equality represents all the sources of income for the representative household, while the right hand side represents all the possible uses of that income. Both sides of the above expression are expressed in dollars. I assume that the composite consumption good can be used for either consumption c_t or investment i_t; thus, they have the same price. The nominal wage rate and the rental rate of capital are represented by w_t and R_t, respectively. In addition, s_t is the nominal exchange rate.

I assume that there are portfolio adjustment costs associated with the issuance of debt, both in pesos and in dollars. In this model, stationarity is induced by assuming that agents face convex costs of holding assets in quantities different from some long-run level. Portfolio adjustment costs for the issuance of peso and dollar bonds are given, respectively, by the following expressions

$$\frac{\psi_3}{2}(B_{t+1} - B)^2$$

and

$$\frac{\psi_2}{2}(B^*_{t+1} - B^*)^2$$

where B and B^* are the steady state values of peso and dollar bonds, respectively. Clearly, in the steady state portfolio adjustment costs are zero.

[10]The present model makes use of gross interest rates on both pesos and dollar bonds (R^p_t and R^*_t, respectively. Notice that $R^p_t = 1 + r^p_t$ and $R^*_t = 1 + r_t$.

In addition, notice that total (dollar) profits π_t equals the profits generated in each of the three sectors of the economy, that is:

$$\pi_t = \pi_{N,t} + \pi_{M,t} + \pi_{X,t} \tag{3.13}$$

where $\pi_{N,t}$, $\pi_{M,t}$, and $\pi_{X,t}$ represent the (dollar) profits generated by non-traded, imports, and exports firms, respectively.

I asume that, because of no arbitrage, the expected gross rate of return on peso bonds (the expected gross interest rate on peso bonds) $E_t\{R^p_{t+1}\}$ equals the expected peso gross rate of return on world assets, that is,

$$E_t\left\{R^p_{t+1}\right\} = E_t\left\{R^*_{t+1}\left(\frac{s_{t+1}}{s_t}\right)\right\} \tag{3.14}$$

In addition, households are subject to a borrowing constraint that prevents them from engaging in Ponzi schemes.

Furthermore, I assume a GHH specification for the period utility function mentioned above following Mendoza (1991)[11]; in particular,

$$U(c_t, h_t) = \frac{\left(c_t - \frac{h_t^\omega}{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

where γ is the coefficient of relative risk aversion, and ω is one plus the inverse of the intertemporal elasticity of substitution in labor supply.

Additionally, I assume a specific functional form for the implicit capital adjustment costs function mentioned above following Mendoza (1991); in particular,

$$\phi(k_{t+1}, k_t) = \frac{\phi}{2}(k_{t+1} - k_t)^2$$

where ϕ is the capital adjustment cost parameter.

The household chooses the set of processes $\{c_t, h_t, k_{t+1}, i_t, B_{t+1}, B^*_{t+1}\}_{t=0}^{\infty}$ and some borrowing limit that prevents it from engaging in Ponzi-type schemes so as to maximize (3.1) subject to (3.11), (3.12) and (3.14), taking as given the set of processes for $\{\pi_t, R^p_t, R^*_t, w_t, R_t, s_t\}_{t=0}^{\infty}$ and the initial conditions k_0, B_0, and B^*_0.

---

[11]The benchmark utility function (GHH) is a generalized version of quasi-linear utility, first introduced into the real business cycle literature by Greenwood, Hercowitz and Huffman (1988). GHH preferences have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period.

Let the multiplier on the flow budget constraint (3.12) be $\lambda_t \beta^t s_t / p_t$. Then the first-order conditions of the household's maximization problem are (3.11), (3.12) and (3.14) holding with equality and

$$\lambda_t = \left(c_t - \frac{h_t^{\omega}}{\omega} \right)^{-\gamma} \tag{3.15}$$

$$\lambda_t \frac{w_t}{p_t} = \lambda_t h_t^{\omega - 1} \tag{3.16}$$

$$\lambda_t \left[1 + \phi(k_{t+1} - k_t) \right] = \beta E_t \left[\lambda_{t+1} \left(\frac{R_{t+1}}{p_{t+1}} + (1 - \delta) + \phi(k_{t+2} - k_{t+1}) \right) \right] \tag{3.17}$$

$$\lambda_t \left[\frac{1}{p_t} - \psi_3(B_{t+1} - B) \right] = \beta E_t \left[\lambda_{t+1} \left(\frac{R_{t+1}^p}{p_{t+1}} \right) \right] \tag{3.18}$$

$$\lambda_t \left[\frac{s_t}{p_t} - \psi_2(B_{t+1}^* - B^*) \right] = \beta E_t \left[\lambda_{t+1} R_{t+1}^* \frac{s_{t+1}}{p_{t+1}} \right] \tag{3.19}$$

The interpretation of the first order conditions above are as follows: Equation (3.15) defines the marginal utility of consumption. Equation (3.16) states that in equilibrium the representative household must be indifferent between enjoying an additional hour of leisure and enjoying the additional units of consumption that it will afford to buy by working one more hour. Equation (3.17) states that in equilibrium, the representative household must be indifferent between consuming an additional unit of good, and investing that additional unit and then consuming the goods that he could buy with the revenues from the investment, net of depreciation. Equation (3.18) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of peso bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more peso bond must equal the discounted value of the marginal utility of consumption lost from the repayment of the unit of peso bond. Equation (3.19) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of dollar bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more dollar bond must equal the discounted value of the marginal utility of consumption lost from the repayment of the unit of dollar bond, including the interest on that additional debt.

3.2.2 The Firms' Problems

3.2.2.1 The Non-tradable Sector Firms' Problems

Each domestic non-tradable firm is the monopolistic producer of one variety of non-tradable goods. The non-tradable firm's output is given by

$$\tilde{y}_{N,t} = A_t F(\tilde{k}_{N,t}, \tilde{h}_{N,t}) - \phi_2(\tilde{p}_{N,t}, \tilde{p}_{N,t-1})$$

I follow Rotemberg (1982) and introduce sluggish price adjustment by assuming that the firm faces a resource cost that is quadratic in the inflation rate of the good it produces:

$$Price\ adjustment\ cost = \frac{\phi_2}{2}\left(\frac{\tilde{p}_{N,t}}{\tilde{p}_{N,t-1}} - 1\right)^2$$

The parameter ϕ_2 measures the degree of price stickiness. The higher is ϕ_2 the more sluggish is the adjustment of nominal prices. If $\phi_2 = 0$, then prices are flexible. The assumption of quadratic adjustment costs implies that firms change their price every period in the presence of shocks, but will adjust only partially towards the optimal price the firm would set in the absence of adjustment costs. As with any type of quadratic adjustment cost, a firm prefers a sequence of small adjustments to very large adjustments in a given period.

As pointed out by Rotemberg (1982), Barro (1972), and Mussa (1976), among others, changing prices is costly for two reasons: First, there is the administrative cost of changing the price lists, informing dealers, etc. Secondly, there is the implicit cost that results from the unfavourable reaction of customers to large prices changes. While the administrative cost is a fixed cost per price change, the second cost can be a different function of the magnitude of the price change. In particular, customers may well prefer small and recurrent price changes to occasional large ones. This is what is assumed implicitly by Rotemberg (1982), when he makes the costs to changing prices a function of the square of the price change.

The monopolist sets the peso price of the good it supplies $\tilde{p}_{N,t}$ taking the level of aggregate demand for non-traded goods as given, and is constrained to satisfy demand at that price; that is,

$$A_t F(\tilde{k}_{N,t}, \tilde{h}_{N,t}) - \phi_2(\tilde{p}_{N,t}, \tilde{p}_{N,t-1}) \geq \left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D} C_{N,t} \tag{3.20}$$

(Dollar) Profits for a non-traded good producing firm are given by

$$\tilde{\pi}_{N,t} = \frac{\tilde{p}_{N,t}}{s_t}\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D} C_{N,t} - \frac{w_t \tilde{h}_{N,t}}{s_t} - \frac{R_t \tilde{k}_{N,t}}{s_t} \tag{3.21}$$

In addition, I assume a Cobb-Douglass specification for the implicit production function mentioned above following Mendoza (1991); in particular,

$$F(k_{N,t}, h_{N,t}) = k_{N,t}^{\alpha} h_{N,t}^{1-\alpha}$$

Since the firm is owned by the representative household, it is natural to assume that the intertemporal marginal rate of substitution can be used to discount future profits. Let me define the stochastic discount Γ_{t+1} factor as follows:

$$\Gamma_{t+1} = \beta \frac{\lambda_{t+1} s_{t+1} p_t}{\lambda_t s_t p_{t+1}}$$

with Γ_0=1.

Let the multiplier on the demand and supply equilibrium condition (3.20) be $\tilde{\mu}_{N,t}\Gamma_t\frac{\tilde{p}_{N,t}}{s_t}$; then the firm will maximize the following expression:

$$\begin{aligned}\mathcal{L} = E_t\left\{\sum_{t=0}^{\infty}\Gamma_t\left[\frac{\tilde{p}_{N,t}}{s_t}\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D} C_{N,t} - \frac{w_t \tilde{h}_{N,t}}{s_t} - \frac{R_t \tilde{k}_{N,t}}{s_t}\right]\right\} \\ + E_t\left\{\sum_{t=0}^{\infty}\tilde{\mu}_{N,t}\Gamma_t\frac{\tilde{p}_{N,t}}{s_t}\left[\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D} C_{N,t} - A_t F(\tilde{k}_{N,t}, \tilde{h}_{N,t}) + \phi_2(\tilde{p}_{N,t}, \tilde{p}_{N,t-1})\right]\right\}\end{aligned} \tag{3.22}$$

taking as given the processes for $\{A_t, C_{N,t}, w_t, R_t, p_{N,t}, s_t, p_t\lambda_t\}_{t=0}^{\infty}$.

As a result of the profit maximization process, input demands and non-tradable's prices must satisfy the following efficiency conditions:

$$R_t = -\tilde{\mu}_{N,t}\tilde{p}_{N,t}A_t\alpha\tilde{k}_{N,t}^{\alpha-1}\tilde{h}_{N,t}^{1-\alpha} \tag{3.23}$$

$$w_t = -\tilde{\mu}_{N,t}\tilde{p}_{N,t}A_t\tilde{k}_{N,t}^{\alpha}(1-\alpha)\tilde{h}_{N,t}^{-\alpha} \tag{3.24}$$

$$\begin{aligned}
&\left\{\left(\frac{1}{s_t}\right)\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D} C_{N,t} - \frac{\tilde{p}_{N,t}}{s_t}\lambda_D\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D-1}\left(\frac{1}{p_{N,t}}\right)C_{N,t}\right\}+\\
&\tilde{\mu}_{N,t}\left\{\frac{1}{s_t}\left[\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D} C_{N,t} - A_tF(\tilde{k}_{N,t},\tilde{h}_{N,t}) + \phi_2(\tilde{p}_{N,t},\tilde{p}_{N,t-1})\right]\right.\\
&\left.+\tilde{\mu}_{N,t}\frac{\tilde{p}_{N,t}}{s_t}\left[-\lambda_D\left(\frac{\tilde{p}_{N,t}}{p_{N,t}}\right)^{-\lambda_D-1}\left(\frac{1}{p_{N,t}}\right)C_{N,t} + \phi_2\left(\frac{\tilde{p}_{N,t}}{\tilde{p}_{N,t-1}}-1\right)\left(\frac{1}{\tilde{p}_{N,t-1}}\right)\right]\right\}\\
&= E_t\left\{\tilde{\mu}_{N,t+1}\Gamma_{t+1}\frac{\tilde{p}_{N,t+1}}{s_{t+1}}\phi_2\left(\frac{\tilde{p}_{N,t+1}}{\tilde{p}_{N,t}}-1\right)\left(\frac{\tilde{p}_{N,t+1}}{\tilde{p}_{N,t}^2}\right)\right\}
\end{aligned} \tag{3.25}$$

3.2.2.2 The Import Sector Firms' Problems

The domestic monopolist importer sets the peso price of the imported good it supplies $\tilde{p}_{M,t}$ taking the level of aggregate demand for imports as given, and is constrained to satisfy demand at that price; that is,

$$\tilde{y}_{M,t} - \frac{\phi_2}{2}\left(\frac{\tilde{p}_{M,t}}{\tilde{p}_{M,t-1}}-1\right)^2 \geq \left(\frac{\tilde{p}_{M,t}}{p_{M,t}}\right)^{-\lambda_D} C_{M,t} \tag{3.26}$$

where $\tilde{y}_{M,t}$ is the total quantity of imported goods, which is in general different from the quantity demanded because of the presence of price adjustment costs.

(Dollar) Profits for an import firm are given by

$$\tilde{\pi}_{M,t} = \left(\frac{\tilde{p}_{M,t}}{s_t} - \tilde{p}_{M,t}^*\right)\left(\frac{\tilde{p}_{M,t}}{p_{M,t}}\right)^{-\lambda_D} C_{M,t} - \tilde{p}_{M,t}^*\frac{\phi_2}{2}\left(\frac{\tilde{p}_{M,t}}{\tilde{p}_{M,t-1}}-1\right)^2 \tag{3.27}$$

where $\tilde{p}_{M,t}^*$ is the dollar price of imports, which for simplicity is assumed to be determined in world markets (that is, exogenously given) and equal to \$1.

The firm will choose the optimal (peso) price $\tilde{p}_{M,t}$ in order to maximize the following expression:

$$E_t\left\{\sum_{t=0}^{\infty}\Gamma_t\left[\left(\frac{\tilde{p}_{M,t}}{s_t} - \tilde{p}_{M,t}^*\right)\left(\frac{\tilde{p}_{M,t}}{p_{M,t}}\right)^{-\lambda_D} C_{M,t} - \tilde{p}_{M,t}^*\frac{\phi_2}{2}\left(\frac{\tilde{p}_{M,t}}{\tilde{p}_{M,t-1}}-1\right)^2\right]\right\} \tag{3.28}$$

taking as given the processes for $\{C_{M,t},\lambda_t,s_t,p_{M,t},p_t\}_{t=0}^{\infty}$.

Thus, the optimal price setting equation is given by

$$\frac{1}{s_t}\left(\frac{\tilde{p}_{M,t}}{p_{M,t}}\right)^{-\lambda_D} C_{M,t} - \left(\frac{\tilde{p}_{M,t}}{s_t} - \tilde{p}^*_{M,t}\right)\lambda_D \left(\frac{\tilde{p}_{M,t}}{p_{M,t}}\right)^{-\lambda_D - 1}\left(\frac{1}{p_{M,t}}\right) C_{M,t}$$
$$-\tilde{p}^*_{M,t}\phi_2\left(\frac{\tilde{p}_{M,t}}{\tilde{p}_{M,t-1}} - 1\right)\left(\frac{1}{\tilde{p}_{M,t-1}}\right)$$
$$= -E_t\left\{\Gamma_{t+1}\tilde{p}^*_{M,t+1}\phi_2\left(\frac{\tilde{p}_{M,t+1}}{\tilde{p}_{M,t}} - 1\right)\left(\frac{\tilde{p}_{M,t+1}}{\tilde{p}^2_{M,t}}\right)\right\} \tag{3.29}$$

3.2.2.3 The Export Sector Firms' Problems

Each export firm is the monopolistic producer of one variety of export goods. The domestic exports firm's output is given by

$$\tilde{y}_{X,t} = A_t\tilde{k}^{\alpha}_{X,t}\tilde{h}^{1-\alpha}_{X,t} - \frac{\phi_2}{2}\left(\frac{\tilde{p}^*_{X,t}}{\tilde{p}^*_{X,t-1}} - 1\right)^2$$

where the first element of the right hand side of the above expression corresponds to the production function of exports firms, which have access to a constant returns to scale production technology. The firm hires labor $\tilde{h}_{X,t}$ and capital $\tilde{k}_{X,t}$ from a perfectly competitive market.

Moreover, the foreign demand for domestic exports is of the form $X_t d(p_{i,t})$, where X_t denotes the level of foreign demand and $p_{i,t}$ denotes the relative (peso) price of the export good in terms of the average (peso) price of domestic exports. The relative price $p_{i,t}$ is defined as $s_t\tilde{p}^*_{X,t}/p_{X,t}$, where s_t is the nominal exchange rate, $\tilde{p}^*_{X,t}$ is the dollar price of the good produced by the firm, and $p_{X,t}$ is the average peso price of domestic exports. The demand function $d(.)$ is assumed to be decreasing and to satisfy $d(1) = 1$ and $d'(1) < -1$. The restrictions on $d(1)$ and $d'(1)$ are necessary for the existence of a symmetric equilibrium. The monopolist exporter sets the dollar price of the good it supplies $\tilde{p}^*_{X,t}$ taking the level of aggregate demand for exports as given, and is constrained to satisfy demand at that price; that is,

$$A_t\tilde{k}^{\alpha}_{X,t}\tilde{h}^{1-\alpha}_{X,t} - \frac{\phi_2}{2}\left(\frac{\tilde{p}^*_{X,t}}{\tilde{p}^*_{X,t-1}} - 1\right)^2 \geq X_t d(p_{i,t}) \tag{3.30}$$

(Dollar) Profits for an export firm are given by

$$\tilde{\pi}_{X,t} = \tilde{p}^*_{X,t}X_t d(p_{i,t}) - \frac{w_t\tilde{h}_{X,t}}{s_t} - \frac{R_t\tilde{k}_{X,t}}{s_t} \tag{3.31}$$

Each period, imperfectly competitive firms choose capital $\tilde{k}_{X,t}$, labor services $\tilde{h}_{X,t}$ and the dollar price of exports $\tilde{p}^*_{X,t}$, subject to demand and technological constraints (3.30), so as to maximize profits (3.31). Let the multiplier on the demand and supply equilibrium condition (3.30) be $\tilde{\mu}_{X,t}\Gamma_t\tilde{p}^*_{X,t}$; then the firm will maximize the following expression:

$$\mathcal{L} = E_t\left\{\sum_{t=0}^{\infty}\Gamma_t\left[\tilde{p}^*_{X,t}X_t d(p_{i,t}) - \frac{w_t\tilde{h}_{X,t}}{s_t} - \frac{R_t\tilde{k}_{X,t}}{s_t}\right]\right\}$$

$$+E_t\left\{\sum_{t=0}^{\infty}\tilde{\mu}_{X,t}\Gamma_t\tilde{p}^*_{X,t}\left[X_t d(p_{i,t}) - A_t\tilde{k}^{\alpha}_{X,t}\tilde{h}^{1-\alpha}_{X,t} + \frac{\phi_2}{2}\left(\frac{\tilde{p}^*_{X,t}}{\tilde{p}^*_{X,t-1}} - 1\right)^2\right]\right\} \tag{3.32}$$

taking as given the processes for $\{A_t, X_t, w_t, R_t, s_t, p_t, p_{X,t}, \lambda_t\}_{t=0}^{\infty}$.

As a result of the profit maximization process, input demands and export prices must satisfy the following efficiency conditions:

$$\frac{R_t}{s_t} = -\tilde{\mu}_{X,t}\tilde{p}^*_{X,t}A_t\alpha\tilde{k}^{\alpha-1}_{X,t}\tilde{h}^{1-\alpha}_{X,t} \tag{3.33}$$

$$\frac{w_t}{s_t} = -\tilde{\mu}_{X,t}\tilde{p}^*_{X,t}A_t\tilde{k}^{\alpha}_{X,t}(1-\alpha)\tilde{h}^{-\alpha}_{X,t} \tag{3.34}$$

$$\begin{aligned}
&X_t\left[d\left(\frac{s_t\tilde{p}^*_{X,t}}{p_{X,t}}\right) + d'\left(\frac{s_t\tilde{p}^*_{X,t}}{p_{X,t}}\right)\right] \\
&+\tilde{\mu}_{X,t}\left[X_t d'\left(\frac{s_t\tilde{p}^*_{X,t}}{p_{X,t}}\right) + \tilde{p}^*_{X,t}\phi_2\left(\frac{\tilde{p}^*_{X,t}}{\tilde{p}^*_{X,t-1}} - 1\right)\left(\frac{1}{\tilde{p}^*_{X,t-1}}\right)\right] \\
&+\tilde{\mu}_{X,t}\left[X_t d\left(\frac{s_t\tilde{p}^*_{X,t}}{p_{X,t}}\right) - A_t\tilde{k}^{\alpha}_{X,t}\tilde{h}^{1-\alpha}_{X,t} + \frac{\phi_2}{2}\left(\frac{\tilde{p}^*_{X,t}}{\tilde{p}^*_{X,t-1}} - 1\right)^2\right] \\
&= E_t\left\{\tilde{\mu}_{X,t+1}\Gamma_{t+1}\tilde{p}^*_{X,t+1}\phi_2\left(\frac{\tilde{p}^*_{X,t+1}}{\tilde{p}^*_{X,t}} - 1\right)\left(\frac{\tilde{p}^*_{X,t+1}}{\tilde{p}^{*2}_{X,t}}\right)\right\}
\end{aligned} \tag{3.35}$$

The interpretation of the first order conditions above are as follows: Equations (3.33) states that in equilibrium there is a wedge between the real rental rate of capital and the marginal productivity of capital, which is explained by the monopolistic power of the firms. Equation (3.34) states that in equilibrium there is a wedge between the real wage rate and the marginal productivity of labor, which is explained, again, by the presence of imperfectly competitive firms in the market. Equation (3.35) states that in equilibrium there is a wedge between marginal revenue and marginal cost, as a result of the presence of price adjustment costs à la Rotemberg (1982).

Let me define the real marginal cost mc_t and real marginal revenue mr_t as follows

$$mc_t = \frac{\frac{w_t}{s_t}}{p^*_{X,t} A_t \tilde{k}^{\alpha}_{X,t} (1-\alpha) \tilde{h}^{-\alpha}_{X,t}}$$

$$mr_t = \frac{s_t \tilde{p}^*_{X,t}}{p_{X,t}} + \frac{d\left(\frac{s_t \tilde{p}^*_{X,t}}{p_{X,t}}\right)}{d'\left(\frac{s_t \tilde{p}^*_{X,t}}{p_{X,t}}\right)}$$

3.2.3 Equilibrium

I restrict attention to symmetric equilibria where all firms in the same sector charge the same price for the good they supply.

In the non-tradable, imports and exports sectors, because of symmetric equilibria, $\tilde{p}_{N,t} = p_{N,t}$, $\tilde{p}_{M,t} = p_{M,t}$, and $\tilde{p}^*_{X,t} = p^*_{X,t}$, respectively. Moreover, in the exports sector, $p_{i,t} = 1$ for all t. It then follows from the fact that all firms in the same sector of production face the same wage rate and rental rate of capital, the same shocks to technology and exports, and the same production technology, that they hire the same amount of labor and capital; that is, in the non-tradable sector, $\tilde{h}_{N,t} = h_{N,t}$ and $\tilde{k}_{N,t} = k_{N,t}$, and in the exports sector, $\tilde{h}_{X,t} = h_{X,t}$ and $\tilde{k}_{X,t} = k_{X,t}$. In addition, let

$$\eta \equiv d'(1)$$

denote the equilibrium value of the elasticity of demand faced by the individual exports firm. Then, in equilibrium, the expression for the real marginal revenue mr_t above simplifies to

$$mr_t = 1 + \frac{1}{\eta}$$

Furthermore, in the market for export goods the equilibrium condition[12] is given by

$$p_{X,t} y_{X,t} = s_t p^*_{X,t} X_t d\left(\frac{s_t p^*_t}{p_t}\right)$$

where s_t is the nominal exchange rate, expressed in number of units of domestic currency per unit of foreign currency, while $X_t d(.)$ is the quantity of domestic exports. In addition, in equilibrium, the production of export goods must equal the (foreign) demand for export goods.

$$y_{X,t} = X_t d\left(\frac{s_t p^*_t}{p_t}\right)$$

[12] The value in pesos of export goods produced equals the value in pesos of the quantity demanded of export goods.

After combining the two previous expressions, I obtain the expected result that

$$p_{X,t} = s_t p^*_{X,t} \tag{3.36}$$

which states that the price in pesos of domestic exports p_t equals the product of the nominal exchange rate s_t times the dollar price of domestic exports p^*_t.

As previously mentiones, due to their monopolistic power, domestic exports firms choose the dollar price of exports p^*_t. Clearly, an increase in p^*_t can be interpreted as a positive change to the terms of trade in the economy. That is, ceteris paribus, a positive change in the price of domestic exports will increase the purchasing power of domestic agents in terms of foreign goods (imports).

Notice that my model does not make explicit the use of a monetary aggregate in the economy, although the domestic price level is a key variable in the model. It is possible to introduce money explicitly to my model, but the conclusions should not change. My model assumes that the monetary authority just supplies the amount of money that maintains the exchange rate s_t at its pegged value under the fixed exchange rate regime, that maintains constant the peso price of domestic exports $p_{X,t}$ under the flexible exchange rate regime that targets this price, and that keeps constant the consumer price index p_t under the exchange rate regime that targets this price.

Furthermore, in equilibrium, input markets must clear:

$$k_t = k_{N,t} + k_{X,t} \tag{3.37}$$

$$h_t = h_{N,t} + h_{X,t} \tag{3.38}$$

The stochastic processes for the level of foreign demand for domestic exports X_t and the technology shock A_t are exogenously given by

$$logX_t = \tau logX_{t-1} + \varepsilon_{X,t}, \quad \text{where} \quad \varepsilon_{X,t} \sim N(0, \sigma^2_X) \tag{3.39}$$

$$logA_t = \rho logA_{t-1} + \varepsilon_{A,t}, \quad \text{where} \quad \varepsilon_{A,t} \sim N(0, \sigma^2_A) \tag{3.40}$$

where both $\varepsilon_{X,t}$ and $\varepsilon_{A,t}$ are white noise random variables.

3.3 Calibration

In this section, I do calibrate the model for the Peru, a country that has experienced a very high level of (de facto) dollarization for more than 16 years. In this exercise, some of the values for the calibrated parameters are taken from studies on the Canadian and Argentinian economies, and some are taken from studies in the related literature. In particular, several values for the parameters of the model have been taken from Mendoza (1991), who calibrates the model to the Canadian economy[13]. Mendoza argues that Canada is viewed as a typical small open economy because of the historical absence of capital controls and the high degree of integration of its financial markets with those of the United States. The parameter values that I will use in my simulation of the model are given in Table 3.1 below.

Table 3.1: Calibration

Symbol	Value	Description
a	0.5	Share of non-tradable goods in the consumption basket
α	0.32	Capital's share of income
β	0.9615	Subjective discount factor
γ	2	Coefficient of relative risk aversion
δ	0.1	Depreciation rate
η	-6	Price elasticity of demand for a specific export good variety
λ_D	6	Elasticity of substitution among varieties of both non-traded and imported goods
ψ_2	0.00074	Parameter of the portfolio adjustment cost function on dollar bonds
ψ_3	0.00074	Parameter of the portfolio adjustment cost function on peso bonds
ϕ	0.028	Parameter of the capital adjustment cost function
ϕ_2	0.028	Degree of price stickiness
ρ	0.42	Degree of autocorrelation for the technology shock
τ	0.56	Degree of autocorrelation for the exports shock
ω	1.455	One plus the inverse of the intertemporal elasticity of substitution in labor supply
σ_A	0.0129	Standard deviation of the technology shock error term
σ_X	0.0129	Standard deviation of the exports shock error term
r	0.04	World's real interest rate
θ	2	Elasticity of substitution between non-tradables and imported goods

In addition, following Schmitt-Grohe and Uribe (2003), I assign small values to the parameters ψ_2 and ψ_3[14], which help measure the portfolio adjustment costs that arise from choosing debt levels in dollars and pesos different from their corresponding steady state values. Also, I assign a value of 0.9615 to the discount factor β, since in the steady

[13]The data considered by Mendoza corresponds to annual observations for the period 1946-1985, expressed in per capita terms of the population older than 14 years, transformed into logarithms and detrended with a quadratic time trend.

[14]I have assumed that the values for these parameters are the same since, in principle, there is no reason to think that the values must be different.

state the discount factor equals the inverse of the gross world interest rate. Regarding the world interest rate in dollars r, I assign it a value of 4 percent. Moreover, I assign the values of 0.07 and 0.14 to the dollar debt and peso debt, respectively, which imply steady state values for the level of dollarization and the ratio of total debt to output equal to 50 percent and 0.25, respectively, which are consistent with the current values for Peru. The value of 0.1 assigned to the annual depreciation rate δ implies an average investment ratio of about 19 percent, which is close to the average value observed in Peru of about 20 percent[15]. I set the parameter α, which determines the average capital share of income, at 0.32, a value commonly used in the related literature. In addition, I set the value of the price elasticity of demand on a specific good η equal to -6. This value implies a steady state value for the (value-added) markup of 0.20, which is a reasonable value[16]. In addition, I assume a value of 2 for the elasticity of substitution between non-tradable and imported goods, and a value of 0.5 for the share of non-tradable goods in the consumption basket.

3.4 Solving the Model

I assume that in period 0 the government chooses the exchange rate regime. The government is assumed to be endowed with a commitment technology that allows it to maintain throughout time the policy decision it makes in period 0. As a result, the announced policy enjoys full credibility on the part of the private sector; in other words, there is no time inconsistency problem in my model.

3.4.1 Flexible Exchange Rate Regime with the peso price of exports as nominal anchor

In the model with flexible exchange rate and the peso price of exports as nominal anchor, first, the government (central bank) fixes the value of the peso price of domestic exports $p_{X,t}$ to its long-run (nonstochastic steady state) level p_X, following Frankel (2003), and then, after observing the realization of the exogenous shocks to technology and the level of exports, households and firms, taking $p_{X,t}$ as given, solve their corresponding

[15]The average investment-output ratio for the period 1950-2008 is 20.9 percent, according to the IFS.

[16]Basu and Fernald (1997) estimate gross-output markup of about 0.1. They show that their estimates are consistent wih values for the added-value markup of up to 0.25.

contrained optimization problems, as explained above. Thus, under the exchange rate regime that pegs the peso price of exports, I have

$$p_{X,t} = p_X \tag{3.41}$$

It is important to mention that Frankel (2003) suggests that pegging the export price (PEP) is a monetary regime that can be applied to countries that are specialized in the production of a particular agricultural or mineral commodity. PEP proposes fixing the price of the single commodity in terms of local currency (here, pesos). It has been objected that PEP is inappropriate for countries where diversification of exports is an issue. For such countries the modified version, PEPI, developed by Frankel (2005), proposes fixing the price of a comprehensive index of export prices. According to Frankel (2005), in either version of the monetary regime (PEP or PEPI), one advantage is that the currency depreciates automatically when the world market for the country's exports deteriorates.

3.4.1.1 The First Order Conditions

I am now ready to define an equilibrium. A competitive equilibrium is a set of plans for $\{c_t, c_{N,t}, c_{M,t}, h_t, h_{X,t},\ h_{N,t}, i_t,\ k_{t+1}, k_{X,t}, k_{N,t}, B_{t+1},\ B^*_{t+1}, \lambda_t, \mu_{X,t}, \mu_{N,t}, p^*_{X,t}, p_{N,t}, p_{M,t}, w_t, R_t, s_t, R^p_t, R^*_t\}$ satisfying (3.2) – (3.4), (3.11) – (3.21), (3.23) – (3.27), (3.29) – (3.31), (3.33) – (3.41), and some non-Ponzi game condition, given the fixed value of the peso price of domestic exports p_X, exogenous processes $\{A_t, X_t\}$ and initial conditions $A_0, X_0, k_0, B_0, B^*_0,\ p^*_{X,-1}, p_{M,-1}, p*_{N,-1}$.

Incidentally, I compute the level of dollarization for the economy (LD_t) and the ratio of total debt to output (RTD_t) for each period in order to make a better analysis of the impact of the different exogenous shocks to the economy. These two indicators are defined as follows

$$LD_t = 1 - \frac{\frac{B_t}{s_t}}{\frac{B_t}{s_t} + B^*_t} \tag{3.42}$$

$$RTD_t = \frac{\frac{B_t}{s_t} + B^*_t}{p^*_t y_t} \tag{3.43}$$

3.4.1.2 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value; that is $\varepsilon_A = 0$ and $\varepsilon_X = 0$, which implies values for the level of domestic exports and the productivity factor of $X = 1$ and $A = 1$, respectively. Due to the high non-linearity of the model, one part of the model has to be solved numerically. A numerical solution is found for the nonstochastic steady-state values of k_N, h_N, p_N, c_N, h_X, and p_X^*. Then, an analytical solution is found for the long-run equilibrium values of the following variables:

$$B = \bar{B}$$

$$B^* = \bar{B}^*$$

$$p_M = \frac{\lambda_D}{\lambda_D - 1}$$

$$\mu_N = \frac{1 - \lambda_D}{\lambda_D}$$

$$\mu_M = \frac{1 - \lambda_D}{\lambda_D}$$

$$\mu_X = -\frac{\eta + 1}{\eta}$$

$$kx = \frac{x}{(Ah_X^{1-\alpha})^{\frac{1}{\alpha}}};$$

$$s = \frac{p}{p^*}$$

$$r^p = r$$

$$c_N = Ak_N^{\alpha} h_N^{1-\alpha};$$

$$h = h_N + h_X;$$

$$k = k_N + k_X;$$

$$w = h^{\omega-1} p$$

$$p = \left[ap_N^{1-\theta} + (1-a)p_M^{1-\theta}\right]^{\frac{1}{1-\theta}}$$

$$R = \left(\frac{1}{\beta} - (1-\delta)\right) p$$

$$\mu = -\left(\frac{1+\eta}{\eta}\right)$$

$$c_M = (1-a)\frac{p_M}{p}^{-\theta}(c + \delta k_H);$$

$$\pi_N = \frac{p_N c_N}{s} - \frac{wh_N}{s} - \frac{Rk_N}{s}$$

$$\lambda = \left(c - \frac{h^\omega}{\omega}\right)^{-\gamma}$$

$$\pi_M = \left(\frac{p_M}{s} - p_M^*\right) c_M$$

$$\pi_X = p^* X - \frac{wh_X}{s} - \frac{Rk_X}{s}$$

$$\pi = \pi_N + \pi_M + \pi_X$$

$$c = \left[a^{\frac{1}{\theta}} c_N^{\frac{\theta-1}{\theta}} + (1-a)^{\frac{1}{\theta}} c_M^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}$$

$$V = \frac{1}{1-\beta} \frac{\left(c - \frac{h^\omega}{\omega}\right)^{1-\gamma} - 1}{1-\gamma};$$

$$i = \delta k$$

$$p_x = sp^*$$

$$y_M = c_M$$

$$y_N = c_N$$

$$y_X = X$$

3.4.1.3 Effects on the Economy of a Positive Technology Shock

Table 3.2 below summarizes the impact effects on the economy that result from a positive technology shock.

Table 3.2: Flexible E.R. (p_X): Impact Effects

Shock	y_X	y_N	c	c_N	c_M	i	h	h_X	h_N	k_{t+1}	k_X	k_N	B_{t+1}	B^*_{t+1}	s
A_t	0	+	+	+	−	+	+	−	+	+	−	+	+	+	+

A positive technology shock has an immediate adverse effect on the dollar price of exports and thus on export firms' revenues and profits: since the level of exports is exogenous in my model, the increase in productivity makes the imperfectly competitive export firms reduce their (dollar) prices significantly as they try to avoid the loss of part of their share of the market in favor of their competitors; then the fall of dollar price of exports affects export firms' revenues and profits, and thus household's income from dividends. Moreover, since the positive technology shock makes the overall economy more productive, less resources (both capital and labor) in the exports sector are required to produce the same level of exports. On the other hand, in the nontraded sector the positive technology shock allows firms to expand production and reduce their price. Thus, nontradables firms will hire more capital and labor in order to increase production. The demand for nontradables increases because of their lower price while the demand for imports drops as they become relatively more expensive (the peso price of imports increases as the peso depreciates on impact). Initially both consumption and investment increase in response to the shock, but after the second year consumption (as well as investment) falls below its long run equilibrium value and thus has a clear adverse effect on welfare.

While the demand for capital in the exports sector drops, it increases in the nontradable sector. The net effect (on impact) on the demand for capital is positive, which explains the initial increase in total investment. Overall, the adverse effects of the technology shock on the economy dominates and, as a result, households will borrow more from world financial markets (an increase in real terms in both debt in pesos and dollars is observed) in order to smooth consumption and reduce the adverse effects of the shock on welfare. However, this increase in total foreign debt will imply greater interest payments and thus more resources will have to be sacrificed (distracted from investment and consumption) by domestic agents to repay their debt, which also explains the resulting welfare loss from the shock.

Moreover, the peso depreciates on impact because of the lower amount of dollars that flow into the economy following the technology shock: since the lower dollar price of exports affects the dollar revenues of export firms, the dollar becomes “scarce” in the domestic economy, which pushes up its price (the nominal exchange rate). In addition, in line with the uncovered interest parity condition, the interest rate on peso bonds fall on impact since domestic agents expect now an appreciation of the peso, which once materialized will return the price of the dollar to is long-run equilibrium value. Also, since an appreciation of the peso is expected, domestic agents will issue more dollar debt, which increases the degree of dollarization in the economy.

Furthermore, as firms adjust capital they incur in costly capital adjustment costs, which make the positive technology shock even more costly for the economy. Figures (6.7) - (6.8) in the Appendix show the impact effects on consumption, hours, investment, debt and other key endogenous variables of the model that follow a positive technology shock to the economy.

3.4.1.4 Effects on the Economy of a Positive Shock to the Value of Exports

Table 3.3 below summarizes the impact effects on the economy that result from a positive shock to exports.

Table 3.3: Flexible E.R. (p_X): Impact Effects

Shock	y_X	y_N	c	c_N	c_M	i	h	h_X	h_N	k_{t+1}	k_X	k_N	B_{t+1}	B^*_{t+1}	s
X_t	+	−	+	−	+	−	+	+	−	−	+	−	−	−	−

A positive shock to exports has an immediate positive effect on both the dollar price and the quantity of exports, and thus on the export firms' revenues and profits: a greater demand for exports allows all monopolistically competitive export firms to charge a higher dollar price for their goods and produce more, which increases export firms' profits immediately, and thus household's income from dividends. Moreover, since the positive shock to exports makes exports firms expand production, more resources (both capital and labor) in this sector will be hired to produce more. Richer households increase their demand for final consumption goods, which in turn generates a greater demand for nontradables and imported goods. But while the price of nontradables increases, the price of imports decreases (due to the appreciation of the peso), which causes a shift in demand from nontradable goods to imports. As a result, the initial net effect on the production of nontradables is negative, which makes nontradables firms hire less capital and labor. On the other hand, the demand for imports increases as they become relatively cheaper. Overall, both consumption and hours worked increase and the net effect on welfare is positive (that is, the positive consumption effect on welfare dominates the negative leisure effect).

While the demand for capital in the exports sector increases, it falls in the nontradable sector. The initial net effect on the demand for capital is negative, which explains the initial drop in total investment. Overall, the positive effects of the shock to exports on the economy dominate and, as a result, households will borrow less from world financial markets (a drop in real terms in both debt in pesos and dollars is observed) in order to smooth consumption and other positive effects on the economy. Notice that the decrease in total foreign debt will imply lower interest payments and thus less resources will have to be sacrificed (distracted from investment and consumption) by domestic agents to repay their debt, which also explains the welfare gain.

Moreover, the peso appreciates on impact because of the greater amount of dollars that flow into the economy following the shock to exports. Since the greater level of exports increases the dollar revenues of export firms, the dollar becomes "abundant" in the domestic economy, which pushes down its price (the nominal exchange rate). In addition, in line with the uncovered interest parity condition, the interest rate on peso bonds jumps up on impact since domestic agents expect now a depreciation of the peso, which once materialized will return the price of the dollar to is long-run equilibrium value. Also, since a depreciation of the peso is expected, domestic agents will issue more peso debt, which reduces the degree of dollarization in the economy.

Even though initially investment drops, after two periods it increases with respect to its long run level: the economy decides to take advantage of the greater demand for exports by increasing its stock of capital. Figures (6.9) - (6.10) in the Appendix show the impact effects on consumption, hours, investment, debt and other key endogenous variables of the model that follow a positive exports shock to the economy.

3.4.2 Flexible Exchange Rate Regime with the CPI as nominal anchor

In the model with flexible exchange rate regime that has the CPI as nominal anchor, first, the government (central bank) fixes the value of the consumer price index p_t to its long-run (nonstochastic steady state) level p, and then, after observing the realization of the exogenous shocks to technology and the level of exports, households and firms, taking p_t as given, solve their corresponding contrained optimization problems, as explained above. Thus, under the flexible exchange rate regime that has the CPI as nominal anchor, I have

$$p_t = p \tag{3.44}$$

3.4.2.1 The First Order Conditions

A competitive equilibrium is a set of plans for $\{c_t, c_{N,t}, c_{M,t}, h_t, h_{X,t}, h_{N,t}, i_t, k_{t+1}, k_{X,t}, k_{N,t}, B_{t+1}, B^*_{t+1}, \lambda_t, \mu_{X,t}, \mu_{N,t}, p^*_{X,t}, p_{N,t}, p_{M,t}, w_t, R_t, s_t, R^p_t, R^*_t\}$ satisfying (3.2) – (3.4), (3.11) – (3.21), (3.23) – (3.27), (3.29) – (3.31), (3.33) – (3.40), (3.52), and some non-Ponzi game condition, given the fixed value of the consumer price index p, exogenous processes $\{A_t, X_t\}$ and initial conditions $A_0, X_0, k_0, B_0, B_0^*$, $p^*_{X,-1}, p_{M,-1}, p*_{N,-1}$.

3.4.2.2 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value; that is $\varepsilon_A = 0$ and $\varepsilon_X = 0$, which implies values for the level of domestic exports and the productivity factor of $X = 1$ and $A = 1$, respectively. In addition, the steady state values for the rest of endogenous variables in the model are the same as the ones stated in section 3.4.1.2 above.

3.4.2.3 Effects on the Economy of a Positive Technology Shock

Table 3.4 below summarizes the impact effects on the economy that result from a positive technology shock.

Table 3.4: Flexible E.R. (CPI): Impact Effects

Shock	y_X	y_N	c	c_N	c_M	i	h	h_X	h_N	k_{t+1}	k_X	k_N	B_{t+1}	B^*_{t+1}	s
A_t	0	+	+	+	−	+	+	−	+	+	−	+	+	+	+

A positive technology shock has an immediate adverse effect on both the peso and dollar price of exports and on the terms of trade: since the level of exports is exogenous in my model, the increase in productivity makes the imperfectly competitive export firms reduce their dollar prices significantly as they try to avoid the loss of part of their share of the market in favor of their competitors (and even though there is a nominal depreciation of the domestic currency on impact, the net effect on the peso price of exports is negative). The fall of the dollar price of exports affects export firms' revenues and profits, and thus household's income from dividends. Moreover, since the positive technology shock makes the overall economy more productive, less resources (both capital and labor) in the exports sector are required to produce the same level of exports. On the other hand, in the nontraded sector the positive technology shock allows firms to expand production and reduce their price. Thus, nontradables firms will hire more capital and labor in order to increase production. The demand for nontradables increases because of their lower price while the demand for imports drops as they become relatively more expensive (the peso price of imports increases as the peso depreciates on impact). Initially both consumption and investment increase in response to the shock, but after the second year consumption (as well as investment) falls below its long run equilibrium value and thus has a clear adverse effect on welfare.

