Essays on International Finance and Economics

by

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Abstract

The first essay explains why credit contracts in developing countries are often denominated in foreign currencies, even after many of these economies succeeded in controlling inflation. I propose a new interpretation based on the demand for insurance against real aggregate shocks. The fact that devaluations occur more frequently in adverse states of the world provides a motive for holding dollar assets when the risk of recession is the main source of volatility in consumption. The model predicts persistence in the degree of "dollarization" in economies with low inflationary risk.

The second essay looks at how the government's lack of commitment technology affects the capacity of resident agents to optimally diversify risk. I find that government's moral hazard introduces a trade-off between pooling idiosyncratic risk and diversifying aggregate country uncertainty. As a result, local agents face excessive consumption risk. This paper also explores how institutions can be designed as to overcome this moral hazard problem.

The third essay proposes an explanation for the variation across countries in the quality of the institutions governing the financial. The explanation based on the proportion of local investors participating in the domestic financial sector. I find that the participation of local investors in the financial market and, correspondingly, the resulting institutions vary according to wealth distribution and the size of capital inflows.

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Contents

Chapter 1

Introduction

Developing economies are often characterized by weak institutions. One way of formalizing them is to assume that governments cannot commit to policies. Instead, only policies that are ex-post optimal can be credibly implemented. As a result, emerging markets must function in poor institutional environments, face high sovereign risk, and must resort to very costly commitment devices that are sub-optimal from an ex-ante perspective. This dissertation explores different implication of government's problem of moral hazard.

The first essay analyzes the interaction between government's optimal exchange rate policy and the currency denomination of credit contracts. Credit contracts in developing countries are often denominated in foreign currencies, even after many of these economies succeeded in controlling inflation. I propose a new interpretation of this apparent puzzle based on the demand for insurance against real aggregate shocks. The fact that devaluations occur more frequently in adverse states of the world provides a motive for holding dollar assets when the risk of recession is the main source of volatility in consumption. This approach implies a complementarity between government's ex-post optimal monetary policy and the currency denomination of contracts. When a large proportion of liabilities is denominated in a foreign currency, the optimal exchange rate volatility is low. This raises the vulnerability of the economy to aggregate shocks and reinforces the demand for dollar assets. Based on this complementarity, the model predicts persistence in the degree of "dollarization" in economies with low inflationary risk.

The second essay looks at how the government's lack of commitment technology affects the capacity of resident agents to optimally diversify risk. Fiscal policy and taxation in particular play an important role in the insurance of local agents against income fluctuations. Government's power to impose taxes is a key tool for optimal redistribution among residents. And, since public debt represents future local tax income, fiscal policy also plays a role in the international risk sharing. I find that government's moral hazard introduces a trade-off between pooling idiosyncratic risk and diversifying aggregate country uncertainty. As a result, local agents face excessive consumption risk. This paper also explores how institutions can be designed as to overcome this moral hazard problem.

The third paper analyzes why the quality of the institutions governing the financial sector varies across countries. The analysis is based on the incentives of the government to protect investors, which depends on the size of the domestic financial market and the proportion of local investors pariticipating in it. I find that the participation of local investors and, therefore, the optimal level of investor protection varies with domestic wealth distribution and the size of capital inflows.

Chapter 2

Persistence of Dollarization after Price Stabilization

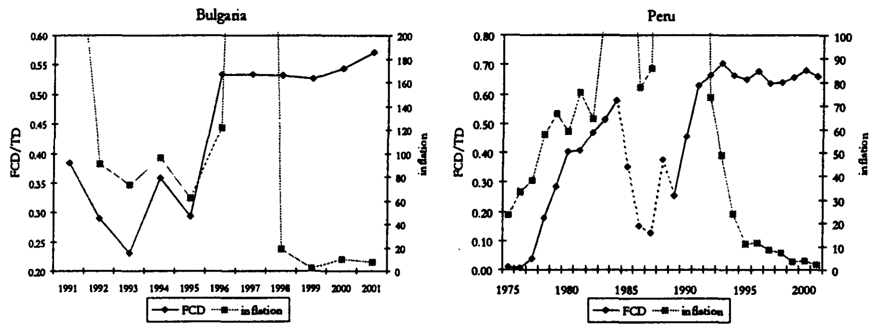
2.1 Introduction

A large share of credit contracts among residents in developing countries is denominated in foreign currencies, mainly dollars.[1] It is often argued that this affects the vulnerability of these economies to real shocks and the ability of their monetary policies to deal with them.[2] This domestic aspect of the phenomenon known as "dollarization" is associated in many cases with a history of large inflationary episodes. Denominating contracts in a foreign currency protects borrowers and lenders against inflationary risk. It is thus unsurprising that countries with high inflation rates are more likely to adopt dollar denominated contracts. However, during the last decade many such countries have made substantial progress in controlling inflation and yet the share of dollar denominated assets in these economies remains high. Figure 2-1 illustrates this phenomenon: the share of dollar denominated deposits in Peru and Bulgaria increased together with the inflationary risk. However, although these countries managed to reduce inflation, their

[1]As an approximation for the domestic demand of foreign denominated assets, see table in appendix 7.2: share of foreign denominated deposits in selected countries.

[2]The level of dollarization is found to increase the likelihood of crisis and the vulnerability of the economy towards real exchange rate perturbations. See Hausmann, Panizza, and Stein (2001), and Calvo, Izquierdo, and Mejia (2004). For a theoretical approach, see, among others, Jeanne and Zettelmeyer (2003), Chang and Velasco (1999), Krugman (1999), and Aghion, Bacchetta, and Banerjee (2001).

banking systems remain heavily dollarized.[3] This persistence in the currency denomination of credit contracts suggests that dollar instruments fulfill some other role apart from protection against inflationary risk.



Note: Different degrees of legal restrictions to foreign currency denominated deposits were imposed in Peru between 1985 and 1989.
Sources: Data on inflation from IFS-IMF, data on deposits denomination from Levy-Yeyati (2003) and data on legal restrictions on dollar deposits from Arteta (2002, 2003).