While the demand for capital in the exports sector drops, it increases in the non-tradable sector. The net effect (on impact) on the demand for capital is positive, which explains the initial increase in total investment. Overall, the adverse effects of the technology shock on the economy dominates and, as a result, households will borrow more from world financial markets (an increase in real terms in both debt in pesos and dollars is observed) in order to smooth consumption and reduce the adverse effects of the shock on welfare. However, this increase in total foreign debt will imply greater interest payments and thus more resources will have to be sacrificed (distracted from investment and consumption) by domestic agents to repay their debt, which also explains the resulting welfare loss from the shock.

Moreover, the peso depreciates on impact because of the lower amount of dollars that flow into the economy following the technology shock: since the lower dollar price of exports affects the dollar revenues of export firms, the dollar becomes "scarce" in the domestic economy, which pushes up its price (the nominal exchange rate). In addition, in line with the uncovered interest parity condition, the interest rate on peso bonds fall on impact since domestic agents expect now an appreciation of the peso, which once materialized will return the price of the dollar to is long-run equilibrium value. Also, since an appreciation of the peso is expected, domestic agents will issue more dollar debt, which increases the degree of dollarization in the economy.

Furthermore, as firms adjust capital they incur in costly capital adjustment costs, which make the positive technology shock even more costly for the economy. Figures (6.11) - (6.12) in the Appendix show the impact effects on consumption, hours, investment, debt and other key endogenous variables of the model that follow a positive technology shock to the economy.

3.4.2.4 Effects on the Economy of a Positive Shock to the Value of Exports

Table 3.5 below summarizes the impact effects on the economy that result from a positive shock to exports.

A positive shock to exports has an immediate positive effect on both the peso

Table 3.5: Flexible E.R. (CPI): Impact Effects

Shock	y_X	y_N	c	c_N	c_M	i	h	h_X	h_N	k_{t+1}	k_X	k_N	B_{t+1}	B^*_{t+1}	s
X_t	+	−	+	−	+	−	+	+	−	−	+	−	−	−	−

and dollar price of exports and the amount of exports, and thus on the export firms' profits: a greater demand for exports allows all monopolistically competitive export firms to charge a higher dollar price for their goods and produce more, which increases export firms' profits immediately, and thus household's income from dividends (and even though there is a nominal appreciation of the domestic currency, the net effect on the peso price of exports is positive). Moreover, since the positive shock to exports makes exports firms expand production, more resources (both capital and labor) in this sector will be hired to produce more. Richer households increase their demand for final consumption goods, which in turn generates a greater demand for nontradables and imported goods. But while the price of nontradables increases, the price of imports decreases (due to the appreciation of the peso), which causes a shift in demand from nontradable goods to imports. As a result, the initial net effect on the production of nontradables is negative, which makes nontradables firms hire less capital and labor. On the other hand, the demand for imports increases as they become relatively cheaper. Overall, both consumption and hours worked increase and the net effect on welfare is positive (that is, the positive consumption effect on welfare dominates the negative leisure effect).

While the demand for capital in the exports sector increases, it falls in the nontradable sector. The initial net effect on the demand for capital is negative, which explains the initial drop in total investment. Overall, the positive effects of the shock to exports on the economy dominate and, as a result, households will borrow less from world financial markets (a drop in real terms in both debt in pesos and dollars is observed) in order to smooth consumption and other positive effects on the economy. Notice that the decrease in total foreign debt will imply lower interest payments and thus less resources will have to be sacrificed (distracted from investment and consumption) by domestic agents to repay their debt, which also explains the welfare gain.

Moreover, the peso appreciates on impact because of the greater amount of dollars that flow into the economy following the shock to exports. Since the greater level of exports increases the dollar revenues of export firms, the dollar becomes "abundant" in the domestic economy, which pushes down its price (the nominal exchange rate). In addition, in line with the uncovered interest parity condition, the interest rate on peso bonds jumps up on impact since domestic agents expect now a depreciation of the peso, which once materialized will return the price of the dollar to is long-run equilibrium value. Also, since a depreciation of the peso is expected, domestic agents will issue more peso debt, which reduces the degree of dollarization in the economy.

Even though initially investment drops, after two periods it increases with respect to its long run level: the economy decides to take advantage of the greater demand for exports by increasing its stock of capital. Figures (6.13) - (6.14) in the Appendix show the impact effects on consumption, hours, investment, debt and other key endogenous variables of the model that follow a positive exports shock to the economy.

3.4.3 Fixed Exchange Rate Regime

In the model with fixed exchange rate regime, first, the government (central bank) fixes the value of the exchange rate s_t to its long-run (nonstochastic steady state) level s, and then, after observing the realization of the exogenous shocks to technology and the level (volume) of exports, households and firms, taking s_t as given, solve their corresponding contrained optimization problems, as explained above. Thus, under the fixed exchange rate regime, I have

$$s_t = s \tag{3.45}$$

3.4.3.1 The First Order Conditions

A competitive equilibrium is a set of plans for $\{c_t, c_{N,t}, c_{M,t}, h_t, h_{X,t}, h_{N,t}, i_t, k_{t+1}, k_{X,t}, k_{N,t}, B_{t+1}, B^*_{t+1}, \lambda_t, \mu_{X,t}, \mu_{N,t}, p^*_{X,t}, p_{N,t}, p_{M,t}, w_t, R_t, s_t, R^p_t, R^*_t\}$ satisfying (3.2) – (3.4), (3.11) – (3.21), (3.23) – (3.27), (3.29) – (3.31), (3.33) – (3.40), (3.53), and some non-Ponzi game condition, given the fixed value of the nominal exchange rate s, exogenous processes $\{A_t, X_t\}$ and initial conditions $A_0, X_0, k_0, B_0, B^*_0, p^*_{X,-1}, p_{M,-1}, p*_{N,-1}$.

3.4.3.2 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value; that is $\varepsilon_A = 0$ and $\varepsilon_X = 0$, which implies values for the level of domestic exports and the productivity factor of $X = 1$ and $A = 1$, respectively. In addition, the steady state values for the rest of endogenous variables in the model are the same as the ones stated in section 3.4.1.2 above.

3.4.3.3 Effects on the Economy of a Positive Technology Shock

Table 3.6 below summarizes the impact effects on the economy that result from a positive technology shock.

Table 3.6: Fixed Exchange Rate: Impact Effects

Shock	y_X	y_N	c	c_N	c_M	i	h	h_X	h_N	k_{t+1}	k_X	k_N	B_{t+1}	B^*_{t+1}	p
A_t	0	+	+	+	−	+	+	−	+	+	−	+	+	+	−

A positive technology shock has an immediate adverse effect on both the peso and dollar price of exports and on the terms of trade: since the level of exports is exogenous in my model, the increase in productivity makes the imperfectly competitive export firms reduce their dollar prices significantly as they try to avoid the loss of part of their share of the market in favor of their competitors (and the peso price of exports falls as the dollar price drops since the exchange rate is fixed). The fall of the dollar price of exports affects export firms' revenues and profits, and thus household's income from dividends. Moreover, since the positive technology shock makes the overall economy more productive, less resources (both capital and labor) in the exports sector are required to produce the same level of exports. On the other hand, in the nontraded sector the positive technology shock allows firms to expand production and reduce their price. Thus, nontradables firms will hire more capital and labor in order to increase production. The demand for nontradables increases because of their lower price while the demand for imports drops as they become relatively more expensive. The combined effect of the shock on these two prices makes the CPI fall, which increases the demand for the final good. Thus, initially both consumption and investment increase in response to the shock, but after the second year consumption (as well as investment) falls below its long run equilibrium value and thus has a clear adverse effect on welfare.

While the demand for capital in the exports sector drops, it increases in the nontradable sector. The net effect (on impact) on the demand for capital is positive, which explains the initial increase in total investment. Overall, the adverse effects of the technology shock on the economy dominates and, as a result, households will borrow more from world financial markets (an increase in real terms in both debt in pesos and dollars is observed) in order to smooth consumption and reduce the adverse effects of the shock on welfare. However, this increase in total foreign debt will imply greater interest payments and thus more resources will have to be sacrificed (distracted from investment and consumption) by domestic agents to repay their debt, which also explains the resulting welfare loss from the shock.

Furthermore, as firms adjust capital they incur in costly capital adjustment costs, which make the positive technology shock even more costly for the economy. Figures (6.15) - (6.16) in the Appendix show the impact effects on consumption, hours, investment, debt and other key endogenous variables of the model that follow a positive technology shock to the economy.

3.4.3.4 Effects on the Economy of a Positive Shock to the Value of Exports

Table 3.7 summarizes the impact effects on the economy that result from a positive shock to exports.

Table 3.7: Fixed Exchange Rate: Impact Effects

Shock	y_X	y_N	c	c_N	c_M	i	h	h_X	h_N	k_{t+1}	k_X	k_N	B_{t+1}	B^*_{t+1}	p
X_t	$+$	$-$	$+$	$-$	$+$	$-$	$+$	$+$	$-$	$-$	$+$	$-$	$-$	$-$	$+$

A positive shock to exports has an immediate positive effect on both the peso and dollar price of exports and the amount of exports, and thus on the export firms' profits: a greater demand for exports allows all monopolistically competitive export firms to charge a higher dollar price for their goods and produce more, which increases export firms' profits immediately, and thus household's income from dividends (and the peso price of exports increases as the dollar price goes up since the exchange rate is fixed). Moreover, since the positive shock to exports makes exports firms expand production, more resources (both capital and labor) in this sector will be hired to produce more. Richer households increase their demand for final consumption goods, which in turn generates a greater demand for nontradables and imported goods. But while the price of nontradables increases, the price of imports stays the same, which causes a shift in demand from nontradable goods to imports. As a result, the initial net effect on the production of nontradables is negative, which makes nontradables firms hire less capital and labor. On the other hand, the demand for imports increases as they become relatively cheaper. Overall, both consumption and hours worked increase and the net effect on welfare is positive (that is, the positive consumption effect on welfare dominates the negative leisure effect).

While the demand for capital in the exports sector increases, it falls in the nontradable sector. The initial net effect on the demand for capital is negative, which explains the initial drop in total investment. Overall, the positive effects of the shock to exports on the economy dominate and, as a result, households will borrow less from world financial markets (a drop in real terms in both debt in pesos and dollars is observed) in order to smooth consumption and other positive effects on the economy. Notice that the decrease in total foreign debt will imply lower interest payments and thus less resources will have to be sacrificed (distracted from investment and consumption) by domestic agents to repay their debt, which also explains the welfare gain.

Even though initially investment drops, after two periods it increases with respect to its long run level: the economy decides to take advantage of the greater demand for exports by increasing its stock of capital. Figures (6.17) - (6.18) in the Appendix show the impact effects on consumption, hours, investment, debt and other key endogenous variables of the model that follow a positive exports shock to the economy.

3.4.4 Comparing Moments under Alternative Exchange Rate Regimes

Tables 3.8 and 3.9 below shows the second moments for some variables of interest. Regarding volatility, under all regimes consumption is more volatile than total domestic output (a common result in small open economy models), capital is less volatile than consumption, and hours worked are less volatile than total output. Regarding comovements, under all regimes consumption, hours worked, and capital are procyclical. It is also worth noticing that among all exchange rate regimes, pegging the peso price of exports delivers the lowest volatility for consumption, peso debt, dollar debt, and welfare. These results are consistent with those from the welfare comparison to be discussed below.

In all cases investment is more volatile than both consumption and output, and

Table 3.8: Comparing Moments

Variables	FIXED E.R.				FLEXIBLE E.R.(CPI)			
	μ	σ	c$(t,-1)$	c(X_t,y_t)	μ	σ	c$(t,-1)$	c(X_t,y_t)
A_t	1.000	0.020	0.357	0.693	1.000	0.020	0.360	0.685
B_{t+1}	0.830	0.318	0.991	-0.415	0.757	0.327	0.992	-0.428
B^*_{t+1}	0.830	0.318	0.991	-0.415	0.759	0.315	0.992	-0.428
$real-B^*_{t+1}$	0.551	0.213	0.989	-0.403	0.503	0.211	0.990	-0.416
$real-B_{t+1}$	0.551	0.213	0.989	-0.403	0.523	0.226	0.992	-0.428
$real-Debt$	1.101	0.426	0.989	-0.403	1.026	0.437	0.991	-0.422
c_t	1.806	0.061	0.727	0.723	1.814	0.062	0.729	0.723
$c_{M,t}$	1.935	0.050	0.772	0.709	1.949	0.051	0.776	0.720
$c_{N,t}$	0.693	0.048	0.521	0.543	0.691	0.049	0.526	0.538
$c-y-ratio$	80.549	1.996	0.680	0.319	80.766	2.011	0.693	0.329
$Debt-y-ratio$	49.121	19.343	0.989	-0.439	45.661	19.884	0.991	-0.457
$Dollarization-ratio$	50.001	0.000	0.991	0.415	48.983	0.338	0.839	0.642
R_t	0.351	0.008	0.614	0.375	0.338	0.007	0.352	0.614
$\frac{R_t}{p_t}$	0.233	0.004	0.337	0.616	0.234	0.005	0.352	0.614
h_t	1.059	0.010	0.478	1.000	1.061	0.010	0.488	1.000
$h_{N,t}$	0.434	0.022	0.496	0.512	0.433	0.022	0.503	0.512
$h_{X,t}$	0.626	0.019	0.441	-0.043	0.628	0.019	0.466	-0.051
i_t	0.638	0.032	0.125	0.570	0.639	0.033	0.135	0.582
$i-y-ratio$	28.483	1.233	0.066	0.281	28.444	1.247	0.082	0.304
k_t	3.312	0.052	0.786	0.609	3.302	0.053	0.785	0.598
$k_{N,t}$	1.356	0.075	0.668	0.380	1.349	0.076	0.674	0.375
$k_{X,t}$	1.956	0.055	0.136	-0.215	1.954	0.055	0.153	-0.233
λ_t	0.970	0.009	0.733	-0.620	0.969	0.010	0.737	-0.623
$\mu_{N,t}$	-0.839	0.000	-0.078	0.332	-0.839	0.000	-0.054	0.356
$\mu_{X,t}$	-0.834	0.000	-0.079	0.332	-0.834	0.000	-0.054	0.356
p_t	1.508	0.015	0.640	-0.303	n.a.	n.a.	n.a.	n.a.
p^*_t	2.001	0.054	0.639	-0.303	2.009	0.056	0.645	-0.293
$p_{M,t}$	1.192	0.000	0.774	0.709	1.143	0.012	0.646	0.293
$p_{N,t}$	1.990	0.054	0.640	-0.303	1.914	0.033	0.646	-0.293
π_t	0.926	0.017	0.723	0.825	0.930	0.018	0.736	0.822
$\pi_{M,t}$	0.372	0.010	0.772	0.709	0.374	0.010	0.779	0.720
$real-\pi_{M,t}$	0.247	0.007	0.619	0.764	0.248	0.007	0.624	0.775
$\pi_{N,t}$	0.222	0.010	0.490	0.646	0.222	0.010	0.496	0.647
$real-\pi_{N,t}$	0.147	0.008	0.497	0.600	0.147	0.008	0.504	0.599
$real-\pi_t$	0.614	0.012	0.572	0.931	0.616	0.012	0.578	0.934
$\pi_{X,t}$	0.332	0.013	0.487	0.069	0.334	0.013	0.513	0.061
$real-\pi_{X,t}$	0.220	0.007	0.426	0.192	0.221	0.007	0.457	0.180
$p_{X,t}$	2.001	0.054	0.639	-0.303	1.926	0.033	0.646	-0.293
$\frac{p_{X,t}}{p_{M,t}}$	1.678	0.046	0.639	-0.303	1.686	0.047	0.646	-0.293
R^p_t	n.a.	n.a.	n.a.	n.a.	1.040	0.004	0.665	-0.228
s_t	n.a.	n.a.	n.a.	n.a.	0.959	0.010	0.645	0.293
V_t	3.988	0.647	0.995	0.469	4.076	0.664	0.996	0.484
w_t	1.570	0.016	0.648	0.363	1.508	0.010	0.488	1.000
$\frac{w_t}{p_t}$	1.041	0.007	0.478	1.000	1.042	0.007	0.488	1.000
X_t	1.000	0.020	0.275	0.548	1.001	0.019	0.304	0.537
$X-y-ratio$	59.202	1.887	0.477	-0.347	59.310	1.909	0.491	-0.350
$y-in-dollars$	3.381	0.056	0.553	0.814	3.390	0.057	0.579	0.806
$y_{M,t}$	1.935	0.050	0.772	0.709	1.949	0.051	0.776	0.720
$y_{N,t}$	0.693	0.048	0.521	0.543	0.691	0.049	0.526	0.538
y_t	2.242	0.037	0.477	1.000	2.246	0.037	0.486	1.000
$y_{X,t}$	1.000	0.020	0.275	0.548	1.001	0.019	0.304	0.537

Table 3.9: Comparing Moments

Variables	FLEXIBLE E.R. (p_X)			
	μ	σ	c(t,−1)	c(X_t,y_t)
A_t	1.000	0.021	0.349	0.711
B_{t+1}	0.922	0.286	0.986	-0.392
B^*_{t+1}	0.910	0.260	0.986	-0.392
$real - B^*_{t+1}$	0.600	0.173	0.983	-0.376
$real - B_{t+1}$	0.678	0.207	0.990	-0.417
$real - Debt$	1.278	0.381	0.988	-0.399
c_t	1.795	0.059	0.704	0.713
$c_{M,t}$	1.956	0.046	0.723	0.716
$c_{N,t}$	0.672	0.049	0.519	0.538
$c - y - ratio$	80.279	1.940	0.668	0.280
$Debt - y - ratio$	57.158	17.364	0.987	-0.441
$Dollarization - ratio$	46.915	0.826	0.787	0.622
R_t	0.323	0.008	0.136	0.747
$\frac{R_t}{p_t}$	0.238	0.005	0.335	0.624
h_t	1.061	0.011	0.458	1.000
$h_{N,t}$	0.426	0.022	0.495	0.505
$h_{X,t}$	0.634	0.019	0.460	-0.039
i_t	0.638	0.033	0.115	0.575
$i - y - ratio$	28.516	1.268	0.069	0.296
k_t	3.216	0.052	0.774	0.582
$k_{N,t}$	1.293	0.075	0.669	0.363
$k_{X,t}$	1.924	0.055	0.134	-0.238
λ_t	0.971	0.010	0.714	-0.601
$\mu_{N,t}$	-0.839	0.000	-0.408	0.256
$\mu_{X,t}$	-0.834	0.000	-0.071	0.361
p_t	1.359	0.024	0.632	0.331
p^*_t	2.035	0.058	0.630	-0.332
$p_{M,t}$	1.067	0.030	0.631	0.332
$p_{N,t}$	1.812	0.000	-0.067	-0.362
π_t	0.931	0.017	0.682	0.823
$\pi_{M,t}$	0.375	0.009	0.732	0.716
$real - \pi_{M,t}$	0.247	0.007	0.569	0.771
$\pi_{N,t}$	0.219	0.010	0.486	0.636
$real - \pi_{N,t}$	0.144	0.008	0.498	0.592
$real - \pi_t$	0.614	0.012	0.533	0.938
$\pi_{X,t}$	0.337	0.013	0.502	0.059
$real - \pi_{X,t}$	0.222	0.007	0.448	0.190
$p_{X,t}$	n.a.	n.a.	n.a.	n.a.
$\frac{p_{X,t}}{p_{M,t}}$	1.707	0.049	0.631	-0.332
R^p_t	1.040	0.011	0.662	-0.249
s_t	0.895	0.025	0.630	0.332
V_t	3.555	0.576	0.992	0.469
w_t	1.414	0.030	0.581	0.600
$\frac{w_t}{p_t}$	1.041	0.007	0.458	1.000
X_t	0.999	0.020	0.297	0.594
$X - y - ratio$	59.940	1.939	0.485	-0.344
$y - in - dollars$	3.392	0.056	0.530	0.800
$y_{M,t}$	1.956	0.046	0.723	0.716
$y_{N,t}$	0.672	0.049	0.519	0.538
y_t	2.236	0.038	0.456	1.000
$y_{X,t}$	0.999	0.020	0.297	0.594

consumption is more volatile than output. The last result is a well-known stylized fact for small open economies, which has been explained mainly by their inability to smooth consumption fully, which is in turn due to their limited access to well developed financial markets (that is why I assume asset market incompleteness in this model).

3.4.5 The Welfare Measure

3.4.5.1 Conditional Welfare

In this study, I evaluate the welfare consequences of three alternative exchange rate regimes. I depart from the usual practice of identifying the welfare measure with the unconditional expectation of lifetime utility because using unconditional expectations of welfare amounts to not taking into account the transitional dynamics leading to the stochastic steady state[17]. The conventional choice of unconditional expectation is usually due to its merit of computational simplicity. Following Schmitt-Grohe and Uribe (2004b), I assume that in the initial state, all state variables are in their non-stochastic steady states, and the exchange rate policies are evaluated by the conditional expectations of the discounted lifetime utility[18]. Because the deterministic steady state is the same across all the exchange rate regimes I consider, my choice of computing expected welfare conditional on the initial state being the nonstochastic steady state ensures that the economy begins from the same initial point under all possible policies. Therefore, my strategy will deliver the constrained optimal exchange rate regime associated with a particular initial state of the economy. An additional advantage in this choice of the initial state is that it can significantly simplify my welfare calculations: all terms containing state variables vanish in my approximation of expected lifetime utility.

To understand how the conditional expectation is calculated, here I follow the steps made by Wang (2006). Let V_t be the conditional expectation of lifetime utility at time

[17]According to Kim and Levin (2005), using a criterion of which the discount factor is set to unity is also equivalent to maximizing the unconditional welfare, since no discounting implies that only the events in the far future matters for welfare evaluations. Though inconsistent with the private agents' behavior, the unconditional welfare criterion has been used since it is easy to compare different policy rules. Under this criterion, the transitional dynamics becomes irrelevant and the comparison does not depend on initial conditions of the economy.

[18]It is of interest to investigate the robustness of my results with respect to alternative initial conditions. For, in principle, the welfare ranking of the alternative polices will depend upon the assumed value for (or distribution of) the initial state vector. For further discussion of this issue, see Kim et al. (2003) and Schmitt-Grohe and Uribe (2004c).

t

$$V_t \equiv E_t \left\{ \sum_{s-t}^{\infty} \beta^{s-t} U(c_s, h_s) \right\} \tag{3.46}$$

To find a second-order approximation of V_t, I can define V_t as a new control variable in my model. From equation (3.46), I can obtain that V_t follows a law of motion as in equation (3.47)

$$V_t - \beta E_t\{V_{t+1}\} = U(c_t, h_t) \tag{3.47}$$

I can put equation (3.47) into my system (in 4.1.1 or 4.2.1, depending on the exchange rate regime) and find a second-order approximation of the solution to this control variable through Schmitt-Grohe and Uribe's (2004c) algorithm[19].

$$\begin{aligned} V_t = g(X_t, \sigma) \approx g(\bar{X}, 0) + (X_t - \bar{X})' g_x(\bar{X}, 0) + g_\sigma(\bar{X}, 0)\sigma \\ + \frac{1}{2}(X_t - \bar{X})' g_{xx}(\bar{X}, 0)(X_t - \bar{X}) + \frac{1}{2} g_{\sigma\sigma}(\bar{X}, 0)\sigma^2 \\ + (X_t - \bar{X})' g_{x\sigma}(\bar{X}, 0)\sigma \end{aligned} \tag{3.48}$$

Here X_t is the vector of state variables in my model, $\bar{X}$ is the deterministic steady-state of the state vector, and σ is a parameter scaling the standard deviation of the exogenous shocks.

Let $V \equiv g(\bar{X}, 0)$ be the non-stochastic steady state lifetime utility. Then, using equation (3.47) I obtain

$$V = \frac{U(\bar{c}, \bar{h})}{1 - \beta} \tag{3.49}$$

I have supposed that at time t, all state variables are in the non-stochastic steady state, therefore $X_t = \bar{X}$. This helps me eliminate all terms containing $X_t - \bar{X}$. Furthermore, from Theorem 1 of Schmitt-Grohe and Uribe (2004c), I know $g_\sigma(\bar{X}, 0) = 0$ and $g_{x\sigma}(\bar{X}, 0) = 0$. Now I can obtain a second-order approximation of V_t in a very simple form

$$V_t = V + \frac{1}{2} g_{\sigma\sigma}(\bar{X}, 0)\sigma^2 \tag{3.50}$$

Clearly, if the initial state of the economy is the non-stochastic steady state, the calculation of conditional welfare is greatly simplified.

---

[19]The Matlab programs for the second-order approximation method are available at Uribe's website.

3.4.5.2 The Conditional Welfare Cost Measure

As the results on conditional welfare will show below, in my model one exchage rate policy dominates the other two. To understand how that result is obtained, here I derive an expression that allows me to quantify the difference on welfare between any two exchange rate regimes. Thus, for instance, the algorithm stated below gives the percentage of the consumption of the "composite good"[20] stream associated with the flexible exchange rate that households are willing to give to be as well off under the flexible exchange rate as under the fixed exchange rate. Let c_t^A be the contingent plan for the consumption of the composite good associated with the flexible exchange rate regime and c_t^B be the contingent plan for consumption of the composite good associated with the fixed exchange rate. Then I can define the welfare cost of the flexible exchange rate regime rather than the fixed exchange rate regime as the value of λ_c such that

$$V_t^B \equiv E_t \left\{ \sum_{t=0}^{\infty} \beta^t U\left((1-\lambda_c)c_t^A\right) \right\} \tag{3.51}$$

where c_t^A represents the value of the composite good in period t under the flexible exchange rate.

Remember that in my model, period utility (as a function of the composite good) under the flexible exchange rate is given by

$$U(c_t^A) = \frac{{c_t^A}^{1-\gamma} - 1}{1-\gamma} \tag{3.52}$$

Now notice that

$$U\left((1-\lambda_c)c_t^A\right) = (1-\lambda_c)^{1-\gamma}\left(\frac{{c_t^A}^{1-\gamma} - 1}{1-\gamma}\right) + \frac{(1-\lambda_c)^{1-\gamma} - 1}{1-\gamma} \tag{3.53}$$

Then it follows that

$$V_t^B = (1-\lambda_c)^{1-\gamma} V_t^A + \frac{(1-\lambda_c)^{1-\gamma} - 1}{(1-\gamma)(1-\beta)} \tag{3.54}$$

---

[20]By "composite good" I mean the combination of consumption and leisure that directly affects the level of period utility and thus welfare. In my model the composite good is given by $(c - \frac{h^\omega}{\omega})$. Even though it is traditional to measure welfare cost in terms of units of consumption goods, I argue that it is also valid to measure the welfare cost in terms of the particular combination of consumption goods and leisure (according to the particular utility function used) since this combination has a direct impact on the level of utility and thus on welfare in the economy.

Now I use $V_t^A = g^A(x_t, \sigma)$ and $V_t^B = g^B(x_t, \sigma)$ to restate the above expression:

$$g^B(x_t, \sigma) = (1 - \lambda_c)^{1-\gamma} g^A(x_t, \sigma) + \frac{(1 - \lambda_c)^{1-\gamma} - 1}{(1 - \gamma)(1 - \beta)} \tag{3.55}$$

It follows that

$$\lambda_c = \Lambda(x_t, \sigma) \tag{3.56}$$

I want to find a second-order accurate approximation of Equations (3.54) and (3.55) around $(x_t, \sigma) = (\bar{x}, 0)$. After totally differentiating both expressions, evaluating both of them at $(x_t, \sigma) = (\bar{x}, 0)$ and applying a set of results found by Schmitt-Grohe and Uribe (2003), I obtain that the conditional welfare cost measure is given by

$$\lambda_c \approx \left[\frac{1 - \beta}{\left(c - \frac{h^{\omega}}{\omega}\right)^{1-\gamma}} \right] \left(V_{\sigma\sigma}^A(\bar{x}, 0) - V_{\sigma\sigma}^B(\bar{x}, 0) \right) \frac{\sigma^2}{2} \tag{3.57}$$

The welfare cost λ_cx100 indicates the percentage of the consumption (of the composite good) stream associated with the flexible exchange rate that households are willing to give up to be as well off as under the fixed exchange rate regime.

3.4.5.3 Conditional Welfare Results

Table 3.10 below shows the results regarding the conditional welfare computed under alternative exchange rate regimes.

Table 3.10: Conditional Welfare

	C.W. Value
Flexible Rate (p_X)	3.7886
Flexible Rate (CPI)	3.7509
Fixed Rate	3.7480
Welfare Cost (p_X vs. CPI)	0.093%
Welfare Cost (p_X vs. fixed)	0.100%

From this table, it is clear that the conditional welfare associated with the flexible exchange rate regime with the peso price of exports as nominal anchor is greater than those related to the flexible rate regime with CPI targeting and the fixed exchange rate regime. Therefore, the best exchange rate policy is the one that pegs the peso price of exports (alternatively, pegging the peso price of exports dominates the other two monetary regimes). The results from the welfare cost analysis are (as expected) consistent with the results from the conditional welfare comparison. Since the welfare costs are strictly positive they clearly show that the flexible exchange rate with the peso price of exports as nominal anchor is superior to the other two exchange rate regimes.

The result that the fixed exchange rate regime is the worst policy (among the three) reflects its creation of an additional costly burden to the economy: First, under this regime, in the market for peso bonds, only the quantity of peso bonds can be adjusted, not its price (the interest rate in pesos r_t^p), and this adjustment is costly (due to the presence of quadratic portfolio adjustment costs). Secondly, since a fixed exchange rate makes the interest rate on peso bonds equal to that on dollar bonds, it follows that in practice the domestic economy will be able to issue only one type of bonds (which pays the interest rate on dollar bonds), and as it is well known, decreasing the number of assets traded internationally should reduce welfare (because it increases the degree of market incompleteness), as suggested by Benigno (2009)[21]. Thirdly, since under the fixed regime there is one less relative price (the interest rate in pesos), the rest of the variables of the model are forced to absorb the shocks, making the variables more volatile (that is, shocks are magnified), and thus increasing their associated uncertainty, which will in turn cause a loss of efficiency in the allocation of resources (both intratemporal and intertemporal); certainly, some of these variables are consumption and hours worked, which directly affect welfare. Overall, under the fixed exchange rate regime, following exogenous shocks to the economy, there will be a significant impact on consumption, hours, investment, the capital stock, output, and welfare.

The result that pegging the peso price of exports (PEP) is a better monetary regime than targeting the CPI is mainly explained by two factors: First, PEP delivers adjustments in the nominal exchange rate that allow the economy to absorb more effectively the exogenous shocks to the economy, with a resulting better smoothing of consumption and thus a greater level of welfare. For example, under PEP and following a positive

[21] In addition, one of the fundamental principles of modern portfolio theory states that, in order to obtain the best possible combination of risk and return on a portfolio of assets, an investor should add to his portfolio an asset whose return is not perfectly positively correlated to the return of any asset that composes the portfolio. Now, notice that in my model, under the flexible exchange rate, the interest rate on peso bonds is not correlated with the interest rate on dollar bonds, which is assumed to be constant.

shock to exports, the government (central bank) keeps constant the peso price of exports and allows an impact appreciation of the peso that is greater than that under targeting the CPI. The appreciation makes imports much cheaper and thus causes a greater increase in their demand. Moreover, the price of final goods drops and thus both consumption and investment increase more than under the CPI-targeting regime; and even though hours work increase more, the positive net effect on welfare is greater under PEP than under CPI targeting. Second, following a depreciation of the domestic currency, an increase in the price of imports will (in general) create a pressure on the CPI to go up, to which the central banck will react by implementing a contractionary monetary policy (which in my model takes the form of an increase in the interest rate on peso bonds), which will affect welfare. In contrast, under PEP, the central bank will not react to such a pressure on the CPI.

3.5 Bayesian estimation using data from Peru

Bayesian methods have become a powerful tool to conduct empirical research. This approach allows a researcher to incorporate prior information to his evaluation of theoretical models with the use of observed data. Using the posterior distributions for parameters, a researcher can use his model to perform policy analysis or forecast the dynamics of macroeconomic variables. In this section I pursue Bayesian analysis to estimate the parameters of the model under each of the exchange rate regimes using DYNARE and assuming GHH preferences.

Peru is a South American developing economy that has grown at an average rate of 6.8 percent during the last seven years, that has had a managed floating exchange rate regime since early 1990's, and that has had a degree of dollarization of at least 50 percent in the last 16 years. Moreover, the current world economic crisis has slowed down its pace of growth: current estimates for its 2009 annual rate of growth indicate an expansion of about 1.3 percent[22]. Certainly, the demand for its export goods from its main trade partners (including the US and Europe) has declined. Regarding the degree of dollarization in Peru, dollarization has been an important problem following the hyperinflation process it experienced in late 1980s.

[22]Figure reported in "The Economist" magazine, September 2009.

3.5.1 The Data

The annual data on consumption, GDP, GDP deflator and population for Peru (for the period 1950-2008) was obtained from the International Financial Statistics (IFS) website. The data on nominal consumption and nominal GDP was deflated using the GDP deflator, divided by the size of the population (in order to express the magnitudes in per capita terms since this is a representative-agent model), and detrended using the Hodrick and Prescott (1980, 1997) filter (the HP-filter hereafter)[23]. Incidentally, since I work with annual data, I used a smoothing parameter equal to 6.25 to apply the HP filter, which is the value proposed by Ravn and Uhlig (2002)[24]. Finally, the resulting GDP and consumption series were normalized in such a way the mean of the consumption series keeps its relative importance with respect to that of GDP (as the real per capita series for these two variables indicate).

3.5.2 Prior densities

The choice of my prior densities is mostly based on the previously discussed calibration and also draws on the related literature. A few values have been chosen so that I can explore a wider range of possibilities regarding the values of parameters. Both innovations's standard deviations have inverted-gamma distributions with mean equal to 0.06 and standard deviation equal to 1. The persistence parameters in the two AR(1) processes for the shocks are beta-distributed with mean equal to 0.5 and standard deviation equal to 0.15. The prior on the parameter α, which measures the capital's share of income, follows a normal distribution with mean equal to 0.32 and standard deviation equal to 0.16. The values for the size of the debt in both currencies in the steady state are beta distributed; the mean of the peso-debt is equal to 0.8 and that of the dollar-debt is equal to 0.8. The standard deviation of the peso debt is equal to 0.1, and that of the dollar debt is equal to 0.1. Both the capital adjustment cost and the price adjustment cost parameters follow a beta distribution with a mean equal to 0.028 and a standard deviation equal to 0.01. Both portfolio adjustment costs parameters follow a beta distribution with a mean equal to 0.00037 and a standard

[23] The HP-filter was actually applied to the natural logarithms of the series.

[24] In contrast, a value of 100 for yearly data has been commonly used in the business cycle literature.

deviation equal to 0.0002. The CRRA parameter is normally distributed with mean equal to 2 and standard deviation equal to 0.5. The parameter associated with the intertemporal elasticity of substitution in labor supply is normally distributed with mean equal to 1.455 and standard deviation equal to 0.5. The rate of depreciation has a beta distribution with mean equal to 0.1 and standard deviation equal to 0.05. The price elasticity of demand for a specific good variety has a normal distribution with mean equal to -6 and standard deviation equal to 1. In a similar way, the elasticity of substitution among varieties of both non-traded and imported goods is normally distributed with a mean equal to 6 and a standard deviation equal to 1. The parameter associated with the elasticity of substitution between non-tradables and imported goods has a normal distribution with mean equal to 2 and standard deviation equal to 0.5. And the share of non-tradable goods in the consumption basket follows a normal distribution with mean equal to 0.5 and standard deviation equal to 0.15.

3.5.3 Analysis of posterior estimates

Posterior densities result from 20,000 replications. As can be seen in Figures (6.19) - (6.20) in the Appendix, the posterior densities obtained from applying the Bayesian estimation using the model that assumes a flexible exchange rate regime with CPI targeting are very similar to those obtained from applying the estimation using the model that assumes a flexible exchange rate regime with pegging the peso price of exports and the model with fixed exchange rate regime. The analysis of the posterior estimates will be based on the results from the model that assumes a fixed exchange rate regime and concentrate in those results that deserve some especial attention.

The main results are summarized in Tables (3.11) and (3.12) below. The persistence parameter of the technology process has a posterior mean equal to 0.39 and that related to the shock to exports has a posterior mean equal to 0.33, that is, the technology shock is more persistent than the shock to exports. These results are consistent with the results obtained from the forecast error variance decomposition (shown below): Even though the evolution of exports and the terms of trade in small open economies is key to explain their macroeconomic dynamics, the technology shock is still the main driving force of business cycles regarding both magnitud and persistence. With respect to the size of the debt in both domestic and foreign currency, their posterior means are close to the priors, suggesting that these values are reasonable. The capital's share of income has a posterior mean of 0.42, which is higher than those in developed economies, but closer to values in the range of 0.5-0.7 that have been used in studies on the Peruvian economy by authors such as Castillo et al (2006) and Carranza et al (2005). With respect to the share of non-tradable goods in the consumption basket, its posterior mean of 0.55 is not very different from the value of 0.4 that has been used by Castillo et al (2006). The parameter associated with the elasticity of substitution between non-tradables and imported goods has a posterior mean of 2.39, which is within the range of estimated values (1.2-3.0) obtained by Castillo et al (2006). Regarding the depreciation rate, its posterior mean is about 0.08, which is smaller than the standard value of 0.1 used in the literature. The CRRA parameter has a posterior mean of 0.28, which is low, implying low risk aversion. Regarding the estimated posterior means for the rest of parameters that have been estimated, the results indicate that their priors are plausible.

Therefore, the analysis of the posterior estimates allows me to conclude that the Bayesian estimation of the model, which uses data from Peru, shows that most of the values of the fundamental parameters of the model used in the first part of this study (the analysis of a calibrated model) are plausible, which makes those results important.

Table 3.11: Estimation Results

		FIXED E.R.			FLEXIBLE E.R. (CPI)		
parameters	prior mean	post. mean	conf.interv.		post. mean	conf.interv.	
α	0.32	0.4201	0.3636	0.4761	0.4202	0.3638	0.4754
B	0.8	0.7994	0.6467	0.9576	0.8026	0.6539	0.9593
B^*	0.8	0.7994	0.6453	0.9602	0.7981	0.6455	0.9568
ϕ	0.028	0.0398	0.011	0.0671	0.0397	0.0109	0.0667
ϕ_2	0.028	0.0279	0.0065	0.0486	0.0275	0.0063	0.0477
ρ	0.5	0.3943	0.1798	0.6059	0.3968	0.1855	0.6085
τ	0.5	0.3391	0.132	0.5359	0.3396	0.1373	0.5377
ψ_2	0.0007	0.0004	0.0001	0.0007	0.0004	0.0001	0.0007
ψ_3	0.0007	0.0004	0.0001	0.0006	0.0004	0.0001	0.0007
γ	2	0.2753	0.0886	0.4659	0.2826	0.1036	0.4594
ω	1.455	1.7957	1.1105	2.4667	1.789	1.1076	2.4512
δ	0.1	0.1983	0.1258	0.2704	0.2008	0.1292	0.2716
η	-6	-6.0099	-7.6884	-4.3627	-6.0665	-7.5918	-4.4845
a	0.5	0.5461	0.4677	0.6266	0.5458	0.4651	0.6259
θ	2	2.3942	1.8421	2.9334	2.3456	1.7601	2.9011
λ_D	6	6.1932	4.7112	7.6684	6.1707	4.5798	7.6979
σ_A	0.06	0.0254	0.0119	0.0388	0.0253	0.0127	0.038
σ_X	0.06	0.0198	0.0145	0.025	0.0197	0.0146	0.0244

Table 3.12: Estimation Results

parameters	prior mean	FLEXIBLE E.R. (p_X) post. mean	conf.interv.		prior distr.	prior σ
α	0.32	0.42	0.3622	0.4768	norm	0.16
B	0.8	0.8072	0.6618	0.9632	beta	0.1
B^*	0.8	0.8009	0.6489	0.9591	beta	0.1
ϕ	0.028	0.0394	0.0106	0.0662	beta	0.014
ϕ_2	0.028	0.0273	0.006	0.0475	beta	0.014
ρ	0.5	0.3991	0.1831	0.6112	beta	0.2
τ	0.5	0.342	0.138	0.5438	beta	0.2
ψ_2	0.0007	0.0004	0.0001	0.0007	beta	0.0002
ψ_3	0.0007	0.0004	0.0001	0.0007	beta	0.0002
γ	2	0.3024	0.0998	0.5008	norm	0.5
ω	1.455	1.7848	1.0828	2.454	norm	0.5
δ	0.1	0.2064	0.1302	0.2838	beta	0.05
η	-6	-6.0412	-7.5761	-4.4499	norm	1
a	0.5	0.5515	0.4632	0.6474	beta	0.15
θ	2	2.3891	1.7769	2.9874	norm	0.5
λ_D	6	6.186	4.5841	7.7901	norm	1
σ_A	0.06	0.0264	0.0126	0.0404	invg	1
σ_X	0.06	0.0196	0.0145	0.0245	invg	1

3.5.4 Forecast Error Variance Decomposition

The results obtained from this part of the analysis (see Table (3.13) below) show that in my model the shock to exports explains all the volatility of output and the level of exports. Regarding the technology shock, more than 50 percent of the volatility of consumption, hours worked and profits is explained by this shock, and more than 70 percent of the volatility of investment and the stock of capital is also explained by this shock. Overall, the technology shock is the main driving force in this small open economy, but the shock to exports plays also an important role in determining the dynamics of its macroeconomic variables.