Figure 2-1: Share of Foreign Denominated Deposits

The main contribution of this paper is to reassess the motives behind domestic dollarization. I propose a new interpretation of this apparent puzzle based on the demand for insurance against real shocks. Because devaluations occur more frequently during recessions, dollar assets provide insurance in economies with incomplete financial markets. The devaluation response to aggregate shocks increases the contingent value of dollar assets. I argue that monetary policy can improve the capacity of an incomplete set of instruments to approximate complete financial markets.

Having analyzed the motive underlying the denomination of credit contracts, I look at the interaction between the currency composition of the credit market and the Central Bank's optimal devaluation response to aggregate shocks. I show how the demand for dollar assets distorts the Central Bank's policy, and, in turn, market's expectations of the devaluation response alters investors' portfolio choice. This interaction may result in multiple equilibria: an equilibrium with a high degree of dollarization in which the Central Bank minimizes price fluctuations;[4]

[3] See Appendix 7.3 for a broader selection of countries.

[4] The reluctance of the monetary authority to let the exchange rate fluctuate in economies with large share of dollar liabilities has been emphasized in the literature on "fear of floating" and "original sin" (Calvo and

and another in which contracts are mainly denominated in domestic currency and monetary policy is highly countercyclical. Based on this complementarity, the model explains persistence in the share of dollar liabilities in economies with low inflationary risk.

The model has three building blocks. First, consumers and entrepreneurs share risk in a small economy subject to a real aggregate shock. The model emphasizes that in emerging economies, in which a significant fraction of consumers do not have access to foreign assets, the domestic corporate sector has a double role. It is both a producer of goods and services and a major supplier of financial instruments. I simplify the analysis by assuming that consumers are risk averse and entrepreneurs are risk neutral. Entrepreneurs can therefore provide insurance to consumers. However, because they are protected by limited liability and bankruptcies are costly, the ability of firms to provide insurance is limited. Improving insurance requires larger payments from the corporate sector to consumers during recessions, precisely when firms' revenues are lower. Thus, smoothing consumption exacerbates their probability of default. In other words, there is a trade-off between insurance and default risk.

Second, credit markets are incomplete and credit contracts cannot be written contingent on the realization of the real aggregate shock. Instead, contracts can be denominated in foreign (dollar) or domestic (peso) currency. These assets enable consumers to trade-off between insurance and default risk. Because devaluations are more likely to occur in bad states of the world, dollar assets provide insurance against the risk of recessions, though they face larger default risk.[5] On the other hand, because devaluation and inflation are positively correlated, real payments of peso debt are lower in bad states. Thus, peso assets involve lower default risk at the expense of a more uneven consumption schedule. The ability of these assets to approximate complete financial markets depends on the magnitude of the devaluation response to aggregate shocks.

Finally, there is a time inconsistency problem in the Central Bank's optimal devaluation response along the lines of Kydland and Prescott (1977) and Barro and Gordon (1983). At the time of the monetary intervention, credit contracts have already been set. The degree of

Reinhart, 2000 and 2002; Hausmann, 1999; Hausmann, Panizza, and Stein, 2001).

[5] See Chamon (2001) for a model where the correlation between default and depreciation explains the currency denomination of foreign debt. And Broda and Levy-Yeyati (2003) using the same feature in a model explaining incentives for dollarization in domestic banking system.

dollarization of the credit market affects the Central Bank's optimal policy. However, the ex-post optimal policy feeds back into credit market expectations and determines borrowers' and lenders' choice of contract denomination. The interplay between market expectations and the Central Bank's optimal policy creates the need for commitment. Under full commitment, the optimal monetary policy enables dollar and peso assets to replicate a complete financial market. Conversely, the monetary authority's lack of commitment implies a suboptimal (from an ex-ante perspective) monetary policy. In this case, the Central Bank pushes the economy towards a default risk below the ex-ante optimum and, as a consequence, consumers are underinsured.

Under lack of commitment, the interplay between the currency composition of debt and the Central Bank's optimal policy may result in multiple equilibria: an equilibrium with full dollarization in which the Central Bank minimizes exchange rate volatility; and another in which contracts are mainly denominated in domestic currency and monetary policy is highly countercyclical. Under full dollarization, real aggregate shocks have larger impact on output. However, when insurance against the risk of recession is the motive behind dollarization, consumers are better off under full dollarization than with a high share of peso denominated contracts. Indeed, if credit contracts are mainly denominated in pesos, the Central Bank succeeds in reducing the number of defaulting firms at the expense of a more volatile return on savings. As a result, the problem of underinsurance is exacerbated.

The model provides some useful policy implications regarding the dollarization dilemma. It rationalizes the observed positive impact of inflation risk on the share of foreign currency denominated contracts. Nevertheless, it predicts that price stabilization will have limited efficacy in reducing dollarization. The model also casts doubts on the effectiveness of CPI-indexed instruments in reducing the level of dollarization. CPI-indexed bonds do not provide contingency against recessions. On the contrary, they are useful only when inflationary risk is the main source of volatility in consumption. Finally, the paper explores the implications of improving the access of atomistic borrowers and lenders to foreign capital. Unlike domestic dollar assets, foreign instruments can perfectly insure consumers against the country risk. The trade-off between insurance and default risk disappears and consumers are better off if the Central Bank pursues a countercyclical monetary policy.

The motives underlying domestic dollarization are analyzed in Ize and Levy-Yeyati (1998,

2003) and Broda and Levy-Yeyati (2003). The interaction between monetary policy and the degree of domestic dollarization is also present in Chamon and Hausmann (2002), Ize and Powell (2004), and Chang and Velasco (2004). However, the role of dollar assets in providing insurance against the risk of recession has not been emphasized.

This paper builds on the insurance view of monetary policy emphasized in Holmstrom and Tirole (1998, 2002) and Caballero and Krishnamurthy (2001, 2003). As in Holmstrom and Tirole (1998), monetary policy is understood as an insurance policy in the presence of aggregate risk. The role of foreign currency denominated assets in providing insurance against country risk is also present in Holmstrom and Tirole (2002). Finally, Caballero and Krishnamurthy (2001, 2003) introduce a similar interplay between monetary policy and the composition of liabilities. However, when applied to the problem of consumers' underinsurance against the risk of recessions, the main conclusions of those papers are fundamentally altered. Since in this framework dollar instruments are issued by the domestic corporate sector, the insurance capacity of these assets is limited. Moreover, the demand for insurance increases the vulnerability of the domestic corporate sector towards the real aggregate shock. In this model, a highly countercyclical monetary policy reduces the insurance capacity of the available financial instruments and decreases consumers' welfare.

The rest of the paper is organized as follows. Section 2 describes the economic environment. Section 3 solves the credit market equilibrium for a given anticipated devaluation response. Different degrees of market imperfections are analyzed. Section 4 endogenizes the optimal devaluation response and closes the model. Section 5 discusses the implications of an increase in inflationary risk, the introduction of CPI-indexed credit contracts, and concludes by relaxing the assumption that the domestic credit market is insulated from international capital flows. Section 6 concludes.

2.2 Basic Framework

The model describes a small monetary economy subject to real aggregate risk, in this case, a productivity shock. The economy is open to trade while the capital account is assumed to be closed (this assumption is relaxed in section 5). This is to capture for the fact that in emerging economies a large share of small firms and atomistic consumers do not have access to foreign capital and are unable to diversify country risk.

There are three goods, a non-tradable final good, used for consumption and investment, and two intermediates, one tradable and one non-tradable.

The economy is populated by consumers and a unit measure of entrepreneurs. Consumers have risk averse preferences over date 2 consumption. They are endowed with $1/2$ units of tradable and non-tradable intermediates. Entrepreneurs are risk neutral with no initial resources and have access to a risky technology that requires a unit of investment. The productive project is specific to the entrepreneur in the sense that its liquidation is socially costly.

There is an imperfect set of contracts. Credit contracts cannot be set contingent on the realization of the aggregate shock. Instead, they can only be expressed in terms of a fixed amount of foreign or domestic currency.

The paper analyzes whether this set of assets can adequately substitute for a complete set of financial contracts under different degrees of market imperfection. This section formulates the problem of a small open economy it terms of risk sharing between consumers and entrepreneurs for the simplest case in which entrepreneurs are not protected by limited liability. In section 3, more interesting risk sharing problems are analyzed.

The timing of events is as follows: Date 1 is a fully flexible period in which all contracts are set. In the credit market, consumers and entrepreneurs choose the currency denomination of contracts and the respective interest rates are set. In the goods market, the price of the intermediate goods and the share of tradable and non-tradable inputs used in the production of the final good are determined. Price of non-tradables is set in domestic currency, while price of tradables is set in dollars. At date 2, the productivity shocks are realized. Firms repay their debts and consumption takes place.

Transactions occur at date 1, when consumers sell their endowment, and at date 2 in the two possible states of nature $s \in \{B, G\}$. The vector of prices in this economy is $\{p_1^T, p_B^T, p_G^T, p_1^N, p_B^N, p_G^N, p_1^F, p_B^F, p_G^F\}$, where the superscript T denotes for tradable, N for non-tradable intermediate goods, and F for the final good. I normalize the initial relative price of tradables and non-tradables to one, $p_1^T = p_1^N$, and I use p_1^N as a numeraire.

2.2.1 Technology

Consumers are endowed with 1/2 units of tradable and non-tradable intermediate goods. Entrepreneurs do not have initial resources. They have access to two production alternatives: either they home-produce an amount K of the final good, or undertake a risky project. The project requires an initial investment $\overline{k}_1 = 1$, and results in date 2 joint output of tradable and non-tradable goods: τA_{is} units of tradables and $(1-\tau) A_{is}$ units of non-tradables, where τ is a fixed proportion $\tau \in (0,1)$. The technology is affected by an aggregate productivity shock z_s and a firm unobservable idiosyncratic sensitivity towards it, a_i. The aggregate shock follows a symmetric binomial distribution, $z_s \in \{-z, z\}$ with $\Pr = 1/2$, and the idiosyncratic shock is uniformly distributed over the unitary interval, $a_i : U[0,1]$.

$$y_{is}^T = \tau A_{is} \text{ and } y_{is}^N = (1-\tau) A_{is} \tag{2.1}$$

$$A_{is} \equiv A(1 + a_i z_s) \tag{2.2}$$

The final good is produced by consumers using tradable and non-tradable intermediates. At date 1, the optimal share of tradable and non-tradable inputs is chosen. At date 2, when the state of nature is revealed, the structure of production is fixed. This assumption accounts for the fact that the productive structure cannot adjust instantaneously to unexpected changes in the relative price of inputs. On the other hand, the productive structure can optimally accommodate to foreseen relative prices. Then, the technology is described by the following production function:

$$y_s^F = \min\left\{\frac{y_s^T}{\eta}, \frac{y_s^N}{1-\eta}\right\} \tag{2.3}$$

$$\eta = \arg\max_{0 \le \eta \le 1} E\left\{y_s^F - p_s^T y_s^T - p_s^N y_s^N\right\} \tag{2.4}$$

where η is chosen at date 1, before the state of nature is revealed.

2.2.2 Goods Market Structure

The goods market is in equilibrium if, for any state of nature $s \in \{B, G\}$, the non-tradable goods market clears, and the trade balance condition is satisfied:

$$y_s^N = (1-\tau)\int_{i=0}^{1} A_{is}di \tag{2.5}$$

$$y_s^F = y_s^N + y_s^T = \int_{i=0}^{1} A_{is}di \tag{2.6}$$

The equilibrium conditions (2.5) and (2.6) require the amount of non-tradables used in the production of the final good $((1-\eta)\, y_s^F)$ to be equal to the domestic production of tradable intermediates $((1-\tau)\, y_s^F)$. And, from equation (2.4), the proportion of tradable inputs (η) is interior only if prices are equal in expectation.

$$\eta = \tau \tag{2.7}$$

$$E\left(p_s^T\right) = E\left(p_s^N\right) \tag{2.8}$$

Markets are assumed to be competitive in the sense that producing final goods results in zero profits. The price of consumption goods is therefore equal to the marginal cost derived from (2.3):

$$p_s^F = \eta p_s^T + (1-\eta)\, p_s^N \tag{2.9}$$

2.2.3 Price Determination

Prices of intermediate goods are set at date 1. The price of non-tradables is set in domestic currency while the price of tradable goods is set in dollars. Thus, in local currency denomination, the price of tradables (p_s^T) is equal to the nominal exchange rate. The devaluation rate is defined as follows:

$$\delta_s \equiv \frac{p_s^T - p_1^T}{p_1^T}$$

The nominal devaluation schedule is assumed exogenous in the basic framework of the model and endogenized in section 4. Importantly, in this context, expected devaluation has no real implications. From (2.8), only deviations from the expected devaluation, which are necessarily symmetric, are going to impact on relative prices and consumption allocation. Then, I am going to restrict the analysis to a devaluation schedule of the form

$$\delta_s \in \{\delta, -\delta\} \tag{2.10}$$

δ is understood as the deviation from expected devaluation rate, that is, the devaluation response to the aggregate shock.