3.6 Conclusions

In this paper I use a dynamic stochastic general equilibrium model with endogenous dollarization to study the welfare implications of three alternative exchange rate regimes. In my model infinitely-lived households finance consumption, investment and debt repayment by issuance of short-term bonds denominated in both domestic (pesos) and foreign currency (dollars). Thus, the optimal currency composition of households' portfolios of liabilities is adjusted every period in response to the economy's performance. In turn, imperfectly competitive domestic firms set the dollar price of exports every

Table 3.13: Forecast Error Variance Decomposition

Variables	FIXED E.R.		FLEXIBLE E.R. (CPI)		FLEXIBLE E.R. (p_X)	
	σ_A	σ_X	σ_A	σ_X	σ_A	σ_X
A_t	100	0	100	0	100	0
B_{t+1}	64.87	35.13	64.05	35.95	62.55	37.45
B^*_{t+1}	64.87	35.13	64.05	35.95	62.55	37.45
$real-B^*_{t+1}$	65.03	34.97	64.24	35.76	62.81	37.19
$real-B_{t+1}$	65.03	34.97	64.05	35.95	62.2	37.8
$real-Debt$	65.03	34.97	64.14	35.86	62.45	37.55
c_t	80.88	19.12	81.26	18.74	82.64	17.36
$c_{M,t}$	70.53	29.47	70.36	29.64	69.87	30.13
$c_{N,t}$	88.78	11.22	88.9	11.1	89.73	10.27
$c-y-ratio$	56.98	43.02	56.66	43.34	56.61	43.39
$Debt-y-ratio$	64.4	35.6	63.49	36.51	61.76	38.24
$Dollarization-ratio$	64.87	35.13	70.48	29.52	71.54	28.46
R_t	57.31	42.69	66.73	33.27	96.4	3.6
$\frac{R_t}{p_t}$	66.58	33.42	66.73	33.27	67.04	32.96
h_t	61.1	38.9	60.83	39.17	59.26	40.74
$h_{N,t}$	83.47	16.53	83.63	16.37	84.82	15.18
$h_{X,t}$	44.66	55.34	44.84	55.16	46.99	53.01
i_t	91.81	8.19	91.8	8.2	92.55	7.45
$i-y-ratio$	75.01	24.99	74.97	25.03	75.98	24.02
k_t	85.82	14.18	86.2	13.8	87.95	12.05
$k_{N,t}$	75.32	24.68	75.51	24.49	77.02	22.98
$k_{X,t}$	67.72	32.28	67.9	32.1	69.79	30.21
λ_t	76.5	23.5	76.7	23.3	77.83	22.17
$\mu_{N,t}$	77.64	22.36	77.79	22.21		
$\mu_{X,t}$	77.63	22.37	77.79	22.21	79.22	20.78
p_t	84.12	15.88			85.31	14.69
p^*_t	84.11	15.89	84.26	15.74	85.29	14.71
$p_{M,t}$			84.26	15.74	85.3	14.7
$p_{N,t}$	84.12	15.88	84.26	15.74	79.25	20.75
π_t	56.97	43.03	55.85	44.15	51.86	48.14
$\pi_{M,t}$	70.53	29.47	70.26	29.74	69.54	30.46
$real-\pi_{M,t}$	77.78	22.22	78.03	21.97	78.75	21.25
$\pi_{N,t}$	88.03	11.97	88.29	11.71	89.56	10.44
$real-\pi_{N,t}$	88.67	11.33	88.88	11.12	89.92	10.08
$real-\pi_t$	76.4	23.6	76.46	23.54	75.51	24.49
$\pi_{X,t}$	40.86	59.14	41.13	58.87	43.33	56.67
$real-\pi_{X,t}$	26.21	73.79	26.42	73.58	28.54	71.46
$p_{X,t}$	84.11	15.89	84.26	15.74		
$\frac{p_{X,t}}{p_{M,t}}$	84.11	15.89	84.26	15.74	85.3	14.7
R^p_t			75.78	24.22	77.41	22.59
s_t			84.25	15.75	85.29	14.71
V_t	64.13	35.87	63.23	36.77	61.5	38.5
w_t	40.32	59.68	60.83	39.17	97.73	2.27
$\frac{w_t}{p_t}$	61.1	38.9	60.83	39.17	59.26	40.74
X_t	0	100	0	100	0	100
$X-y-ratio$	71.05	28.95	71.21	28.79	72.91	27.09
$y-in-dollars$	30.67	69.33	29.31	70.69	25.19	74.81
$y_{M,t}$	70.53	29.47	70.36	29.64	69.87	30.13
$y_{N,t}$	88.78	11.22	88.9	11.1	89.73	10.27
y_t	61.05	38.95	60.71	39.29	58.77	41.23
$y_{X,t}$	0	100	0	100	0	100

period taking into account current technology and demand conditions. The economy can be affected by two shocks that follow independent stochastic processes, a technology shock and a (level of) exports shock. Finally, the government chooses the exchange rate regime (fixed or flexible with CPI targeting or flexible with pegging the peso price of exports), and then defends the nominal anchor (the pegged value of the exchange rate, the CPI, or the peso price of domestic exports, depending on the chosen regime). The most important finding in my study is that the flexible exchange rate regime dominates the other two regimes, while pegging the peso price of exports dominates the fixed exchange rate regime. This result is based upon the comparison of welfare levels associated with each monetary regime. This key result can be explained as follows: On one hand, the fixed exchange rate regime creates an additional costly burden to the economy, because under this regime (i) in the market for peso bonds only the quantity of peso bonds can be adjusted, not its price, and this adjustment is costly; (ii) the interest rate on peso bonds and dollar bonds is the same, which means that in practice the domestic economy can issue only one type of bonds, which pays the interest rate on dollars; and the implied increase in the degree of market incompleteness will affect welfare, as Benigno (2009) has suggested; and (iii) since there is one less relative price in the economy (the interest rate on peso bonds), the remaning variables of the model will have to absorb the shocks, which will make them more volatile and increase the uncertainty in the model; two of these variables are consumption and hours worked, which directly affect welfare. On the other hand, targeting the CPI implies that the central bank will pursue a contractionary monetary policy whenever a depreciation of the exchange rate creates a presure on the CPI (via an increase in the peso price of imports); such a contractionary policy is absent under pegging the peso price of exports. In addition, pegging the peso price of exports is a regime that delivers a depreciation of the domestic currency whenever the economy experiences an adverse shock to exports, and this depreciation will create incentives for domestic firms to produce and export more goods.

The main result in my paper is consistent with the conventional wisdom, which states that for economies mainly affected by real shocks, it is recommended to have a flexible exchange rate regime. Another important result is that the model replicates some stylized facts for emergent economies. In particular, regarding volatility, consumption is more volatile than output, capital is less volatile than consumption, and hours worked is less volatile than output; regarding comovements, consumption, hours, and capital are all procyclical. Moreover, another important finding is that my model is consistent with the contributions made by Frankel (2003, 2005): for an emergent economy that exports mainly primary goods, pegging the peso price of domestic exports PEP is a desirable exchange rate regime.

Finally, the Bayesian analysis of my model lets me conclude that pegging the peso price of exports is the best monetary regime for Peru, an economy that has experienced a high degree of dollarization for more than 16 years and that has had a floating exchange rate regime for more than 20 years.

Chapter 4

Optimal Fiscal Policy Rule in a Small Open Economy with Endogenous Dollarization

4.1 Introduction

Some authors have stated that monetary policy is not as effective in a (de facto) dollarized economy as in an economy where this phenomenom is absent. For instance, Cespedes, Chang and Velasco (2001) state that monetary policy in a dollarized economy becomes ineffective in offsetting real shocks. As they explain, in an open economy an interest-rate cut operates mainly by allowing the domestic currency to devalue in order to make domestic goods cheaper abroad. But if debts are dollarized, then a nominal devaluation might increase substantially the costs of the debt, generating bankruptcies in both companies and banks and potentially causing output to fall. Thus, the effectiveness of the central bank to fight inflation and contribute to the stabilization of the economy is reduced. Therefore, some authors have proposed that the fiscal authority should play a more active role in the control of inflation and the stabilization of the economy. In this paper I evaluate alternative fiscal policy rules in a highly dollarized small open economy in order to identify the optimal fiscal policy rule, defined as the one that maximizes the expected life-time utility of the representative agent.

Monetary policy has substantially changed during the last three decades following theoretical and empirical debates around policy optimality. One of the outcomes from the debate is that interest rate decisions of central banks have in general become more explicit and systematic. Regarding fiscal policy, fiscal rules have received much less attention by scholars and policymakers; however, in recent years the design and evaluation of fiscal rules have become an important topic of policy discussion; for instance, Taylor (2000) focus on the role of automatic stabilizers in the design of fiscal policy. In this paper, I analyze the link between public debt and government spending and fiscal instruments (in particular, government tax revenues).

A number of papers deal with the fiscal policy's ability to stabilize the economy using simple rules (see for instance Gali and Perotti, 2003, Taylor, 2000, and Fatas and Mihov, 2001). Other papers use fiscal policy rules to test for the link between prices and public debt, as induced by the fiscal theory of the price level (FTPL), and for the sustainability of fiscal policy in general (for instance Bohn, 1998, finds out that US fiscal surpluses have responded positively to debt, and argues that this result is evidence that the US fiscal policy has been sustainable).

In my model, the government is assumed to be benevolent (that is, it seeks to bring about the equilibrium that maximizes the expected lifetime utility of the representative agent) and to have access to a commitment technology that allows it to honor its promises. The policy instruments that the government uses are assumed to be lump-sum taxes and the short-term nominal interest rate. Moreover, public debt is assumed to be nominal and non-state contingent. Since I am also interested in characterizing optimal policies that can be easily implemented, I only evaluate simple monetary and fiscal rules. These simple rules are defined over a small set of readily available macro indicators and are designed to ensure local uniqueness of the rational expectations equilibrium.

But why is it especially interesting to study alternative fiscal policy rules in a model of a highly dollarized economy? As highlighted by Chang (2005) and other authors, the dollarization of liabilities explains why central banks are concerned with "undesired" fluctuations on the exchange rate[1] and the potential balance sheet effects. Balance sheet effects refer to the adverse economic and/or financial impact on firms and individuals that follows a depreciation of the domestic currency in economies in which a significant amount of debt is denominated in foreign currency while the income is generated in domestic currency[2]. Thus, since depreciation of the domestic currency could be particularly dangerous for highly-dollarized small open economies, governments evaluate alternative fiscal policy rules in order to preserve the solvency of the fiscal sector. A

[1] It is well understood and documented that economies become dollarized during episodes of high inflation. However, disinflations are not necessarily followed by dedollarization. In particular, Argentina, Bolivia, Peru, Russia, Ukraine and other countries have remained highly dollarized long after the inflation rate was brought down to single digits.

[2] According to Ize and Levy-Yeyati (2003), many emergent economies facing dollarization have tried to eliminate it by implementing disinflationary policies, but most of them have been unsuccessful. They state that the main reason for that result is that dollarization levels can remain high if the expected volatility of the inflation rate is high in relation to the expected volatility of the real exchange rate

fiscal sector with no significant deficits creates the confidence that economic agents need to continue with their normal economic activities. In contrast, it is well known that periods of substantial fiscal deficits are associated with high inflation and continuous and dramatic devaluations/depreciations of the domestic currency. Peru in the late 1980s and Argentina during the 1980s are examples of countries that experienced profound crisis characterized by large fiscal deficits, high inflation rates, and constant dramatics devaluations of the domestic currency[3]. Only after deep macroeconomic reforms (which certainly included the fiscal sector), these economies could start recovering and, then, continue growing. This type of crisis is exactly what the fiscal authority wants to avoid. These examples explain the huge importance that fiscal policy rules have for governments' economic and political stability and viability (and the economies themselves) in economies characterized by a high degree of dollarization.

In this paper I use a stochastic dynamic general equilibrium model to determine the fiscal rule that maximizes the welfare of a small open economy with a high level of dollarization. In this regard, I build a model of a small open economy with an incomplete menu of assets: domestic residents can only borrow internationally using short-term bonds denominated in domestic or foreign currency, and the government can only borrow using foreig-currency denominated short-term bonds. In addition, the small open economy with an endogenous degree of dollarization is inhabited by households, firms and a government. Households live infinite periods and accumulate capital partly financed with the sale of bonds. Uncertainty in my model is given by four shocks that follow independent exogenous processes: a technology shock to output, a random level of domestic exports, a government spending shock, and a transfer shock.

In addition, the model features convex portfolio adjustment costs for both peso and dollar bonds, in order to induce stationarity of the equilibrium dynamics. This stationarity inducing technique has been used, among others, in recent papers by Neumeyer and Perri (2001), and Schmitt-Grohe and Uribe (2002). In this model, the cost of increasing asset holdings by one unit is greater than one because it includes the marginal cost of adjusting the size of the portfolio.

In order to compare alternative fiscal policies, I solve the model for the decentralized

[3]In 2007, both Argentina and Peru were economies with a degree of dollarization of around 60-70%.

economy, that is, I solve the problems of both households and firms independently. All variables are in per capita terms (that is, there is no population growth). Moreover, perfect integration to international capital markets and arbitrage guarantee that in equilibrium the expected next-period (dollar) domestic interest rate in pesos equals the expected next-period (dollar) world interest rate, which in turn is assumed to be exogenously given. I use a Matlab code in order to compute the impulse response functions, the moments for the endogenous variables in the model, the conditional welfare, and other relevant statistical information. The code is based on those provided by Schmitt-Grohe and Uribe (2003, 2004a, 2004c).

Furthermore, following the recommendations given by Kim et al. (2003), the fiscal policy rules in my paper are evaluated in terms of conditional expected welfare instead of the unconditional one. Thus, the object that fiscal policy aims to maximize in my study is the expectation of lifetime utility of the representative household conditional on a particular initial state of the economy. In contrast, many existing normative evaluations of monetary policy rank policies based upon unconditional expectations of utility. As Kim et al. (2003) point out, unconditional welfare measures ignore the welfare effects of transitioning from a particular initial state to the stochastic steady state induced by the policy under consideration. By using conditional welfare, I highlight the fact that transitional dynamics matter for policy evaluation.

Finally, the results suggest that an optimal fiscal policy rule for the economy modeled in this paper should take into account deviations (from their corresponding steady states) of the amount of government debt, government spending, and inflation.

The paper is structured as follows. The next section outlines the basic model, and section 4.3 discusses the calibration of the parameters of the model. Section 4.4 explains how the model is solved. Finally, section 4.5 concludes.

4.2 The Model

Consider a small open economy populated by a large number of identical households, monopolistically competitive firms and a government. I develop a simple infinite-horizon production economy with imperfectly competitive product markets and sticky prices.

4.2.1 The Household's Problem

Each household has preferences defined over processes of consumption and leisure and described by the utility function

$$E_0 \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \right\} \tag{4.1}$$

where c_t denotes consumption, h_t denotes labor effort, $\beta \in (0,1)$ denotes the subjective discount factor, and E_0 denotes the mathematical expectation operator conditional on information available in period 0. The single period utility function U is assumed to be increasing in consumption, decreasing in effort, strictly concave, and twice continuously differentiable.

Households can hold physical capital, k_t. The law of motion of the capital stock k_t is given by

$$k_{t+1} = (1-\delta)k_t + i_t - \phi(k_{t+1}, k_t) \tag{4.2}$$

where $\delta \in (0,1)$ denotes the constant rate of depreciation of the capital stock, i_t is (gross) investment, and $\phi(k_{t+1}, k_t)$ is a measure of capital adjustment costs.

Capital adjustment costs have many explanations. Changing the level of capital services at a business generates disruption costs during installation of any new or replacement capital and costly learning must be incurred as the structure of production may have been changed. Moreover, installing new equipment or structures often involves delivery lags and time to install or build. The irreversibility of many projects caused by a lack of secondary markets for capital goods acts as another form of adjustment cost. It is assumed that $\phi(0) = \phi'(0) = 0$. Small open economy models typically include capital adjustment costs to avoid excessive investment volatility in response to shocks to the domestic economy. I introduce capital adjustment costs to avoid the excess volatility of investment that typically arises in small open economy models (see Schmitt-Grohe, 1998)[4].

Every period, in order to finance current consumption c_t, investment i_t and foreign debt repayment, domestic households can issue one-period bonds denominated in both

[4]See also Schmitt-Grohe and Uribe's "Optimal Simple and Implementable Monetary and Fiscal Rules," July 2006.

domestic currency ("peso bonds" B_{t+1}) and foreign currency ("dollar bonds" B^*_{t+1}). The domestic economy borrows from the world financial market, represented by a continuum of risk-neutral lenders. A peso-bond is a promise to pay a principal plus an interest r^p_t in pesos after one period. In turn, dollar-bonds are promises to pay a principal plus an interest r_t in dollars after one period. Peso bonds and dollar bonds are sold for one peso and one dollar, respectively. The representative household's optimal borrowing decisions, together with the amount of dollar debt issued by the government, determine the degree of "dollarization" in the economy, which will be influenced by its expectations about equilibrium prices and the exchange rate.

Households must pay taxes on labor income, capital income, and profits, in addition to lump sum taxes. I denote τ^h_t, τ^k_t and τ^π_t, respectively, the labor income tax rate, the capital income tax rate and the profit tax rate in period t; the current period lump sum tax is denoted by TL_t. In addition, households receive a lump-sum transfer from the government in an amount in pesos TR_t per period.

The representative household's period-by-period (dollar) budget constraint is given by

$$\frac{B_{t+1}}{s_t} + B^*_{t+1} + (1-\tau^\pi_t)\pi_t + (1-\tau^h_t)\frac{w_t h_t}{s_t} + (1-\tau^k_t)\frac{R_t k_t}{s_t} + \frac{TR_t}{s_t}$$
$$= c_t + i_t + (1+r^p_t)\frac{B_t}{s_t} + (1+r_t)B^*_t + \frac{\psi_2}{2}(B^*_{t+1} - B^*)^2 + \frac{\psi_3}{2}(B_{t+1} - B)^2 + \frac{TL_t}{s_t} \quad (4.3)$$

where the left hand side of the equality represents all the sources of income for the representative household, while the right hand side represents all the possible uses of that income. Both sides of the above expression are expressed in dollars. I assume that all domestic consumption and investment is made in only foreign goods, and that the dollar price of foreign consumption and investment goods is equal to \$1, and that this dollar price does not change. That means that consumption c_t and (gross) investment i_t in the expression above represent, at the same time, quantities of goods and the dollar value of these components of aggregate demand. The nominal wage rate and rental rate of capital are represented by w_t and R_t, respectively. Since free trade prevails and the law of one price holds, the peso price of imports is given by the exchange rate s_t (expressed in pesos per dollar); in other words, s_t in my model is not only the nominal exchange rate, but also the aggregate level of prices in the domestic economy. This implies that the real wage rate and the real rental rate of capital in the domestic economy are given by $\frac{w_t}{s_t}$ and $\frac{R_t}{s_t}$, respectively.

I assume that there are portfolio adjustment costs associated with the issuance of debt, both in pesos and in dollars. Portfolio adjustment costs for the issuance of peso and dollar bonds are given, respectively, by the following expressions,

$$\frac{\psi_3}{2}(B_{t+1} - B)^2$$

and

$$\frac{\psi_2}{2}(B^*_{t+1} - B^*)^2$$

where B and B^* are the steady state values of peso and dollar bonds, respectively. Clearly, in the steady state portfolio adjustment costs are zero.

I asume that, because of no arbitrage, the expected gross rate of return on peso bonds (the expected gross interest rate on peso bonds) $E_t\{1+r^p_{t+1}\}$ equals the expected peso gross rate of return on world assets, that is,

$$E_t\left\{1 + r^p_{t+1}\right\} = E_t\left\{(1 + r_{t+1})\left(\frac{s_{t+1}}{s_t}\right)\right\} \tag{4.4}$$

In addition, households are subject to a borrowing constraint that prevents them from engaging in Ponzi schemes.

Furthermore, I assume a specific functional form for the period utility function mentioned above following Mendoza (1991)[5]; in particular,

$$U(c_t, h_t) = \frac{\left(c_t - \frac{h_t^\omega}{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

where γ is the coefficient of relative risk aversion, and ω is one plus the inverse of the intertemporal elasticity of substitution in labor supply.

In addition, I assume a specific functional form for the implicit capital adjustment cost function mentioned above following Mendoza (1991); in particular,

[5]The benchmark utility function (GHH) is a generalized version of quasi-linear utility, first introduced into the real business cycle literature by Greenwood, Hercowitz and Huffman (1988). GHH preferences have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period.

$$\phi(k_{t+1}, k_t) = \frac{\phi}{2}(k_{t+1} - k_t)^2$$

where ϕ is the capital adjustment cost parameter.

The household chooses the set of processes $\{c_t, h_t, k_{t+1}, i_t, B_{t+1}, B^*_{t+1}\}_{t=0}^{\infty}$ and some borrowing limit that prevents it from engaging in Ponzi-type schemes so as to maximize (4.1) subject to (4.2)−(4.4), taking as given the set of processes for $\{s_t, r_t^p, r_t, w_t, R_t,$ $\pi_t, \tau_t^\pi, \tau_t^h, \tau_t^k, TL_t, TR_t\}_{t=0}^{\infty}$ and the initial conditions k_0, B_0 and B_0^*.

Let the multiplier on the flow budget constraint (4.3) be $\lambda_t \beta^t$. Then the first-order conditions of the household's maximization problem are (4.2) − (4.4) holding with equality and

$$\lambda_t = \left(c_t - \frac{h_t^\omega}{\omega}\right)^{-\gamma} \tag{4.5}$$

$$(1 - \tau_t^h)\frac{w_t}{s_t} = h_t^{\omega - 1} \tag{4.6}$$

$$\lambda_t \left[1 + \phi(k_{t+1} - k_t)\right] = \beta E_0 \left[\lambda_{t+1}\left((1 - \tau_{t+1}^k)\frac{R_{t+1}}{s_{t+1}} + (1 - \delta) + \phi(k_{t+2} - k_{t+1})\right)\right] \tag{4.7}$$

$$\lambda_t \left[\frac{1}{s_t} - \psi_3(B_{t+1} - B)\right] - \beta E_t \left[\lambda_{t+1}\left(\frac{1 + r_{t+1}^p}{s_{t+1}}\right)\right] = 0 \tag{4.8}$$

$$\lambda_t \left[1 - \psi_2(B^*_{t+1} - B^*)\right] - \beta E_0 \left[\lambda_{t+1}(1 + r_{t+1})\right] = 0 \tag{4.9}$$

The interpretation of the first order conditions above are as follows: Equation (4.5) defines the marginal utility of consumption. Equation (4.6) states that in equilibrium the representative household must be indifferent between enjoying an additional hour of leisure and enjoying the additional units of consumption that it will afford to buy by working one more hour. Equation (4.7) states that in equilibrium, the representative household must be indifferent between consuming an additional unit of good, and investing that additional unit and then consuming the goods that he could buy with the revenues from the investment, net of depreciation. Equation (4.8) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of peso bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more peso bond must equal the discounted value of the marginal utility of consumption lost from the repayment of the unit of peso bond. Equation (4.9) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of dollar bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more dollar bond must equal the discounted value of the marginal utility of consumption lost from the repayment of the unit of dollar bond, including the interest on that additional debt.

4.2.2 The Firms' Problem

Each firm is the monopolistic producer of one variety of final goods[6]. The domestic firm's output is given by

$$\tilde{y}_t = A_t F(\tilde{k}_t, \tilde{h}_t) - \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*)$$

where the first element of the right hand side of the above expression corresponds to the production function of domestic firms, which have access to a constant returns to scale production technology. Imperfectly competitive domestic firms produce a single good that is sold abroad.

I follow Rotemberg (1982) and introduce sluggish price adjustment by assuming that the firm faces a resource cost that is quadratic in the inflation rate of the good it produces. Each firm is assumed to be the monopolistic supplier of a differentiated traded good.

$$Price\ adjustment\ cost = \frac{\phi_2}{2}\left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*} - 1\right)^2$$

The parameter ϕ_2 measures the degree of price stickiness. The higher is ϕ_2 the more sluggish is the adjustment of nominal prices. If $\phi_2 = 0$, then prices are flexible.

[6]The assumption of imperfect competition is consistent with the assumption that firms optimally choose prices subject to nominal frictions, as well as with the idea that output is demand-determined over some range in which firms can meet demand at non-negative profits.

The firm hires labor and capital from a perfectly competitive market. The foreign demand for the domestic good is of the form $X_t d(\hat{p}_t)$, where X_t denotes the level of foreign demand and $\hat{p}_t$ denotes the relative price of the good in terms of the average price of domestic exports. The relative price $\hat{p}_t$ is defined as $s_t \tilde{p}_t^* / p_t$; where s_t is the nominal exchange rate, $\tilde{p}_t^*$ is the dollar price of the good produced by the firm, and p_t is the average peso price of domestic exports. The demand function $d(.)$ is assumed to be decreasing and to satisfy $d(1) = 1$ and $d'(1) < -1$. The restrictions on $d(1)$ and $d'(1)$ are necessary for the existence of a symmetric equilibrium. The monopolist sets the dollar price of the good $\tilde{p}_t^*$ it supplies taking the level of aggregate demand as given, and is constrained to satisfy demand at that price, that is,

$$A_t F(\tilde{k}_t, \tilde{h}_t) - \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*) \geq X_t d(\hat{p}_t) \tag{4.10}$$

(Dollar) Profits are given by

$$\tilde{\pi}_t = \tilde{p}_t^* X_t d(\hat{p}_t) - \frac{w_t \tilde{h}_t}{s_t} - \frac{R_t \tilde{k}_t}{s_t} \tag{4.11}$$

In addition, I assume a specific functional form for the implicit function mentioned above following Mendoza (1991); in particular,

$$F(k_t, h_t) = k_t^{\alpha} h_t^{1-\alpha}$$

Each period, imperfectly competitive firms choose capital $\tilde{k}_t$, labor services $\tilde{h}_t$ and the dollar price of exports $\tilde{p}_t^*$[7], subject to demand and technological constraints (4.10), so as to maximize profits (4.11). Since the firm is owned by the representative household, it is natural to assume that the intertemporal marginal rate of substitution $\beta \frac{\lambda_{t+1}}{\lambda_t}$ can be used to discount future profits. Let the multiplier on the demand and supply equilibrium condition (4.10) be $\mu_t \beta^t \left(\frac{\lambda_{t+1}}{\lambda_t} \right) \tilde{p}_t^*$; then the firm will maximize the following expression:

[7] As explined by Corsetti (2007), for a firm located in a country with noisy monetary policy, pricing its exports in foreign currency (that is, choosing local currency pricing LCP) is quite attractive: it ensures that revenues from exports in domestic currency will tend to rise in parallel with nominal marginal costs, with stabilizing effects on the markup. This may help explain why exporters from emerging markets with relatively unstable domestic monetary policies prefer to price their exports to advanced countries in the importers' currency. The same argument, however, suggests that LCP is not necessarily optimal for exporters producing in countries where monetary policy systematically stabilizes marginal costs; Goldberg and Tille (2005) provide empirical evidence on this point.

$$L = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{t+1}}{\lambda_t} \left[\tilde{p}_t^* X_t d(\hat{p}_t) - \frac{w_t \tilde{h}_t}{s_t} - \frac{R_t \tilde{k}_t}{s_t} \right] \right\}$$
$$+E_t \left\{ \sum_{t=0}^{\infty} \mu_t \beta^t \frac{\lambda_{t+1}}{\lambda_t} \tilde{p}_t^* \left[X_t d(\hat{p}_t) - A_t F(\tilde{k}_t, \tilde{h}_t) + \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*) \right] \right\} \tag{4.12}$$

taking as given the processes for $\{A_t, X_t, w_t, R_t, s_t, \lambda_t\}_{t=0}^{\infty}$.

As a result of the profit maximization process, input demands and export prices must satisfy the following efficiency conditions:

$$\frac{R_t}{s_t} = -\tilde{\mu}_t \tilde{p}_t^* A_t \alpha \tilde{k}_t^{\alpha-1} \tilde{h}_t^{1-\alpha} \tag{4.13}$$

$$\frac{w_t}{s_t} = -\tilde{\mu}_t \tilde{p}_t^* A_t \tilde{k}_t^{\alpha} (1-\alpha) \tilde{h}^{-\alpha} \tag{4.14}$$

$$X_t \left[d\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) + d'\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) \right] + \tilde{\mu}_t \left[X_t d'\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) + \tilde{p}_t^* \phi_2 \left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*} - 1\right)\left(\frac{1}{\tilde{p}_{t-1}^*}\right) \right]$$
$$+\tilde{\mu}_t \left[X_t d\left(\frac{s_t \tilde{p}_t^*}{p_t}\right) - A_t \tilde{k}_t^{\alpha} \tilde{h}_t^{1-\alpha} + \frac{\phi_2}{2}\left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*} - 1\right)^2 \right]$$
$$= E_t \left\{ \tilde{\mu}_{t+1} \beta \left(\frac{\lambda_{t+1}}{\lambda_t}\right) \tilde{p}_{t+1}^* \phi_2 \left(\frac{\tilde{p}_{t+1}^*}{\tilde{p}_t^*} - 1\right)\left(\frac{\tilde{p}_{t+1}^*}{\tilde{p}_t^{*2}}\right) \right\} \tag{4.15}$$

The interpretation of the first order conditions above are as follows: Equations (4.13) states that in equilibrium there is a wedge between the real rental rate of capital and the marginal productivity of capital, which is explained by the monopolistic power of the firms. Equation (4.14) states that in equilibrium there is a wedge between the real wage rate and the marginal productivity of labor, which is explained, again, by the presence of imperfectly competitive firms in the market. Equation (4.15) states that in equilibrium there is a wedge between marginal revenue and marginal cost, as a result of the monopolistic power of firms.

Let me define the marginal cost mc_t and marginal revenue mr_t as follows

$$mc_t = \frac{\frac{w_t}{s_t}}{p_t^* A_t \tilde{k}_t^{\alpha} (1-\alpha) \tilde{h}^{-\alpha}}$$

$$mr_t = \frac{s_t \tilde{p}_t^*}{p_t} + \frac{d\left(\frac{s_t \tilde{p}_t^*}{p_t}\right)}{d'\left(\frac{s_t \tilde{p}_t^*}{p_t}\right)}$$

4.2.3 The Government

In large-scale macroeconomic forecasting models, including those used by leading international institutions, the modelling of the fiscal sector involves some type of fiscal closure rule. Its inclusion is used to generate solvency for the fiscal sector, guaranteeing that the intertemporal budget constraint of the government is satisfied and generating model closure. That is, the possibility of an unstable or explosive path for the government debt ratio is ruled out, and as a result agents in the model are willing to hold public debt.

In the absence of a monetary authority monetising shocks to debt, which is the case in most industrialised countries, a fiscal authority can be thought of as reacting to innovations affecting debt through the adjustment of budgetary items in order to guarantee debt sustainability. Indeed, some empirical evidence supports this notion (see, for instance, Bohn, 1998 and Kilpatrick, 2001).

The use of fiscal closure rules for model economies approximates the actual reaction to shocks by a fiscal authority. Nevertheless, some empirical evidence supports the notion of capturing actual government behaviour via a rule. For example, Bohn (1998) has provided evidence that governments take corrective measures in response to disturbances to avert an unstable or explosive path for debt. Specifically, based on the analysis of time series data for the United States, he finds evidence that the government has historically reacted to increases in the debt-to-GDP ratio by either reducing its primary deficit or improving its primary surplus.

Seigniorage revenues are assumed to be nil for simplicity. Moreover, the monetary authority is assumed to be "active" (in the sense of Leeper, 1991) since it sets its instrument (the interest rate on peso bonds) independently of tax collection and debt issuance. Currently, there is no agreement on the appropriate fiscal policy instrument, which therefore will be model-specific. Moreover, there may be the lack of a sound theoretical or empirical criterion for this selection, although this may be of limited concern if taxes are lump sum (i.e. changes in tax rates have no real effects) and depends on the focus of the model at hand. Any attempt to model distortionary elements of taxation, however, could be complicated by the behaviour induced by such a rule. Were a modeller to introduce such elements, the choice of revenue item reacting to budgetary variability would no longer have neutral effects, and as such could have important consequences for aspects of agents behaviour. Accordingly, modellers have generally opted to model tax revenues accruing from the rule as lump-sum.

Monetary policy is conducted by means of an interest rate in pesos r_t^p reaction function[8], whose general form is

$$log\left(\frac{1+r_{t+1}^p}{1+r}\right) = \phi_\pi log\left(\frac{s_t}{s_{t-1}}\right) + \phi_y log\left(\frac{y_t}{y}\right) + \phi_r log\left(\frac{1+r_t^p}{1+r}\right) \tag{4.16}$$

where y and r denote the steady state values of output and the peso interest rate[9], respectively.

In this paper, I assume that the monetary authority chooses some arbitrary monetary policy rule, and then the fiscal authority chooses the fiscal policy rule according to a procedure to be explained below[10].

In addition, remember that, because of arbitrage, the following condition between the domestic peso interest rate and the dollar interest rate on domestic dollar bonds must hold every period

$$E_0\{1+r_{t+1}^p\} = E_0\left\{(1+r_{t+1})\frac{s_{t+1}}{s_t}\right\}$$

otherwise, risk-neutral foreign investors will either buy only domestic assets that promise to pay the peso interest rate, or only domestic dollar bonds, which promise to pay a dollar interest rate.

Regarding the fiscal authority, each period the government spends g_t pesos in the consumption of imported goods. I assume that the variable g_t is exogenous and that it follows an autoregressive process of the form

---

[8]Monetary policy rules are often expressed such that the choice variable for the central bank, usually a short-term nominal interest rate, is determined by a number of economic variables. However, a well-known problem with such rules is that certain specifications of the rule can lead to indeterminacy, that is, an economy for which many different outcomes are possible given the same fundamental economic situation. A good monetary policy should avoid such non-uniqueness. One solution that works well in many models is to make the interest rate rule be "active," in the sense that the nominal interest rate responds more than one-for-one to movements in the inflation rate.

[9]Notice that, in the steady state, all domestic interest rates (both in pesos and in dollars) are equal to the constant world (dollar) interest rate r.

[10]It is important to mention that nominal rigidities, in the form of sticky prices, lead to real effects of monetary policy. In particular, in a model with sticky prices, monetary policy affects real activity because output is demand-determined and firms are not allowed to readjust their price completely in any given period.

$$log\left(\frac{g_t}{g}\right) = \rho_g log\left(\frac{g_{t-1}}{g}\right) + \epsilon_t^g, \quad \text{where} \quad \epsilon_t^g \sim N(0, \sigma_g^2) \tag{4.17}$$

where ϵ_t^g is a white noise random variable. The parameter g represents the nonstochastic steady state level of government absorption. A second source of government expenditures is transfer payments to households in the amount TR_t in pesos. Like government consumption, transfers are assumed to be exogenous and to follow the law of motion

$$log\left(\frac{TR_t}{TR}\right) = \rho_{TR} log\left(\frac{TR_{t-1}}{TR}\right) + \epsilon_t^{TR}, \quad \text{where} \quad \epsilon_t^{TR} \sim N(0, \sigma_{TR}^2) \tag{4.18}$$

where ϵ_t^{TR} is a white noise random variable. The parameter TR represents the nonstochastic steady state level of government transfers.

The government levies labor, capital and profit income taxes, in addition to a lump sum tax. Thus, total tax revenues (in pesos) TT_t are then given by

$$TT_t = \tau_t^k R_t k_t + \tau_t^h w_t h_t + \tau_t^\pi s_t \pi_t + TL_t \tag{4.19}$$

Every period, the fiscal authority covers deficits by issuing one period nominally risk-free bonds $\tilde{B}_{t+1}$, which promise to pay the principal of the debt plus an interest[11]. Government bonds are sold in international markets to only foreign investors at a dollar price of \$1 and, for simplicity, are assumed to pay the world interest rate on dollars r_t[12]. The period-by-period budget constraint of the government[13] (in dollars) is given by

$$\tilde{B}_{t+1} + \frac{TT_t}{s_t} = \frac{g_t}{s_t} + \frac{TR_t}{s_t} + (1 + r_t)\tilde{B}_t \tag{4.20}$$

Fiscal policy is conducted by means of a tax reaction function, by which the fiscal authority adjusts the level of taxes in order to (i) preserve the solvency on the fiscal

[11]For simplicity, I assume that the government suffers from "original sin." Authors like Eichengreen and Haussman (1999) have studied the problems associated with the inability of countries to issue long term debt domestically or borrow abroad in terms of the domestic currency.

[12]That is, from the perspective of foreign investors, the debt in dollars issued by the government is a perfect substitute of the debt in dollars issued by domestic private households.

[13]Like in the recent literature, I will abstract from monetary frictions and consider the limit of a "cashless economy" (see Woodford 2003). As a result, in my model, seigniorage is not a source of revenues for the government.

sector[14], and/or (ii) smooth the fluctuations in the economy[15]. An example of a tax reaction function that I will evaluate in my model is given by

$$log\left(\frac{TL_t}{TL}\right) = \psi_{\tilde{B}} log\left(\frac{\tilde{B}_{t+1}}{\tilde{B}}\right) + \psi_g log\left(\frac{g_t}{g}\right) + \psi_y log\left(\frac{y_t}{y}\right) \tag{4.21}$$

where TL and $\tilde{B}$ denote the steady state levels of lump-sum taxes and government (dollar) debt, respectively.

I assume that at time 0 the benevolent government has been operating for an infinite number of periods. In choosing optimal policy, the government is assumed to honor commitments made in the past. This form of policy commitment has been referred to as "optimal from the timeless perspective" (Woodford, 2003).

4.2.4 Equilibrium

I restrict attention to symmetric equilibria where all firms charge the same price for the good they produce ($\tilde{p}_t^* = p_t^*$). As a result, I have that $\hat{p}_t = 1$ for all t. It then follows from the fact that all firms face the same wage rate and rental rate of capital, the same technology shock, and the same production technology, that they all hire the same amount of labor and capital; that is, $\tilde{h}_t = h_t$ and $\tilde{k}_t = k_t$. Let

$$\eta \equiv d'(1)$$

denote the equilibrium value of the elasticity of demand faced by the individual producers of goods. Then, in equilibrium, the expression for the marginal revenue mr_t above simplifies to

$$mr_t = 1 + \frac{1}{\eta}$$

Furthermore, the domestic goods market equilibrium condition[16] is given by

$$p_t y_t = s_t p_t^* X_t d\left(\frac{s_t p_t^*}{p_t}\right)$$

[14]Here, I consider the possibility that the government tries to preserve solvency either directly (by adjusting taxes so that the government debt is stabilized), or indirectly (by adjusting taxes so that increases in government spending do not materialize in a much greater government debt).

[15]In this case, taxes play the role of automatic stabilizers.

[16]That is, the value in pesos of domestic output equals the value in pesos of the quantity demanded of domestic output.

where s_t is the nominal exchange rate, expressed in number of units of domestic currency per unit of foreign currency, while $X_t d(.)$ is the quantity of domestic exports. As in Chang and Velasco (2004), I assume that domestic residents do not consume home goods, and thus the demand for home output comes from foreigners[17]. Since by assumption total domestic production y_t is exported

$$y_t = X_t d\left(\frac{s_t p_t^*}{p_t}\right)$$

I obtain the expected result that

$$p_t = s_t p_t^* \tag{4.22}$$

which states that the price in pesos of domestic exports p_t equals the product of the nominal exchange rate s_t times the dollar price of domestic exports p_t^*.

Due to their monopolistic power, domestic firms choose the dollar price of exports p_t^*. Clearly, an increase in p_t^* can be interpreted as a positive change to the terms of trade in the economy. That is, a positive change to the exports price will increase the domestic purchasing power of domestic agents in terms of foreign goods (imports).

Notice that my model does not make explicit the use of a monetary aggregate in this economy, although the domestic price is a key variable in the model. It is possible to introduce money explicitly to my model, but the conclusions should not change. My model assumes that the monetary authority just supplies the amount of money consistent with the value of the interest rate that it wants the economy to face, according to the prevailing monetary policy rule (4.16).

The stochastic processes for the level of aggregate demand X_t and the technology shock A_t are exogenously given by

$$logX_t = \tau logX_{t-1} + \xi_t, \quad \text{where} \quad \xi_t \sim N(0, \sigma_X^2) \tag{4.23}$$

$$logA_t = \rho logA_{t-1} + \epsilon_t, \quad \text{where} \quad \epsilon_t \sim N(0, \sigma_A^2) \tag{4.24}$$

where both ξ_t and ϵ_t are white noise random variables.

[17]According to the World Development Indicators, ten countries export goods with a value greater than 90% of GDP. This group of countries includes Singapore, Malaysia, Hong Kong, Luxeamburg, and UAE. In addition, thirteen countries in the world import goods with a value greater than 90% of GDP. This second group of countries includes Singapore, Malaysia, Hong Kong, Luxeamburg, and Puerto Rico

4.3 Calibration

The model is calibrated for an average small open economy with a high degree of dollarization; thus, some parameters are picked from studies on the Mexican and Canadian economies, and some parameters are calibrated using data from Argentina. The basic calibration and parameterization of the model is taken from Mendoza (1991). Mendoza calibrates the model to the Canadian economy[18]. Mendoza argues that Canada is viewed as a typical small open economy because of the historical absence of capital controls and the high degree of integration of its financial markets with those of the United States. I also use some calibrated parameters from Schmitt-Grohe and Uribe (2003 and 2005).

The parameter values that I will use in my simulation of the model are given in Table 4.1 below.

Table 4.1: Calibration

Symbol	Value	Description
α	0.32	Capital's share of income
γ	2	Coefficient of relative risk aversion
δ	0.1	Depreciation rate
η	-6	Price elasticity of demand for a specific export good variety
ψ_2	0.00074	Parameter of the portfolio adjustment cost function on dollar bonds
ψ_3	0.00074	Parameter of the portfolio adjustment cost function on peso bonds
ϕ	0.028	Parameter of the capital adjustment cost function
ϕ_2	0.028	Degree of price stickiness
ρ	0.8556	Serial correlation of the log of the technology shock
τ	0.8556	Serial correlation of the log of the exports shock
ρ_{TR}	0.78	Serial correlation of the log of the transfers shock
ρ_g	0.87	Serial correlation of the log of the government spending shock
ω	1.455	One plus the inverse of the intertemporal elasticity of substitution in labor supply
σ_A	0.0064	Standard deviation of the technology shock error term
σ_X	0.0064	Standard deviation of the exports shock error term
σ_{TR}	0.022	Standard deviation of the transfers shock error term
σ_g	0.016	Standard deviation of the government spending shock error term
r	0.04	World's real interest rate

Following Mendoza (1991), I assign a value of 1.455 to the parameter ω, which is key to compute the value of the elasticity of labor suply $1/(1-\omega)$; in addition, I assign a

[18]The data considered by Mendoza corresponds to annual observations for the period 1946-1985, expressed in per capita terms of the population older than 14 years, transformed into logarithms and detrended with a quadratic time trend.

value of 2 to the coefficient of relative risk aversion γ, and a value of 0.028 to the capital adjustment cost parameter ϕ. Since I do not have an estimation of the price adjustment costs parameter ϕ_2, I make its value small and equal to the value of ϕ[19]. Furthermore, following Schmitt-Grohe and Uribe (2003), I assign small values to the parameters ψ_2 and ψ_3[20], which measure the costs associated with issuing debt in dollars and pesos in amounts different from their respective steady state values. Regarding the world interest rate in dollars r, I assign it a value of 4 percent[21]. I calibrate the steady state values for the private peso bonds B, private dollar bonds B^*, and public dollar bonds $\tilde{B}$ so that they are consistent with a level of dollarization and ratios of government debt to output and total (private and government) debt to output equal to 70 percent, 0.2, and 0.8, respectively, which are consistent with empirical values for small open economies[22]. The value of 0.1 assigned to the annual depreciation rate δ implies an average investment ratio of about 19 percent, which is close to the average value observed in Argentina of about 17 percent. I set the parameter α, which determines the average capital share of income, at 0.32, a value commonly used in the related literature. In addition, I set the value of the price elasticity of demand on a specific good η equal to -6. This value implies a steady state value for the markup of 0.20, which is a reasonable value[23]. The calibration of the rest of the parameter values were taken from Schmitt-Grohe and Uribe (2005).

Following Schmitt-Grohe and Uribe (2005), I assign the value of 0.8556 to the parameter ρ, which measures the serial correlation of the technology shock. In addition, I assign the value of 0.87 to the parameter ρ_g, which measures the serial correlation of government spending. I also assign the value of 0.78 to the parameter ρ_{TR}, which measures the serial correlation of government transfers. Since in my model domestic output equals the quantity of domestic exports, I assume that the value of the parameter τ, which measures the serial correlation of exports is the same as that of domestic output,

---

[19]According to the menu cost literature, a small value will be enough to get significative effects.

[20]I have assumed that the values for these parameters are the same since, in principle, there is no reason to think that the values must be different.

[21]Which in turn, implies a value of about 0.96 for the discount factor β.

[22]The expressions for the level of dollarization and the ratio of total debt to output are given by Equations (4.36) and (4.37), respectively

[23]Basu and Fernald (1997) estimate gross-output markup of about 0.1. They show that their estimates are consistent wih values for the added-value markup of up to 0.25.

that is 0.8556. Regarding the values of the parameters associated to the volatility of the shocks, I assign a value of 0.0064 to both σ_A and σ_X, the standard deviations of the technology shock and the exports shocks[24]. In addition, I assign a value of 0.016 to the parameter σ_g, which measures the standard deviation of government spending, and a value of 0.022 to the parameter σ_{TR}, which measures the standard deviation of government transfers.

Additional and implied parameter values that I will use in my simulation of the model are given in Table 4.2 below.