Combining (2.8), (2.7), and (2.9), the goods market equilibrium is a vector $\{p_1^T, p_B^T, p_G^T, p_1^N, p_B^N, p_G^N, p_1^F, p_B^F, , p_G^F\}$ such that for $s \in \{B, G\}$:

$$\begin{aligned} p_1^F &= p_1^T = p_1^N = 1 \\ p_s^N &= 1 \\ p_s^T &= 1 + \delta_s \\ p_s^F &= 1 + \tau\delta_s \end{aligned}$$

The domestic inflation rate is therefore positively correlated with the devaluation response, through the proportion of tradable intermediates used in the production of the final good:

$$\pi_s \equiv \frac{p_s^F - p_1^F}{p_1^F} = \tau\delta_s \tag{2.11}$$

2.2.4 The Risk Sharing Problem

The economic structure described above can be summarized in terms of risk sharing between risk averse consumers and risk neutral entrepreneurs.

Consumers are endowed with 1/2 units of tradable and non-tradable intermediates. The resulting unit of final good is sold to the entrepreneurs at the market price (p_1^F). The credit contracts can be denominated in domestic currency or dollars. Consumers diversify away firms' idiosyncratic risk and the return on their assets only follows the realization of the aggregate shock $s \in \{B, G\}$. Then, consumers choose the optimal portfolio currency composition, subject to short selling constraint ($\mu \in [0,1]$), to maximize their expected utility:

$$\begin{aligned} & \max_{1\geq\mu\geq 0} EU\left(c_s^c\right) && (2.12) \\ s.t.\ \ p_s^F c_s^c &= p_1^F \left[\mu r_p + (1-\mu) r_d p_s^T\right] \end{aligned}$$

where r_p and r_d are the interest rates for peso and dollar assets respectively and U is a risk averse utility function with $U' > 0$ and $U'' < 0$. Using (2.7), (2.10), and (2.11), the budget constraint can be rewritten as:

$$c_s^c = \mu R_{ps} + (1-\mu) R_{ds} \tag{2.13}$$

where R_{ps} and R_{ds} are respectively the real return on peso and dollar assets in the s-state:[6]

$$R_{ps} = \begin{cases} r_p - \tau\delta & s = B \\ r_p + \tau\delta & s = G \end{cases} \tag{2.14}$$

$$R_{ds} = \begin{cases} r_d + (1-\tau)\delta & s = B \\ r_d - (1-\tau)\delta & s = G \end{cases} \tag{2.15}$$

Entrepreneurs choose whether to undertake the project. If they do, they borrow from consumers to finance investment. Credit contracts can be denominated in pesos or dollars. Each entrepreneur $i \in [0,1]$ chooses a strategy $\{\imath_i, v_i\} \in \{0,1\} \times [0,1]$, where $\imath_i$ indicates whether she undertakes the project and v_i corresponds to the currency composition of debt.

$$\max_{\substack{0\leq v_i\leq 1 \\ \imath_i\in\{0,1\}}} E\left(c_{is}^e\right) \tag{2.16}$$

[6]Real returns on assets are approximated, for interest rates close to one and devaluation and inflation rates close to zero, using :

$$\begin{aligned} r_p \frac{1}{1+\pi_s} &\simeq r_p - \pi_s \\ r_d \frac{1+\delta_s}{1+\pi_s} &\simeq r_d + \delta_s - \pi_s \end{aligned}$$

$$s.t.\ \ p_s^F c_{is}^e = \imath_i \left(A_{is}\left[\tau p_s^T + (1-\tau)\, p_s^N\right] - p_1^F\left[v_i r_{ip} + (1-v_i)\, r_{id} p_s^T\right]\right) + (1-\imath_i)\, p_s^F K$$

where r_{ip} and r_{id} are respectively the interest rates for peso and dollar contracts, and A_{is} is defined in (2.2). Using (2.7), (2.10), and (2.11), the entrepreneur's budget constraint can be rewritten as:

$$c_{is}^e = \imath_i \left[A_{is} - v_i R_{ips} - (1-v_i)\, R_{ids}\right] + (1-\imath_i)\, K \tag{2.17}$$

where R_{ips} and R_{ids} are respectively the real return on peso and dollar assets faced by the firm i in the s-state:

$$R_{ips} = \begin{cases} r_{ip} - \tau\delta & s = B \\ r_{ip} + \tau\delta & s = G \end{cases} \tag{2.18}$$

$$R_{ids} = \begin{cases} r_{id} + (1-\tau)\,\delta & s = B \\ r_{id} - (1-\tau)\,\delta & s = G \end{cases} \tag{2.19}$$

Notice from equations (2.14)-(2.15) and (2.19)-(2.18), that the devaluation response to the aggregate shock differentiates dollar and peso contracts. If devaluations happen in the B-state –i.e. $\delta \geq 0$, dollar contracts involve larger payments in the negative realization of the shock. From (2.11), inflation and devaluation are positively correlated, thus the real return on peso assets is lower in the B-state. The contingent value of the assets is given by the size of the devaluation response δ.