Table 4.2: Additional and Implied Parameter Values

Symbol	Value	Description
$\tilde{B}/(p^*y)$	0.2	Ratio of government debt to output
$(B^* + \tilde{B})/(B^* + \tilde{B} + B/s)$	0.7	Ratio of dollar debt to total debt
$(1+r)(B^* + \tilde{B} + B/s)/(p^*y)$	0.8	Ratio of total debt to output

4.4 Solving the Model

4.4.1 Evaluating Fiscal Rules that combat Inflation, and that smooth Output Fluctuations

In this section, I consider two alternative sets of fiscal policy rules[25]. In particular, I first evaluate the importance of incorporating in the fiscal policy rule a component that tries to smooth the fluctuations in inflation; then I evaluate the importance of incorporating in the fiscal policy rule a component that tries to smooth output fluctuations.

The simple monetary policy rule that I consider in this section is given by,

[24] As explained above, domestic output and exports are the same in my model.

[25] As stated by the Federal Reserve Bank of San Francisco, active use of countercyclical fiscal policy in Japan and the United States, and the formation of a monetary union in Europe have provided an motivation for research on fiscal policy and its relationship with monetary policy. For instance, Gali and Monacelli (2004) argue that national fiscal policy in a monetary union should take over some of the short-run stabilization duties normally performed by monetary policy. They found out that when prices are sticky, members of a monetary union will have a motive for fiscal stabilization, which emerges because monetary policy, which would normally be used to stabilize the economy in response to shocks, can instead be used only to address disturbances with limited power. To stabilize an economy, fiscal policy should “lean against the wind,” with policy expansionary when output and inflation are below their equilibrium levels and contractionary when they are above their equilibrium levels. It is often argued that the loss of monetary policy flexibility due to the merger of currencies increases the potential role of fiscal policy as a stabilisation tool and increases the need for fiscal policy cooperation within Europe.

$$log\left(\frac{1+r^p_{t+1}}{1+r}\right) = \phi_\pi\left(\frac{s_t}{s}\right) \tag{4.25}$$

where s denotes the steady-state value of the nominal exchange rate.

4.4.1.1 A Simple Taylor Rule and a Fiscal Rule that takes into account inflation

Here I assume a the simple Taylor rule in Equation (4.25) and a fiscal rule that tries to (i) preserve the solvency of the fiscal authority, and (ii) control the inflationary pressures in the economy. I assume that, first, the government (central bank) announces the monetary and fiscal policy rules that they will maintain, and then after observing the realization of the exogenous shocks to technology, to the volume of exports, to transfers, and to government spending, households and firms solve their corresponding contrained optimization problems, as explained above. I define as optimal fiscal policy rule the one that maximizes the life-time utility of the representative agent.

In addition, the fiscal policy rule that I consider in this section is given by,

$$log\left(\frac{TL_t}{TL}\right) = \psi_{\tilde{B}} log\left(\frac{\tilde{B}_t}{\tilde{B}}\right) + \psi_g log\left(\frac{g_t}{g}\right) + \psi_\pi log\left(\frac{s_t}{s}\right) \tag{4.26}$$

Notice that in this section I am ignoring ouptut in the fiscal policy rule. Instead, I consider the exchange rate (the price level in the domestic economy). And also notice that, for simplicity, I asumme that taxes to wages, rent and profits equal zero; that is, lump sum taxes are the only type of taxes in the economy.

4.4.1.2 A Simple Taylor Rule and a Fiscal Rule that takes into account output

In a second analysis I assume the simple Taylor rule stated in Equation (4.25), and a Fiscal rule that tries to (i) preserve the solvency of the fiscal authority, and (ii) smooth the fluctuations of output in the economy. Notice that in this section I am considering output in the fiscal policy rule as suggested by Equation (4.21).

Thus, the fiscal policy rule that I consider in this section is given by,

$$log\left(\frac{TL_t}{TL}\right) = \psi_{\tilde{B}} log\left(\frac{\tilde{B}_t}{\tilde{B}}\right) + \psi_g log\left(\frac{g_t}{g}\right) + \psi_y log\left(\frac{y_t}{y}\right) \tag{4.27}$$

Again, for simplicity I asumme that taxes to wages, rent and profits equal zero; that is, lump sum taxes are the only taxes in the economy.

4.4.2 The First Order Conditions

I am now ready to define an equilibrium. A competitive equilibrium is a set of plans for $\{c_t, h_t, i_t, k_{t+1}, B_{t+1},\ B^*_{t+1}, \lambda_t, \mu_t, p^*_t, w_t, R_t, s_t, p_t, r_t, r^p_t,\ TL_t, \tilde{B}_{t+1}\}$ satisfying (4.2) – (4.4), (4.10) – (4.11), (4.16), (4.19) – (4.22), some non-Ponzi game condition, and the following conditions

$$\lambda_t = \left(c_t - \frac{h_t^\omega}{\omega}\right)^{-\gamma} \tag{4.28}$$

$$(1-\tau_t^h)\frac{w_t}{s_t} = h_t^{\omega-1} \tag{4.29}$$

$$\begin{aligned} &\lambda_t\left[1+\phi(k_{t+1}-k_t)\right] \\ = \beta E_0 &\left[\lambda_{t+1}\left((1-\tau^k_{t+1})\frac{R_{t+1}}{s_{t+1}} + (1-\delta) + \phi(k_{t+2}-k_{t+1})\right)\right] \end{aligned} \tag{4.30}$$

$$\lambda_t\left[q_t - \psi_3(B_{t+1}-B)\right] - \beta E_0\left[\lambda_{t+1}\left(\frac{1}{s_{t+1}}\right)\right] = 0 \tag{4.31}$$

$$\lambda_t\left[1-\psi_2(B^*_{t+1}-B^*)\right] - \beta E_0\left[\lambda_{t+1}(1+r_{t+1})\right] = 0 \tag{4.32}$$

$$\frac{R_t}{s_t} = -\mu_t p^*_t A_t \alpha k_t^{\alpha-1} h_t^{1-\alpha} \tag{4.33}$$

$$\frac{w_t}{s_t} = -\mu_t p^*_t A_t k_t^{\alpha}(1-\alpha) h^{-\alpha} \tag{4.34}$$

$$\begin{aligned} &X_t\eta\left[\left(1+\frac{1}{\eta}\right) - (-\mu_t)\right] + \mu_t p^*_t \phi_2\left(\frac{p^*_t}{p^*_{t-1}} - 1\right)\left(\frac{1}{p^*_{t-1}}\right) \\ -E_0&\left\{\mu_{t+1}\left(\frac{1}{1+r_{t+1}}\right) p^*_{t+1}\phi_2\left(\frac{p^*_{t+1}}{p^*_t} - 1\right)\left(\frac{p^*_{t+1}}{p^{*2}_t}\right)\right\} = 0 \end{aligned} \tag{4.35}$$

given exogenous processes $\{A_t, X_t, g_t, TR_t\}$ and initial conditions $A_0, X_0, k_0, B_0, B^*_0$, $p*_{-1}, TR_0, g_0, \tilde{B}_0$.

Incidentally, I compute the level of dollarization for the economy (LD_t) and the ratio of total debt to output (RTD_t) for each period in order to make a better analysis of the impact of the different exogenous shocks to the economy. These two indicators are defined as follows

$$LD_t = 1 - \frac{\frac{(1+r_t^p)B_t}{s_t}}{\frac{(1+r_t^p)B_t}{s_t} + (1+r_t)(B_t^* + \tilde{B}_t)} \tag{4.36}$$

$$RTD_t = \frac{\frac{(1+r_t^p)B_t}{s_t} + (1+r_t)(B_t^* + \tilde{B}_t)}{p_t^* y_t} \tag{4.37}$$

4.4.3 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value; that is $\xi = 0$, $\epsilon = 0$, $\epsilon^g = 0$, and $\epsilon^{TR} = 0$, which implies values for the level of domestic exports, productivity factor, government spending, and transfers of $X = 1$, $A = 1$, $g = 0.05$, and $TR = 0.02$, respectively. In addition,

$$B = \bar{B}$$

$$B^* = \bar{B}^*$$

$$\tilde{B} = \bar{\tilde{B}}$$

$$p = \bar{p}$$

$$p^* = \left(\frac{X^{\frac{(1-\alpha)(\omega-1)}{\omega}}}{[-\mu(1-\alpha)]^{\frac{1-\alpha}{\omega}} \left[\frac{-\mu\alpha}{\frac{1}{\beta}-(1-\delta)} \right]^{\alpha}} \right)^{\frac{1}{\frac{1-\alpha}{\omega}+\alpha}}$$

$$k = \frac{-\mu\alpha p^* X}{\frac{1}{\beta} - (1-\delta)}$$

$$h = [p^*(-\mu)(1-\alpha)X]^{\frac{1}{\omega}}$$

$$s = \frac{p}{p^*}$$

$$r^p = r$$

$$y = Ak^{\alpha}h^{(1-\alpha)} = X$$

$$w = h^{\omega-1}s$$

$$R = -\mu\alpha \left(\frac{X}{k}\right) p$$

$$\mu = -\left(\frac{1+\eta}{\eta}\right)$$

$$\lambda = \left(c - \frac{h^{\omega}}{\omega}\right)^{-\gamma}$$

$$\pi = p^{*} X \left(-\frac{1}{\eta}\right)$$

$$c = \left(q - \frac{1}{s}\right) B - rB^{*} - \delta k + (1-\tau^{\pi})\pi + (1-\tau^{h})\frac{wh}{s} + (1-\tau^{k})\frac{Rk}{s} + \frac{TR}{s} - \frac{TL}{s}$$

$$i = \delta k$$

4.4.4 Conditional Welfare

In this study, I evaluate the welfare consequences of alternative fiscal policy rules. I depart from the usual practice of identifying the welfare measure with the unconditional expectation of lifetime utility because using unconditional expectations of welfare amounts to not taking into account the transitional dynamics leading to the stochastic steady state[26]. The conventional choice of unconditional expectation is usually due to its merit of computational simplicity. Following Schmitt-Grohe and Uribe (2004b), I assume that in the initial state, all state variables are in their non-stochastic steady states, and the fiscal policies are evaluated by the conditional expectations of the discounted lifetime utility[27]. Because the deterministic steady state is the same across all fiscal policies I consider, my choice of computing expected welfare conditional on the initial state being the nonstochastic steady state ensures that the economy begins from the same initial point under all possible policies. Therefore, my strategy will deliver the constrained optimal fiscal policy associated with a particular initial state of the

[26]According to Kim and Levin (2005), using a criterion of which the discount factor is set to unity is also equivalent to maximizing the unconditional welfare, since no discounting implies that only the events in the far future matters for welfare evaluations. Though inconsistent with the private agents' behavior, the unconditional welfare criterion has been used since it is easy to compare different policy rules. Under this criterion, the transitional dynamics becomes irrelevant and the comparison does not depend on initial conditions of the economy.

[27]It is of interest to investigate the robustness of my results with respect to alternative initial conditions. For, in principle, the welfare ranking of the alternative polices will depend upon the assumed value for (or distribution of) the initial state vector. For further discussion of this issue, see Kim et al. (2003) and Schmitt-Grohe and Uribe (2004c).

economy. An additional advantage in this choice of the initial state is that it can significantly simplify my welfare calculations: all terms containing state variables vanish in my approximation of expected lifetime utility.

Futhermore, the conditional expectation of lifetime utility at time t (V_t) is given by the following expression:

$$V_t = V + \frac{1}{2} g_{\sigma\sigma}(\bar{X}, 0)\sigma^2 \tag{4.38}$$

where V is the steady state value of welfare, σ is a parameter scaling the standard deviation of the exogenous shocks, $g_{\sigma\sigma}$ is the second-order derivative of the policy function for welfare with respecto to the scalar σ, and $\bar{X}$ is a vector containing the deterministic steady-state of the state varibles in the model. Details about the derivation of the expression above can be found in Wang (2006) and Palacios-Salguero (2009).

4.4.5 Simulation of the Economy and Welfare Effects

I solve the model using a second order approximation to the policy functions. I assume that the value of the parameter in the simple monetary policy rule in (4.25), ϕ_π, is equal to 1.5, which is a common value for this parameter in the monetary policy literature[28]; that is, our monetary policy rule conforms to the Taylor principle (that the central bank should raise its interest rate instrument more than one-to-one with increases in inflation). Moreover, according to the terminology introduced by Leeper (1991), the monetary policy considered here is "active" (ϕ_π >1)[29].

4.4.5.1 Simulation of the Economy and Welfare Effects when the Fiscal Rule takes into account inflation

Here, I solve the model using different combinations of the parameter values in the fiscal policy function: $\psi_{\tilde{B}}$, ψ_g, and ψ_π. In particular, I let each of these three parameters take values between 0 and 3[30].

[28]According to Woodford (2003), in Taylor's discussions of the rule, he highlights the importance of responding to inflation above its target rate (I assume that the target inflation rate is zero, for simplicity) by raising the nominal interest-rate operating target by more than the amount by which inflation exceeds its target.

[29]On the other hand, a "passive" monetary policy implies ϕ_π <1

[30]To be more specific, due to the long time that it would take for the program to solve the model for every possible combination of the parameters in the (closed) interval $[0, 3]$, I just let each parameter

The results from the simulations tell us that the optimal fiscal policy in the dollarized economy that I model should take into account deviations (with respect to their corresponding steady-state values) of the amount of government debt, government spending and inflation in order to maximize the welfare of the representative agent. In particular, the values for the parameters $\psi_{\tilde{B}}$, ψ_g, and ψ_π that maximize the life-time utility of the representative agent are 3.0, 3.0 and 2.8, respectively. Table 4.3 below summarizes the main result of the simulation (notice that the value of welfare has been rounded to four decimals).

Table 4.3: Optimal Fiscal Rule with Inflation

$\psi_{\tilde{B}}$	ψ_g	ψ_π	Conditional Welfare
3.0	3.0	2.8	-101.2620

In the Appendix, Figures I.1, I.2 and I.3 show the levels of welfare associated with different combinations of the values for the parameters in the fiscal rule that takes into account inflation. In particular, in Figure I.1, I keep constant the value of parameter $\psi_{\tilde{B}}$ at its "optimal" level of 3.0, and then show the different levels of welfare that result from combining this fixed value with all the possible values for parameters ψ_g and ψ_π. In a similar fashion, I keep constant the value of ψ_g at its optimal level of 3.0 in Figure I.2, and then keep constant the value of ψ_π at its optimal level of 2.8 in Figure I.3.

4.4.5.2 Simulation of the Economy and Welfare Effects when the Fiscal Rule takes into account output

Here, I solve the model using different combinations of the parameter values in the fiscal policy function: $\psi_{\tilde{B}}$, ψ_g, and ψ_y. In particular, I let each of these three parameters take values between 0 and 3[31].

The results from the simulations tell us that the optimal fiscal policy in the dollarized economy that I model should take into account deviations (with respect to their corresponding steady-state values) of the amount of government debt and government spending in order to maximize the welfare of the representative agent. In particular,

take the values 0, 0.1, 0.2, 0.3, ..., 2.9, and 3.

[31]To be more specific, due to the long time that it would take for the program to solve the model for every possible combination of the parameters in the (closed) interval [0,3], I let each parameter take the values 0, 0.1, 0.2, 0.3, ..., 2.9, and 3.

the values for the parameters $\psi_{\tilde{B}}$, ψ_g and ψ_y that maximize the life-time utility of the representative agent are 3.0, 3.0 and 0.0, respectively. Table 4.4 below summarizes the main result of the simulation (notice that the value of welfare has been rounded to four decimals).

Table 4.4: Optimal Fiscal Rule with Output

$\psi_{\tilde{B}}$	ψ_g	ψ_y	Conditional Welfare
3.0	3.0	0.0	-101.2620

In the Appendix, Figures II.1, II.2 and II.3 show the levels of welfare associated with different combinations of the values for the parameters in the fiscal rule that takes into account output. In particular, in Figure II.1, I keep constant the value of parameter $\psi_{\tilde{B}}$ at its "optimal" level of 3.0, and then show the different levels of welfare that result from combining this fixed value with all the possible values for parameters ψ_g and ψ_y. In a similar fashion, I keep constant the value of ψ_g at its optimal level of 3.0 in Figure II.2, and then keep constant the value of ψ_y at its optimal level of 0 in Figure II.3.

4.4.5.3 Main Result from the Two Previous Simulations of the Economy

Apparently, from a quick comparison of the results shown in Tables 4.3 and 4.4 above, it is unclear whether the optimal fiscal policy rule should include the inflation rate or not: Both Tables show a value of welfare equal to -101.2620; but remember, both values have been rounded to four decimals. However, if I take into account more decimals for the values of welfare, I obtain the correct result from the comparison: The inflation rate must be included in the fiscal rule. Therefore, I can conclude that the inflation rate must be considered in the optimal fiscal rule.

4.5 Conclusions

Some authors have stated that monetary policy is not as effective in a dollarized economy as in an economy where this phenomenom is absent. If this is true, how important is to characterize an optimal fiscal policy rule in a dollarized economy? Should this rule also contribute to the stabilization of prices and output? In this paper I use a dynamic stochastic general equilibrium model for a small open economy with endogenous dollarization to evaluate alternative fiscal policy rules. Optimal fiscal policy is given by a constrained plan in which the fiscal authority maximizes the agent's welfare subject to the competitive economy relations and the assumed monetary and fiscal policy rules. In my model infinitely-lived households finance consumption, investment and debt repayment by issuance of short-term bonds denominated in both domestic (pesos) and foreign currency (dollars). In turn, imperfectly competitive domestic firms set the dollar price of exports every period taking into account current technology and demand conditions. In addition, the optimal currency composition of households' portfolios of liabilities is adjusted every period in response to the economy's performance. The economy can be affected by four shocks that follow independent stochastic processes: a technology shock, a (volume of) exports shock, a government spending shock and a transfer shock. Finally, the government chooses the monetary policy and fiscal rules. The results suggest that an optimal fiscal policy rule should take into account deviations (from their corresponding steady state values) of the amount of government debt, government spending, and inflation in order to maximize the welfare of the representative agent in a dollarized economy that is continuously affected by exogenous shocks.

Chapter 5

Portfolio Choice, Dollarization, and Exchange Rates

5.1 Introduction

The world is currently experiencing the most important economic and financial crisis after the Great Depression, and every country in the world has been affected in many aspects. Some of the consequences of the current international crisis have been a significant capital outflow, a depreciation of the domestic currency, the fall in exports, and a contraction in production. In particular, countries such as Argentina, Brazil, and Mexico have experienced a substantial depreciation of their currencies since the onset of the crisis. Moreover, in early 2009 the IMF projected that net private capital inflows to emerging markets would be negative in \$175 billion, an amount that is substantially different from the \$610 and \$122 billion that these markets received in 2007 and 2008, respectively[1]. In this paper I use a recently developed method created by Devereux and Sutherland (2007, 2008) to evaluate alternative exchange rates and characterize the optimal currency composition of foreign assets and liabilities in a small open economy that is highly dollarized.

To float or not to float? This seems to be one of the key macroeconomic questions that every emerging economy has to answer. Since early 1970s most countries in the world have decided to let their currencies float. However, most of these countries actually have a managed floating exchange rate regime, that is, one in which the central bank will intervene the foreign exchange market in order to affect the domestic price of the foreign currency. As highlighted by Chang (2005) and other authors, the dollarization of liabilities explains why central banks are concerned with “undesired”

[1]Also, according to a World Bank report prepared for the G-20 meeting in September 2009, private capital flows to low-income countries are expected to drop to \$13 billion in 2009 from \$21.4 billion in the last year.

fluctuations on the exchange rate[2] and the potential balance sheet effects. Balance sheet effects refer to the adverse economic and/or financial impact on firms and individuals that follows a depreciation of the domestic currency in economies in which a significant amount of debt is denominated in foreign currency while most income is generated in domestic currency[3]. Thus, since depreciation of the domestic currency could be particularly dangerous for highly-dollarized small open economies, governments evaluate alternative exchange rate regimes to that of a pure floating exchange. Recent adoptions of exchange rate regimes alternative to the flexible one, like in Argentina and Ecuador[4] confirm the huge importance that the exchange rate regime has for governments' economic and political stability and viability (and for the economies themselves) in economies characterized by a high degree of dollarization. This paper contributes to the debate on optimal exchange rate regime for emergent economies by showing, with the help of a straightforward dynamic model, that the flexible exchange rate regime is the best policy, which is a result consistent with the conventional wisdom.

In previous papers, like in Ize and Levy-Yeyati (2003), the effect of dollarization on the economic performance of countries and other related issues have been studied using portfolio models and other similar approaches. In addition, some of these studies have assumed that the degree of dollarization is exogenously given, like in Moron and Castro (2003). This paper studies this problem using an alternative approach: The stochastic dynamic general equilibrium model. In this study, under two different alternative exchange rate regimes, I analyze how real exogenous shocks to a small open economy affect the optimal currency composition of its portfolio of liabilities, which is determined endogenously by the model, and thus how much the overall economy is ultimately affected. In order to do so, I build a model of a small open economy with

[2]It is well understood and documented that economies become dollarized during episodes of high inflation. However, disinflations are not necessarily followed by dedollarization. In particular, Argentina, Bolivia, Peru, Russia, Ukraine and other countries have remained highly dollarized long after the inflation rate was brought down to single digits. Peru is a remarkable case: During the last 16 years it has had a dollarization ratio greater than 50% even though during the last 12 years it has had a one-digit inflation rate.

[3]According to Ize and Levy-Yeyati (2003), many emergent economies facing dollarization have tried to eliminate it by implementing disinflationary policies, but most of them have been unsuccessful. They state that the main reason for that result is that dollarization levels can remain high if the expected volatility of the inflation rate is high in relation to the expected volatility of the real exchange rate.

[4]While Argentina had a currency board between 1991 to 2002, Ecuador and Salvador adopted official dollarization in 2000 and 2001, respectively.

an incomplete menu of assets: domestic residents can only borrow internationally using short-term bonds denominated in domestic or foreign currency. In addition, the small open economy with an endogenous degree of dollarization is inhabited by households, firms and a government. Households live infinite periods and accumulate capital partly financed with the sale of one-period bonds denominated in both domestic and foreign currency. Uncertainty in my model is given by four shocks that follow independent exogenous processes: A technology shock to output A_t, a random level (volume) of domestic exports X_t[5], a shock to the gross nominal interest rate on dollar bonds R_t^*, and a shock to the dollar price of imports p_t^m.

Authors have identified characteristics of business cycles in emerging economies that distinguish them from business cycles in industrialized economies. A couple of these characteristics are as follows: (1) business cycles are more volatile in emerging economies, and (2) emerging economies are susceptible to additional sources of volatility, such as terms of trade fluctuations[6]. In many emerging economies, exports are characterized by a high concentration in a small number of commodities whose world prices are very volatile[7]. Also, their fiscal revenues tend to be largely dependent on the prices of the main export commodities, and so the stance of their public finances is vulnerable to major changes in the world prices of export goods. In my model, shocks to the level (volume) of exports will cause (ceteris paribus) a change in the terms of trade of the economy because domestic firms are assumed to have some monopolistic power in the (foreign) market for their goods.

Additionally, the model features convex portfolio adjustment costs for both peso and dollar bonds in order to induce stationarity of the equilibrium dynamics. This stationarity inducing technique has been used, among others, in recent papers by Neumeyer and Perri (2001) and Schmitt-Grohe and Uribe (2003). In this model, the cost of increasing asset holdings by one unit is greater than one because it includes the marginal

[5]As explained below, domestic firms are assumed to have some monopolistic power in world markets and thus face a downward sloping demand curve; therefore, a shock to the level of exports will have an effect on the terms of trade.

[6]The literature on small open economies recognizes the terms of trade shocks as one of the most relevant shocks affecting these economies. See, for instance, Mendoza (1995), Kose (2002), and Broda (2003). Mendoza (1995) finds that terms of trade disturbances explain 56 percent of aggregate output fluctuations in developing countries.

[7]According to UNCTAD, in 1995, 57 developing countries depended on three commodities for more than half of their exports.

cost of adjusting the size of the portfolio[8].

In order to compare the fixed and flexible exchange regimes' outcomes that result from exogenous shocks, I solve the model for the decentralized economy, that is, I solve the problems of both households and firms independently. All variables are in per capita terms (i.e., there is no population growth). Moreover, since a small open economy is analyzed, the domestic (dollar) interest rate equals the world (dollar) interest rate, which in turn is assumed to be exogenously given. This assumption greatly simplifies the analysis. I write a Matlab code in order to compute the impulse response functions, the expected path for some variables in the model, the conditional welfare, and other relevant statistical information. The code is based on those provided by Sutherland and Devereux (2007 and 2008).

As highlighted by Sutherland and Devereux (2008), recent data show that there are large cross-country gross asset and liability positions. Lane and Milessi-Ferretti (2001, 2006) show that these gross portfolio holdings have grown rapidly, particular in the last decade. Gross asset and liability positions can have important effects on macroeconomic dynamics; for instance, a sudden depreciation of the domestic currency can give rise to capital losses in gross liability positions, which can have very large effects on the value of net foreign assets. The method developed by Sutherland and Devereux (2006, 2008) allows me to compute both the non-stochastic steady state and the time-varying equilibrium gross portfolio positions in my model; thus, my model features fully endogenous dollarization.

It is important to mention that Frankel (2003) suggests that pegging the export price (PEP) is a monetary regime that can be applied to countries that are specialized in the production of a particular agricultural or mineral commodity. PEP proposes fixing the price of the single commodity in terms of local currency (here, pesos). It has been objected that PEP is inappropriate for countries where diversification of exports is an issue. For such countries the modified version, PEPI, developed by Frankel (2005), proposes fixing the price of a comprehensive index of export prices. According to Frankel (2005), in either version of the monetary regime (PEP or PEPI), one advantage

[8]To be more specific, and as will become more clear below, in my model households will have to pay a "fee" in terms of lost output if their transactions in the international asset market lead to deviations from some long-run (steady state) level.

is that the domestic currency depreciates automatically when the world market for the country's exports deteriorates. This depreciation will certainly help the economy reduce the negative effects of the weak exports market conditions.

Furthermore, following the recommendations given by Kim et al. (2003), the exchange rate policies in my paper are evaluated in terms of conditional expected welfare instead of the unconditional one. Thus, the object that exchange rate policy aims to maximize in my study is the expectation of lifetime utility of the representative household conditional on a particular initial state of the economy. In contrast, many existing normative evaluations of monetary policy rank policies based upon unconditional expectations of utility. As Kim et al. (2003) point out, unconditional welfare measures ignore the welfare effects of transitioning from a particular initial state to the stochastic steady state induced by the policy under consideration. By using conditional welfare, I highlight the fact that transitional dynamics matter for policy evaluation.

Finally, the most important finding in my study is that the flexible exchange rate regime is the best policy in terms of providing a greater level of (conditional) welfare to the domestic economy than the one provided by the fixed exchange rate regime. What explains this key result is that the fixed exchange rate regime creates an additional costly burden: under this regime, in the market for peso bonds, only the quantity of peso bonds can be adjusted, not its price (the interest rate in pesos), and this adjustment is costly. As a result, following exogenous shocks to the economy, there will be a significant impact on investment, the capital stock, output, and welfare. In addition, since the gross nominal interest rate on peso bonds become fixed under the fixed exchange rate regime, that means that there will be one less variable in the model (to be more precise, one less relative price) that will help absorb the exogenous shokcs; as a result, the remaining variables will have to work "harder" to stabilize the economy. Some of these variables are real variables that directly affect the level of welfare (consumption and hours worked) and their response to the exogenous shocks also explain the main result of the paper.

The paper is structured as follows. The next section outlines the model, and section 5.3 discusses how the steady state portfolio for the model is solved. Section 5.4 explains how the first-order time variation in the portfolio is solved under each alternative exchange rate regime, and section 5.5 discusses the calibration of the model and the welfare measure. Section 5.6 shows the impulse response functions, elaborates on the expected paths of the main variables of the model, including the conditional welfare measure, and makes a comparison of the dynamics of the model and welfare effects under the alternative exchange rate regimes. Finally, section 5.7 concludes.

5.2 The Model

Consider a small open economy populated by a large number of identical households, monopolistically competitive firms and a government. I develop an infinite-horizon production economy with imperfectly competitive product markets and sticky prices.

5.2.1 The Household's Problem

Each household has preferences defined over processes of consumption and leisure and described by the utility function

$$E_t \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, h_t) \right\} \tag{5.1}$$

where c_t denotes consumption, h_t denotes labor effort (or hours worked), $\beta \in (0,1)$ denotes the subjective discount factor, and E_t denotes the mathematical expectation operator conditional on information available in period t. The single period utility function U is assumed to be increasing in consumption, decreasing in effort, strictly concave, and twice continuously differentiable.

Households can hold physical capital, k_t. The law of motion of the capital stock k_t is given by

$$k_{t+1} = (1-\delta)k_t + i_t - \phi(k_{t+1}, k_t) \tag{5.2}$$

where $\delta \in (0,1)$ denotes the constant rate of depreciation of the capital stock, i_t is (gross) investment, and $\phi(k_{t+1} - k_t)$ [9] is a measure of capital adjustment costs.

Capital adjustment costs have many explanations. Changing the level of capital services at a business generates disruption costs during installation of any new or replacement capital and costly learning must be incurred as the structure of production

[9] Notice that I have implicitly made a monotonic transformation of the function $\phi(k_{t+1}, k_t)$, which has two arguments, into the function $\phi(k_{t+1} - k_t)$, which has just one argument

may have been changed. Moreover, installing new equipment or structures often involves delivery lags and time to install or build. The irreversibility of many projects caused by a lack of secondary markets for capital goods acts as another form of adjustment cost. It is assumed that $\phi(0) = \phi'(0) = 0$. Small open economy models typically include capital adjustment costs to avoid excessive investment volatility in response to shocks to the domestic economy. Thus, I introduce capital adjustment costs, as in Schmitt-Grohe and Uribe (2006), to avoid the excess volatility of investment that typically arises in small open economy models.

Every period, in order to finance current consumption c_t, investment i_t and foreign debt repayment, domestic households can issue one-period bonds denominated in both domestic currency ("peso bonds" B_{t+1}) and foreign currency ("dollar bonds" B^*_{t+1})[10]. The domestic economy borrows from the world financial market, represented by a continuum of risk-neutral lenders. A peso-bond is a promise to pay a principal plus an interest in pesos after one period, and the gross (nominal) interest rate on peso bonds is given by R_t^p[11]. In turn, dollar-bonds are promises to pay a principal plus an interest in dollars after one period, and the gross (nominal) interest rate on dollar bonds is given by R_t^*. Peso bonds and dollar bonds are sold for one peso and one dollar, respectively. The representative household's optimal borrowing decisions determine the degree of "dollarization" in the economy, which will be influenced by his expectations about equilibrium prices and the exchange rate[12].

The representative household's period-by-period (dollar) budget constraint is given by

$$\begin{aligned}\frac{B_{t+1}}{s_t} + B^*_{t+1} + \pi_t + \frac{w_t h_t}{s_t} + \frac{R_t k_t}{s_t} = p_t^m c_t + p_t^m i_t + \frac{R_t^p B_t}{s_t} + R_t^* B_t^* + \\ p_t^m \frac{\psi_2}{2}\left[\frac{B_{t+1}}{s_t} + B^*_{t+1} - \left(\frac{\bar{B}}{\bar{s}} + \bar{B}^*\right)\right]^2\end{aligned} \tag{5.3}$$

where the left hand side of the equality represents all the sources of income for the representative household, while the right hand side represents all the possible uses of that income. Notice that both sides of the above expression are expressed in dollars. I

[10]Notice that if the value of bond holdings (in dollars/pesos) is negative at some moment of time, it means that domestic household are holding bonds (in dollars/pesos) issued by foreigners as assets.

[11]Notice that R_t^p is the gross nominal interest rate on peso bonds set at the end of period $t-1$. The same applies to the gross nominal interest rate on dollar bonds, R_t^*.

[12]For instance, if domestic households are expecting a depreciation of the peso, they will issue more debt in pesos and less debt in dollars.

assume that all domestic consumption and investment is made in only foreign goods, that the dollar price of foreign consumption and investment goods, p_t^m, follows an autoregressive process of order one which will be characterized later and that its steady state value is equal to one dollar (that is, $\bar{p}^m = 1$). The nominal wage rate and the rental rate of capital are represented by w_t and R_t, respectively and are expressed in pesos. Since free trade prevails and there are no transportation costs nor tariffs, the law of one price holds; therefore, the peso price of imports $p_t^{m,p}$ (which is also the aggregate level of prices in this economy) is given by the product of the (nominal) exchange rate s_t (expressed in pesos per dollar) and the dollar price of imports p_t^m. Thus, the real wage rate and the real rental rate of capital in the domestic economy are given by $w_t/p_t^{m,p}$ and $R_t/p_t^{m,p}$, respectively. Moreover, dollar profits are represented by π_t.

I assume that there are portfolio adjustment costs associated with the issuance of debt, both in pesos and in dollars. In this model, stationarity is induced by assuming that agents face convex costs of holding assets in quantities different from some long-run level. Portfolio adjustment costs for the issuance of peso and dollar bonds is given by the following expression:

$$\frac{\psi_2}{2}\left[\frac{B_{t+1}}{s_t} + B_{t+1}^* - \left(\frac{\bar{B}}{\bar{s}} + \bar{B}^*\right)\right]^2$$

where $\bar{B}$ and $\bar{B}^*$ are the steady state values of peso and dollar bonds, respectively, and $\bar{s}$ is the steady state value of the nominal exchange rate. Clearly, in the steady state portfolio adjustment costs are zero.

In order to restate the budget constraint in a more convenient way for my analysis of the model, I proceed to state the two expressions that establish the link between gross real interest rates and gross nominal interest rates:

$$r_t^p = \frac{R_t^p}{\frac{p_t^{m,p}}{p_{t-1}^{m,p}}} \tag{5.4}$$

$$r_t^* = \frac{R_t^*}{\frac{p_t^m}{p_{t-1}^m}} \tag{5.5}$$

where r_t^p and r_t^* represent the gross real interest rates on peso and dollar bonds, respectively, and $p_t^{m,p} = s_t p_t^m$[13].

---

[13]For simplicity, I have assumed that the percentual change in the dollar price of the imported good

Moreover, the net debt of the household at the end of period t, W_t, is defined as follows[14]:

$$W_t = \frac{B_{t+1}}{s_t} + B^*_{t+1} \tag{5.6}$$

I follow Devereaux and Sutherland (2007 and 2008) and take advantage of the three previous definitions to transform Equation (5.3) as follows

$$\begin{aligned} W_t + \pi_t + \frac{w_t h_t}{s_t} + \frac{R_t k_t}{s_t} = p^m_t c_t + p^m_t i_t + \left(r^p_t - r^*_t\right) \frac{B_t}{s_{t-1}} \frac{p^m_t}{p^m_{t-1}} + r^*_t W_{t-1} \frac{p^m_t}{p^m_{t-1}} \\ + p^m_t \frac{\psi_2}{2} \left(W_t - \bar{W}\right)^2 \end{aligned} \tag{5.7}$$

where $\bar{W}$ is the steady state value of net debt.

An additional definition that is worth introducing in my model is that of the (real) "excess return" on peso bonds $r_{x,t}$, which is given by

$$r_{x,t} = r^p_t - r^*_t$$

Then, the budget constraint can be re-written in the following way:

$$\begin{aligned} W_t + \pi_t + \frac{w_t h_t}{s_t} + \frac{R_t k_t}{s_t} = p^m_t c_t + p^m_t i_t + r_{x,t} \frac{B_t}{s_{t-1}} \frac{p^m_t}{p^m_{t-1}} + r^*_t W_{t-1} \frac{p^m_t}{p^m_{t-1}} \\ + p^m_t \frac{\psi_2}{2} \left(W_t - \bar{W}\right)^2 \end{aligned} \tag{5.8}$$

Furthermore, I asume that, because of no arbitrage, the expected gross rate of return on peso bonds (the expected gross interest rate on peso bonds) $E_t\{R^p_{t+1}\}$ equals the expected peso gross rate of return on world assets, that is,

$$E_t \left\{R^p_{t+1}\right\} = E_t \left\{R^*_{t+1} \left(\frac{s_{t+1}}{s_t}\right)\right\} \tag{5.9}$$

In addition, households are subject to a borrowing constraint that prevents them from engaging in Ponzi schemes.

Furthermore, I assume that the period utility function mentioned above has a GHH-preferences form following the current standard literature in small open economies,

by the domestic economy is equal to the percentual change of dollar price of the the representative basket of goods that foreigners consume. It is straightforward to introduce the evolution of the dollar price of the representative basket of goods using an autoregressive process of order one for this variable.

[14]Notice that in my model the net debt W_t is actually the net foreign debt of the domestic economy since both B_{t+1} and B^*_{t+1} represent domestic foreing debt, which in the calibration stage is assumed to be equivalent to 20 percent of the total dollar value of the domestic output in the steady state ($\bar{W} = (0.2)\bar{p}^*\bar{y}$).

including Mendoza (1991)[15]; in particular,

$$U(c_t, h_t) = \frac{\left(c_t - \frac{h_t^\omega}{\omega}\right)^{1-\gamma} - 1}{1-\gamma}$$

where γ is the coefficient of relative risk aversion, and ω is one plus the inverse of the intertemporal elasticity of substitution in labor supply.

Additionally, I assume a specific functional form for the implicit capital adjustment costs function mentioned above following Mendoza (1991); in particular,

$$\phi(k_{t+1}, k_t) = \frac{\phi}{2}(k_{t+1} - k_t)^2$$

where ϕ is the capital adjustment cost parameter.

The household chooses the set of processes $\{c_t, h_t, k_{t+1}, i_t, B_{t+1}, B^*_{t+1}\}_{t=0}^{\infty}$ and some borrowing limit that prevents it from engaging in Ponzi-type schemes so as to maximize (5.1) subject to (5.2)−(5.4), taking as given the set of processes for $\{\pi_t, r_t^p, r_t, w_t, R_t, s_t, p_t^m\}_{t=0}^{\infty}$ and the initial conditions k_0, B_0, and B_0^*.

Let the multiplier on the flow budget constraint (5.3) be $\lambda_t \beta^t / p_t^m$. Then the first-order conditions of the household's maximization problem are (5.2), (5.4) – (5.6) and (5.8) – (5.9) holding with equality and

$$\lambda_t = \left(c_t - \frac{h_t^\omega}{\omega}\right)^{-\gamma} \tag{5.10}$$

$$\lambda_t \frac{\left(\frac{w_t}{s_t}\right)}{p_t^m} = \lambda_t h_t^{\omega-1} \tag{5.11}$$

$$\lambda_t \left[1 + \phi(k_{t+1} - k_t)\right] = \beta E_t \left[\lambda_{t+1} \left(\frac{\left(\frac{R_{t+1}}{s_{t+1}}\right)}{p_{t+1}^m} + (1-\delta) + \phi(k_{t+2} - k_{t+1})\right)\right] \tag{5.12}$$

$$\lambda_t \left[\frac{1}{p_t^m} - \psi(W_t - \bar{W})\right] = \beta E_t \left[\lambda_{t+1} r_{t+1}^* \left(\frac{1}{p_t^m}\right)\right] \tag{5.13}$$

[15]The benchmark utility function (GHH) is a generalized version of quasi-linear utility, first introduced into the real business cycle literature by Greenwood, Hercowitz and Huffman (1988). GHH preferences have the property that the marginal rate of substitution between consumption and leisure is independent of the consumption level within the period.

$$E_t \left[\lambda_{t+1} r_{x,t+1} \left(\frac{1}{s_t p_t^m} \right) \right] \tag{5.14}$$

The interpretation of the first order conditions above are as follows: Equation (5.10) defines the marginal utility of consumption. Equation (5.11) states that in equilibrium the representative household must be indifferent between enjoying an additional hour of leisure and enjoying the additional units of consumption that he will afford to buy by working one more hour. Equation (5.12) states that in equilibrium, the representative household must be indifferent between consuming an additional unit of good, and investing that additional unit and then consuming the goods that he could buy with the revenues from the investment, net of depreciation. Equation (5.13) states that in equilibrium, the representative household must be indifferent between issuing and not issuing an additional unit of dollar bonds; in other words, the marginal utility of consumption from the goods that it could buy with the money it can borrow by issuing one more dollar bond must equal the discounted value of the marginal utility of consumption lost from the repayment of that unit of dollar bond. Equation (5.14) is the portfolio equation of the model (and also the Euler equation for bond holdings). This equation states that, in equilibrium, the representative household must be indifferent between issuing an additional unit of peso bonds and an additional unit of dollar bonds; in other words, the expected excess return on peso and dollar bonds must be equal in equilibrium.

5.2.2 The Firms' Problem

Each firm is the monopolistic producer of one variety of final goods. The domestic firm's output is given by

$$\tilde{y}_t = A_t F(\tilde{k}_t, \tilde{h}_t) - \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*)$$

where the first element of the right hand side of the above expression corresponds to the production function of domestic firms, which have access to a constant returns to scale production technology. Imperfectly competitive domestic firms produce a single good that is sold abroad.

I follow Rotemberg (1982) and introduce sluggish price adjustment by assuming that the firm faces a resource cost that is quadratic in the inflation rate of the good it produces:

$$Price\ adjustment\ cost = \frac{\phi_2}{2}\left(\frac{\tilde{p}^*_t}{\tilde{p}^*_{t-1}} - 1\right)^2$$

The parameter ϕ_2 measures the degree of price stickiness. The higher is ϕ_2 the more sluggish is the adjustment of nominal prices. If $\phi_2 = 0$, then prices are flexible. The assumption of quadratic adjustment costs implies that firms change their price every period in the presence of shocks, but will adjust only partially towards the optimal price the firm would set in the absence of adjustment costs. As with any type of quadratic adjustment cost, a firm prefers a sequence of small adjustments to very large adjustments in a given period.

As pointed out by Rotemberg (1982), Barro (1972), and Mussa (1976), among others, changing prices is costly for two reasons: First, there is the administrative cost of changing the price lists, informing dealers, etc. Secondly, there is the implicit cost that results from the unfavourable reaction of customers to large prices changes. While the administrative cost is a fixed cost per price change, the second cost can be a different function of the magnitude of the price change. In particular, customers may well prefer small and recurrent price changes to occasional large ones. This is what is assumed implicitly by Rotemberg (1982), when he makes the costs to changing prices a function of the square of the price change.