Finally, firms compete in the credit market and the zero profit condition holds: expected entrepreneurs' profits are equal to their opportunity cost, that is, the home-production of K units of final good. In equilibrium, the free entry condition (2.20) pins down the interest rate so investors retain the expected net present value of production.

$$E\left(c_{is}^e\right) = K \tag{2.20}$$

2.3 Credit Market Equilibrium

This section characterizes the Credit Market Equilibrium under different degrees of market imperfection. In particular, it analyzes whether the restricted set of credit contracts available, namely dollar and peso denominated debt, suffices to attain the optimal allocation.

Initially, the first best equilibrium is presented for the simplest case in which entrepreneurs are not protected by limited liability. Then, limited liability is introduced. The Second Best allocation is used as a benchmark to analyze whether dollar and peso denominated contracts can substitute for a perfect set of financial instruments. Ultimately, as a final departure from the simplest specification, this section characterizes the Credit Market Equilibrium when firms have non-exclusive contractual relationships.

The Credit Market Equilibrium is defined as follows:

Definition 1 (Credit Market Equilibrium) *For a given devaluation schedule $\delta_s \in \{\delta, -\delta\}$, with $\delta \geq 0$, a credit market equilibrium is a set*
$\{\{r_{ip}\}_{i=0}^{1}, \{r_{id}\}_{i=0}^{1}, \{v_i\}_{i=0}^{1}, \mu\}$ *such that:*

i) $\forall i \in [0,1] : v_i$ *maximizes (2.16) subject to (2.17), for* $\{r_{ip}, r_{id}\}$

ii) μ *maximizes (2.12) subject to (2.13), for a given* $\{r_p, r_d\}$

iii) $E(c_{is}^{e}) = K$

iv) $\mu = \int_{i=0}^{1} v_i di$

v) $\forall i \in [0,1] : r_{pi} = r_p$ *and* $r_{di} = r_d$

2.3.1 Absence of Limited Liability

The basic framework without limited liability results in First Best allocation. That is, the corporate sector bears the aggregate and the unobservable idiosyncratic risk and freely insures consumers.

From (2.17), (2.18), and (2.19), entrepreneurs' expected consumption is linear in the currency composition of debt (v_i). Then, firms are indifferent in the currency composition of debt as long as the respective interest rates are equalized, $r_{ip} = r_{id}$. Moreover, all firms are ex-ante identical, so they all face the same interest rates, $r_{ip} = r_{id} = r$, which is pinned down from the free entry condition (2.20).

The aggregate productivity shock indirectly affects consumers through the realization of the devaluation response, $\delta_s \in \{\delta, -\delta\}$, which determines the real return on assets in (2.14) and (2.15). The optimal portfolio composition is $\mu = 1 - \tau$. From (2.13), at $\mu = 1 - \tau$ consumers avoid the currency risk by holding a portfolio that replicates the share of tradables and non-tradables in the consumption price index.[7] Consumption in each state of nature $s \in \{B, G\}$ is simply given by the fixed real payment r.

Finally, the size of the devaluation response δ is irrelevant in this case.

2.3.2 Limited Liability and Exclusive Credit Contracts

In this subsection I analyze the existence of limited liability. The technology is assumed specific to the entrepreneur and its liquidation is socially costly. For simplicity, I assume that, in the case of default, the firm makes zero profits and consumers get no liquidation value.[8] Before, the aggregate shock indirectly affected consumers through the realization of the devaluation response, now they are also affected through the risk of default on credit contracts.

I make parametric restrictions to assure that defaults only happen in the B-state –i.e. $2K \geq Az \geq K$. The Second Best with limited liability replicates the following program:

$$\begin{aligned}
&\max_{R_B^{SB}} U\left(c_B^c\right) + U\left(c_G^c\right) \\
&s.t. \\
&c_B^c = \Pr\left(A_{iB} > R_B^{SB}\right) R_B^{SB} \\
&c_G^c = R_G^{SB} \\
&2K = \Pr\left(A_{iB} > R_B^{SB}\right) E\left(A_{iB} - R_B^{SB} | A_{iB} > R_B^{SB}\right) + E\left(A_{iG} - R_G^{SB}\right) \\
&\Pr\left(A_{iB} > R_B^{SB}\right) = a_{SB} = \frac{A - R_B^{SB}}{Az}
\end{aligned}$$

where R_B^{SB} and R_G^{SB} denote for consumers' claims on the corporate sector in the B-state and the G-state respectively. The solution to this program is independent of the exchange rate volatility,

[7] The same optimal portfolio choice arises in an economy where the default risk is independent of the currency risk. See Ize and Levy Yeyati (1998, 2003) for a model of asset substitution in these lines.

[8] This assumption can be interpreted as a reduced form of a model with specificity in production in which the entrepreneur can "divert" the project returns. See Hart and More (1998).

$\bar{v}$, as can be seen in the first order condition characterizing the Second Best allocation:

$$foc\left(R_B^{SB}\right) = \left[U'\left(c_B^c\right) - U'\left(c_G^c\right)\right] a_{SB} - U'\left(c_B^c\right) \frac{R_B^{SB}}{Az} = 0 \tag{2.21}$$

The first term in (2.21) corresponds to the marginal benefit of improving insurance, while the second term is its cost in terms of default risk. Improving smoothness requires greater payments from the corporate sector to consumers in the adverse realization, precisely when firms' revenues are lower. Thus, it increases the probability of default. Indeed, even though entrepreneurs are risk neutral and the credit market is competitive, insurance is costly. Since the corporate sector is protected by limited liability, it does not redistribute consumers' resources from the G-state to the B-state in actuarially fair basis. Instead, because a positive number of firms defaults in the B-state, for every unit of G-goods surrendered by the consumers, only a fraction is transformed into B-consumption. From (2.21), the cost of insurance increases in R_B^{SB}. Therefore, there is an optimal trade off between smoothness and maximization of consumption. The optimal allocation is always interior: neither perfect smoothness nor maximum expected consumption are optimal.

Can an economy with only dollar and peso denominated contracts reach the Second Best allocation?

The corporate sector's default risk is a function of the currency composition of debt. From (2.17), firm i decides to stay active and repay its debts in the B-state if its sensitivity towards the shock is smaller than the threshold value $a_B\left(v_i\right)$:

$$a_i \leq a_B\left(v_i\right) = \frac{A - v_i R_{ipB} - \left(1 - v_i\right) R_{idB}}{Az} \tag{2.22}$$

Dollarization increases the *vulnerability* of firms. That is, since dollar contracts involve larger payments in the bad state (and the opposite occurs for peso contracts), the default risk of a firm increases in the share of dollar denominated debt.

If firms have exclusive contractual relationships, investors can set debt contracts according to the firm's default risk. That is, the interest rate faced by each firm depends on its currency composition of debt. In this case, entrepreneurs are induced to hold a composition of debt

–i.e. a default risk– that is in line with consumers' preferences. All firms are ex-ante identical, therefore, the composition of debt is equal to the consumers' portfolio choice, $\forall i \in [0,1] : v_i = \mu$.

The decentralized equilibrium with dollar and peso assets replicates the following program:

$$\begin{aligned}
&\max_{R_B} U\left(c_B^c\right) + U\left(c_G^c\right) \\
&s.t. \\
&c_B^c = R_B \Pr\left(A_{iB} > R_B\right) \\
&c_G^c = R_G \\
&2K = \Pr\left(A_{iB} > R_B\right) E\left(A_{iB} - R_B | A_{iB} > R_B\right) + E\left(A_{iG} - R_G\right) \\
&\Pr\left(A_{iB} > R_B\right) = a_B = \frac{A - R_B}{Az} \\
&R_B \leq R_{dB}\left(v_i = 0, \delta\right) \\
&R_B \geq R_{pB}\left(v_i = 1, \delta\right)
\end{aligned}$$

$R_{pB}\left(v_i = 1, \delta\right)$ and $R_{dB}\left(v_i = 0, \delta\right)$ are specified in (2.14) and (2.15), and satisfy the free entry condition (2.20) for $v_i = 1$ and $v_i = 0$ respectively. Since $R_{pB}\left(v_i = 1, \delta\right) \leq R_{dB}\left(v_i = 0, \delta\right)$, the two constraints cannot be binding simultaneously.

The only difference between this program and the one characterizing the Second Best equilibrium results from the existence of short selling constraints. That is, consumers' real claims in the B-state can never be greater than the payments stipulated for dollar debt ($R_{dB}\left(v_i = 0, \delta\right)$). Similarly, consumers cannot reduce their claims below the payments specified in a fully peso denominated contract ($R_{pB}\left(v_i = 1, \delta\right)$). The Second Best allocation is therefore attained when these constraints are not binding.

When the set of instruments is restricted to dollar and peso assets, the optimal allocation is characterized by the following first order condition:

$$\begin{aligned}
foc\left(R_B | \delta\right) &: \left[U'\left(c_B^c\right) - U'\left(c_G^c\right)\right] a_B - U'\left(c_B^c\right) \frac{R_B}{Az} = \lambda_d - \lambda_p \qquad (2.23) \\
\lambda_d \geq 0 &: \lambda_d \left[R_B - R_{dB}\left(v_i = 0, \delta\right)\right] = 0 \\
\lambda_p \geq 0 &: \lambda_p \left[R_B - R_{pB}\left(v_i = 1, \delta\right)\right] = 0
\end{aligned}$$

where λ_d is the multiplier for the upper bound of R_B, and λ_p for its lower bound. Whenever the upper bound restriction binds ($\lambda_d > 0$), consumers are constrained in their demand for insurance. And, conversely, if they are constrained in their demand for peso assets ($\lambda_p > 0$), the level of insurance is above the Second Best optimum.

Notice that the short selling constraint can only be binding for low devaluation response. Augmenting the exchange rate volatility increases the contingent value of assets. Therefore, there is always a sufficiently large devaluation response (which I denote $\underline{\delta}_{SB}$) such that the equilibrium is interior and the Second Best allocation is attained. Combining (2.14), (2.15), and (2.20), $R_{pB}(v_i = 1, \delta)$ and $R_{dB}(v_i = 0, \delta)$ are uniquely determined by the devaluation response and satisfy:

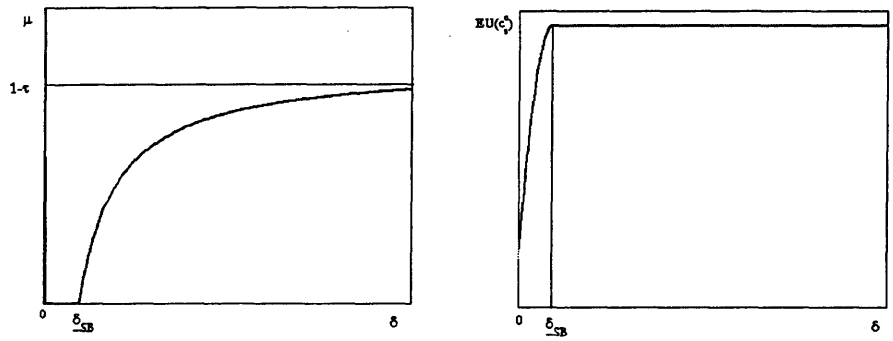
$$\frac{\partial R_{pB}}{\partial \delta} = -\frac{2\tau}{1 - a_{B1}}\delta < 0 \implies \frac{\partial \lambda_p}{\partial \delta} \leq 0$$
$$\frac{\partial R_{dB}}{\partial \delta} = \frac{2(1-\tau)}{1 - a_{B0}}\delta > 0 \implies \frac{\partial \lambda_d}{\partial \delta} \leq 0$$

where a_{B1} and a_{B0} correspond to the probabilities of default, defined in (2.22), for $v_i = 1$ and $v_i = 0$ respectively. The multipliers on the financial restrictions decrease in the exchange rate volatility. In this sense, monetary policy is understood as a tool for improving the efficiency of the credit market.

I am going to restrict the analysis to the case in which, for low devaluation response, consumers are constrained in their demand for insurance: $\lambda_d(\delta = 0) > 0$. That occurs if $r < R_B^{SB}$, where $r = r_d(\delta = 0) = r_p(\delta = 0)$ satisfies the free entry condition (2.20). Then, for low devaluation response, the credit market is fully dollarized and consumers are underinsured (see figure 2-2.a). In this case the equilibrium interest rate is pinned down from the free entry condition (2.20) for $v_i = 0$.