The firm hires labor and capital from a perfectly competitive market. Moreover, the foreign demand for the domestic good is of the form $X_t d(\breve{p}_t)$, where X_t denotes the level of foreign demand and $\breve{p}_t$ denotes the relative (peso) price of the good in terms of the average (peso) price of domestic exports. The relative price $\breve{p}_t$ is defined as $s_t\tilde{p}^*_t/p_t$; where s_t is the nominal exchange rate, $\tilde{p}^*_t$ is the dollar price of the good produced by the firm, and p_t is the average peso price of domestic exports. The demand function $d(.)$ is assumed to be decreasing and to satisfy $d(1) = 1$ and $d'(1) < -1$. The restrictions on $d(1)$ and $d'(1)$ are necessary for the existence of a symmetric equilibrium. The monopolist sets the dollar price of the good it supplies $\tilde{p}^*_t$ taking the level of aggregate demand as given, and is constrained to satisfy demand at that price; that is,

$$A_t F(\tilde{k}_t, \tilde{h}_t) - \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*) \geq X_t d(\breve{p}_t) \tag{5.15}$$

(Dollar) Profits are given by

$$\tilde{\pi}_t = \tilde{p}_t^* X_t d(\breve{p}_t) - \frac{w_t \tilde{h}_t}{s_t} - \frac{R_t \tilde{k}_t}{s_t} \tag{5.16}$$

In addition, I assume a specific functional form for the implicit production function mentioned above following Mendoza (1991); in particular,

$$F(k_t, h_t) = k_t^{\alpha} h_t^{1-\alpha}$$

Each period, imperfectly competitive firms choose capital $\tilde{k}_t$, labor services $\tilde{h}_t$ and the dollar price of exports $\tilde{p}_t^*$, subject to demand and technological constraints (5.15), so as to maximize profits (5.16). Since the firm is owned by the representative household, it is natural to assume that the intertemporal marginal rate of substitution $\beta \frac{\lambda_{t+1}}{\lambda_t}$ can be used to discount future profits. Let the multiplier on the demand and supply equilibrium condition (5.15) be $\tilde{\mu}_t \beta^t \left(\frac{\lambda_{t+1}}{\lambda_t}\right) \tilde{p}_t^*$; then the firm will maximize the following expression:

$$\begin{aligned} L = E_t \left\{ \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{t+1}}{\lambda_t} \left[\tilde{p}_t^* X_t d(\breve{p}_t) - \frac{w_t \tilde{h}_t}{s_t} - \frac{R_t \tilde{k}_t}{s_t} \right] \right\} \\ + E_t \left\{ \sum_{t=0}^{\infty} \tilde{\mu}_t \beta^t \frac{\lambda_{t+1}}{\lambda_t} \tilde{p}_t^* \left[X_t d(\breve{p}_t) - A_t F(\tilde{k}_t, \tilde{h}_t) + \phi_2(\tilde{p}_t^*, \tilde{p}_{t-1}^*) \right] \right\} \end{aligned} \tag{5.17}$$

taking as given the processes for $\{A_t, X_t, w_t, R_t, s_t, \lambda_t\}_{t=0}^{\infty}$.

As a result of the profit maximization process, input demands and export prices must satisfy the following efficiency conditions:

$$\frac{R_t}{s_t} = -\tilde{\mu}_t \tilde{p}_t^* A_t \alpha \tilde{k}_t^{\alpha-1} \tilde{h}_t^{1-\alpha} \tag{5.18}$$

$$\frac{w_t}{s_t} = -\tilde{\mu}_t \tilde{p}_t^* A_t \tilde{k}_t^{\alpha} (1-\alpha) \tilde{h}_t^{-\alpha} \tag{5.19}$$

$$X_t\left[d\left(\frac{s_t\tilde{p}_t^*}{p_t}\right)+d'\left(\frac{s_t\tilde{p}_t^*}{p_t}\right)\right]+\tilde{\mu}_t\left[X_t d'\left(\frac{s_t\tilde{p}_t^*}{p_t}\right)+\tilde{p}_t^*\phi_2\left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*}-1\right)\left(\frac{1}{\tilde{p}_{t-1}^*}\right)\right]$$
$$+\tilde{\mu}_t\left[X_t d\left(\frac{s_t\tilde{p}_t^*}{p_t}\right)-A_t\tilde{k}_t^\alpha\tilde{h}_t^{1-\alpha}+\frac{\phi_2}{2}\left(\frac{\tilde{p}_t^*}{\tilde{p}_{t-1}^*}-1\right)^2\right]$$
$$=E_t\left\{\tilde{\mu}_{t+1}\beta\left(\frac{\lambda_{t+1}}{\lambda_t}\right)\tilde{p}_{t+1}^*\phi_2\left(\frac{\tilde{p}_{t+1}^*}{\tilde{p}_t^*}-1\right)\left(\frac{\tilde{p}_{t+1}^*}{\tilde{p}_t^{*2}}\right)\right\} \quad (5.20)$$

The interpretation of the first order conditions above are as follows: Equation (5.18) states that in equilibrium there is a wedge between the rental rate of capital and the marginal productivity of capital (both expressed in dollars), which is explained by the monopolistic power of the firms[16]. Equation (5.19) states that in equilibrium there is a wedge between the wage rate and the marginal productivity of labor (both expressed in dollars), which is explained, again, by the presence of imperfectly competitive firms in the market. Equation (5.20) states that in equilibrium there is a wedge between marginal revenue and marginal cost (both expressed in dollars), as a result of the presence of price adjustment costs à la Rotemberg (1982).

Let me define the marginal cost mc_t and marginal revenue mr_t as follows

$$mc_t=\frac{\frac{w_t}{s_t}}{p_t^*A_t\tilde{k}_t^\alpha(1-\alpha)\tilde{h}_t^{-\alpha}}$$

$$mr_t=\frac{s_t\tilde{p}_t^*}{p_t}+\frac{d\left(\frac{s_t\tilde{p}_t^*}{p_t}\right)}{d'\left(\frac{s_t\tilde{p}_t^*}{p_t}\right)}$$

5.2.3 Equilibrium

I restrict attention to symmetric equilibria where all firms charge the same price for the good they produce ($\tilde{p}_t^*=p_t^*$). As a result, I have that $\breve{p}_t=1$ for all t. It then follows from the fact that all firms face the same wage rate and rental rate of capital, the same shocks to technology and exports, and the same production technology, that they all hire the same amount of labor and capital; that is, $\tilde{h}_t=h_t$ and $\tilde{k}_t=k_t$. Let

$$\eta\equiv d'(1)$$

[16] In contrast, under perfect competition, marginal productivity equals the factor price for each factor of production.

denote the equilibrium value of the elasticity of demand faced by the individual producers of goods. Then, in equilibrium, the expression for the marginal revenue mr_t above simplifies to

$$mr_t = 1 + \frac{1}{\eta}$$

Furthermore, the domestic goods market equilibrium condition[17] is given by

$$p_t y_t = s_t p_t^* X_t d\left(\frac{s_t p_t^*}{p_t}\right)$$

where s_t is the nominal exchange rate, expressed in number of units of domestic currency per unit of foreign currency, while $X_t d(.)$ is the quantity of domestic exports. As in Chang and Velasco (2004), I assume that domestic residents do not consume home goods, and thus the demand for home output comes from foreigners. This is a simplifying assumption and should not affect the main results of the paper. Since by assumption total domestic production y_t is exported

$$y_t = X_t d\left(\frac{s_t p_t^*}{p_t}\right)$$

I obtain the expected result that

$$p_t = s_t p_t^* \tag{5.21}$$

which states that the price in pesos of domestic exports p_t equals the product of the nominal exchange rate s_t times the dollar price of domestic exports p_t^*.

Due to their monopolistic power, domestic firms choose the dollar price of exports p_t^*. Clearly, an increase in p_t^* can be interpreted as a positive change to the terms of trade in the economy. That is, ceteris paribus, a positive change in the price of domestic exports will increase the purchasing power of domestic agents in terms of foreign goods (imports).

Notice that my model does not make explicit the use of a monetary aggregate in the economy, although the domestic price level is a key variable in the model. It is possible to introduce money explicitly to my model, but the conclusions should not change. My model assumes that the monetary authority just supplies the amount of money that maintains the exchange rate s_t at its pegged value under the fixed exchange

[17]The value in pesos of domestic output equals the value in pesos of the quantity demanded of domestic output.

rate regime, and that maintains constant the peso price of domestic exports p_t under the flexible exchange rate regime[18].

The stochastic processes for the level of aggregate demand X_t, the technology shock A_t, the shock to the nominal gross interest rate on dollar bonds R_t^*, and the shock to the dollar price of imports p_t^m are exogenously given by

$$logX_t = \tau logX_{t-1} + \varepsilon_{X,t}, \quad \text{where} \quad \varepsilon_{X,t} \sim N(0, \sigma_X^2) \tag{5.22}$$

$$logA_t = \rho logA_{t-1} + \varepsilon_{A,t}, \quad \text{where} \quad \varepsilon_{A,t} \sim N(0, \sigma_A^2) \tag{5.23}$$

$$log\left(\frac{R_t^*}{\bar{R}^*}\right) = \theta_R log\left(\frac{R_{t-1}^*}{\bar{R}^*}\right) + \varepsilon_{R,t}, \quad \text{where} \quad \varepsilon_{R,t} \sim N(0, \sigma_R^2) \tag{5.24}$$

$$log\left(\frac{p_t^m}{\bar{p}^m}\right) = \theta_p log\left(\frac{p_{t-1}^m}{\bar{p}^m}\right) + \varepsilon_{p,t}, \quad \text{where} \quad \varepsilon_{p,t} \sim N(0, \sigma_p^2) \tag{5.25}$$

where $\varepsilon_{X,t}$, $\varepsilon_{A,t}$, $\varepsilon_{R,t}$, and $\varepsilon_{p,t}$ are white noise random variables, and $\bar{R}^*$ and $\bar{p}^m$ are the steady state values of the gross nominal interest rate on dollar bonds and the dollar price of imports, respectively.

5.3 Steady-State Portfolios

This section follows the steps necessary to solve for the steady state portfolio $\bar{B}$.

The first-order approximation of the budget constraint is given by

$$\begin{gathered}
-\bar{W}\hat{W}_t - \bar{\pi}\hat{\pi}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(\frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}\bar{k}}{\bar{s}}\right)\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t + \\
\left(-\frac{\bar{R}\bar{k}}{\bar{s}} - (1-\delta)\bar{k}\right)\hat{k}_t + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^* + \left(\bar{c} + \bar{k} - (1-\delta)\bar{k} + \bar{r}\bar{W}\right)\hat{p}_t^m \\
+\bar{c}c_t + \bar{k}k_{t+1} + \bar{r}\bar{W}\hat{r}_t^* - \bar{r}\bar{W}p_{t-1}^m + \bar{r}\bar{W}W_{t-1} = 0 + O(\epsilon^2)
\end{gathered} \tag{5.26}$$

where a bar over a variable denotes its steady state value.

The following definition will allow me to simplify further Equation (5.26):

[18] To be more precise, the flexible exchange rate regime in my model implies that the central bank pursues a price targeting/flexible rate policy, where the target is the peso price of domestic exports.

$$\hat{r}_{x,t} = \hat{r}^p_t - \hat{r}^*_t$$

Using this definition, Equation (5.26) becomes

$$\begin{aligned} -\bar{W}\hat{W}_t - \bar{\pi}\hat{\pi}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(\frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}\bar{k}}{\bar{s}}\right)\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t \\ + \left(-\frac{\bar{R}\bar{k}}{\bar{s}} - (1-\delta)\bar{k}\right)\hat{k}_t + \tilde{B}\hat{r}_{x,t} + \left(\bar{c} + \bar{k} - (1-\delta)\bar{k} + \bar{r}\bar{W}\right)\hat{p}^m_t + \bar{c}c_t \\ + \bar{k}k_{t+1} + \bar{r}\bar{W}\hat{r}^*_t - \bar{r}\bar{W}p^m_{t-1} + \bar{r}\bar{W}W_{t-1} = 0 + O(\epsilon^2) \end{aligned} \tag{5.27}$$

where

$$\tilde{B} = \bar{r}\frac{\bar{B}}{\bar{s}}$$

Following Devereux and Sutherland (2007 and 2008), I will exploit the fact that up to first order accuracy, the realized excess asset return $\hat{r}_{x,t}$ is a zero mean i.i.d. random variable. Thus, I initially treat the realized excess return on the portfolio ($\tilde{B}\hat{r}_{x,t}$) as an exogenous independent mean zero i.i.d. random variable denoted ξ_t. Then, the home country budget constraint can be re-written as follows:

$$\begin{aligned} -\bar{W}\hat{W}_t - \bar{\pi}\hat{\pi}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(\frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}\bar{k}}{\bar{s}}\right)\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t \\ + \left(-\frac{\bar{R}\bar{k}}{\bar{s}} - (1-\delta)\bar{k}\right)\hat{k}_t + \xi_t + \left(\bar{c} + \bar{k} - (1-\delta)\bar{k} + \bar{r}\bar{W}\right)\hat{p}^m_t + \bar{c}c_t \\ + \bar{k}k_{t+1} + \bar{r}\bar{W}\hat{r}^*_t - \bar{r}\bar{W}p^m_{t-1} + \bar{r}\bar{W}W_{t-1} = 0 + O(\epsilon^2) \end{aligned} \tag{5.28}$$

The first-order linearization of the rest of the non-portfolio equations of the model are as follows[19]:

$$\bar{\lambda}\hat{\lambda}_t + (-\bar{\lambda} + \beta\bar{\lambda}\bar{r})\hat{p}^m_t - \bar{\lambda}\psi\bar{W}\hat{W}_t - \beta\bar{\lambda}\bar{r}E_t[\hat{\lambda}_{t+1}] - \beta\bar{\lambda}\bar{r}E_t[\hat{r}^*_{t+1}] = 0 + O(\epsilon^2) \tag{5.29}$$

$$\begin{aligned} \bar{\mu}\bar{x}x_t + (\bar{\mu}x + \bar{\mu}(x - \bar{A}\bar{k}^\alpha\bar{h}^{1-\alpha}))\hat{\mu}_t + (\bar{\mu}\phi + \bar{\mu}\beta\phi)\hat{p}^d_t - \bar{\mu}\phi p^d_{t-1} - \bar{\mu}\bar{A}\bar{k}^\alpha\bar{h}^{1-\alpha}\hat{A}_t \\ -\bar{\mu}\bar{A}\bar{k}^\alpha\alpha\bar{h}^{1-\alpha}\hat{k}_t - \bar{\mu}\bar{A}\bar{k}^\alpha\bar{h}^{1-\alpha}(1-\alpha)\hat{h}_t - \bar{\mu}\beta\phi E_t[\hat{p}^d_{t+1}] = 0 + O(\epsilon^2) \end{aligned} \tag{5.30}$$

[19]Some of these linearized equations correspond to the linearization of the definitions of some dummy variables that were introduced to the model in order to apply the method developed by Devereux and Sutherland (2007 and 2008); in particular, the dummy variables are pdf_t, pma_t, $ke2_t$, λ^D_t, s^D_t, W^D_t, $pdfe_t$, and ls^D_t. Some of these dummy variables are explicitly defined below.

$$\bar{y}\hat{y}_t - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t - \bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{k}_t - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}(1-\alpha)\hat{h}_t = 0 + O(\epsilon^2) \tag{5.31}$$

$$\bar{\pi}\hat{\pi}_t - \bar{p}^d\bar{x}\hat{p}^d_t - \bar{p}^d\bar{x}x_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(-\frac{\bar{w}\bar{h}}{\bar{s}} - \frac{\bar{r}\bar{k}}{\bar{s}}\right)\hat{s}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{k}_t = 0 + O(\epsilon^2) \tag{5.32}$$

$$\begin{aligned}\frac{\bar{R}}{\bar{s}}\hat{R}_t - \frac{\bar{R}}{\bar{s}}\hat{s}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}^d_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t \\ +\bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}(\alpha-1)\bar{h}^{1-\alpha}\hat{k}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}(1-\alpha)\hat{h}_t = 0 + O(\epsilon^2)\end{aligned} \tag{5.33}$$

$$\hat{A}_{t+1} = \rho\hat{A}_t + \varepsilon^A_{t+1} \tag{5.34}$$

$$\hat{x}_{t+1} = \tau x_t + \varepsilon^x_{t+1} \tag{5.35}$$

$$\hat{r}^*_{t+1} = \theta_1\hat{r}^*_t + \varepsilon^r_{t+1} \tag{5.36}$$

$$\hat{p}^m_{t+1} = \theta_2\hat{p}^m_t + \varepsilon^p_{t+1} \tag{5.37}$$

$$\begin{aligned}\frac{\bar{w}}{\bar{s}}\hat{w}_t - \frac{\bar{w}}{\bar{s}}\hat{s}_t + \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\bar{h}^{-\alpha}\hat{\mu}_t + \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\bar{h}^{-\alpha}\hat{p}^d_t \\ +\bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\bar{h}^{-\alpha}\hat{A}_t + \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{-\alpha}\hat{k}_t \\ -\bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{-\alpha}\hat{h}_t = 0 + O(\epsilon^2)\end{aligned} \tag{5.38}$$

$$-\left(\bar{c} - \frac{\bar{h}^{\omega}}{\omega}\right)^{-\gamma-1}\gamma\bar{c}\hat{c}_t + \left(\bar{c} - \frac{\bar{h}^{\omega}}{\omega}\right)^{-\gamma-1}\gamma\bar{h}^{\omega}\hat{h}_t - \bar{\lambda}\hat{\lambda}_t = 0 + O(\epsilon^2) \tag{5.39}$$

$$(\bar{\lambda}\bar{h}^{\omega-1} - \bar{\lambda}\frac{\bar{w}}{\bar{s}})\hat{\lambda}_t + \bar{\lambda}\bar{h}^{\omega-1}(\omega-1)\hat{h}_t - \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{w}_t + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{s}_t + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{p}^m_t = 0 + O(\epsilon^2) \tag{5.40}$$

$$\begin{aligned}\bar{\lambda}\hat{\lambda}_t + (\bar{\lambda}\phi\bar{k} + \bar{\lambda}\beta\phi\bar{k})k_{t+1} - \bar{\lambda}\phi\bar{k}\hat{k}_t - \bar{\lambda}\beta\left(\frac{\bar{R}}{\bar{s}} + 1 - \delta\right)E_t[\hat{\lambda}_{t+1}] - \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[R_{t+1}] \\ +\bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[s_{t+1}] + \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{p}^m_{t+1}] - \bar{\lambda}\beta\phi\bar{k}E_t[k_{t+2}] = 0 + O(\epsilon^2)\end{aligned} \tag{5.41}$$

$$\hat{y}_t = \hat{x}_t \tag{5.42}$$

$$\hat{p}_t = \hat{s}_t + \hat{p}^d_t \tag{5.43}$$

$$\bar{r}E_t[\hat{r}^p_{t+1}] - \bar{r}E_t[\hat{r}^*_{t+1}] = 0 + O(\epsilon^2) \tag{5.44}$$

$$\widehat{pdf}_t = \hat{p}^d_t \tag{5.45}$$

$$\widehat{pma}_t = \hat{p}^m_t \tag{5.46}$$

$$\widehat{ke2}_t = \hat{k}_{t+1} \tag{5.47}$$

$$\hat{R}^p_t = \hat{r}^p_t + \hat{s}_t + \hat{p}^m_t - \hat{s}_{t-1} - \hat{p}^m_{t-1} \tag{5.48}$$

$$\hat{R}^*_t = \hat{r}^*_t + \hat{p}^m_t - \hat{p}^m_{t-1} \tag{5.49}$$

$$\widehat{sa}_t = \hat{s}_t \tag{5.50}$$

$$U\bar{T}F\widehat{uf}_t - \left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma} \bar{c}\hat{c}_t + \left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma} \bar{h}^\omega \hat{h}_t + L15_t = 0 + O(\epsilon^2) \tag{5.51}$$

$$\widehat{WELF}_t - \beta E_t[\widehat{WELF}_{t+1}] = (1-\beta)\widehat{uf}_t \tag{5.52}$$

$$\hat{r}_{x,t} = \hat{r}^p_t - \hat{r}^*_t \tag{5.53}$$

$$\hat{\lambda}^D_t = \hat{\lambda}_t - \hat{s}_{t-1} - \hat{p}^m_{t-1} \tag{5.54}$$

$$\hat{s}_t^D = \hat{s}_t + \hat{p}_t^m - \hat{s}_{t-1} - \hat{p}_{t-1}^m \tag{5.55}$$

$$\hat{W}_t^D = \hat{W}_t \tag{5.56}$$

$$\widehat{pdfe}_t = E_t[\hat{p}_{t+1}^d] \tag{5.57}$$

$$\widehat{ls}_t^D = \hat{\lambda}_t^D - \hat{s}_t^D \tag{5.58}$$

In order to have as many dynamic equations as variables in the model so that I can solve it, one more relationship is required[20]. I obtain the additional equation as follows. First, I introduce two dummy variables (λ_{t+1}^D and s_{t+1}^D) to the model in order to simplify my calculations; they are defined in the following way:

$$\lambda_{t+1}^D = \lambda_{t+1} \frac{1}{s_t p_t^m}$$

$$s_{t+1}^D = \frac{s_{t+1} p_{t+1}^m}{s_t p_t^m}$$

With the help of these two dummy variables and the relationships between the nominal and real interest rates, I can restate the first order condition for bond holdings, Equation (5.14), and the uncovered interest parity condition, Equation (5.9), as follows:

$$E_t\left[\lambda_{t+1}^D r_{x,t+1}\right] \tag{5.59}$$

$$E_t\left\{r_{t+1}^p s_{t+1}^D\right\} = E_t\left\{r_{t+1}^d \lambda_{t+1}\right\} \tag{5.60}$$

Second, I take a second order approximation of the "simplified" first order condition for bond holdings, Equation (5.59):

$$E_t\left[\hat{r}_{t+1}^p - \hat{r}_{t+1}^* + \hat{\lambda}_{t+1}^D \hat{r}_{t+1}^p - \hat{\lambda}_{t+1}^D \hat{r}_{t+1}^* + \frac{1}{2}\hat{r}_{t+1}^{p2} - \frac{1}{2}\hat{r}_{t+1}^{*2}\right] = 0 + O(\epsilon^2) \tag{5.61}$$

[20]The variable that is absent in the solution of the first-order system is B_t, which will be "reintroduced" later in the model when I solve the second-order system.

Third, I take a second order approximation of the "simplified" uncovered interest parity condition, Equation (5.60):

$$E_t\left[\hat{r}^p_{t+1} - \hat{r}^*_{t+1} + \hat{s}^D_{t+1}\hat{r}^p_{t+1} - \hat{s}^D_{t+1}\hat{r}^*_{t+1} + \frac{1}{2}\hat{r}^{p2}_{t+1} - \frac{1}{2}\hat{r}^{*2}_{t+1}\right] = 0 + O(\epsilon^2) \tag{5.62}$$

Fourth, I subtract Equation (5.62) from Equation (5.61), from which I obtain

$$E_t\left[\left(\hat{\lambda}^D_{t+1} - \hat{s}^D_{t+1}\right)\left(\hat{r}^p_{t+1} - \hat{r}^*_{t+1}\right)\right] = 0 + O(\epsilon^2) \tag{5.63}$$

As it will become clear later, Equation (5.63) above is key to solve for the equilibrium value of $\tilde{B}$, the first big step towards solving my model[21].

The equations of the model can now be collected together in the form of a matrix equation system, where the vectors s, c and x are defined as follows[22]:

$$s'_t = \left[\begin{array}{cccccc} \hat{k}_t & \hat{W}_{t-1} & \hat{p}^d_{t-1} & \widehat{pma}_{t-1} & \hat{R}^p_t & \widehat{sa}_{t-1} \end{array}\right]$$

$$c'_t = \left[\begin{array}{l} \hat{c}_t \;\; \hat{h}_t \;\; \hat{\lambda}_t \;\; \hat{\pi}_t \;\; \hat{y}_t \;\; \hat{\mu}_t \;\; \hat{w}_t \;\; \hat{R}_t \;\; \hat{s}_t \;\; \hat{p}_t \;\; \hat{r}^*_t \;\; \hat{r}^p_t \;\; \hat{r}_{x,t} \;\; \widehat{pdf}_t \;\; \widehat{ke2}_t \;\; \widehat{uf}_t \;\; \widehat{WELF}_t \\ \hfill \hat{\lambda}^D_t \;\; \hat{s}^D_t \;\; \hat{W}^D_t \;\; \widehat{pdfe}_t \;\; \widehat{ls}^D_t \end{array}\right]$$

$$x'_t = \left[\begin{array}{cccc} \hat{A}_t & \hat{X}_t & \hat{R}^*_t & \hat{p}^m_t \end{array}\right]$$

where $\widehat{sa}_{t-1}$, $\widehat{ke2}_t$, $\hat{W}^D_t$, $\widehat{pdf}_t$, $\widehat{pdfe}_t$, $\hat{s}^D_t$ $\hat{\lambda}^D_t$, and $\widehat{ls}^D_t$ are dummy variables that are used to make the model a first order system and to facilitate the computation of a key component of the solution for the dynamics of the portfolio of assets, γ_x; and $\widehat{uf}_t$ and $\widehat{WELF}_t$ are the percentual deviations of the period utility and the life-time utility with respect to their corresponding steady states. I add these two last variables to the model in order to compute the welfare measure, as explained in detail in a later section.

Moreover, as it will be explained later with more detail, under flexible exchange rate regime the peso price of domestic exports is fixed; therefore, under this regime $\hat{p}_t$ is dropped from the overall system including the vectors above. On the other hand, under

[21] Notice that Equation (5.63) is not part of the first-order system that I proceed to build up below.

[22] Notice that even though I have listed both $\hat{s}_t$ and $\hat{p}_t$ as "jumping" variables in the model, only one of them is relevant under a particular exchange rate regime. To be more precise, under the flexible exchange rate I drop $\hat{p}_t$ from the model since under this regime the peso price of domestic exports is assumed to be fixed, and under the fixed exchange rate I drop $\hat{s}_t$ and $\widehat{sa}_{t-1}$ from the model since under this regime the nominal exchange rate is assumed to be fixed.

fixed exchange rate regime the nominal exchange rate is fixed; it follows that under this regime $\hat{s}_t$ and $\widehat{sa}_{t-1}$ are dropped from the overall system including the vectors above.

Then, the entire first-order approximation of the non-portfolio equations of the model can be summarized in a matrix equation of the form

$$A_1 \begin{bmatrix} s_{t+1} \\ E_t[c_{t+1}] \end{bmatrix} + A_2 \begin{bmatrix} s_t \\ c_t \end{bmatrix} + A_3 x_t + B\xi_t \tag{5.64}$$

$$x_t = N x_{t-1} + \varepsilon_t$$

where s is a vector of predetermined variables, c is a vector of jump variables, x is a vector of exogenos forcing processes and ε is a vector of i.i.d. shocks and B is column vector with unity in the row corresponding to the equation for the evolution of net debt (5.28) and zero in all other rows.

The state space solution to Equation (5.64) can be derived using any standard solution method for linear rational expectations models, and can be written as follows:

$$\begin{aligned} s_{t+1} &= F_1 x_t + F_2 s_t + F_3 \xi_t + O(\epsilon^2) \\ c_t &= P_1 x_t + P_2 s_t + P_3 \xi_t + O(\epsilon^2) \end{aligned} \tag{5.65}$$

This form of the solution shows explicitly, via the F_3 and P_3 matrices, how the first order accurate behaviour of all the model's variables depend on exogenous i.i.d. innovations to net debt.

By extracting the appropriate rows from Equation (5.65) it is possible to write the following expression for the first order accurate realized excess returns $\hat{r}_{x,t+1}$:

$$\hat{r}_{x,t+1} = R_1 \xi_{t+1} + R_2 \varepsilon_{t+1} + O(\epsilon^2) \tag{5.66}$$

where matrices R_1 and R_2 are formed from the appropriate rows of Equation (5.65). Equation (5.66) shows how first order accurate realized excess returns depend on the exogenous i.i.d. shocks ε_{t+1}, and the excess return on the portfolio ξ_{t+1}.

Now remember that ξ_{t+1} is determined by the endogenous excess portfolio returns via the relationship

$$\xi_{t+1} = \tilde{B}' \hat{r}_{x,t+1} \tag{5.67}$$

where the vector of portfolio allocations $\tilde{B}$ is to be determined. Equations (5.66) and (5.67) can be solved together to yield expressions for $\hat{r}_{x,t+1}$ and ξ_{t+1} in terms of the exogenous innovations as follows

$$\xi_{t+1} = \tilde{H}\varepsilon_{t+1} \tag{5.68}$$

$$\hat{r}_{x,t+1} = \tilde{R}\varepsilon_{t+1} + O(\epsilon^2) \tag{5.69}$$

where

$$\tilde{H} = \frac{\tilde{B}R_2}{1 - \tilde{B}'R_1}, \qquad \tilde{R} = R_1\tilde{H} + R_2$$

Equation (5.69), which shows how realized excess returns $\hat{r}_{x,t+1}$ depend on the exogenous i.i.d. innovations of the model ε_{t+1}, provides one of the relationships necessary to evaluate the left-hand side of Equation (5.63). The other required relationship is the link between $(\hat{\lambda}^D_{t+1} - \hat{s}^D_t)$ and the vector of exogenous innovations ε_{t+1}. This relationship can be derived in a similar way to equation (5.69). First, extract the appropriate row of Equation (5.65) to yield the following

$$(\hat{\lambda}^D_{t+1} - \hat{s}^D_t) = D_1\xi_{t+1} + D_2\varepsilon_{t+1} + D_3 \begin{bmatrix} x_t \\ s_{t+1} \end{bmatrix} + O(\epsilon^2) \tag{5.70}$$

where matrices D_1, D_2 and D_3 are formed from the appropriate rows of equation (5.69). After substituting for ξ_{t+1}, I obtain

$$(\hat{\lambda}^D_{t+1} - \hat{s}^D_t) = \tilde{D}\varepsilon_{t+1} + D_3 \begin{bmatrix} x_t \\ s_{t+1} \end{bmatrix} + O(\epsilon^2) \tag{5.71}$$

where

$$\tilde{D} = D_1\tilde{H} + D_2 \tag{5.72}$$

Using equations (5.63), (5.69), and (5.71) allows me to derive the following expression

$$E_t\left[(\hat{\lambda}^D_{t+1} - \hat{s}^D_t)\hat{r}_{x,t+1}\right] = \tilde{R}\Sigma\tilde{D}' = 0 + O(\epsilon^3) \tag{5.73}$$

where Σ is the covariance matrix of ε

The equilibrium value of $\tilde{B}$ is the one that satisfies the following equation

$$\tilde{R}\Sigma\tilde{D}' = 0 \tag{5.74}$$

To solve for $\tilde{B}$, first substitute for $\tilde{R}$ and $\tilde{D}$ in equation (5.74) and expand to yield

$$R_1\tilde{H}\Sigma\tilde{H}'D_1' + R_2\Sigma\tilde{H}'D_1' + R_1'\tilde{H}\Sigma D_2' + R_2\Sigma D_2' = 0 + O(\epsilon^3) \tag{5.75}$$

Substituting for $\hat{H}$ and $\hat{H}'$, multiplying by $(1-\tilde{B}'R_1)^2$, and then solving for $\tilde{B}$ yields

$$\tilde{B} = [R_2\Sigma D_2'R_1' - D_1R_2\Sigma'R_2']^{-1}[R_2'\Sigma D_2'] + O(\epsilon) \tag{5.76}$$

And the solution for $\bar{B}$ is given by $\bar{B} = \tilde{B}\beta\bar{s}$.

5.3.1 Comparing the Steady State Value of the Portfolio of Assets under Alternative Exchange Rate Regimes

Under flexible exchange rate $\bar{B}$=3.34 (since $\tilde{B}$=3.4737) and thus $\bar{B}^*$=-3.12[23]. This means that under this regime, the domestic economy optimally issues debt only in pesos while it accumulates assets only in dollars. Since domestic households generate income in pesos (both wages and the rental rate of capital are paid in pesos), they will issue debt in pesos so that they can hedge themselves against the exchange rate risk (and certainly be able to buy more consumption and investment goods). In addition, domestic households accumulate assets in dollars (by purchasing them in the world financial markets) in order help them smooth consumption in case there is negative shock to the economy and to diversify risks because of the presence of the exchange rate risk and the potential balance sheet effects.

Under fixed exchange rate $\bar{B}$=-2.08 (since $\tilde{B}$=-2.1624) and thus $\bar{B}^*$=2.29. This means that under this this regime, the domestic economy optimally issues debt only in dollars while it accumulates assets only in pesos. Remember that under this regime the government is assumed to guarantee the exchange of one dollar for a fixed amount of pesos, that is, the nominal exchange rate is fixed ($s_t = \bar{s}$). In addition, I assume that $\bar{s} = 1$ for simplicity. Therefore, under this regime domestic households will issue debt

[23]The results discussed in this section are based on the calibration of the model, which is explained later in detail.

only in dollars since there is no exchange rate risk at all for them. Moreover, domestic households accumulate assets in pesos (by purchasing them in the world financial markets) that will help them eventually buy the dollars to repay their dolar debt and buy the consumption and investment goods they may want[24].

5.4 First-Order Time Variation in Portfolios

The objective in this section is to solve for the behavior of $\hat{B}_t$. To do so first I have to compute a third-order approximation of both the "simplified" uncovered interest parity condition, Equation (5.60), and the "simplified" first order condition for bond holdings, Equation (5.59). The two resulting expressions are as follows:

$$\begin{aligned} E_t\Bigg[&\hat{r}^p_{t+1} - \hat{r}^*_{t+1} + \hat{\lambda}^D_{t+1}\hat{r}^p_{t+1} - \hat{\lambda}^D_{t+1}\hat{r}^*_{t+1} + \frac{1}{2}\hat{r}^{p2}_{t+1} - \frac{1}{2}\hat{r}^{*2}_{t+1} + \frac{1}{2}\hat{\lambda}^{D2}_{t+1}\hat{r}^p_{t+1} \\ &-\frac{1}{2}\hat{\lambda}^{D2}_{t+1}\hat{r}^*_{t+1} + \frac{1}{2}\hat{\lambda}^D_{t+1}\hat{r}^{p2}_{t+1} - \frac{1}{2}\hat{\lambda}^D_{t+1}\hat{r}^{*2}_{t+1} + \frac{1}{6}\hat{r}^{p3}_{t+1} - \frac{1}{6}\hat{r}^{*3}_{t+1}\Bigg] + O(\epsilon^4) = 0 \end{aligned} \tag{5.77}$$

$$\begin{aligned} E_t\Bigg[&\hat{r}^p_{t+1} - \hat{r}^*_{t+1} + \hat{s}^D_{t+1}\hat{r}^p_{t+1} - \hat{s}^D_{t+1}\hat{r}^*_{t+1} + \frac{1}{2}\hat{r}^{p2}_{t+1} - \frac{1}{2}\hat{r}^{*2}_{t+1} + \frac{1}{2}\hat{s}^{D2}_{t+1}\hat{r}^p_{t+1} \\ &-\frac{1}{2}\hat{s}^{D2}_{t+1}\hat{r}^*_{t+1} + \frac{1}{2}\hat{s}^D_{t+1}\hat{r}^{p2}_{t+1} - \frac{1}{2}\hat{s}^D_{t+1}\hat{r}^{*2}_{t+1} + \frac{1}{6}\hat{r}^{p3}_{t+1} - \frac{1}{6}\hat{r}^{*3}_{t+1}\Bigg] + O(\epsilon^4) = 0 \end{aligned} \tag{5.78}$$

After substracting Equation (5.78) from Equation (5.77), I obtain

$$\begin{aligned} E_t\Bigg[&\left(\hat{\lambda}^D_{t+1} - \hat{s}^D_{t+1}\right)\left(\hat{r}^p_{t+1} - \hat{r}^*_{t+1}\right) + \frac{1}{2}\left(\hat{\lambda}^{D2}_{t+1} - \hat{s2}^D_{t+1}\right)\left(\hat{r}^p_{t+1} - \hat{r}^*_{t+1}\right) \\ &+\frac{1}{2}\left(\hat{\lambda}^D_{t+1} - \hat{s}^D_{t+1}\right)\left(\hat{r}^{p2}_{t+1} - \hat{r}^{*2}_{t+1}\right)\Bigg] = 0 + O(\epsilon^4) \end{aligned} \tag{5.79}$$

The expression above is key to solve for the dynamics of the equilibrium portfolio ($\hat{B}_t$).

Next, I take a second-order approximation of the budget constraint and the result is the following:

[24] Since in principle ex-post the real return on dollar assets may be different to the real return on peso assets, households may want to accumulate assets in pesos, even though they have the commitment of the government that they can buy and sell as many dollars as they want at the fixed exchange rate.

$$
\begin{aligned}
-\bar{W}\hat{W}_t - \bar{\pi}\hat{\pi}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(\frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}\bar{k}}{\bar{s}}\right)\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t \\
+\left(-\frac{\bar{R}\bar{k}}{\bar{s}} - (1-\delta)\bar{k}\right)\hat{k}_t + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^* + \big(\bar{c} + \bar{k} \\
-(1-\delta)\bar{k} + \bar{r}\bar{W}\hat{p}_t^m + \bar{c}c_t + \bar{k}k_{t+1} + \bar{r}\bar{W}\hat{r}_t^* - \bar{r}\bar{W}p_{t-1}^m + \bar{r}\bar{W}W_{t-1} \\
-\frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{w}_t - \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{h}_t - \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{R}_t - \frac{1}{2}\bar{W}\hat{W}_t\hat{W}_t \\
-\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{h}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{s}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{s}_t - \frac{1}{2}\bar{k}\hat{k}_t\hat{k}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{R}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{k}_t \\
-\frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{k}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{k}_t\hat{k}_t + \bar{k}\delta\hat{k}_t\hat{p}_t^m - \phi\bar{k}^2\hat{k}_t\hat{k}_{t+1} + \bar{r}\bar{W}\hat{p}_t^m\hat{r}_t^* \\
-\bar{r}\bar{W}p_{t-1}^m\hat{p}_t^m + \bar{r}\bar{W}\hat{p}_t^m\hat{W}_{t-1} + \frac{1}{2}\phi\bar{k}^2\hat{k}_t\hat{k}_t - \bar{r}\bar{W}\hat{r}_t^*\hat{p}_{t-1}^m + \bar{r}\bar{W}\hat{r}_t^*\hat{W}_{t-1} \\
-\bar{r}\bar{W}p_{t-1}^m\hat{W}_{t-1} - \bar{k}\hat{k}_t\hat{p}_t^m + \frac{1}{2}\bar{c}\hat{p}_t^m\hat{p}_t^m + \frac{1}{2}\bar{c}\hat{c}_t\hat{c}_t + \frac{1}{2}\bar{k}k_{t+1}k_{t+1} \\
+\frac{1}{2}\bar{k}\delta\hat{p}_t^m\hat{p}_t^m + \frac{1}{2}\bar{r}\bar{W}\hat{p}_t^m\hat{p}_t^m + \bar{c}\hat{p}_t^m c_t + \bar{k}\hat{p}_t^m\hat{k}_{t+1} + \frac{1}{2}\phi\bar{k}^2 k_{t+1}k_{t+1} \\
+\frac{1}{2}\bar{k}\delta\hat{k}_t\hat{k}_t + \frac{1}{2}\psi\bar{W}^2\hat{W}_t\hat{W}_t - \frac{1}{2}\bar{\pi}\hat{\pi}_t\hat{\pi}_t + \frac{1}{2}\bar{r}\bar{W}\hat{r}_t^*\hat{r}_t^* + \frac{1}{2}\bar{r}\bar{W}\hat{p}_{t-1}^m\hat{p}_{t-1}^m \\
+\frac{1}{2}\bar{r}\bar{W}\hat{W}_{t-1}\hat{W}_{t-1} + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{p}^m(t)\hat{r}_t^p - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{p}^m(t) \\
\hat{r}_t^* + \frac{1}{2}\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{r}_t^p - \frac{1}{2}\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{r}_t^* - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{s}_{t-1} + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{s}_{t-1} - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{p}_{t-1}^m \\
+\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{p}_{t-1}^m + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{B}_t - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{B}_t = 0 + O(\epsilon^3)
\end{aligned}
\tag{5.80}
$$

To make easier my calculations, I define $\tilde{B}_t$ as follows:

$$\tilde{B}_t = \bar{r}\frac{\bar{B}}{\bar{s}}\hat{B}_t$$

Following Sutherland and Devereux (2007 and 2008), I postulate that $\tilde{B}_t$ has the following functional form:

$$\tilde{B}_t = \gamma_x' z_{t+1} = [\gamma_x]_k [z_{t+1}]^k \tag{5.81}$$

where $z_{t+1} = [x_t \quad s_{t+1}]$. The next big step is to solve for the vector of coefficients in this expression (γ_x).

As in the previous section, initially assume that the realized excess return on the time varying part of the portfolio, $\tilde{B}_t r_{x,t}$, is an exogenous independent mean-zero i.i.d. random variable denoted ξ_t. The second order approximation of the budget constraint in period t can therefore be written in the form

$$
\begin{aligned}
-\bar{W}\hat{W}_t - \bar{\pi}\hat{\pi}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(\frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}\bar{k}}{\bar{s}}\right)\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t \\
+\left(-\frac{\bar{R}\bar{k}}{\bar{s}} - (1-\delta)\bar{k}\right)\hat{k}_t + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^p_t - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^*_t + \left(\bar{c} + \bar{k} - (1-\delta)\bar{k} + \bar{r}\bar{W}\right)\hat{p}^m_t \\
+\bar{c}c_t + \bar{k}k_{t+1} + \bar{r}\bar{W}\hat{r}^*_t - \bar{r}\bar{W}p^m_{t-1} + \bar{r}\bar{W}W_{t-1} - \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{w}_t \\
-\frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{h}_t - \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{R}_t - \frac{1}{2}\bar{W}\hat{W}_t\hat{W}_t \\
-\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{h}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{s}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{s}_t - \frac{1}{2}\bar{k}\hat{k}_t\hat{k}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{R}_t \\
+\frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{k}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{k}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{k}_t\hat{k}_t + \bar{k}\delta\hat{k}_t\hat{p}^m_t - \phi\bar{k}^2\hat{k}_t\hat{k}_{t+1} + \bar{r}\bar{W}\hat{p}^m_t\hat{r}^*_t \\
-\bar{r}\bar{W}p^m_{t-1}\hat{p}^m_t + \bar{r}\bar{W}\hat{p}^m_t\hat{W}_{t-1} + \frac{1}{2}\phi\bar{k}^2\hat{k}_t\hat{k}_t - \bar{r}\bar{W}\hat{r}^*_t\hat{p}^m_{t-1} + \bar{r}\bar{W}\hat{r}^*_t\hat{W}_{t-1} \\
-\bar{r}\bar{W}p^m_{t-1}\hat{W}_{t-1} - \bar{k}\hat{k}_t\hat{p}^m_t + \frac{1}{2}\bar{c}\hat{p}^m_t\hat{p}^m_t + \frac{1}{2}\bar{c}\hat{c}_t\hat{c}_t + \frac{1}{2}\bar{k}k_{t+1}k_{t+1} \\
+\frac{1}{2}\bar{k}\delta\hat{p}^m_t\hat{p}^m_t + \frac{1}{2}\bar{r}\bar{W}\hat{p}^m_t\hat{p}^m_t + \bar{c}\hat{p}^m_t c_t + \bar{k}\hat{p}^m_t\hat{k}_{t+1} + \frac{1}{2}\phi\bar{k}^2k_{t+1}k_{t+1} \\
+\frac{1}{2}\bar{k}\delta\hat{k}_t\hat{k}_t + \frac{1}{2}\psi\bar{W}^2\hat{W}_t\hat{W}_t - \frac{1}{2}\bar{\pi}\hat{\pi}_t\hat{\pi}_t + \frac{1}{2}\bar{r}\bar{W}\hat{r}^*_t\hat{r}^*_t + \frac{1}{2}\bar{r}\bar{W}\hat{p}^m_{t-1}\hat{p}^m_{t-1} \\
+\frac{1}{2}\bar{r}\bar{W}\hat{W}_{t-1}\hat{W}_{t-1} + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{p}^m(t)\hat{r}^p_t - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{p}^m(t)\hat{r}^*_t + \frac{1}{2}\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^p_t\hat{r}^p_t - \frac{1}{2}\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^*_t\hat{r}^*_t \\
-\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^p_t\hat{s}_{t-1} + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^*_t\hat{s}_{t-1} - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^p_t\hat{p}^m_{t-1} \\
+\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}^*_t\hat{p}^m_{t-1} + \xi_t = 0 + O(\epsilon^3)
\end{aligned}
\tag{5.82}
$$

where the value of $\tilde{B}$ is given by Equation (5.76).