In the interior solution $(\delta \geq \underline{\delta}_{SB})$, the first order condition (2.23) is identical to the one characterizing the Second Best allocation (2.21). Dollar and peso assets can replicate the optimal contingent contract $\{R_B^{SB}, R_G^{SB}\}$. The decentralized solution for this program is implicitly given by $\mu \in (0,1)$ such that:

$$\mu(r_p - \tau\delta) + (1-\mu)(r_d + (1-\tau)\delta) = R_B^{SB} \tag{2.24}$$



a. Optimal Portfolio Composition

b. Consumers' Expected Utility

Figure 2-2: Exclusive Credit Contracts

The Second Best allocation is invariant to the size of the devaluation response. That implies that consumers' portfolio composition adjusts to changes in the devaluation response so to keep real claims on the corporate sector constant. Correspondingly, the default risk on peso and dollar assets is identical and independent of the exchange rate volatility.

The equilibrium interest rates satisfy the free entry condition (2.20) for $v_i = \mu$, and, at the margin, leave the consumers indifferent in their currency portfolio composition:

$$r_p - r_d = \theta\delta > 0 \tag{2.25}$$

where $\theta = \frac{U'(c_B^c)a_B - U'(c_G^c)}{U'(c_B^c)a_B + U'(c_G^c)}$ is a positive constant derived from the consumers' first order condition.[9]

For $\delta \geq \underline{\delta}_{SB}$, the share of peso denominated assets increases in the devaluation response.[10] Combining (2.24), (2.25), and (2.20), the portfolio composition that achieves the Second Best allocation is characterized by:

$$\frac{\partial\mu}{\partial\delta} = \beta\frac{(1-\tau-\mu)}{\delta} > 0$$

[9] θ is derived from the consumers' first order condition, recognizing that in the interior optimum ($\mu \in (0,1)$) the Second Best allocation is attained. Therefore, the optimal allocation is invariant to the devaluation response $\left(\frac{\partial c_B^c}{\partial\delta} = \frac{\partial c_G^c}{\partial\delta} = 0\right)$ and θ is constant.

[10] The opposite occurs if $r > R_B^{SB}$. For low δ, consumers are constrained in their demand for peso contracts: $\lambda_p(\delta = 0) > 0$. Then, $\mu(\delta = 0) = 1$ and $\frac{\partial\mu(\delta)}{\partial\delta} < 0$ for $\delta \geq \underline{\delta}_{SB}$. In this case, consumers have too much insurance and too little expected consumption for low values of δ.

where $\beta = \frac{U'(c_B^c)a_B + U'(c_G^c)}{U'(c_G^c)(1+a_B)}$ is a positive constant.

Notice that $\lim_{\delta \to \infty} \mu = 1 - \tau$ (see figure 2-2.a). The portfolio $\mu = 1 - \tau$ is neutral in the sense that real claims are not affected by the exchange rate response. When the contingent value of assets is very large, an infinitesimal deviation from this neutral portfolio suffices to achieve the optimal trade-off between insurance and maximization of consumption.

Consumers' expected utility is plotted in figure 2-2.b. The Second Best allocation is independent of the devaluation response δ, but can only be achieved for sufficient contingent value of assets.

The following proposition summarizes these findings:

Proposition 1 (Exclusive Contracts) *For a set of parameters $\{A, z, \tau, K\}$ and a given devaluation schedule $\delta_s \in \{\delta, -\delta\}$, with $\delta \geq 0$, the credit market equilibrium is characterized by:*

i) $\forall i \in [0,1] : v_i = \mu$

ii) $\lim_{\delta \to \infty} \mu(\delta) = 1 - \tau$

If, evaluated at $\delta = 0$, $[U'(c_B^c) - U'(c_G^c)]\, a_B - U'(c_B^c) \frac{\tau}{Az} > 0$. *Then:*

iii) $\forall \delta \leq \underline{\delta}_{SB} : \mu(\delta) = 0$

iv) $\forall \delta \geq \underline{\delta}_{SB} : \frac{\partial \mu(\delta)}{\partial \delta} > 0$

where $\underline{\delta}_{SB} : \lambda_d(\underline{\delta}_{SB}) = 0$ *and* $\delta < \underline{\delta}_{SB} : \lambda_d(\delta) > 0$

2.3.3 Limited Liability and Non-Exclusive Credit Contracts

When the corporate sector is protected by limited liability, the default risk depends on the currency composition of debt. Exclusive credit contracts can stipulate the composition of debt in line with the investor's preferences. However, if firms have non-exclusive contractual relationships and the terms of these contracts are not contractible, it is impossible for a single investor to enforce a certain currency composition of debt.[11] This is the natural environment to analyze the problem of domestic dollarization since atomistic lenders can hardly impose exclusive contracts on firms. Then, entrepreneurs cannot commit to maintain the composition

[11] See Bisin and Guaitoli (2002) and Arnott and Stiglitz (1991) for models of moral hazard with multiple contractual relationships.

of liabilities agreed with the original investors. Instead, they have incentives to pursue an unduly currency risk relative to the consumers' preferences. I this case, the probability of bankruptcy of firms with dollar liabilities increases in the exchange rate volatility.[12] Dollar contracts inherit the firms' default risk and their ability to provide insurance is jeopardized. As before, the size of the devaluation response determines the contingency value of assets, now also the magnitude of dollar assets' default risk.