Assume that the entire second-order approximation of the non-portfolio equations of the model can be summarized in a matrix system of the form

$$
\tilde{A}_1\begin{bmatrix} s_{t+1} \\ E_t[c_{t+1}] \end{bmatrix} + \tilde{A}_2\begin{bmatrix} s_t \\ c_t \end{bmatrix} + \tilde{A}_3x_t + \tilde{A}_4\Lambda_t + B\xi_t + O(\epsilon^3) \tag{5.83}
$$

$$
x_t = Nx_{t-1} + \varepsilon_t \tag{5.84}
$$

$$
\Lambda_t = vech\left(\begin{bmatrix} x_t \\ s_t \\ c_t \end{bmatrix}\begin{bmatrix} x_t & s_t & c_t \end{bmatrix}\right) \tag{5.85}
$$

where B is column vector with unity in the row corresponding to the equation for the evolution of net debt (5.82) and zero in all other rows. This is the second order analogue of Equation (5.64), which was used in the derivation of the solution for the steady-state portfolio. However, note that in this case the coefficient matrices on the first order terms differ from Equation (5.64) because Equation (5.83) incorporates the effects of the steady state portfolio. This is indicated by the tildes over the matrices ($\tilde{A}_1$, $\tilde{A}_2$, $\tilde{A}_3$, and $\tilde{A}_4$).

The state-space solution to this set of equations can be derived using any second-order solution method such as that by Lombardo and Sutherland (2005). In order to simplify further the next steps in the derivation of the solution for the dynamics of B_t, I introduce one more dummy variable ($\widehat{ls}^D$), which is defined as follows:

$$\widehat{ls}^D = \hat{\lambda}^D - \hat{s}^d$$

Now, by extracting the appropriate rows and columns from the state-space solution it is possible to write the following expressions for the second-order behavior of $\widehat{ls}^D$ and $\hat{r}_x$:

$$\begin{aligned}\widehat{ls}^D = [\tilde{D}_0] + [\tilde{D}_1][\xi] + [\tilde{D}_2]_i[\varepsilon]^i + [\tilde{D}_3]_k\left([z^f]^k + [z^s]^k\right) + [\tilde{D}_4]_{ij}[\varepsilon]^i[\varepsilon]^j \\ +[\tilde{D}_5]_{ki}[\varepsilon]^i[z^f]^k + [\tilde{D}_6]_{ij}[z^f]^i[z^f]^j + O(\epsilon^3)\end{aligned} \tag{5.86}$$

$$\begin{aligned}\hat{r}_x = [\tilde{R}_0] + [\tilde{R}_1][\xi] + [\tilde{R}_2]_i[\varepsilon]^i + [\tilde{R}_3]_k\left([z^f]^k + [z^s]^k\right) + [\tilde{R}_4]_{ij}[\varepsilon]^i[\varepsilon]^j \\ +[\tilde{R}_5]_{ki}[\varepsilon]^i[z^f]^k + [\tilde{R}_6]_{ij}[z^f]^i[z^f]^j + O(\epsilon^3)\end{aligned} \tag{5.87}$$

where time subscripts have been omitted to simplify the notation and z^f and z^s are the first and second-oder parts of the solution for z. These expressions show how the second-order behavior of $\widehat{ls}^D$ and $\hat{r}_x$ depend on the excess returns on the time-varying element of portfolios (represented by ξ) and the state variables and exogenous i.i.d. innovations.

As mentioned earlier, up to first order accuracy, the expected excess return is zero, and up to second-order accuracy, it is a constant with a value given by Equation (5.79) below. This implies that $[\tilde{R}_3]_k[z^f]^k = 0$ and that the terms $[\tilde{R}_3]_k[z^s]^k$ and $[\tilde{R}_6]_{ij}[z^f]^i[z^f]^j$ are constants. Now, after taking expectations on Equation (5.87), I obtain

$$[\tilde{R}_0] = E[r_x] - [\tilde{R}_3]_k[z^s]^k - [\tilde{R}_4]_{ij}[\Sigma]^{ij} - [\tilde{R}_6]_{ij}[z^f]^i[z^f]^j \tag{5.88}$$

which combined with Equation (5.87) results in the following expression:

$$\hat{r}_x = E[r_x] - [\tilde{R}_4]_{ij}[\Sigma]^{ij} + [\tilde{R}_1][\xi] + [\tilde{R}_2]_i[\varepsilon]^i + [\tilde{R}_4]_{ij}[\varepsilon]^i[\varepsilon]^j + [\tilde{R}_5]_{ki}[\varepsilon]^i[z^f]^k + O(\epsilon^3) \quad (5.89)$$

In this analysis, ξ is endogenous and given by

$$\xi = \hat{\alpha}\hat{r}_x = [\gamma_x]_k[z^f]^k\hat{r}_x \quad (5.90)$$

Since ξ is a second-order term, $\hat{r_x}$ can be replaced by the first-order parts of Equation (5.89); therefore

$$\xi = [\gamma_x]_k[z^f]^k\hat{r}_x = [\tilde{R}_2]_i[\gamma_x]_k[\varepsilon]^i[z^f]^k \quad (5.91)$$

After combining this expression with Equations (5.86) and (5.89), I obtain that

$$\begin{aligned}\widehat{ls}^D &= [\tilde{D}_0] + [\tilde{D}_2]_i[\varepsilon]^i + [\tilde{D}_3]_k\left([z^f]^k + [z^s]^k\right) + [\tilde{D}_4]_{ij}[\varepsilon]^i[\varepsilon]^j + \Big([\tilde{D}_5]_{ki} \\ &\quad +[\tilde{D}_1][\tilde{R}_2]_i[\gamma_x]_k[\varepsilon]^i[z^f]^k + [\tilde{D}_6]_{ij}[z^f]^i[z^f]^j + O(\epsilon^3)\end{aligned} \quad (5.92)$$

$$\begin{aligned}\hat{r}_x &= E[r_x] - [\tilde{R}_4]_{ij}[\Sigma]^{ij} + [\tilde{R}_2]_i[\varepsilon]^i + [\tilde{R}_4]_{ij}[\varepsilon]^i[\varepsilon]^j \\ &\quad + \left([\tilde{R}_5]_{ki} + [\tilde{R}_1][\tilde{R}_2]_i[\gamma_x]_k\right)[\varepsilon]^i[z^f]^k + O(\epsilon^3)\end{aligned} \quad (5.93)$$

The two expressions above provide two components necessary to evaluate the left hand side of Equation (5.79). The following expressions for the first order behavior of $\hat{\lambda}^D$, $\hat{s}^D$, $\hat{r}^p$ and $\hat{r}^*$ are necessary to obtain a simpler expression for Equation (5.79) above:

$$\hat{\lambda}^D = [\tilde{C}_2^H]_i[\varepsilon]^i + [\tilde{C}_3^H]_k[z^f]^k \quad (5.94)$$

$$\hat{s}^D = [\tilde{C}_2^F]_i[\varepsilon]^i + [\tilde{C}_3^F]_k[z^f]^k \quad (5.95)$$

$$\hat{r}^p = [\tilde{R}_2^1]_i[\varepsilon]^i + [\tilde{R}_3^1]_k[z^f]^k \quad (5.96)$$

$$\hat{r}^* = [\tilde{R}_2^2]_i[\varepsilon]^i + [\tilde{R}_3^2]_k[z^f]^k \quad (5.97)$$

Notice that $[\tilde{R}_3^1]_k = [\tilde{R}_3^2]_k$. The coefficient matrices for these expressions can be formed by extracting the appropriate elements from the first order parts of the solution to the system (5.83). After replacing Equations (5.92), (5.93), (5.94), (5.95), (5.96), and (5.97) in Equation (5.79) and deleting terms of order higher than three, I obtain

$$
\begin{aligned}
&[\tilde{D}_3]_k[z^f]^k E[r_x] + [\tilde{D}_2]_i[z^f]^k[\tilde{R}_5]_{kj}[\Sigma]^{ij} + [z^f]^k[\tilde{D}_5]_{kj}[\tilde{R}_2]_i[\Sigma]^{ij} \\
&+[\tilde{D}_2]_i[\tilde{R}_2]_i[\Sigma]^{ij} + [\tilde{D}_2]_i[z^f]^k[\tilde{R}_1][\tilde{R}_2]_i\gamma_x[\Sigma]^{ij} \\
&+[z^f]^k[\tilde{D}_1][\tilde{R}_2]_i^2\gamma_x[\Sigma]^{ij} + \frac{1}{2}[\tilde{D}_3]_k[z^f]^k[\tilde{R}_2^1]_i^2[\Sigma]^{ij} - \frac{1}{2}[\tilde{D}_3]_k[z^f]^k[\tilde{R}_2^2]_i^2[\Sigma]^{ij} \\
&+[\tilde{R}_2]_i[\tilde{C}_2^H]_j[\tilde{C}_3^H]_k[z^f]^k[\Sigma]^{ij} - [\tilde{R}_2]_i[\tilde{C}_2^F]_j[\tilde{C}_3^F]_k[z^f]^k[\Sigma]^{ij} \\
&+[\tilde{D}_2]_i[\tilde{R}_1]_i[\tilde{R}_3^1]_k[z^f]^k[\Sigma]^{ij} = 0 + O(\epsilon^3)
\end{aligned}
\tag{5.98}
$$

where I used the fact that $[\tilde{D}_0]$ is a second-order term and the assumption that all third moments of ε are equal to zero. Notice that since Solutions (5.86) and (5.87) are based on an approximation where the steady state portfolio is given by Equation (5.76), it follows that

$$
[\tilde{D}_2]_i[\tilde{R}_2]_j[\Sigma]^{ij} = 0 \tag{5.99}
$$

which I also used to obtain Equation (5.98), which in turn implies that the following expression must be satisfied for all k

$$
\begin{aligned}
&[\tilde{D}_3]_k E[r_x] + [\tilde{D}_2]_i[\tilde{R}_5]_{kj}[\Sigma]^{ij} + [\tilde{D}_5]_{kj}[\tilde{R}_2]_i[\Sigma]^{ij} + [\tilde{D}_2]_i[\tilde{R}_2]_i[\Sigma]^{ij} \\
&+[\tilde{D}_2]_i[\tilde{R}_1][\tilde{R}_2]_i\gamma_x[\Sigma]^{ij} + [\tilde{D}_1][\tilde{R}_2]_i^2\gamma_x[\Sigma]^{ij} + \frac{1}{2}[\tilde{D}_3]_k[\tilde{R}_2^1]_i^2[\Sigma]^{ij} \\
&-\frac{1}{2}[\tilde{D}_3]_k[\tilde{R}_2^2]_i^2[\Sigma]^{ij} + [\tilde{R}_2]_i[\tilde{C}_2^H]_j[\tilde{C}_3^H]_k[\Sigma]^{ij} \\
&-[\tilde{R}_2]_i[\tilde{C}_2^F]_j[\tilde{C}_3^F]_k[\Sigma]^{ij} + [\tilde{D}_2]_i[\tilde{R}_1]_i[\tilde{R}_3^1]_k[\Sigma]^{ij} = 0 + O(\epsilon^3)
\end{aligned}
\tag{5.100}
$$

In order to obtain an expression for $E[r_x]$ that will allow me to simplify further Equation (5.100), I add up Equations (5.61) and (5.62) and then rearrange the sum so that I can obtain the following expression:

$$
E[\hat{r}_x] = -\frac{1}{2}E\left[\left(\lambda^D + s^D\right)r_x + \left(r^{p2} - r^{d2}\right)\right] + O(\epsilon^3) \tag{5.101}
$$

Using Equations (5.94), (5.95), (5.96), and (5.97) it is possible to write Equation (5.101) as follows:

$$
\begin{aligned}
E[\hat{r}_x] = -\frac{1}{2}[\tilde{R}_2^1]_i^2[\Sigma]^{ij} + \frac{1}{2}[\tilde{R}_2^2]_i^2[\Sigma]^{ij} - \frac{1}{2}[\tilde{C}_2^H]_i[\Sigma]^{ij}[\tilde{R}_2]_i \\
-\frac{1}{2}[\tilde{C}_2^F]_i[\Sigma]^{ij}[\tilde{R}_2]_i + O(\epsilon^3)
\end{aligned} \tag{5.102}
$$

After replacing this expression for $E[r_x]$ into Equation (5.100), taking advantage of the fact that $[\tilde{C}_2^H] - [\tilde{C}_2^F] = [\tilde{D}_2]$ and $[\tilde{C}_3^H] - [\tilde{C}_3^F] = [\tilde{D}_3]$, applying Equation (5.99), and solving for γ_x, I obtain the following solution in matrix form:

$$
\gamma_x = -\left[\tilde{R}_2\Sigma\tilde{R}_2'\tilde{D}_1\right]^{-1}\left[\tilde{R}_2\Sigma\tilde{D}_5' + \tilde{D}_2\Sigma\tilde{R}_5'\right] + O(\epsilon) \tag{5.103}
$$

which holds for all k.

5.5 Calibration

I do calibrate the model for an average small open economy that has a high level of dollarization. Some values for the parameters of the model are obtained from studies on the Argentinian, Canadian, and Mexican economies, and some values are obtained from the related literature. The basic calibration and parameterization of the model is taken from Mendoza (1991). Mendoza calibrates the model to the Canadian economy[25]. Mendoza argues that Canada is viewed as a typical small open economy because of the historical absence of capital controls and the high degree of integration of its financial markets with those of the United States. The parameter values that I will use in my simulation of the model are given in Table 5.1 below.

In addition, following Schmitt-Grohe and Uribe (2003), I assign a small value to the parameter ψ_2, which helps measure the portfolio adjustment costs that arise from choosing a debt level different from its steady state value. Also, I assign a value of 0.9615 to the discount factor β, since in the steady state the discount factor equals the inverse of the gross world interest rate on dollar assets ($\bar{R}^*$), to which I assign a value of 1.04. The value of 0.1 assigned to the annual depreciation rate δ implies an average investment ratio of about 19 percent, which is close to the average value observed in Argentina of about 17 percent. I set the parameter α, which determines the average

[25] The data considered by Mendoza corresponds to annual observations for the period 1946-1985, expressed in per capita terms of the population older than 14 years, transformed into logarithms and detrended with a quadratic time trend.

Table 5.1: Calibration

Symbol	Value	Description
α	0.32	Capital's share of income
β	0.9615	Subjective discount factor
γ	2	Coefficient of relative risk aversion
δ	0.1	Depreciation rate
η	-6	Price elasticity of demand for a specific export good variety
ψ_2	0.00074	Parameter of the portfolio adjustment cost function
ϕ	0.028	Parameter of the capital adjustment cost function
ϕ_2	0.028	Degree of price stickiness
ρ	0.42	Degree of autocorrelation for the technology shock
τ	0.56	Degree of autocorrelation for the exports shock
θ_1	0.42	Degree of autocorrelation for the interest rate on dollar bonds
θ_2	0.42	Degree of autocorrelation for the dollar price of imports
ω	1.455	One plus the inverse of the intertemporal elasticity of substitution in labor supply
σ_A	0.0129	Standard deviation of the technology shock error term
σ_X	0.0129	Standard deviation of the exports shock error term
σ_R	0.0129	Standard deviation of the interest rate on dollar bonds shock error term
σ_p	0.0129	Standard deviation of the dollar price of imports shock error term
$\bar{r}$	1.04	World's gross real interest rate

capital share of income, at 0.32, a value commonly used in the related literature. In addition, I set the value of the price elasticity of demand on a specific good η equal to -6. This value implies a steady state value for the (value-added) markup of 0.20, which is a reasonable value[26]. Furthermore, I assume that the net debt in the long run equilibrium is equal to 20 percent of the dollar value of domestic output.

5.5.1 The Welfare Measure

Let V_t be the conditional expectation of lifetime utility at time t

$$V_t \equiv E_t \left\{ \sum_{s-t}^{\infty} \beta^{s-t} U(c_s, h_s) \right\} \tag{5.104}$$

To find a second-order approximation of V_t, I can define V_t as a new control variable in my model. From Equation (5.104), I can obtain that V_t follows a law of motion as in equation (5.105)

$$V_t - \beta E_t\{V_{t+1}\} = U(c_t, h_t) \tag{5.105}$$

[26]Basu and Fernald (1997) estimate gross-output markup of about 0.1. They show that their estimates are consistent wih values for the added-value markup of up to 0.25.

5.5.1.1 Using the Expected Path to Evaluate Welfare

As Sutherland (2002) has pointed out, the expected path of variables is all that is required to evaluate welfare.

Following Devereux and Sutherland (2007), the solution to the second-order approximation of the non-portfolio equations of the model can be written as follows:

$$s_{t+1} = \tilde{F}_1 x_t + \tilde{F}_2 s_t + \tilde{F}_3 \xi_t + \tilde{F}_4 V_t + \tilde{F}_5 vech(\Sigma) + O(\epsilon^3) \tag{5.106}$$

$$c_t = \tilde{P}_1 x_t + \tilde{P}_2 s_t + \tilde{P}_3 \xi_t + \tilde{P}_4 V_t + \tilde{P}_5 vech(\Sigma) + O(\epsilon^3) \tag{5.107}$$

where

$$\Sigma = E_t[\varepsilon_{t+1}\varepsilon'_{t+1}] \tag{5.108}$$

$$V_t = vech\left(\begin{bmatrix} x_t \\ s_t \end{bmatrix} [x_t \quad s_t]\right) \tag{5.109}$$

This state-space representation allows me to calculate a second-order accurate solution for the conditional expectation (at all horizons) of the variables of the model by simply applying the conditional expectation operator through all the equations in (5.106) to (5.109). In addition, as Sutherland (2005) explains, when one seeks to measure the effects of some policy (here a particular exchange rate regime) on future welfare, it is convenient to choose initial conditions that are "neutral". That is why I will choose $\hat{k}_0$=$\hat{W}_{-1}$=$\hat{p}^d_{-1}$=$\widehat{pma}_{-1}$=$\hat{R}^p_0$=$\widehat{sa}_{-1}$=0 as initial conditions to compute the expected path of variables.

5.6 Impulse Response Functions and Expected Paths of Variables under Alternative Exchange Rate Regimes

We assume that in period 0 the government chooses the exchange rate regime. The government is assumed to be endowed with a commitment technology that allows it to maintain throughout time the policy decision it makes in period 0. As a result, the announced policy enjoys full credibility on the part of the private sector; in other words, there is no time inconsistency problem in my model.

5.6.1 Flexible Exchange Rate Regime

In the model with flexible exchange rate regime, first, the government (central bank) fixes the value of the peso price of domestic exports p_t to its long-run (nonstochastic steady state) level p, following Frankel (2003), and then, after observing the realization of the exogenous shocks to technology, the nominal interest rate on dollar bonds and the level (volume) of exports, households and firms, taking p_t as given, solve their corresponding contrained optimization problems, as explained above. Thus, under the flexible exchange rate regime, I have

$$p_t = p \tag{5.110}$$

It is important to mention that Frankel (2003) suggests that pegging the export price (PEP) is a monetary regime that can be applied to countries that are specialized in the production of a particular agricultural or mineral commodity. PEP proposes fixing the price of the single commodity in terms of local currency (here, pesos). It has been objected that PEP is inappropriate for countries where diversification of exports is an issue. For such countries the modified version, PEPI, developed by Frankel (2005), proposes fixing the price of a comprehensive index of export prices. According to Frankel (2005), in either version of the monetary regime (PEP or PEPI), one advantage is that the currency depreciates automatically when the world market for the country's exports deteriorates.

5.6.1.1 The Nonstochastic Steady State

In the nonstochastic steady state, the disturbance term in each exogenous process for the model shocks is equal to its unconditional expected value, that is, $\varepsilon_A = 0$, $\varepsilon_X = 0$, $\varepsilon_R = 0$, and $\varepsilon_p = 0$, which implies values for the level of domestic exports, the productivity factor, the gross nominal interest rate on dollar bonds and the dollar price of imports of $\bar{X} = 1$, $\bar{A} = 1$, $\bar{R}^* = 1/\beta$, and $\bar{p}^m = 1$ respectively. In addition[27],

$$\bar{s} = 1$$

[27] The model has been built up such that the nonstochastic steady state for the non-portfolio variables is the same under both exchange rate regimes.

$$\bar{R} = \bar{s}\left(\frac{1}{\beta} - (1-\delta)\right)$$

$$\bar{k} = \left\{\frac{\bar{y}}{\bar{A}}\left(\frac{(1-\alpha)}{\alpha}\frac{\bar{R}}{\bar{s}}\right)^{\frac{\alpha-1}{\omega}}\right\}^{\frac{\omega}{\alpha\omega-\alpha+1}}$$

$$\bar{h} = \left(\frac{\bar{y}}{\bar{A}}\bar{k}^{-\alpha}\right)^{\frac{1}{1-\alpha}}$$

$$\bar{R}^p = \bar{R}^* = \frac{1}{\beta}$$

$$\bar{\mu} = -\left(\frac{1+\eta}{\eta}\right)$$

$$\bar{y} = \bar{X} = 1$$

$$\bar{w} = \bar{h}^{\omega-1}\bar{s}$$

$$\bar{p}^* = \frac{\frac{\bar{R}}{\bar{s}}}{-\bar{\mu}\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{(1-\alpha)}}$$

$$\bar{p} = \bar{s}\bar{p}^*$$

$$\bar{\lambda} = \left(\bar{c} - \frac{\bar{h}^{\omega}}{\omega}\right)^{-\gamma}$$

$$\bar{\pi} = \bar{p}^*\bar{X}\left(-\frac{1}{\eta}\right)$$

$$\bar{c} = \bar{\pi} + \frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}}{\bar{s}} - \delta\bar{k} + \left(\frac{1}{\beta}\bar{W}\right)$$

$$\bar{i} = \delta\bar{k}$$

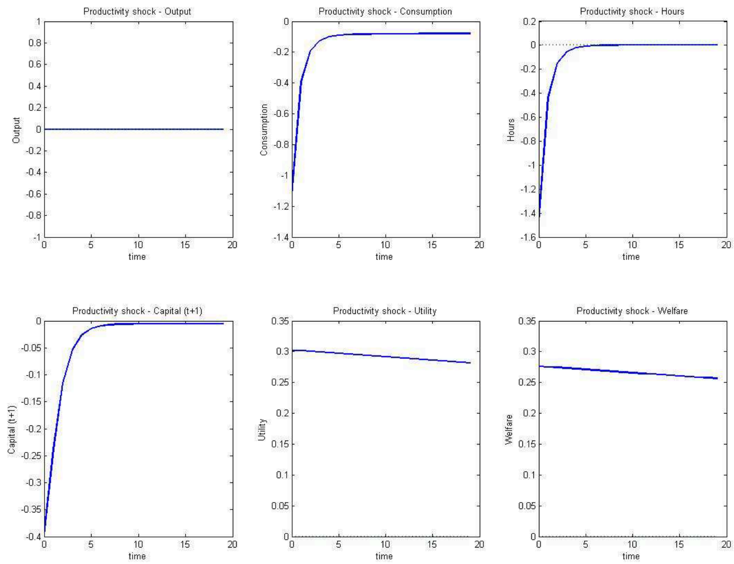

Figure 5.1: Flexible Rate: Technology Shock

5.6.1.2 The Impulse Response Function

All the graphs for the impulse response functions below show the impact on the domestic economy of a one time positive shock equivalent to one standard deviation of a particular innovation.

5.6.1.3 Technology Shock

The model delivers "impoverishing growth", that is, a positive technology shock will make the economy poorer. As argued by Bhagwati (1958), a small economy that exports a good in which it has some market power may be adversely affected by a technology shock by means of a drop of its terms of trade. As can be seen in Figure (5.1) below, the positive technology shock reduces consumption, hours worked, and next-period capital. Consistent with the drop in output and consumption, welfare is adversely affected[28]. In my model, "impoverishing growth" arises because the demand for exports is exogenously given; therefore, a technology innovation will make the dollar price of exports drop and, thus, less revenues and income will flow into the economy.

[28]Notice that an "increase" on a variable whose steady state value is negative implies that this variables becomes more negative. This is the case of both the period utility and welfare in this economy.

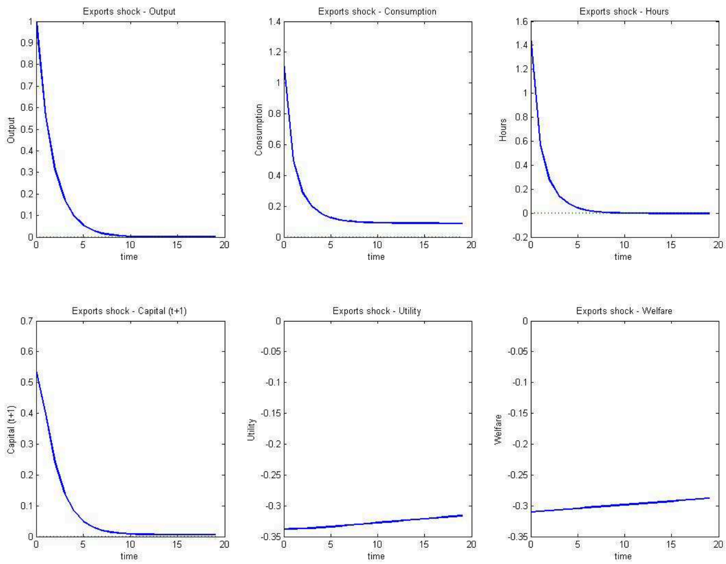

Figure 5.2: Flexible Rate: Exports Shock

5.6.1.4 Shock to Exports

Following a positive shock to exports, all output, consumption, hours worked and next-period capital increase. The greater foreign demand for domestic goods allows output to expand and increases the dollar price of domestic exports. As a result, more revenues and income will flow into the domestic economy, which means that welfare will increase[29].

5.6.1.5 Shock to the Interest Rate on Dollar Bonds

Since the domestic economy is a net debtor in world financial markets, a positive shock to the gross nominal interest rate on dollar bonds will make the domestic debt more costly. As a result, the domestic economy will reduce its net debt, as well as consumption and the stock of capital. In addition, given the fact that capital will drop, hours worked will increase in order to keep constant the level of domestic output, which is driven by the foreign demand in this model.

---

[29] Notice that an "drop" (a negative percentual change) on a variable whose steady state value is negative implies that this variables becomes less negative (that is, it increases!). This is the case of both the period utility and welfare in this economy

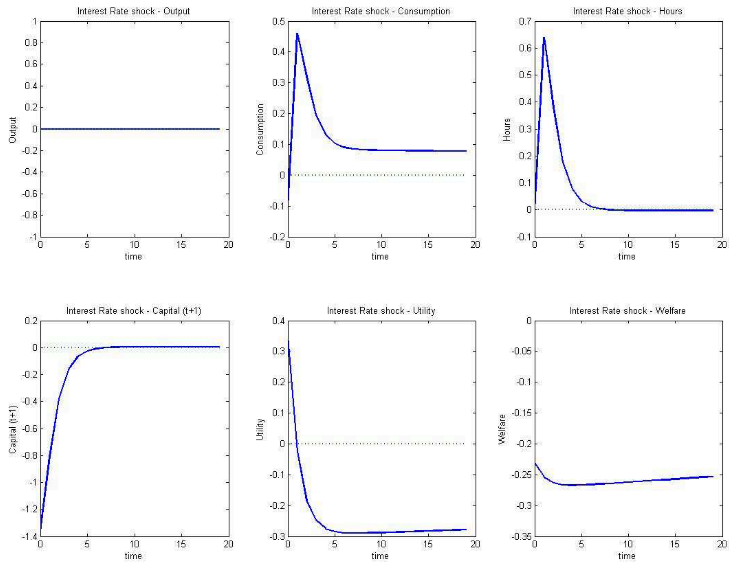

Figure 5.3: Flexible Rate: Interest Rate Shock

5.6.1.6 Shock to the Price of Imports

Following a positive shock to the dollar price of imports, consumption and the stock of capital will fall. In addition, given the fact that capital will drop, hours worked will increase in order to keep constant the level of domestic output, which is driven by the foreign demand in this model.

5.6.1.7 The Expected Path of Some Variables of the Model

Table (5.2) below shows the evolution of the expected path of some variables of the model for 20 periods. While the expected value of welfare stabiilizes around -0.1803, the net debt does around -42.0584. Moreover, consumption and hours worked stabilize around 0.0484 and -0.0012, respectively.

5.6.2 Fixed Exchange Rate Regime

In the model with fixed exchange rate regime, first, the government (central bank) fixes the value of the exchange rate s_t to its long-run (nonstochastic steady state) level s, and then, after observing the realization of the exogenous shocks to technology, the nominal interest rate on dollar bonds and the level (volume) of exports, households and

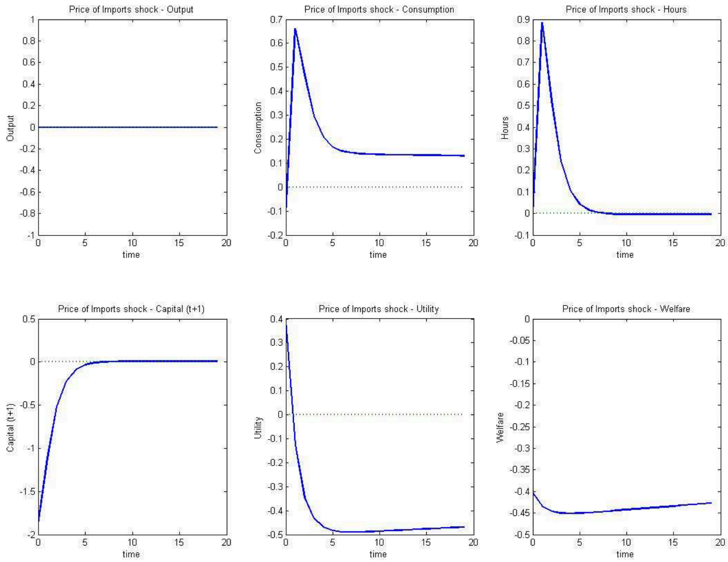

Figure 5.4: Flexible Rate: Price of Imports Shock

Table 5.2: Expected Path of Variables

t	$E_0[\hat{c}_t]$	$E_0[\hat{h}_t]$	$E_0[\hat{y}_t]$	$E_0[\hat{k}_{t+1}]$	$E_0[\widehat{WELF}_t]$	$E_0[\hat{W}_t]$
1	0.0007	0	0	-0.0013	-0.022	-0.0079
2	0.0015	0.0006	0	-0.0012	-0.0228	-0.268
3	0.0017	0.0006	0	-0.001	-0.0235	-0.5553
4	0.0018	0.0005	0	-0.0008	-0.0243	-0.8525
5	0.002	0.0004	0	-0.0008	-0.0251	-1.1537
6	0.0022	0.0004	0	-0.0008	-0.0259	-1.4559
7	0.0024	0.0004	0	-0.0008	-0.0266	-1.7576
8	0.0027	0.0004	0	-0.0007	-0.0274	-2.058
9	0.0029	0.0004	0	-0.0007	-0.0281	-2.3568
10	0.0031	0.0004	0	-0.0007	-0.0289	-2.6535
11	0.0033	0.0004	0	-0.0007	-0.0296	-2.9482
12	0.0035	0.0004	0	-0.0007	-0.0304	-3.2407
13	0.0038	0.0004	0	-0.0007	-0.0311	-3.5311
14	0.004	0.0004	0	-0.0006	-0.0318	-3.8193
15	0.0042	0.0003	0	-0.0006	-0.0325	-4.1052
16	0.0044	0.0003	0	-0.0006	-0.0333	-4.389
17	0.0046	0.0003	0	-0.0006	-0.034	-4.6707
18	0.0048	0.0003	0	-0.0006	-0.0347	-4.9501
19	0.005	0.0003	0	-0.0006	-0.0354	-5.2275
20	0.0053	0.0003	0	-0.0005	-0.0361	-5.5027

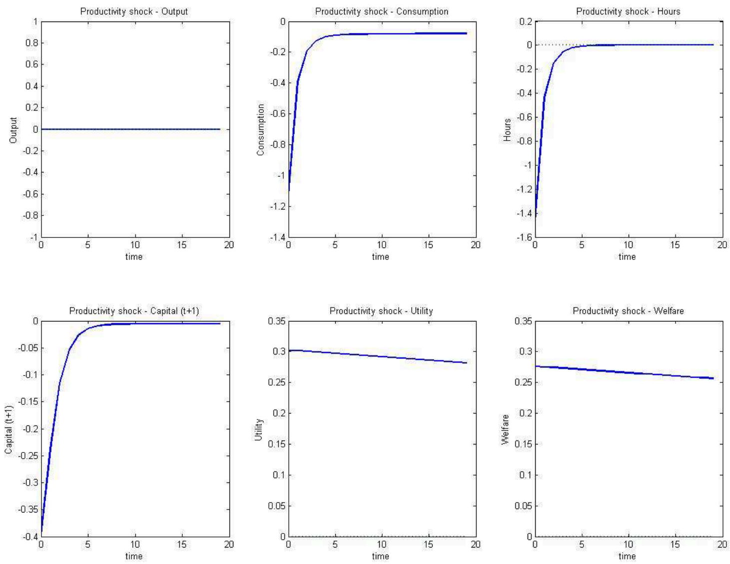

Figure 5.5: Fixed Rate: Technology Shock

firms, taking s_t as given, solve their corresponding contrained optimization problems, as explained above. Thus, under the fixed exchange rate regime, I have

$$s_t = s \tag{5.111}$$

5.6.2.1 The Impulse Response Function

5.6.2.2 Technology Shock

As mentioned previously, the model delivers "impoverishing growth", that is, a positive technology shock will make the economy poorer. As can be seen in Figure (5.5) below, the positive technology shock reduces consumption, hours worked, and next-period capital. Consistent with the drop in output and consumption, welfare is adversely affected[30]. In my model, "impoverishing growth" arises because the demand for exports is exogenously given; therefore, a technology innovation will make the dollar price of exports drop and, thus, less revenues and income will flow into the economy.

[30]Notice that an "increase" on a variable whose steady state value is negative implies that this variables becomes more negative. This is the case of both the period utility and welfare in this economy.

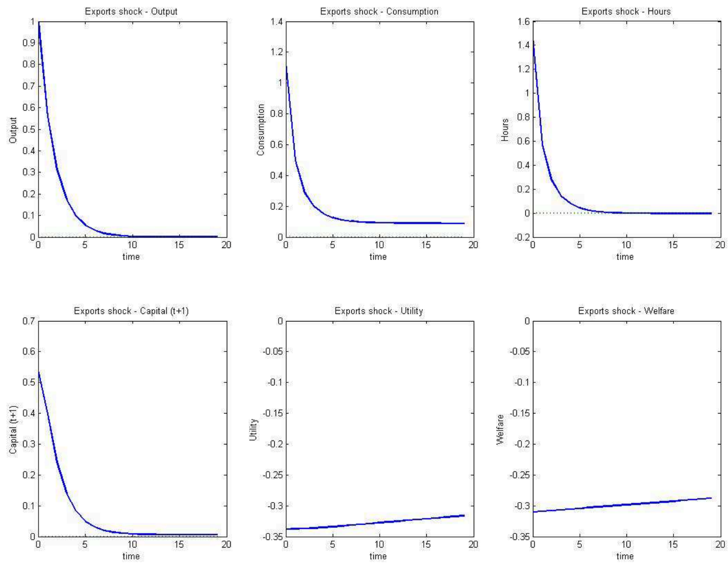

Figure 5.6: Fixed Rate: Exports Shock

5.6.2.3 Shock to Exports

Following a positive shock to exports, all output, consumption, hours worked and next-period capital increase. The greater foreign demand for domestic goods allows output to expand and increases the dollar price of domestic exports. As a result, more revenues and income will flow into the domestic economy, which means that welfare will increase[31].

5.6.2.4 Shock to the Interest Rate on Dollar Bonds

Since the domestic economy is a net debtor in world financial markets, a positive shock to the gross nominal interest rate on dollar bonds will make the domestic debt more costly. As a result, the domestic economy will reduce its net debt, as well as consumption and the stock of capital. In addition, given the fact that capital will drop, hours worked will increase in order to keep constant the level of domestic output, which is driven by the foreign demand in this model.

[31]Notice that an “drop” on a variable whose steady state value is negative implies that this variables becomes less negative (that is, it increases!). This is the case of both the period utility and welfare in this economy

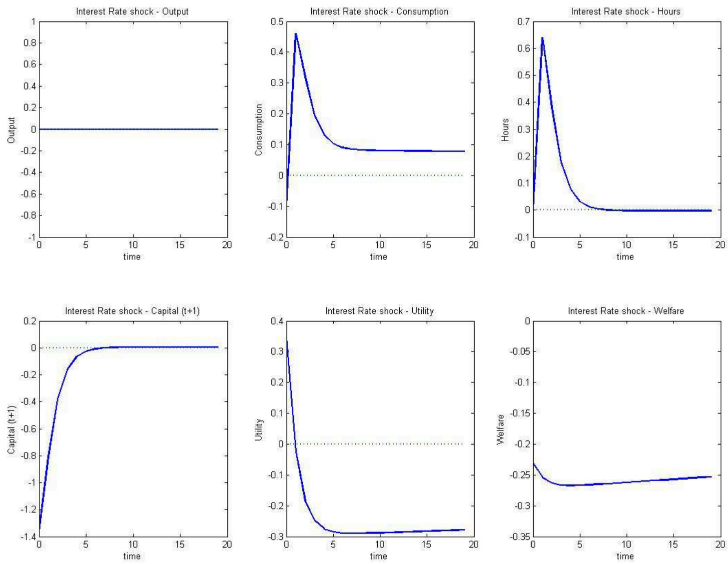

Figure 5.7: Fixed Rate: Interest Rate Shock

5.6.2.5 Price of Imports Shock

Following a positive shock to the dollar price of imports, consumption and the stock of capital will fall. In addition, given the fact that capital will drop, hours worked will increase in order to keep constant the level of domestic output, which is driven by the foreign demand in this model.

5.6.2.6 The Expected Path of Some Variables under Fixed Exchange Rate

Table (5.3) below shows the evolution of the expected path of some variables of the model for 20 periods. While the expected value of welfare stabiilizes around -0.0321, the net debt does around -8.4305. Moreover, consumption and hours worked stabilize around 0.0085 and -0.0006, respectively.

5.6.3 Comparing Some Results Under Alternative Exchange Rate Regimes

In this part of the analysis, first I proceed to highlight some of the main quantitative results of the model; then, I state the main findings from the comparison of these results.

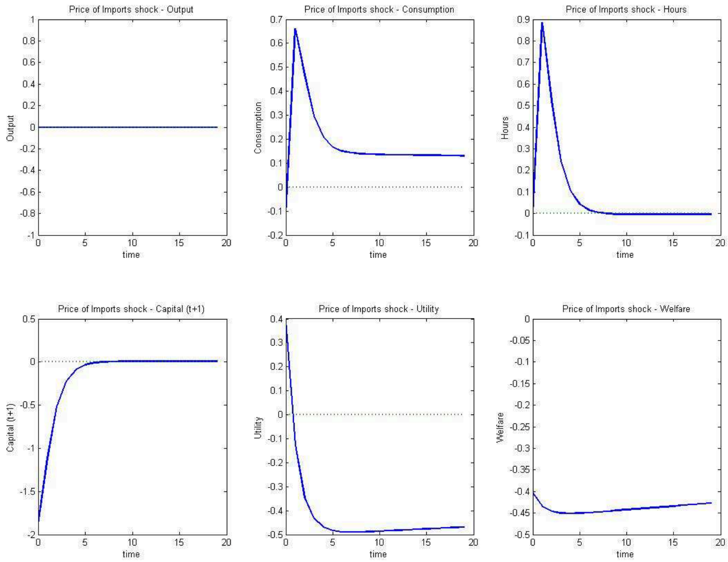

Figure 5.8: Fixed Rate: Price of Imports Shock

Table 5.3: Expected Path of Some Variables

t	$E_0[\hat{c}_t]$	$E_0[\hat{h}_t]$	$E_0[\hat{y}_t]$	$E_0[\hat{k}_{t+1}]$	$E_0[\widehat{WELF}_t]$	$E_0[\hat{W}_t]$
1	0.0014	0	0	0.0001	-0.0081	0.007
2	0.0016	0	0	0.0005	-0.0082	-0.0537
3	0.0016	-0.0002	0	0.0007	-0.0083	-0.1223
4	0.0015	-0.0003	0	0.0008	-0.0085	-0.1878
5	0.0015	-0.0003	0	0.0008	-0.0086	-0.2511
6	0.0016	-0.0004	0	0.0009	-0.0087	-0.3132
7	0.0016	-0.0004	0	0.0009	-0.0088	-0.3747
8	0.0016	-0.0004	0	0.0009	-0.009	-0.4357
9	0.0017	-0.0004	0	0.0009	-0.0091	-0.4963
10	0.0017	-0.0004	0	0.0009	-0.0092	-0.5565
11	0.0017	-0.0004	0	0.0009	-0.0093	-0.6162
12	0.0018	-0.0004	0	0.0009	-0.0095	-0.6755
13	0.0018	-0.0004	0	0.0009	-0.0096	-0.7344
14	0.0018	-0.0004	0	0.0009	-0.0097	-0.7928
15	0.0019	-0.0004	0	0.0009	-0.0098	-0.8508
16	0.0019	-0.0004	0	0.0009	-0.0099	-0.9084
17	0.0019	-0.0004	0	0.0009	-0.01	-0.9655
18	0.002	-0.0004	0	0.0009	-0.0102	-1.0221
19	0.002	-0.0004	0	0.0009	-0.0103	-1.0784
20	0.002	-0.0004	0	0.0009	-0.0104	-1.1342

5.6.3.1 Flexible Exchange Rate Regime

Under flexible exchange rate regime, $\bar{B} = 3.34$, $\bar{B}^* = -3.12$, $E_0[\widehat{WELF}_t] = -0.1803$, and

$$\gamma_x = [1.5695 \ -1.3338 \ -1.6267 \ -0.1606 \ 1.8789 \ -0.1345 \ -0.1500 \ 0.0811 \\ -1.3909 \ 2.0828] \tag{5.112}$$

Thus, the solution for $\tilde{B}_t$ is given by

$$\tilde{B}_t = 1.5695\hat{A}_t - 1.3338\hat{X}_t - 1.6267\hat{R}_t^* - 0.1606\hat{p}_t^m + 1.8789\hat{k}_t - 0.1345\hat{W}_{t-1} \\ -0.1500\hat{p}_{t-1}^d + 0.0811\hat{p}_{t-1}^m - 1.3909\hat{R}_t^p + 2.0828\hat{s}_{t-1} \tag{5.113}$$

5.6.3.2 Dynamics of Bonds and Net Debt Under Flexible Exchange Rate

I can compute the dynamics of peso bonds $\hat{B}_t$ by taking advantage of Equation (5.113) and applying the following formula:

$$\hat{B}_t = \frac{\beta\bar{s}}{\bar{B}}\tilde{B}_t \tag{5.114}$$

In addition, I can compute the dynamics of dollars bonds using the following formula[32]:

$$\hat{B}_t^* = \frac{\hat{W}_t - \frac{\frac{\bar{B}}{\bar{s}}}{\bar{W}}\hat{B}_t + \frac{\frac{\bar{B}}{\bar{s}}}{\bar{W}}\hat{s}_t}{\frac{\bar{B}^*}{\bar{W}}} \tag{5.115}$$

As can be seen in Figure (5.9) below, following a positive shock to technology, net debt increases. This occurs because the country issues more debt (in net terms) as it becomes poorer (as the model delivers immiserizing growth). In addition, while more debt in pesos is issued[33], less assets in dollars are accumulated (since they are used to smooth consumption). Furthermore, following a positive exports shock, net debt decreases. This happens because the country issues less debt (in net terms) as it becomes richer. In addition, while less debt in pesos is issued, more assets in dollars are

[32]The formula was derived by log-linearizing the definition of net wealth, Equation (5.6).

[33]Remember that under flexible exchange rate, domestic households optimally issue debt in pesos while accumulate assets in dollars.

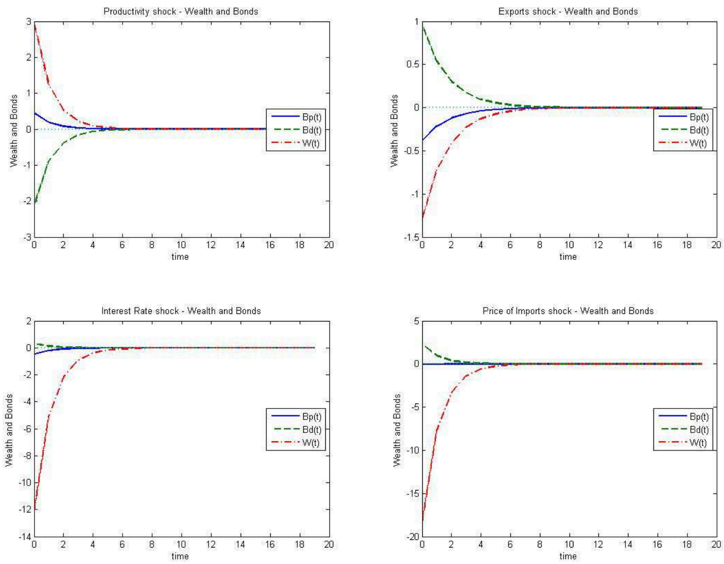

Figure 5.9: Flexible Rate: Dynamics of $\hat{B}_t$, $\hat{B}_t^*$ and $\hat{W}_t$

accumulated (the increase in dollar revenues due to the positive exports shock allows the country to accumulate more dollars).

5.6.3.3 Fixed Exchange Rate Regime

Under fixed exchange rate regime, $\bar{B} = -2.08$, $\bar{B}^* = 2.29$, $E_0[\widehat{WELF}_t] = -0.0321$, and

$$\gamma_x = [-0.2013\; 0.2375\; 3.4658\; 2.4203\; -0.0134\; -0.2902\; -0.0067\; 0.0659\; -0.6357] \quad (5.116)$$

Thus, the solution for $\tilde{B}_t$ is given by

$$\begin{aligned} \tilde{B}_t = & -0.2013\hat{A}_t + 0.2375\hat{X}_t + 3.4658\hat{R}_t^* + 2.4203\hat{p}_t^m - 0.0134\hat{k}_t \\ & -0.2902\hat{W}_{t-1} - 0.0067\hat{p}_{t-1}^d + 0.0659\hat{p}_{t-1}^m - 0.6357\hat{R}_t^p \end{aligned} \quad (5.117)$$

5.6.3.4 Dynamics of Bonds and Net Debt Under Fixed Exchange Rate

As can be seen in Figure (5.10) below, following a positive shock to technology, net debt increases. This occurs because the country issues more debt (in net terms) as it becomes poorer (as the model delivers immiserizing growth). In addition, while more

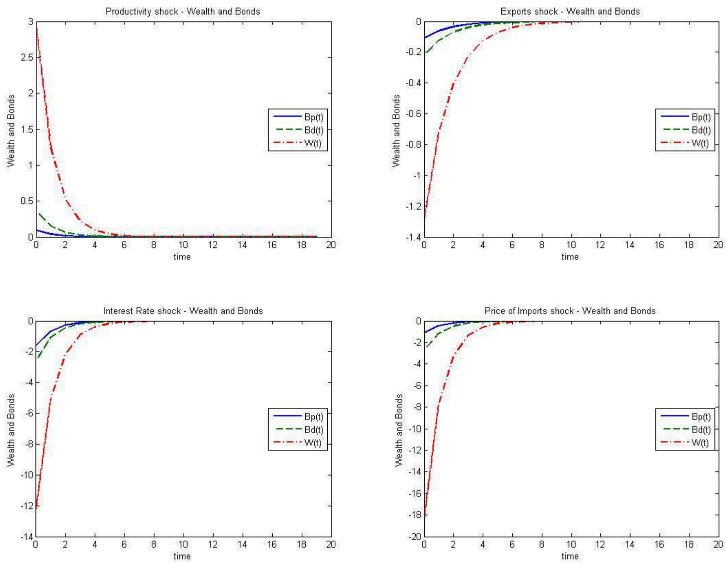

Figure 5.10: Fixed Rate: Dynamics of $\hat{B}_t$, $\hat{B}_t^*$ and $\hat{W}_t$

debt in dollars is issued[34] (since they will be needed to smooth consumption), more assets in pesos are accumulated. Furthermore, following a positive exports shock, net debt decreases. This happens because the country issues less debt (in net terms) as it becomes richer. In addition, while less debt in dollars is issued (the increase in dollar revenues makes borrowing less needed to smooth consumption), less assets in pesos are accumulated.

5.6.3.5 Main Results

One of the key findings in this study is that the conditional expected value of welfare is greater under flexible exchange rate than under fixed exchange rate. In particular, under the flexible rate regime $E_0[\widehat{WELF}_t] = -0.1803$, while under the fixed rate regime $E_0[\widehat{WELF}_t] = -0.0321$. Since the value of welfare (the expected life-time utility of the representative agent) is negative in the steady state, these figures imply that under the flexible rate regime the value of welfare is expected to be greater than that under the fixed exchange rate. This finding is consistent with the result that, under the flexible exchange rate, consumption is expected to be greater and hours worked is expected to

[34] Remember that under flexible exchange rate, domestic households optimally issue debt in dollars while accumulate assets in pesos.

be lower than their values under the fixed exchange rate. In addition, the burden of the (net) debt under flexible exchange rate is expected to be lower than that under the fixed exchange rate. In particular, under flexible exchange rate $E_0[\hat{c}_t] = 0.0484$ and $E_0[\hat{h}_t] - 0.0012$, while under the fixed exchange rate $E_0[\hat{c}_t] = 0.0085$ and $E_0[\hat{h}_t] - 0.0006$. Moreover, under the flexible exchange rate, $E_0[\hat{W}_t] = -42.0584$, while under fixed exchange rate $E_0[\hat{W}_t] = -8.4305$. Since the value of consumption, hours worked and net debt are positive in the steady state, these figures imply that under the flexibe rate regime the value of consumption is expected to be greater and the values of hours worked and net debt are expected to be lower than those under the fixed exchange rate. Furthermore, under flexible exchange rate, the domestic economy issues only debt in pesos and acummulates assets in dollars. In contrast, under fixed exchange rate, the domestic economy issues only debt in dollars and accumulates assets in pesos.

5.7 Conclusions

The current world economic crisis has already had a number of effects on all economies. One of them is the significant depreciation of the domestic currency in a number of emerging economies including Argentina, Brazil, and Mexico. As a result the degree of dollarization in many emerging economies has been increasing since domestic agents try to avoid a loss of purchasing power by holding hard (foreign) currency. Since potencial balance sheet effects increase as dollarization deepens it is worth studying alternatives exchange rate regimes in dollarized economies using state of the art approaches. One of them is the approach developed by Devereux and Sutherland (2007 and 2008). These authors use their method to study the composition of portfolio of assets in a two-country world. Here, I used this method to study optimal exchange rate in a small open economy where the degree of dollarization is fully endogenous. The main findings are as follows: (i) under flexible exchange rate, the small economy will optimally issue only debt in pesos while accumulate substantial foreign reserves, (ii) under fixed exchange rate, the country will issue only debt in dollars while accumulating assets in pesos, and (iii) the flexible exchange rate is the best policy, in particular, the conditional expected value of welfare under flexible exchange rate is greater than that under fixed exchange rate. These findings are consistent with the assumptions that the country's residents consume only foreign goods and that the economy is affected by shocks to productivity, exports, the interest rate on dollar bonds, and the dollar price of imports.

Chapter 6

Appendices

6.1 Appendix I

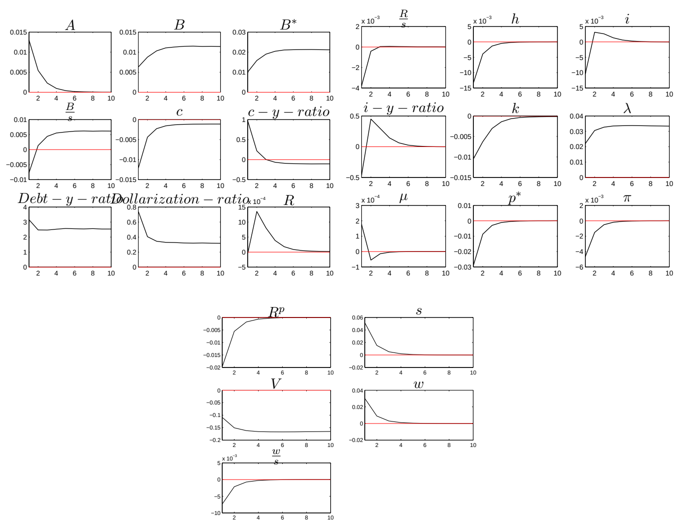

Figure 6.1: Flexible Rate: Technology Shock

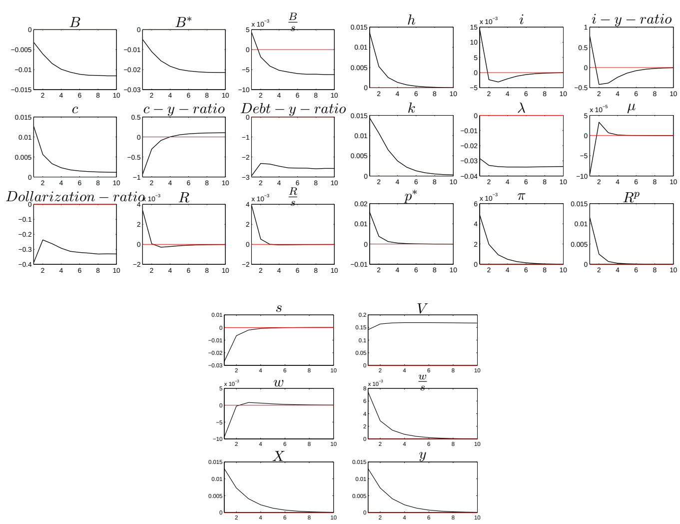

Figure 6.2: Flexible Rate: Exports Shock

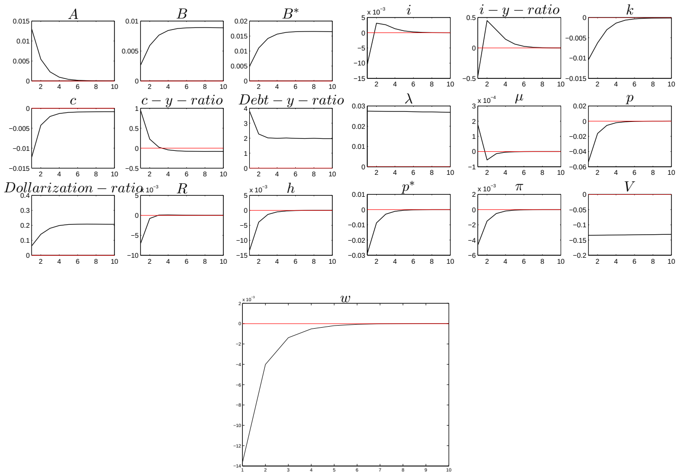

Figure 6.3: Fixed Rate: Technology Shock

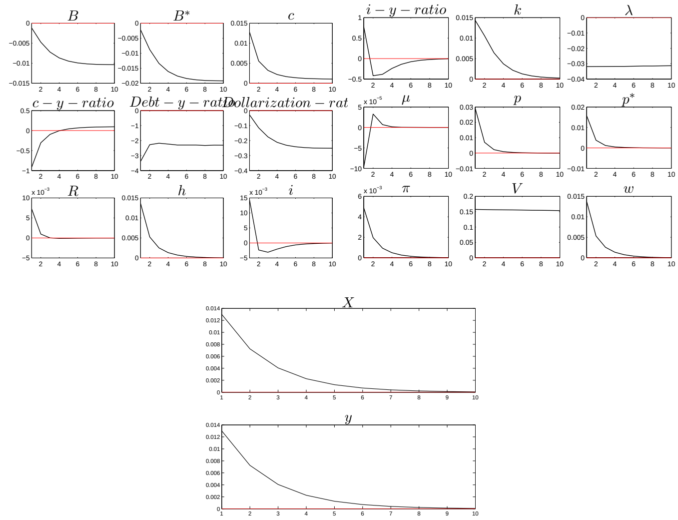

Figure 6.4: Fixed Rate: Exports Shock

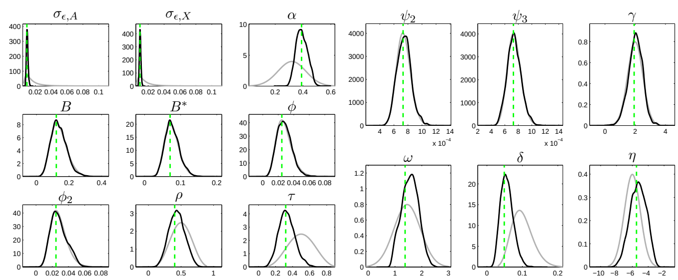

Figure 6.5: Prior and Posterior Densities - Fixed Rate

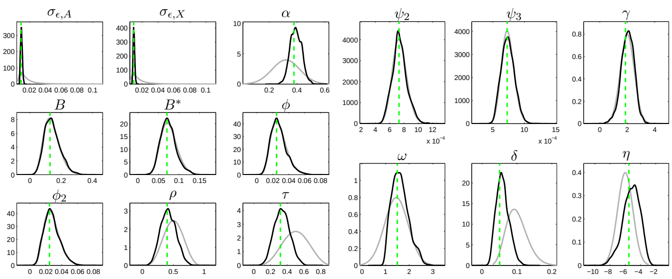

Figure 6.6: Prior and Posterior Densities - Flexible Rate

6.2 Appendix II

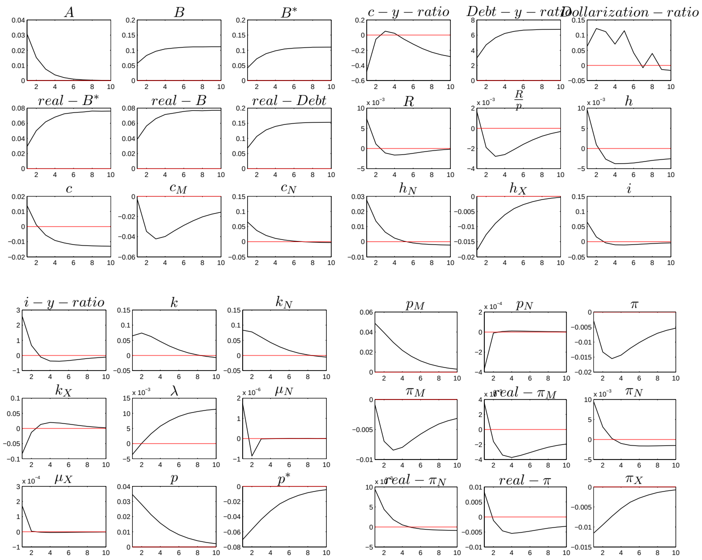

Figure 6.7: Flexible E.R. (p_X): Technology Shock (1)

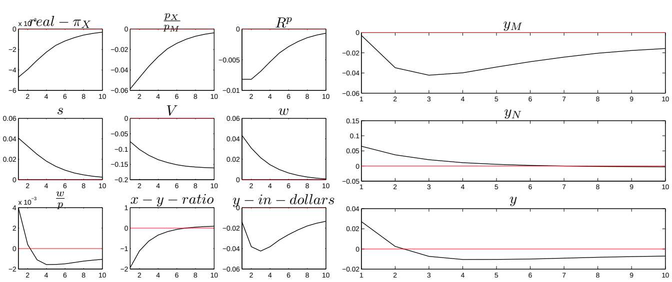

Figure 6.8: Flexible E.R. (p_X): Technology Shock (2)

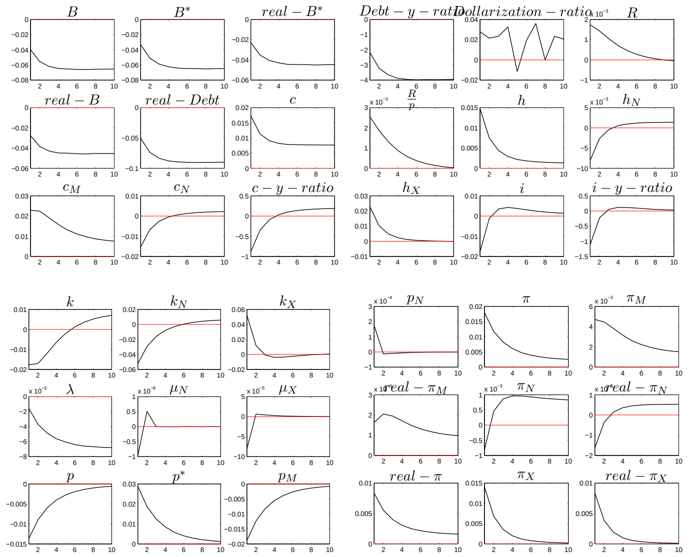

Figure 6.9: Flexible E.R. (p_X): Exports Shock (1)

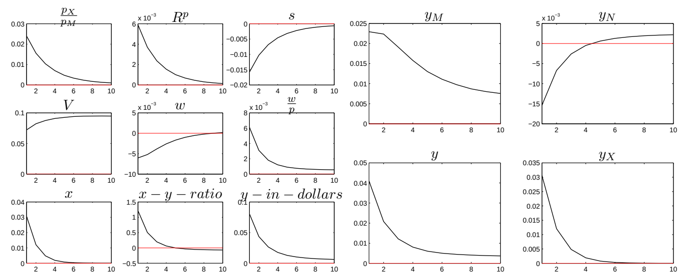

Figure 6.10: Flexible E.R. (p_X): Exports Shock (2)

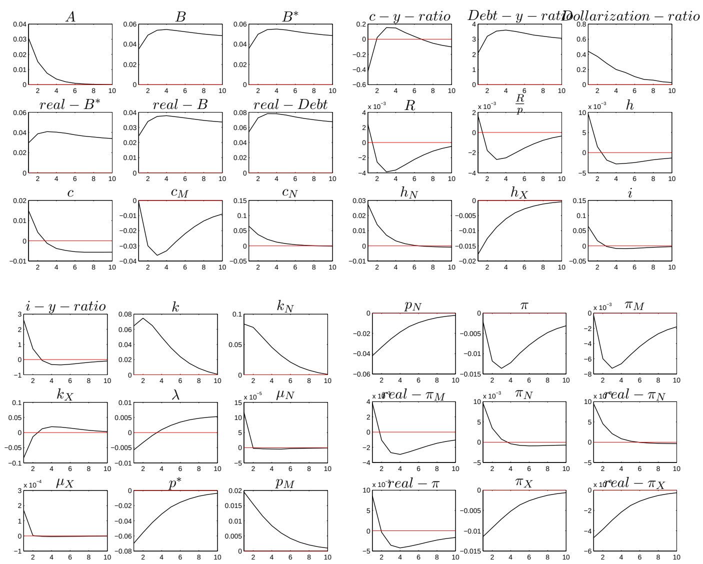

Figure 6.11: Flexible E.R. (CPI): Technology Shock (1)

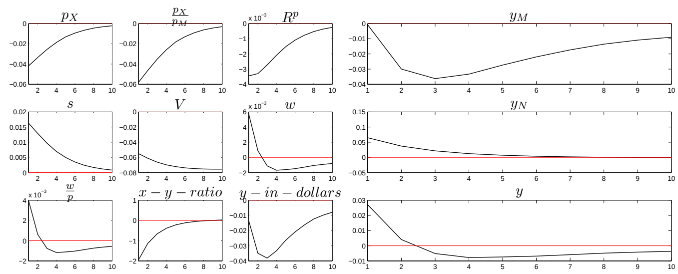

Figure 6.12: Flexible E.R. (CPI): Technology Shock (2)

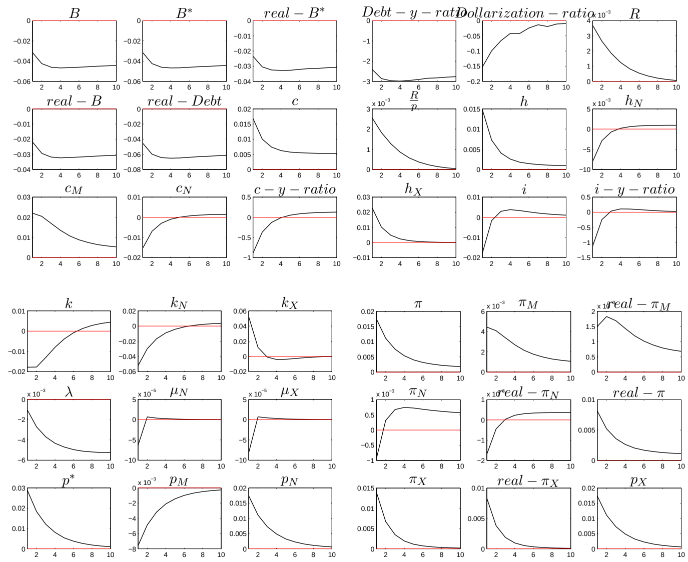

Figure 6.13: Flexible E.R. (CPI): Exports Shock (1)

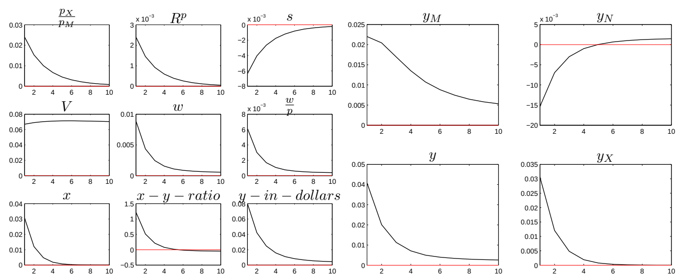

Figure 6.14: Flexible E.R. (CPI): Exports Shock (2)

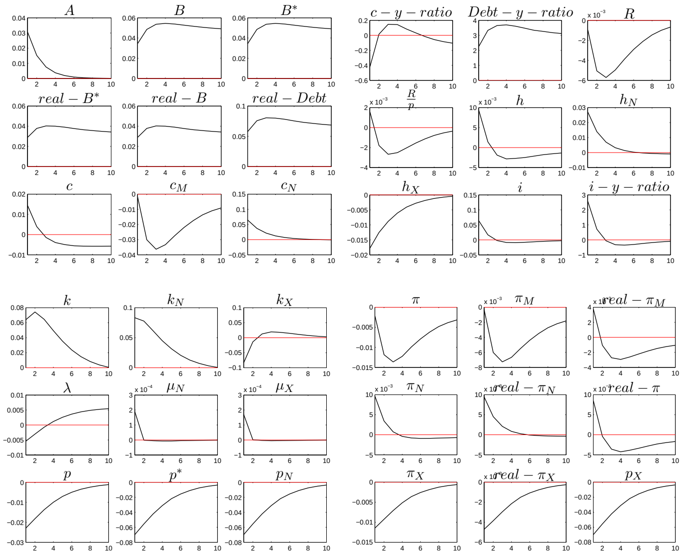

Figure 6.15: Fixed E.R.: Technology Shock (1)

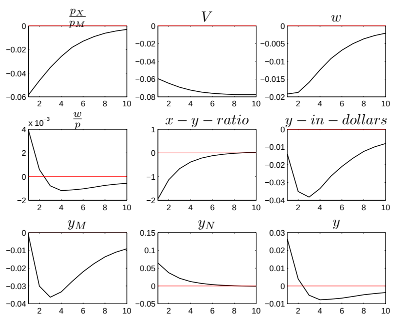

Figure 6.16: Fixed E.R.: Technology Shock (2)

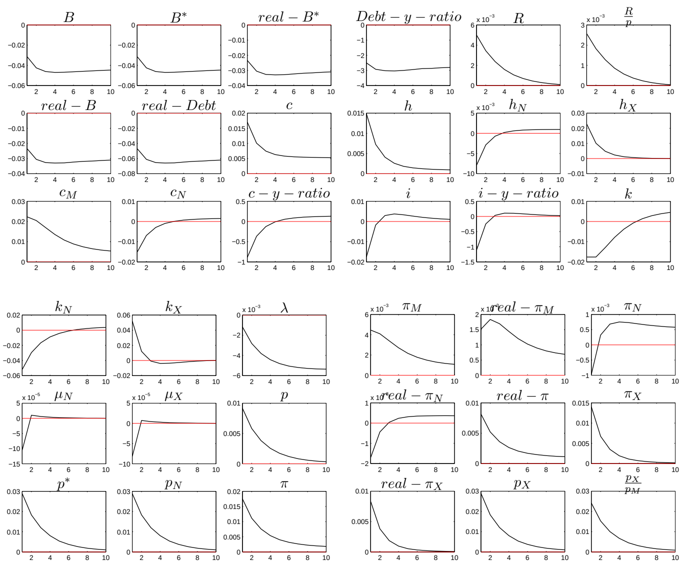

Figure 6.17: Fixed E.R.: Exports Shock (1)

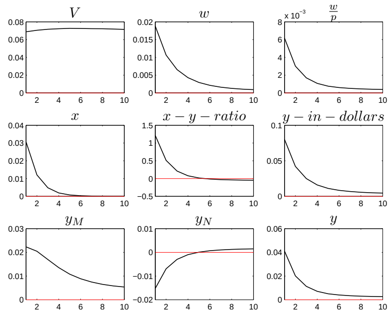

Figure 6.18: Fixed E.R.: Exports Shock (2)

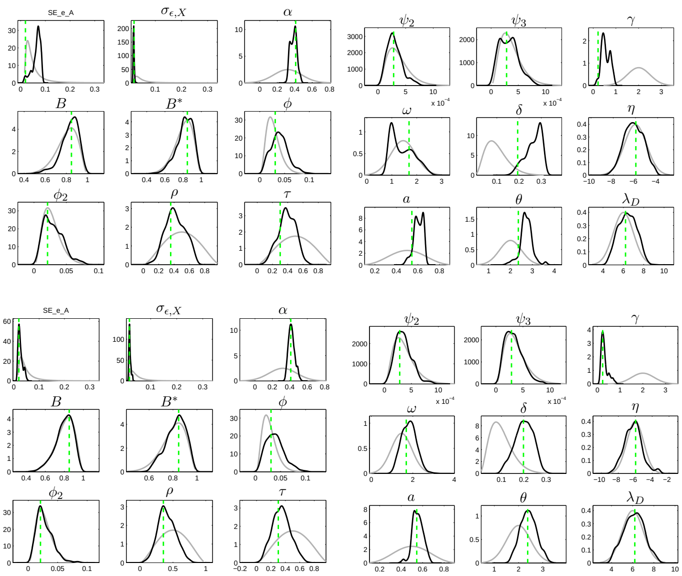

Figure 6.19: Posterior Densities - Flexible E.R. (CPI and p_X)

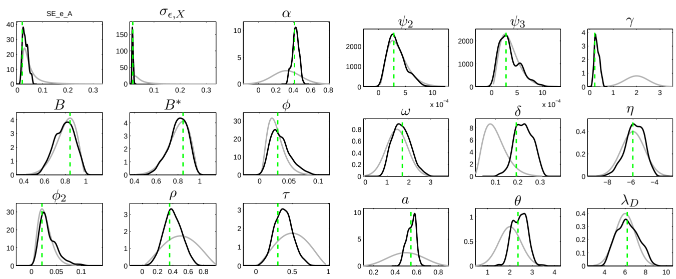

Figure 6.20: Posterior Densities - Fixed E.R.

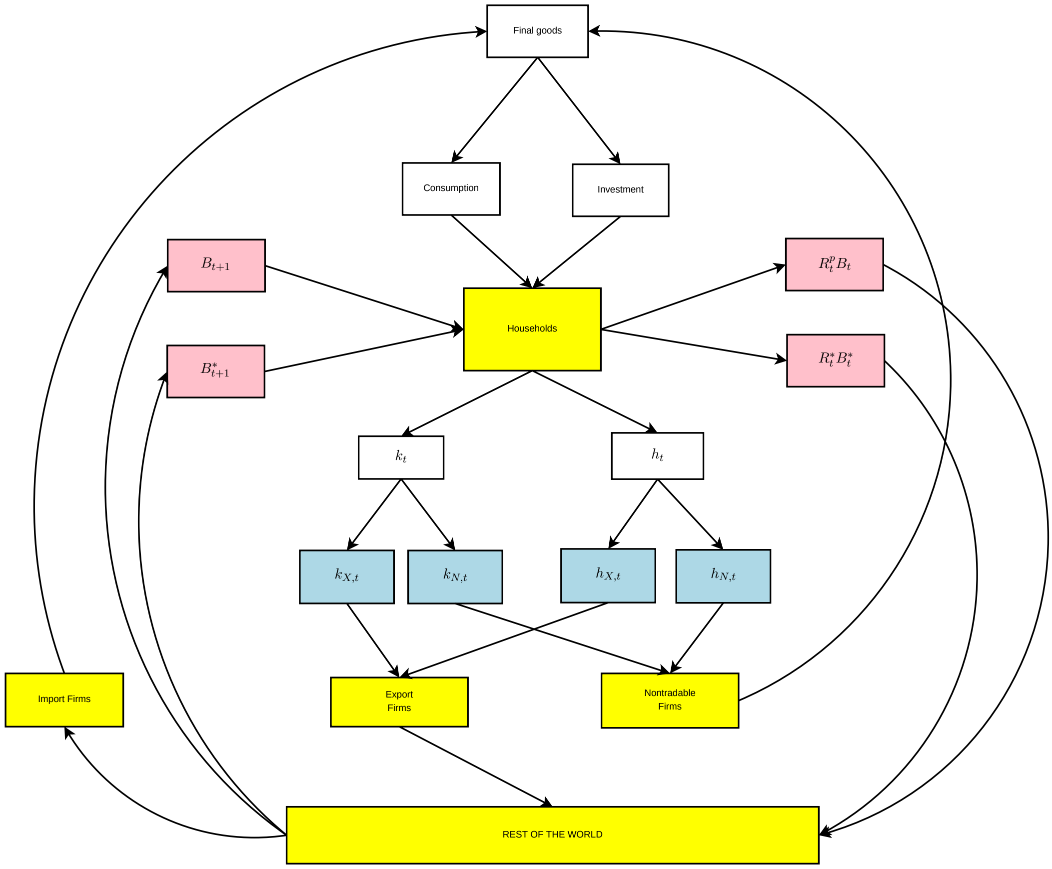

Figure 6.21: The Model

Table 6.1: Autocorrelation of Simulated Variables

Variables	FIXED E.R.			FLEXIBLE E.R. (CPI)		
	1	2	3	1	2	3
A_t	0.3569	0.1258	0.0564	0.3596	0.1103	0.0458
B_{t+1}	0.9914	0.9753	0.9565	0.9922	0.9773	0.9603
B^*_{t+1}	0.9914	0.9753	0.9565	0.9922	0.9773	0.9603
$real - B^*_{t+1}$	0.9893	0.9717	0.9521	0.99	0.9736	0.9558
$real - B_{t+1}$	0.9893	0.9717	0.9521	0.9922	0.9773	0.9603
$real - Debt$	0.9893	0.9717	0.9521	0.9912	0.9756	0.9583
c_t	0.727	0.5456	0.436	0.7291	0.5402	0.4356
$c_{M,t}$	0.7723	0.6914	0.6632	0.7757	0.6892	0.6636
$c_{N,t}$	0.5206	0.2752	0.1521	0.5256	0.2626	0.144
$c - y - ratio$	0.6796	0.4849	0.3653	0.6926	0.4853	0.3641
$Debt - y - ratio$	0.9894	0.9723	0.9528	0.9912	0.9757	0.9583
$Dollarization - ratio$	0.9914	0.9753	0.9565	0.8391	0.7226	0.6536
R_t	0.6141	0.369	0.2223	0.3521	0.1048	0.0309
$\frac{R_t}{p_t}$	0.3371	0.1079	0.0415	0.3521	0.1048	0.0309
h_t	0.4784	0.293	0.2317	0.4877	0.3015	0.2393
$h_{N,t}$	0.4962	0.2573	0.1438	0.5029	0.2445	0.1348
$h_{X,t}$	0.4414	0.2154	0.1133	0.4664	0.2189	0.1125
i_t	0.125	-0.0816	-0.0818	0.1345	-0.1055	-0.102
$i - y - ratio$	0.066	-0.1309	-0.1177	0.0821	-0.1517	-0.135
k_t	0.7859	0.5491	0.3762	0.7849	0.5412	0.3728
$k_{N,t}$	0.6675	0.4146	0.2488	0.6741	0.4077	0.2441
$k_{X,t}$	0.1356	-0.0614	-0.0651	0.153	-0.0781	-0.0793
λ_t	0.7327	0.5484	0.433	0.7366	0.5431	0.4316
$\mu_{N,t}$	-0.0775	-0.0675	-0.032	-0.0541	-0.0894	-0.0524
$\mu_{X,t}$	-0.0787	-0.0673	-0.0318	-0.0543	-0.0894	-0.0524
p_t	0.6396	0.4	0.2549	n.a.	n.a.	n.a.
p^*_t	0.6388	0.3995	0.2546	0.6454	0.3932	0.2526
$p_{M,t}$	0.7737	0.6926	0.6644	0.6455	0.3933	0.2527
$p_{N,t}$	0.6396	0.4	0.2549	0.6455	0.3933	0.2527
π_t	0.7232	0.6234	0.5858	0.7363	0.6345	0.5946
$\pi_{M,t}$	0.7723	0.6914	0.6632	0.7785	0.6925	0.6667
$real - \pi_{M,t}$	0.6187	0.4873	0.4475	0.6238	0.481	0.4451
$\pi_{N,t}$	0.4895	0.2666	0.1686	0.4963	0.2538	0.1599
$real - \pi_{N,t}$	0.4967	0.2622	0.1524	0.5035	0.2496	0.1438
$real - \pi_t$	0.5721	0.4191	0.3696	0.5783	0.419	0.3722
$\pi_{X,t}$	0.4869	0.2646	0.158	0.5132	0.2722	0.1604
$real - \pi_{X,t}$	0.4255	0.2098	0.1192	0.4573	0.2228	0.1238
$p_{X,t}$	0.6388	0.3995	0.2546	0.6459	0.3936	0.2528
$\frac{p_{X,t}}{p_{M,t}}$	0.6388	0.3995	0.2546	0.6458	0.3935	0.2528
R^p_t	n.a.	n.a.	n.a.	0.6645	0.4022	0.2447
s_t	n.a.	n.a.	n.a.	0.6446	0.3926	0.2522
V_t	0.9946	0.9821	0.9658	0.9956	0.9844	0.9697
w_t	0.6481	0.4781	0.3835	0.4877	0.3015	0.2393
$\frac{w_t}{p_t}$	0.4784	0.293	0.2317	0.4877	0.3015	0.2393
X_t	0.2747	0.077	0.0267	0.3042	0.0962	0.0343
$X - y - ratio$	0.4774	0.2397	0.127	0.4909	0.2318	0.1203
$y - in - dollars$	0.5527	0.41	0.3615	0.5792	0.4339	0.3771
$y_{M,t}$	0.7723	0.6914	0.6632	0.7757	0.6892	0.6636
$y_{N,t}$	0.5206	0.2752	0.1521	0.5256	0.2626	0.144
y_t	0.4766	0.2915	0.2306	0.486	0.3001	0.2383
$y_{X,t}$	0.2747	0.077	0.0267	0.3042	0.0962	0.0343

Table 6.2: Autocorrelation of Simulated Variables

Variables	FIXED E.R.		
	1	2	3
A_t	0.3491	0.1202	0.0453
B_{t+1}	0.9864	0.9702	0.9521
B^*_{t+1}	0.9864	0.9702	0.9521
$real - B^*_{t+1}$	0.983	0.9646	0.9452
$real - B_{t+1}$	0.9901	0.9765	0.96
$real - Debt$	0.9875	0.9721	0.9546
c_t	0.7044	0.5135	0.3996
$c_{M,t}$	0.7226	0.6349	0.6084
$c_{N,t}$	0.5193	0.2738	0.1542
$c - y - ratio$	0.6679	0.4551	0.3343
$Debt - y - ratio$	0.9869	0.9715	0.954
$Dollarization - ratio$	0.7865	0.6423	0.5552
R_t	0.136	-0.0712	-0.083
$\frac{R_t}{p_t}$	0.3346	0.1035	0.0232
h_t	0.4576	0.2664	0.1896
$h_{N,t}$	0.4945	0.2547	0.1474
$h_{X,t}$	0.4598	0.2243	0.1314
i_t	0.1154	-0.0826	-0.0694
$i - y - ratio$	0.0691	-0.1216	-0.0856
k_t	0.7735	0.5258	0.3456
$k_{N,t}$	0.6693	0.4094	0.2451
$k_{X,t}$	0.1337	-0.0603	-0.0406
λ_t	0.7143	0.518	0.3996
$\mu_{N,t}$	-0.4084	-0.0288	0.0339
$\mu_{X,t}$	-0.0709	-0.0743	-0.0122
p_t	0.6317	0.3821	0.2352
p^*_t	0.6297	0.3807	0.2344
$p_{M,t}$	0.6306	0.3813	0.2347
$p_{N,t}$	-0.0667	-0.0749	-0.0129
π_t	0.6821	0.5676	0.5197
$\pi_{M,t}$	0.7315	0.6445	0.6174
$real - \pi_{M,t}$	0.569	0.4318	0.3966
$\pi_{N,t}$	0.4864	0.2591	0.1626
$real - \pi_{N,t}$	0.498	0.2608	0.1531
$real - \pi_t$	0.5325	0.374	0.3175
$\pi_{X,t}$	0.5024	0.2678	0.1671
$real - \pi_{X,t}$	0.4482	0.2189	0.1339
$p_{X,t}$	n.a.	n.a.	n.a.
$\frac{p_{X,t}}{p_{M,t}}$	0.6306	0.3813	0.2347
R^p_t	0.6623	0.4024	0.2413
s_t	0.6297	0.3807	0.2344
V_t	0.9918	0.9805	0.9658
w_t	0.5812	0.3261	0.1803
$\frac{w_t}{p_t}$	0.4576	0.2664	0.1896
X_t	0.297	0.0845	0.0327
$X - y - ratio$	0.4851	0.2435	0.1392
$y - in - dollars$	0.53	0.3673	0.3068
$y_{M,t}$	0.7226	0.6349	0.6084
$y_{N,t}$	0.5193	0.2738	0.1542
y_t	0.4564	0.2655	0.1889
$y_{X,t}$	0.297	0.0845	0.0327

Table 6.3: Results from Posterior Maximization

parameters	prior mean	FIXED E.R. post. mean	conf.interv.		FLEXIBLE E.R. (CPI) post. mean	conf.interv.	
α	0.32	0.4115	0.0305	13.4821	0.4108	0.0301	13.644
B	0.8	0.8467	0.0997	8.4885	0.8485	0.0988	8.5873
B^*	0.8	0.8467	0.0997	8.4896	0.8467	0.0998	8.487
ϕ	0.028	0.0309	0.0166	1.8592	0.031	0.0167	1.8581
ϕ_2	0.028	0.0211	0.0123	1.7094	0.0209	0.0122	1.709
ρ	0.5	0.3565	0.1259	2.8314	0.3566	0.1259	2.8311
τ	0.5	0.3012	0.1256	2.3987	0.301	0.1255	2.3979
ψ_2	0	0.0003	0.0001	2.2745	0.0003	0.0001	2.2697
ψ_3	0	0.0003	0.0001	2.2745	0.0003	0.0001	2.26
γ	2	0.2091	0.0774	2.7018	0.2141	0.0799	2.6802
ω	1.455	1.6979	0.4447	3.818	1.6939	0.4459	3.799
δ	0.1	0.1927	0.0457	4.222	0.1934	0.0453	4.2734
η	-6	-6.0249	0.9807	6.1434	-6.0187	0.9813	6.1337
a	0.5	0.5454	0.0584	9.3453	0.5445	0.0584	9.322
θ	2	2.3601	0.3925	6.0124	2.3561	0.3909	6.0274
λ_D	6	6.204	0.9439	6.5728	6.2105	0.9434	6.5829
σ_A	0.06	0.019	0.0052	3.6143	0.0191	0.0053	3.5798
σ_X	0.06	0.0187	0.003	6.1372	0.0187	0.003	6.1535

Table 6.4: Results from Posterior Maximization

parameters	prior mean	FLEXIBLE E.R. (p_X) post. mean	conf.interv.		prior distr.	prior σ
α	0.32	0.4096	0.0304	13.4733	norm	0.16
B	0.8	0.8519	0.097	8.7829	beta	0.1
B^*	0.8	0.8467	0.0998	8.4877	beta	0.1
ϕ	0.028	0.0309	0.0167	1.8511	beta	0.014
ϕ_2	0.028	0.0207	0.0121	1.7074	beta	0.014
ρ	0.5	0.3549	0.1261	2.8146	beta	0.2
τ	0.5	0.3025	0.1255	2.4095	beta	0.2
ψ_2	0	0.0003	0.0001	2.2718	beta	0.0002
ψ_3	0	0.0003	0.0001	2.2367	beta	0.0002
γ	2	0.227	0.0872	2.6042	norm	0.5
ω	1.455	1.6803	0.4507	3.7281	norm	0.5
δ	0.1	0.1982	0.0456	4.3482	beta	0.05
η	-6	-6.0363	0.9816	6.1497	norm	1
a	0.5	0.546	0.0593	9.2143	beta	0.15
θ	2	2.3683	0.3865	6.1276	norm	0.5
λ_D	6	6.2128	0.9422	6.5938	norm	1
σ_A	0.06	0.0196	0.0057	3.4322	invg	1
σ_X	0.06	0.0185	0.003	6.2415	invg	1

6.3 Appendix III

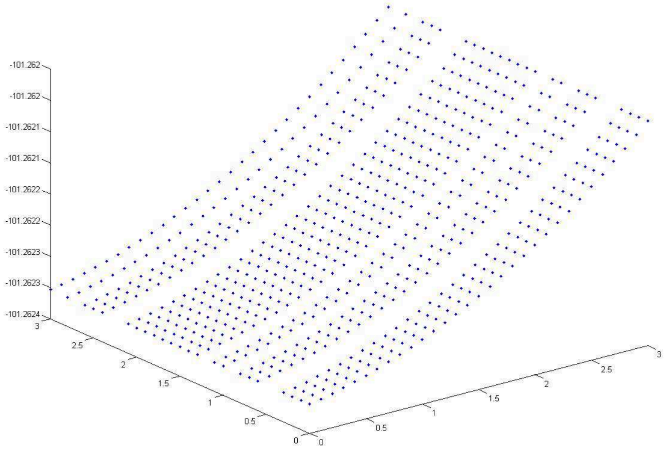

Figure I.1. Welfare: $\psi_{\tilde{B}}$=3.0 and changes in ψ_g and ψ_π

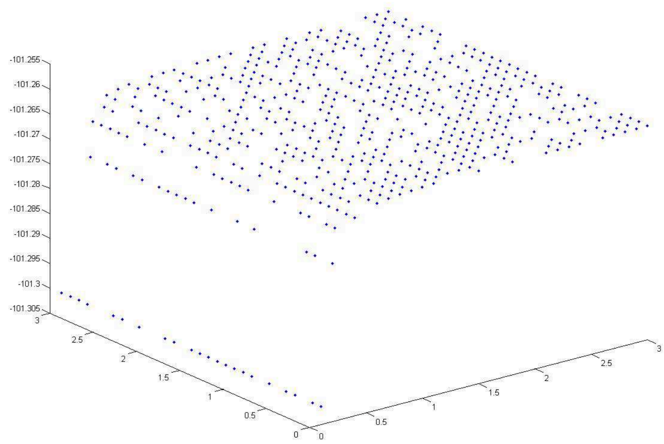

Figure I.2. Welfare: ψ_g=3.0 and changes in $\psi_{\tilde{B}}$ and ψ_π

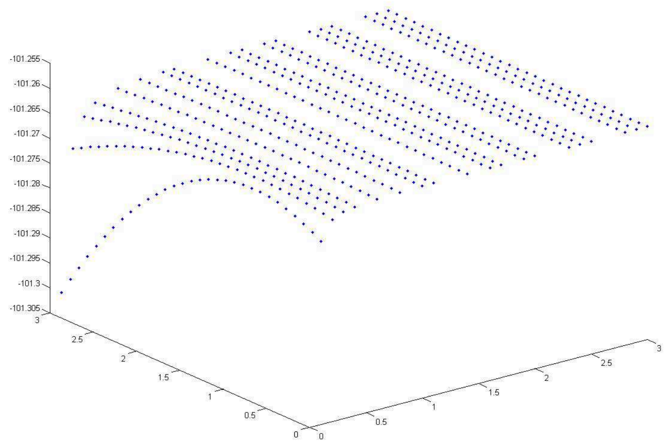

Figure I.3. Welfare: ψ_π=2.8 and changes in $\psi_{\tilde{B}}$ and ψ_g

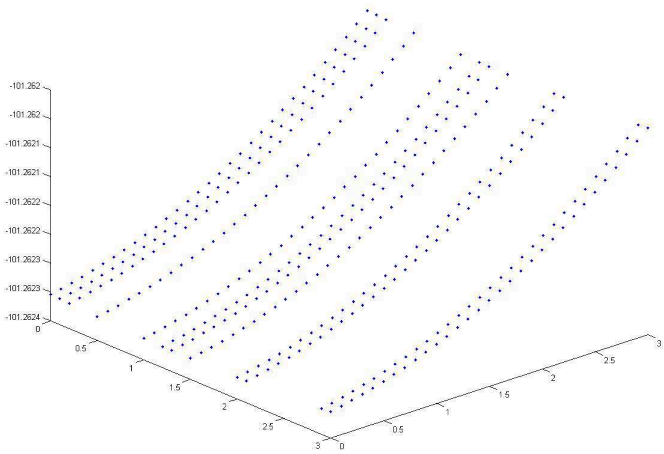

Figure II.1. Welfare: $\psi_{\tilde{B}}$=3.0 and changes in ψ_g and ψ_y

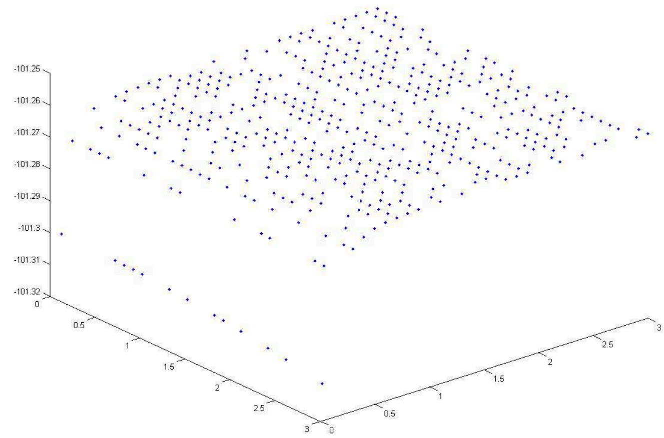

Figure II.2. Welfare: ψ_g=3.0 and changes in $\psi_{\tilde{B}}$ and ψ_y

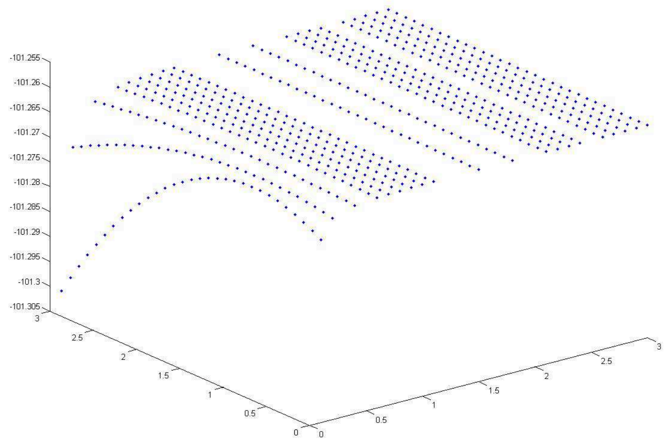

Figure II.3. Welfare: ψ_y=0 and changes in $\psi_{\tilde{B}}$ and ψ_g

6.4 Appendix IV

6.4.1 The Full Second-Order Linearized Model

$$\begin{aligned} &-\bar{W}\hat{W}_t - \bar{\pi}\hat{\pi}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + \left(\frac{\bar{w}\bar{h}}{\bar{s}} + \frac{\bar{R}\bar{k}}{\bar{s}}\right)\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t + \left(-\frac{\bar{R}\bar{k}}{\bar{s}} - (1-\delta)\bar{k}\right)\hat{k}_t + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p \\ &-\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^* + \left(\bar{c} + \bar{k} - (1-\delta)\bar{k} + \bar{r}\bar{W}\right)\hat{p}_t^m + \bar{c}c_t + \bar{k}k_{t+1} + \bar{r}\bar{W}\hat{r}_t^* - \bar{r}\bar{W}p_{t-1}^m + \bar{r}\bar{W}W_{t-1} + L1_t = 0 \end{aligned} \tag{6.1}$$

$$\bar{\lambda}\hat{\lambda}_t + (-\bar{\lambda} + \beta\bar{\lambda}\bar{r})\hat{p}_t^m - \bar{\lambda}\psi\bar{W}\hat{W}_t - \beta\bar{\lambda}\bar{r}E_t[\hat{\lambda}_{t+1}] - \beta\bar{\lambda}\bar{r}E_t[\hat{r}_{t+1}^*] + L2_t = 0 \tag{6.2}$$

$$\bar{\mu}\bar{x}x_t + (\bar{\mu}x + \bar{\mu}(x - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}))\hat{\mu}_t + (\bar{\mu}\phi + \bar{\mu}\beta\phi)\hat{p}_t^d - \bar{\mu}\phi p_{t-1}^d - \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t$$
$$-\bar{\mu}\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{k}_t - \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}(1-\alpha)\hat{h}_t - \bar{\mu}\beta\phi E_t[\hat{p}_{t+1}^d] + L3_t + L4_t = 0 \tag{6.3}$$

$$\bar{y}\hat{y}_t - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t - \bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{k}_t - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}(1-\alpha)\hat{h}_t + L5_t = 0 \tag{6.4}$$

$$\bar{\pi}\hat{\pi}_t - \bar{p}^d\bar{x}\hat{p}_t^d - \bar{p}^d\bar{x}x_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t + (-\frac{\bar{w}\bar{h}}{\bar{s}} - \frac{\bar{r}\bar{k}}{\bar{s}})\hat{s}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{k}_t + L6_t = 0 \tag{6.5}$$

$$\frac{\bar{R}}{\bar{s}}\hat{R}_t - \frac{\bar{R}}{\bar{s}}\hat{s}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t$$
$$+\bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}(\alpha-1)\bar{h}^{1-\alpha}\hat{k}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}(1-\alpha)\hat{h}_t + L7_t + L8_t = 0 \tag{6.6}$$

$$\hat{A}_{t+1} = \rho\hat{A}_t + \varepsilon_{t+1}^A \tag{6.7}$$

$$\hat{x}_{t+1} = \tau x_t + \varepsilon_{t+1}^x \tag{6.8}$$

$$\hat{r}_{t+1}^* = \theta_1\hat{r}_t^* + \varepsilon_{t+1}^r \tag{6.9}$$

$$\hat{p}_{t+1}^m = \theta_2\hat{p}_t^m + \varepsilon_{t+1}^p \tag{6.10}$$

$$\frac{\bar{w}}{\bar{s}}\hat{w}_t - \frac{\bar{w}}{\bar{s}}\hat{s}_t + \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\bar{h}^{-\alpha}\hat{\mu}_t + \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\bar{h}^{-\alpha}\hat{p}_t^d + \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\bar{h}^{-\alpha}\hat{A}_t$$
$$+\bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{-\alpha}\hat{k}_t - \bar{\mu}\bar{p}^d(1-\alpha)\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{-\alpha}\hat{h}_t + L9_t + L10_t = 0 \tag{6.11}$$

$$-\left(\bar{c} - \frac{\bar{h}^{\omega}}{\omega}\right)^{-\gamma-1}\gamma\bar{c}\hat{c}_t + \left(\bar{c} - \frac{\bar{h}^{\omega}}{\omega}\right)^{-\gamma-1}\gamma\bar{h}^{\omega}\hat{h}_t - \bar{\lambda}\hat{\lambda}_t + L11_t = 0 \tag{6.12}$$

$$(\bar{\lambda}\bar{h}^{\omega-1} - \bar{\lambda}\frac{\bar{w}}{\bar{s}})\hat{\lambda}_t + \bar{\lambda}\bar{h}^{\omega-1}(\omega-1)\hat{h}_t - \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{w}_t + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{s}_t + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{p}_t^m + L12_t = 0 \tag{6.13}$$

$$\bar{\lambda}\hat{\lambda}_t + (\bar{\lambda}\phi\bar{k} + \bar{\lambda}\beta\phi\bar{k})k_{t+1} - \bar{\lambda}\phi\bar{k}\hat{k}_t - \bar{\lambda}\beta\left(\frac{\bar{R}}{\bar{s}} + 1 - \delta\right)E_t[\hat{\lambda}_{t+1}] - \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[R_{t+1}]$$
$$+\bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[s_{t+1}] + \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{p}_{t+1}^m] - \bar{\lambda}\beta\phi\bar{k}E_t[k_{t+2}] + L13_t = 0 \tag{6.14}$$

$$\hat{y}_t = \hat{x}_t \tag{6.15}$$

$$\hat{p}_t = \hat{s}_t + \hat{p}_t^d \tag{6.16}$$

$$\bar{r}E_t[\hat{r}_{t+1}^p] - \bar{r}E_t[\hat{r}_{t+1}^*] + L14_t = 0 \tag{6.17}$$

$$\widehat{pdf}_t = \hat{p}_t^d \tag{6.18}$$

$$\widehat{pma}_t = \hat{p}_t^m \tag{6.19}$$

$$\widehat{ke2}_t = \hat{k}_{t+1} \tag{6.20}$$

$$\hat{R}_t^p = \hat{r}_t^p + \hat{s}_t + \hat{p}_t^m - \hat{s}_{t-1} - \hat{p}_{t-1}^m \tag{6.21}$$

$$\hat{R}_t^* = \hat{r}_t^* + \hat{p}_t^m - \hat{p}_{t-1}^m \tag{6.22}$$

$$\widehat{sa}_t = \hat{s}_t \tag{6.23}$$

$$U\bar{T}F\widehat{uf}_t - \left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma} \bar{c}\hat{c}_t + \left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma} \bar{h}^\omega \hat{h}_t + L15_t = 0 \tag{6.24}$$

$$\widehat{WELF}_t - \beta E_t[\widehat{WELF}_{t+1}] = (1-\beta)\widehat{uf}_t \tag{6.25}$$

$$\hat{r}_{x,t} = \hat{r}_t^p - \hat{r}_t^* \tag{6.26}$$

$$\hat{\lambda}_t^D = \hat{\lambda}_t - \hat{s}_{t-1} - \hat{p}_{t-1}^m \tag{6.27}$$

$$\hat{s}_t^D = \hat{s}_t + \hat{p}_t^m - \hat{s}_{t-1} - \hat{p}_{t-1}^m \tag{6.28}$$

$$\hat{W}_t^D = \hat{W}_t \tag{6.29}$$

$$\widehat{pdfe}_t = E_t[\hat{p}_{t+1}^d] \tag{6.30}$$

$$\widehat{ls}_t^D = \hat{\lambda}_t^D - \hat{s}_t^D \tag{6.31}$$

$$\begin{aligned}
L1_t = &-\frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{w}_t - \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{h}_t - \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{R}_t - \frac{1}{2}\bar{W}\hat{W}_t\hat{W}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{h}_t \\
&+\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{s}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{s}_t - \frac{1}{2}\bar{k}\hat{k}_t\hat{k}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{R}_t + \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{k}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{k}_t - \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{k}_t\hat{k}_t + \bar{k}\delta\hat{k}_t\hat{p}_t^m \\
&-\phi\bar{k}^2\hat{k}_t\hat{k}_{t+1} + \bar{r}\bar{W}\hat{p}_t^m\hat{r}_t^* - \bar{r}\bar{W}p_{t-1}^m\hat{p}_t^m + \bar{r}\bar{W}\hat{p}_t^m\hat{W}_{t-1} + \frac{1}{2}\phi\bar{k}^2\hat{k}_t\hat{k}_t \\
&-\bar{r}\bar{W}\hat{r}_t^*\hat{p}_{t-1}^m + \bar{r}\bar{W}\hat{r}_t^*\hat{W}_{t-1} - \bar{r}\bar{W}p_{t-1}^m\hat{W}_{t-1} - \bar{k}\hat{k}_t\hat{p}_t^m + \frac{1}{2}\bar{c}\hat{p}_t^m\hat{p}_t^m + \frac{1}{2}\bar{c}\hat{c}_t\hat{c}_t + \frac{1}{2}\bar{k}k_{t+1}k_{t+1} \\
&+\frac{1}{2}\bar{k}\delta\hat{p}_t^m\hat{p}_t^m + \frac{1}{2}\bar{r}\bar{W}\hat{p}_t^m\hat{p}_t^m + \bar{c}\hat{p}_t^m c_t + \bar{k}\hat{p}_t^m\hat{k}_{t+1} + \frac{1}{2}\phi\bar{k}^2k_{t+1}k_{t+1} \\
&+\frac{1}{2}\bar{k}\delta\hat{k}_t\hat{k}_t + \frac{1}{2}\psi\bar{W}^2\hat{W}_t\hat{W}_t - \frac{1}{2}\bar{\pi}\hat{\pi}_t\hat{\pi}_t + \frac{1}{2}\bar{r}\bar{W}\hat{r}_t^*\hat{r}_t^* + \frac{1}{2}\bar{r}\bar{W}\hat{p}_{t-1}^m\hat{p}_{t-1}^m + \frac{1}{2}\bar{r}\bar{W}\hat{W}_{t-1}\hat{W}_{t-1} \\
&+\bar{r}\frac{\bar{B}}{\bar{s}}\hat{p}^m(t)\hat{r}_t^p - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{p}^m(t)\hat{r}_t^* + \frac{1}{2}\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{r}_t^p - \frac{1}{2}\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{r}_t^* - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{s}_{t-1} + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{s}_{t-1} - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{p}_{t-1}^m \\
&+\bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{p}_{t-1}^m + \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^p\hat{B}_t - \bar{r}\frac{\bar{B}}{\bar{s}}\hat{r}_t^*\hat{B}_t
\end{aligned} \tag{6.32}$$

$$\begin{aligned}
L2_t = &\frac{1}{2}\bar{\lambda}\hat{\lambda}_t\hat{\lambda}_t - \bar{\lambda}\hat{\lambda}_t\hat{p}_t^m - \bar{\lambda}\psi\bar{W}\hat{\lambda}_t\hat{W}_t + \frac{1}{2}\bar{\lambda}\hat{p}_t^m\hat{p}_t^m - \frac{1}{2}\beta\bar{\lambda}\bar{r}\hat{p}_t^m\hat{p}_t^m + \beta\bar{\lambda}\bar{r}E_t[\hat{\lambda}_{t+1}]\hat{p}_t^m \\
&+\beta\bar{\lambda}\bar{r}\hat{p}_t^m E_t[\hat{r}_{t+1}^*] - \frac{1}{2}\bar{\lambda}\psi\bar{W}\hat{W}_t\hat{W}_t - \frac{1}{2}\beta\bar{\lambda}\bar{r}E_t[\hat{\lambda}_{t+1}\hat{\lambda}_{t+1}] - \beta\bar{\lambda}\bar{r}E_t[\hat{\lambda}_{t+1}\hat{r}_{t+1}^*] - \frac{1}{2}\beta\bar{\lambda}\bar{r}E_t[\hat{r}_{t+1}^*\hat{r}_{t+1}^*]
\end{aligned} \tag{6.33}$$

$$\begin{aligned}
L3_t = &-\frac{1}{2}\bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{h}_t\hat{h}_t + \frac{1}{2}\mu\bar{x}\hat{x}_t\hat{x}_t + \bar{\mu}\bar{x}\hat{\mu}_t\hat{\mu}_t + 2\bar{\mu}\phi\hat{p}_t^d\hat{p}_t^d + 2\bar{\mu}\phi\hat{p}_{t-1}^d\hat{p}_{t-1}^d + 2\bar{\mu}\bar{x}\hat{x}_t\hat{\mu}_t \\
&+\bar{\mu}\phi\hat{\mu}_t\bar{p}^d f_t - \bar{\mu}\phi\hat{\mu}_t\hat{p}_{t-1}^d - \frac{5}{2}\bar{\mu}\beta\phi\hat{p}_t^d\hat{p}_t^d - 4\bar{\mu}\phi\hat{p}_{t-1}^d\hat{p}_t^d - \frac{5}{2}\bar{\mu}\beta\phi E_t[\hat{p}_{t+1}^d\hat{p}_{t+1}^d] \\
&-\frac{1}{2}\bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{\mu}_t - \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{A}_t
\end{aligned} \tag{6.34}$$

$$\begin{aligned}
L4_t = &-\bar{\mu}\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{\mu}_t\hat{k}_t - \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{h}_t + \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{\mu}_t\hat{h}_t + \bar{\mu}\beta\phi\hat{p}_t^d E_t[\hat{\mu}_{t+1}] \\
&+\bar{\mu}\beta\phi\hat{p}_t^d E_t[\hat{\lambda}_{t+1}] - \bar{\mu}\beta\phi\hat{p}_t^d\hat{\lambda}_t + 5\bar{\mu}\beta\phi E_t[\hat{p}_{t+1}^d]\hat{p}_t^d - \frac{1}{2}\bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t\hat{A}_t \\
&-\bar{\mu}\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{A}_t\hat{k}_t - \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t\hat{h}_t + \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{A}_t\hat{h}_t \\
&-\bar{\mu}\bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{A}_t\hat{k}_t - \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t\hat{h}_t + \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{A}_t\hat{h}_t - \frac{1}{2}\bar{\mu}\bar{A}\bar{k}^{\alpha}\alpha^2\bar{h}^{1-\alpha}\hat{k}_t\hat{k}_t \\
&-\bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{k}_t\hat{h}_t + \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha^2\hat{k}_t\hat{h}_t + \bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{h}_t\hat{h}_t \\
&-\frac{1}{2}\bar{\mu}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha^2\hat{h}_t\hat{h}_t - \bar{\mu}\beta\phi E_t[\hat{\mu}_{t+1}\hat{p}_{t+1}^d] - \bar{\mu}\beta\phi E_t[\hat{\lambda}_{t+1}\hat{p}_{t+1}^d] + \bar{\mu}\beta\phi\hat{\lambda}_t\hat{p}_{t+1}^d
\end{aligned} \tag{6.35}$$

$$\begin{aligned}
L5_t = &\frac{1}{2}\bar{y}\hat{y}_t\hat{y}_t - \frac{1}{2}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t\hat{A}_t - \bar{A}\bar{k}^{\alpha}\alpha\bar{h}^{1-\alpha}\hat{A}_t\hat{k}_t - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{A}_t\hat{h}_t + \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{A}_t\hat{h}_t \\
&-\frac{1}{2}\bar{A}\bar{k}^{\alpha}\alpha^2\bar{h}^{1-\alpha}\hat{k}_t\hat{k}_t - \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{k}_t\hat{h}_t + \bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha^2\hat{k}_t\hat{h}_t - \frac{1}{2}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\hat{h}_t\hat{h}_t \\
&+\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha\hat{h}_t\hat{h}_t - \frac{1}{2}\bar{A}\bar{k}^{\alpha}\bar{h}^{1-\alpha}\alpha^2\hat{h}_t\hat{h}_t + \frac{1}{2}\phi\hat{p}_t^d\hat{p}_t^d - \phi\hat{p}_t^d\hat{p}_{t-1}^d + \frac{1}{2}\phi\hat{p}_{t-1}^d\hat{p}_{t-1}^d
\end{aligned} \tag{6.36}$$

$$\begin{aligned}
L6_t = &\frac{1}{2}\bar{\pi}\hat{\pi}_t\hat{\pi}_t - \frac{1}{2}\bar{p}^d\bar{x}\hat{p}_t^d\hat{p}_t^d - \bar{p}^d\bar{x}\hat{p}_t^d\hat{x}_t - \frac{1}{2}\bar{p}^d\bar{x}\hat{x}_t\hat{x}_t + \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{w}_t + \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{h}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{w}_t\hat{s}_t \\
&+\frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{h}_t - \frac{\bar{w}\bar{h}}{\bar{s}}\hat{h}_t\hat{s}_t + \frac{1}{2}\frac{\bar{w}\bar{h}}{\bar{s}}\hat{s}_t\hat{s}_t + \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{s}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{R}_t - \frac{\bar{R}\bar{k}}{\bar{s}}\hat{s}_t\hat{k}_t + \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{k}_t \\
&+\frac{\bar{R}\bar{k}}{\bar{s}}\hat{R}_t\hat{k}_t + \frac{1}{2}\frac{\bar{R}\bar{k}}{\bar{s}}\hat{k}_t\hat{k}_t
\end{aligned} \tag{6.37}$$

$$
\begin{aligned}
L7_t = {} & \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha^3\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{h}_t\hat{h}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{h}_t\hat{h}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{h}_t\hat{h}_t + \frac{1}{2}\frac{\bar{R}}{\bar{s}}\hat{s}_t\hat{s}_t \\
& + \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha^3\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{k}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{k}_t\hat{k}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{k}_t\hat{k}_t \\
& + \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{\mu}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{p}_t^d + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{A}_t \\
& + \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{k}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{h}_t \\
& - \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{\mu}_t\hat{h}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d\hat{p}_t^d + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d\hat{A}_t \\
& + 2\mu\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{h}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha^3\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{k}_t\hat{h}_t
\end{aligned}
\tag{6.38}
$$

$$
\begin{aligned}
L8_t = {} & -\bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{k}_t\hat{h}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d\hat{k}_t \\
& + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d\hat{h}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{p}_t^d\hat{h}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t\hat{A}_t \\
& + \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t\hat{k}_t + \bar{\mu}\bar{p}^d\bar{A}\alpha\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t\hat{h}_t \\
& - \bar{\mu}\bar{p}^d\bar{A}\alpha^2\bar{k}^{\alpha-1}\bar{h}^{1-\alpha}\hat{A}_t\hat{h}_t + \frac{1}{2}\frac{\bar{R}}{\bar{s}}\hat{R}_t\hat{k}_t - \frac{\bar{R}}{\bar{s}}\hat{R}_t\hat{s}_t
\end{aligned}
\tag{6.39}
$$

$$
\begin{aligned}
L9_t = {} & \frac{1}{2}\frac{\bar{w}}{\bar{s}}\hat{s}_t\hat{s}_t + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\hat{p}_t^d\hat{A}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\hat{A}_t\hat{A}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\hat{\mu}_t\hat{\mu}_t \\
& - \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\alpha\hat{\mu}_t\hat{\mu}_t + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\hat{\mu}_t\hat{p}_t^d - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\alpha\hat{\mu}_t\hat{p}_t^d + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\hat{\mu}_t\hat{A}_t \\
& - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\alpha\hat{\mu}_t\hat{A}_t + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha\bar{h}^{-\alpha}\hat{\mu}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{\mu}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha\bar{h}^{-\alpha}\hat{\mu}_t\hat{h}_t \\
& + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{\mu}_t\hat{h}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\hat{p}_t^d\hat{p}_t^d + \frac{1}{2}\frac{\bar{w}}{\bar{s}}\hat{w}_t\hat{w}_t - \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\alpha\hat{p}_t^d\hat{p}_t^d \\
& - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\alpha\hat{p}_t^d\hat{A}_t + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha\bar{h}^{-\alpha}\hat{p}_t^d\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha} \\
& - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha\bar{h}^{-\alpha}\hat{p}_t^d\hat{h}_t + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{p}_t^d\hat{h}_t
\end{aligned}
\tag{6.40}
$$

$$
\begin{aligned}
L10_t = {} & -\frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\bar{h}^{-\alpha}\alpha\hat{A}_t\hat{A}_t + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha\bar{h}^{-\alpha}\hat{A}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{A}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha\bar{h}^{-\alpha}\hat{A}_t\hat{h}_t \\
& + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{A}_t\hat{h}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{k}_t\hat{k}_t - \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^3\bar{h}^{-\alpha}\hat{k}_t\hat{k}_t - \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{k}_t\hat{h}_t \\
& + \bar{\mu}\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^3\bar{h}^{-\alpha}\hat{k}_t\hat{h}_t + \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^2\bar{h}^{-\alpha}\hat{h}_t\hat{h}_t - \frac{1}{2}\mu\bar{p}^d\bar{A}\bar{k}^\alpha\alpha^3\bar{h}^{-\alpha}\hat{h}_t\hat{h}_t - \frac{\bar{w}}{\bar{s}}\hat{w}_t\hat{s}_t
\end{aligned}
\tag{6.41}
$$

$$
\begin{aligned}
L11_t = {} & \frac{1}{2}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma^2\bar{c}^2\hat{c}_t\hat{c}_t - \frac{1}{2}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-1}\gamma\bar{c}\hat{c}_t\hat{c}_t + \frac{1}{2}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma\bar{c}^2\hat{c}_t\hat{c}_t \\
& - \left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma^2\bar{h}^\omega\bar{c}\hat{c}_t\hat{h}_t - \left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma\bar{c}\bar{h}^\omega\hat{c}_t\hat{h}_t + \frac{1}{2}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma^2(\bar{h}^\omega)^2\hat{h}_t\hat{h}_t \\
& + \frac{1}{2}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-1}\gamma\bar{h}^\omega\omega\hat{h}_t\hat{h}_t + \frac{1}{2}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma(\bar{h}^\omega)^2\hat{h}_t\hat{h}_t - \frac{1}{2}\bar{\lambda}\hat{\lambda}_t\hat{\lambda}_t
\end{aligned}
\tag{6.42}
$$

$$
\begin{aligned}
L12_t = {} & \frac{1}{2}\bar{\lambda}\bar{h}^{\omega-1}\hat{\lambda}_t\hat{\lambda}_t - \frac{1}{2}\bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{\lambda}_t\hat{\lambda}_t + \bar{\lambda}\bar{h}^{\omega-1}\omega\hat{\lambda}_t\hat{h}_t - \bar{\lambda}\bar{h}^{\omega-1}\hat{\lambda}_t\hat{h}_t - \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{\lambda}_t\hat{w}_t + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{\lambda}_t\hat{s}_t \\
& + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{\lambda}_t\hat{p}_t^m + \frac{1}{2}\bar{\lambda}\bar{h}^{\omega-1}\omega^2\hat{h}_t\hat{h}_t - \bar{\lambda}\bar{h}^{\omega-1}\omega\hat{h}_t\hat{h}_t + \frac{1}{2}\bar{\lambda}\bar{h}^{\omega-1}\hat{h}_t\hat{h}_t - \frac{1}{2}\bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{w}_t\hat{w}_t + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{w}_t\hat{s}_t \\
& + \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{w}_t\hat{p}_t^m - \frac{1}{2}\bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{s}_t\hat{s}_t - \bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{s}_t\hat{p}_t^m - \frac{1}{2}\bar{\lambda}\frac{\bar{w}}{\bar{s}}\hat{p}_t^m\hat{p}_t^m
\end{aligned}
\tag{6.43}
$$

$$
\begin{aligned}
L13_t = & -\frac{1}{2}\bar{\lambda}\beta E_t[\hat{\lambda}_{t+1}\hat{\lambda}_{t+1}] + \frac{1}{2}\bar{\lambda}\hat{\lambda}_t\hat{\lambda}_t + \bar{\lambda}\phi\bar{k}\hat{\lambda}_t ke2_t - \bar{\lambda}\phi\bar{k}\hat{\lambda}_t\hat{k}_t + \frac{1}{2}\bar{\lambda}\phi\bar{k}k_{t+1}k_{t+1} - \frac{1}{2}\bar{\lambda}\phi\bar{k}\hat{k}_t\hat{k}_t \\
& + \frac{1}{2}\bar{\lambda}\beta\phi\bar{k}k_{t+1}k_{t+1} + \bar{\lambda}\beta\phi\bar{k}k_{t+1}E_t[\hat{\lambda}_{t+1}] + \frac{1}{2}\bar{\lambda}\beta\delta E_t[\hat{\lambda}_{t+1}\hat{\lambda}_{t+1}] - \frac{1}{2}\bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{\lambda}_{t+1}\hat{\lambda}_{t+1}] \\
& - \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{\lambda}_{t+1}\hat{R}_{t+1}] + \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{\lambda}_{t+1}s_{t+1}] + \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{\lambda}_{t+1}\hat{p}^m_{t+1}] - \bar{\lambda}\beta\phi\bar{k}E_t[\hat{\lambda}_{t+1}\hat{k}_{t+2}] \\
& - \frac{1}{2}\bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{R}_{t+1}]k_{t+1} + \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{R}_{t+1}s_{t+1}] + \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{R}_{t+1}\hat{p}^m_{t+1}] - \frac{1}{2}\bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[s_{t+1}s_{t+1}] \\
& - \bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[s_{t+1}\hat{p}^m_{t+1}] - \frac{1}{2}\bar{\lambda}\beta\frac{\bar{R}}{\bar{s}}E_t[\hat{p}^m_{t+1}\hat{p}^m_{t+1}] - \frac{1}{2}\bar{\lambda}\beta\phi\bar{k}E_t[\hat{k}_{t+2}\hat{k}_{t+2}]
\end{aligned} \tag{6.44}
$$

$$
\begin{aligned}
L14_t = & \frac{1}{2}\bar{r}E_t[\hat{r}^p_{t+1}\hat{r}^p_{t+1}] + \bar{r}E_t[\hat{r}^p_{t+1}s_{t+1}] + \bar{r}E_t[\hat{r}^p_{t+1}\hat{p}^m_{t+1}] - \bar{r}E_t[\hat{r}^p_{t+1}]\hat{s}_t - \bar{r}E_t[\hat{r}^p_{t+1}]\hat{p}^m_t \\
& - \bar{r}E_t[s_{t+1}\hat{r}^*_{t+1}] - \bar{r}E_t[\hat{p}^m_{t+1}\hat{r}^*_{t+1}] + \bar{r}\hat{s}_tE_t[\hat{r}^*_{t+1}] + \bar{r}\hat{p}^m_tE_t[\hat{r}^*_{t+1}] - \frac{1}{2}\bar{r}E_t[\hat{r}^*_{t+1}\hat{r}^*_{t+1}]
\end{aligned} \tag{6.45}
$$

$$
\begin{aligned}
L15_t = & \frac{1}{2}U\bar{T}F\widehat{uf}_t\widehat{uf}_t + \frac{1}{2}\bar{c}^3\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma\hat{c}_t\hat{c}_t - \frac{1}{2}\bar{c}^2\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\frac{\bar{h}^\omega}{\omega}\gamma\hat{c}_t\hat{c}_t \\
& - \frac{1}{2}\bar{c}^2\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-1}\hat{c}_t\hat{c}_t + \frac{1}{2}\bar{c}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-1}\frac{\bar{h}^\omega}{\omega}\hat{c}_t\hat{c}_t - \bar{h}^\omega\bar{c}^2\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\gamma\hat{c}_t\hat{h}_t \\
& + (\bar{h}^\omega)^2\bar{c}\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\frac{\gamma}{\omega}\hat{c}_t\hat{h}_t + \frac{1}{2}(\bar{h}^\omega)^2\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\bar{c}\gamma\hat{h}_t\hat{h}_t \\
& - \frac{1}{2}(\bar{h}^\omega)^3\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-2}\frac{\gamma}{\omega}\hat{h}_t\hat{h}_t + \frac{1}{2}\bar{h}^\omega\omega\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-1}\bar{c}\hat{h}_t\hat{h}_t \\
& - \frac{1}{2}(\bar{h}^\omega)^2\left(\bar{c} - \frac{\bar{h}^\omega}{\omega}\right)^{-\gamma-1}\hat{h}_t\hat{h}_t
\end{aligned} \tag{6.46}
$$

References

[1] Aghion, P., P. Bacchetta, and A. Banerjee, 2000. "A Simple Model of Monetary Policy and Currency Crises," European Economic Review, vol. 44(4-6), pages 728-738, May.

[2] Basu, S., and J.G. Fernald, 1997. "Returns to scale in U.S. Production: Estimates and Implications," Journal of Political Economy 105, 249-283.

[3] Benigno, Pierpaolo, 2009. "Price Stability with Imperfect Financial Integration," Journal of Money, Credit and Banking, Supplement to Vol. 41, No. 1.

[4] Bohn, Henning, 1998. "The Behaviour of U.S. Public Debt and Deficits". Quarterly Journal of Economics, 113(3), 949-63.

[5] Caballero, R., and A. Krishnamurthy, 2004. "Exchange Rate Volatility and the Credit Channel in Emerging Markets: A Vertical Perspective," Working paper, MIT.

[6] Calvo, G., 1999. "Fixed vs. Flexible Exchange Rates: Preliminaries of a Turn-of-Millennium Rematch." Working paper, University of Maryland.

[7] Calvo, G., 2001. "Capital markets and the exchange rate with special reference to the dollarization debate in Latin America." Journal of Money, Credit and Banking 33, 312334.

[8] Calvo, G., and C. Reinhart, 2002. "Fear of floating," Quarterly Journal of Economics 98 (2), 379 408.

[9] Castillo, Paul, C. Montoro, and V. Tuesta, 2006. "An Estimated Stochastic General Equilibrium Model with Partial Dollarization: A Bayesian Approach." Working Paper 381, Central Bank of Chile.

[10] Cespedes, L. F., R. Chang, and A. Velasco, 2001. Dollarization of Liabilities, Financial Fragility and Exchange Rate Policy." Currency Unions, A. Alesina and R. Barro (Editors), Hoover Institution Press.

[11] Cespedes, L. F., R. Chang, and A. Velasco, 2004. "Balance Sheets and Exchange Rates," American Economic Review, 94, 1183-1193.

[12] Chamon, M., and R. Hausmann, 2005. "Why do countries borrow the way they borrow?" In *Other Peoples Money*, B. Eichengreen and R. Hausmann (eds.), University of Chicago Press, January 2005.

[13] Chang, Roberto, 2001. "Monetary Policy in a Dollarized Economy where Balance Sheets Matter," Journal of Development Economics Vol. 812

[14] Chang, Roberto, 2003. "Endogenous Dollarization and Monetary Policy," presented at the IADB/World Bank conference "Financial Dedollarization: Policy Options." December 1-2.

[15] Chang, Roberto, 2005. "Currency Mismatches and Monetary Policy: A Tale of two Equilibria," presented at San Francisco Federeal Reserve Bank conference on Emerging Markets.

[16] Chang, R. and A. Velasco, 2004. "Endogenous Dollarization, Expectations and Equilibrium Monetary Policy." Proceedings, Federal Reserve Bank of San Francisco, Issue June.

[17] Chari, V.V. and P. Kehoe, 1990. "Sustainable Plans." Journal of Political Economy 98, 783 802.

[18] Corsetti, Giancarlo, 2007. "New Open Macroeconomics," memeo, New Palgrave.

[19] Corsetti, G. and P. Pesenti, 2002. "Self-Validating Optimum Currency Areas," NBER Working Paper, 8783.

[20] Devereux, M, and A. Sutherland, 2007. "Country Portfolio Dynamics." CEPR Discussion Paper No 6208.

[21] Devereux, M, and A. Sutherland, 2008. "Country Portfolios in Open Economy Macro Models." NBER Working Paper No 14372 (Forthcoming in the Journal of the European Economic Association).

[22] Eichengreen, B. and R. Hausmann, 1999. "Exchange Rates and Financial Fragility," NBER Working Papers 7418, National Bureau of Economic Research, Inc.

[23] Fatas, Antonio and Ilian Mihov, 2001, "Government Size and Automatic Stabilizers: International and Intranational Evidence". Journal of International Economics, 55(1), 3-28.

[24] Frankel, Jeffrey A., 2003. "A Proposed Monetary Regime for Small Commodity-Exporters: Peg the Export Price ("PEP")." International Finance (Vol. 6, no. 1, pp. 61-88). Blackwell Publishers.

[25] Frankel, Jeffrey A., 2005. "Peg the Export Price Index: A Proposed Monetary Regime for Small Countries." Journal of Policy Modeling 27, 495-508.

[26] Gali, J. and T. Monacelli, 2005. "Optimal Fiscal Policy in a Monetary Union." Federal Reserve Bank of San Francisco, Proceedings.

[27] Gali, J. and R. Perroti., 2003, "Fiscal Policy and Monetary Integration in Europe." Economic Policy, 18(37), 533-72.

[28] Goldberg, L. and Tille, C. 2005. "Vehicle Currency Use in International Trade." Staff Report No. 200, Federal Reserve Bank of New York.

[29] Greenwood, J., G. Huffman, and Z. Hercowitz, 1988. "Investment, Capacity utilization and Real Business Cycles." American Economic Review 78, no 3, 402-17.

[30] Hausmann, R. (Eds.), "Other Peoples Money: Debt Denomination and Financial Instability in Emerging Market Economies." (2004) University of Chicago Press, Chicago.

[31] Ize, A. and E. Levy-Yeyati, 2003. "Financial dollarization." Journal of International Economics 59 (2), 323 347.

[32] Ize, A. and E. Parrado, 2002. "Dollarization, Monetary Policy and the Pass-Through," Working Paper 188, International Monetary Fund.

[33] Kilpatrick, A. 2001, "Transparent Frameworks, Fiscal Rules and Policy Making under Uncertainty." paper presented at Bank of Italy workshop on Fiscal Rules, Perugia, February.

[34] Kim, Jinill and A. Levin, 2005. "Conditional Welfare Comparisons of Monetary Policy Rules", Computing in Economics and Finance 2005 148, Society for Computational Economics.

[35] Kim, J., S. Kim, E. Schaumburg, and C. Sims, 2003. "Calculating and Using Second Order Accurate Solutions of Discrete Time Dynamic Equilibrium Models," Working Paper, Princeton University.

[36] Krugman, Paul, 1999. "Balance Sheets, the Transfer Problem and Financial Crises." In: Isard, P., Razin, A., Rose, A. (Eds.), International Finance and Financial Crises. Kluwer Academic Publishers, pp. 3145.

[37] Leeper, E.M., 1991. "Equilibria under 'Active' and 'Passive' Monetary and Fiscal Policies." Journal of Monetary Economics, 27, November, pp. 129-47.

[38] Lombardo, G. and A. Sutherland, 2005. "Computing second-order-accurate solutions for rational expectation models using linear solution methods." Working Paper Series 487, European Central Bank.

[39] Mendoza, Enrique, 1991. "Real Business Cycles in a Small-Open Economy," American Economic Review 81, 797-818.

[40] Moron, E., and J. Castro, 2003. "Dedollarizing the Peruvian Economy: A Portfolio Approach." Working Paper, Universidad del Pacifico, Lima.

[41] Neumeyer, P.A., and F. Perri, 2001. "Business Cycles in Emerging Markets: The Role of Interest Rates." Manuscript. New York University, May.

[42] Palacios-Salguero, Luis, 2006. "Some Empirical Evidence of Shocks to Monetary and Fiscal Policies on the Exchange Rate: Germany 1974-1998," memeo, Rutgers University.

[43] Palacios-Salguero, Luis, 2009. "Endogenous Dollarization in a Small Open Economy: Fixed or Flexible Exchange Rate?," memeo, Rutgers University.

[44] Rotemberg, Julio J., 1982. "Sticky Prices in the United States." Journal of Political Economy 90 (December 1982): 1187-1211.

[45] Schmitt-Grohe, Stephanie, 1998. "Endogenous business cycles and the dynamics of output, hours, and consumption," Finance and Economics Discussion Series 1998-19, Board of Governors of the Federal Reserve System (U.S.).

[46] Schmitt-Grohe, S. and M. Uribe., 2001. "Stabilization Policy and the Costs of Dollarization." Journal of Money, Credit and Banking, Ohio State University Press, vol. 33(2), pages 482-509, May.

[47] Schmitt-Grohe, S. and M. Uribe, 2003. "Closing Small Open Economy Model." Journal of International Economics, Volume 61, Number 1, October, pp. 163-185(23).

[48] Schmitt-Grohe, S. and M. Uribe, 2004a. "Optimal Operational Monetary Policy in the Christiano-Eichenbaum-Evans Model of the U.S. Business Cycle." NBER Working Papers 10724, National Bureau of Economic Research, Inc.

[49] Schmitt-Grohe, S. and M. Uribe, 2004b. "Optimal Simple And Implementable Monetary and Fiscal Rules." NBER working paper no. 10253, January.

[50] Schmitt-Grohe, S. and M. Uribe, 2004c. "Solving Dynamic General Equilibrium Models Using a Second-Order Approximation to the Policy Function." Journal of Economic Dynamics and Control 28, January, 755-775.

[51] Schmitt-Grohe, S. and M. Uribe., 2004d. "Optimal Monetary and Fiscal Policy under Sticky Prices." Journal of Economic Theory, 114, February 2004, pp 198-230.

[52] Schmitt-Grohe, S. and M. Uribe., 2006. "Optimal Simple and Implementable Monetary and Fiscal Rules." NBER Working Papers 10253.

[53] Stein, E.H., R. Hausmann, M. Gavin, and C. Page's-Serra, 1999. "Financial Turmoil and Choice of Exchange Rate Regime." Working Paper, Research Department, Inter American Development Bank.

[54] Sutherland, Alan, 2002. "A Simple Second-Order Solution Method for Dynamic General Equilibrium Models." CEPR Discussion Paper No 3554.

[55] Taylor, John B., 1993, "Discretion versus Policy Rules in Practice." Carnegie-Rochester Conference Series on Public Policy 39, 195-214.

[56] Taylor, John B., 2000, "Reassessing Discretionary Fiscal Policy." Journal of Economic Perspectives, 14(3), 21-36.

[57] Wang, Jian, 2006. "Home Bias, Exchange Rate Disconnect, and Optimal Exchange Rate Policy." Working Paper 0701, Federal Reserve Bank of Dallas.

[58] Woodford, Michael, 2003. "Interest and Prices: Foundations of a Theory of Monetary Policy." Princeton University Press.

Vita

Luis V. Palacios-Salguero

2010	Ph. D. in Economics, Rutgers University
2004	M.A. in Economics, Rutgers University
2001	Licentiate in Economics, Universidad del Pacifico
2001	B.A. in Economics, Universidad del Pacifico

2007-2008	Teaching assistant, Department of English, Rutgers University
2003-2006	Teaching assistant, Department of Economics, Rutgers University