Entrepreneurs

Entrepreneurs choose the currency composition of debt $v_i \in [0,1]$ to maximize expected consumption:

$$\begin{aligned}
&\max_{0\leq v_i\leq 1} E\left(c^e_{is}\right) = \Pr\left(c^e_{iB} > 0\right) E\left(c^e_{iB}|c^e_{iB} > 0\right) + E\left(c^e_{iG}\right) \\
&s.t. \\
&E\left(c^e_{iB}|c^e_{iB} > 0\right) = A\left(1 - 1/2a_B\left(v_i\right)z\right) - v_iR_{ipB} - \left(1 - v_i\right)R_{idB} \\
&E\left(c^e_{iG}\right) = A\left(1 + 1/2z\right) - v_iR_{ipB} - \left(1 - v_i\right)R_{idG}
\end{aligned}$$

Default is assumed to occur only in the B-state, in which case the probability of remaining active is a function of the composition of debt, $\Pr\left(c^e_{iB} > 0\right) = a_B\left(v_i\right)$, defined in (2.22).[13]

At date 1, when credit contracts are set, firms only differ in their chosen composition of debt. However, firms cannot commit to maintain the specified share of dollar debt, thus credit contracts cannot be set as a function of v_i. As a result, R_{ips} and R_{ids} are not firm specific and entrepreneurs face a convex objective function:

$$\frac{\partial^2 E\left(c^e_{is}\right)}{\partial v_i^2} = \frac{1}{Az}\left[\left(r_d - r_p + \delta\right)^2 + \left(r_d - r_p - \delta\right)^2\right] > 0$$

Entrepreneurs have incentives to incur undue currency risk relative to consumers' preferences. Firms hold extreme composition of liabilities, either entirely denominated in pesos ($v_i = 1$) or

[12] See Galiani et al. (2003), Bleakley and Cowan (2002), Martinez and Werner (2002), and Aguiar (2002) for different estimations of currency mismatches in the Latin American corporate sector.

[13] The same parametric restriction imposed in the previous subsection assures that default only happens in the B-state for all relevant values of $\delta : K \leq Az \leq 2K$

dollars ($v_i = 0$).[14]

Because firms with only peso debt have lower financial obligations in the B-state, they are less exposed to the aggregate shock than dollarized firms. From (2.22), the vulnerability gap heightens in the exchange rate volatility.

The equilibrium interest rate is the one that induces the corporate sector to issue debt according to consumers' demand for dollar and peso assets. As long as consumers diversify their portfolio composition, firms with dollar and peso debt must coexist. Thus, the equilibrium interest rate is the one that leaves firms indifferent between the two extremes of debt composition:

$$E\left(c_{is}^{e}|v_i = 1, r_p\right) = E\left(c_{is}^{e}|v_i = 0, r_d\right) \tag{2.26}$$

and the free entry condition (2.20) is satisfied.

The peso interest rate is always lower than dollar interest rate. Since peso denominated contracts involve greater claims in the state with higher probability of repayment, entrepreneurs are only willing to accept them at a lower interest rate. The opposite occurs with dollar denominated contracts.

$$\begin{aligned} \frac{\partial r_p}{\partial \delta} &= -\tau \frac{1 - a_{B1}}{1 + a_{B1}} < 0 \\ \frac{\partial r_d}{\partial \delta} &= (1 - \tau) \frac{1 - a_{B0}}{1 + a_{B0}} > 0 \end{aligned} \tag{2.27}$$

where a_{B1} and a_{B0} are the probabilities of remaining active for firms with $v_i = 1$ and $v_i = 0$ respectively.

Summing up, entrepreneurs do not diversify the currency composition of debt. Firms with different currency composition of debt can coexist as long as the indifference condition (2.26) is satisfied, in which case, the proportions of each type of firm are determined by the demand side.

Credit Market Equilibrium

Consumers choose the portfolio composition $\mu \in [0, 1]$ to maximize their expected utility

[14] Chamon (2001) and Broda and Levy-Yeyati (2003) also find that *currency-blind* credit contracts incentive entrepreneurs (or banks) to excessive currency risk.

(2.12) subject to their budget constraint. Entrepreneurs are protected by limited liability so the return on assets inherits their default risk. Moreover, because the vulnerability of dollarized firms and those with only peso liabilities are different, so are the probabilities of default associated with the respective credit contracts. Consumers diversify away the idiosyncratic risk and the law of large numbers holds. Hence, the proportion of performing peso denominated contracts (resp. dollar) is equal to the probability that firms with only peso debt (resp. dollar) remain active.

In the presence of non-exclusive contractual relationships, firms cannot commit to a certain currency composition of debt. Therefore, the interest rates faced by each firm cannot be set as a function of the currency composition of debt. Instead, they are determined by the free entry condition (2.20) for $v_i = 0$ and $v_i = 1$ respectively. Moreover, consumers cannot have long positions of dollar or peso assets. Then, the credit market equilibrium is characterized by the following program:

$$\begin{aligned}
&\max_{\mu} U\left(c_B^c\right) + U\left(c_G^c\right) \\
&s.t. \\
&c_B^c = \mu R_{pB} \Pr\left(A_{iB} > R_{pB}\right) + (1-\mu) R_{dB} \Pr\left(A_{iB} > R_{dB}\right) \\
&c_G^c = \mu R_{pG} + (1-\mu) R_{dG} \\
&2K = \Pr\left(A_{iB} > R_{pB}\right) E\left(A_{iB} - R_{pB} | A_{iB} > R_{pB}\right) + E\left(A_{iG} - R_{pG}\right) \\
&2K = \Pr\left(A_{iB} > R_{dB}\right) E\left(A_{iB} - R_{dB} | A_{iB} > R_{dB}\right) + E\left(A_{iG} - R_{dG}\right) \\
&\mu \leq 1 \\
&\mu \geq 0
\end{aligned}$$

where $\Pr\left(A_{iB} > R_{pB}\right) = a_{B1}$ and $\Pr\left(A_{iB} > R_{dB}\right) = a_{B0}$.

The credit market currency composition is given the first order condition:

$$\begin{aligned}
foc\left(\mu|\delta\right) &: U'\left(c_B^c\right)\left[a_{B1} R_{pB} - a_{B0} R_{dB}\right] + U'\left(c_G^c\right)\left[R_{pG} - R_{dG}\right] = -\lambda_d + \lambda_p \\
\lambda_d \geq 0 &: \lambda_d \mu = 0 \\
\lambda_p \geq 0 &: \lambda_p (1-\mu) = 0
\end{aligned}$$

where λ_d and λ_p are the multipliers for the lower and the upper bound of μ respectively.

As it was explained above, firms choose not to diversify the composition of liabilities. Then, default probabilities of dollar and peso assets are different. From (2.22), the default risk on dollar assets increases in the exchange rate volatility, while the probability of default of peso assets declines in δ. In the presence of non-exclusive contractual relationships, the size of the devaluation response not only affects the contingency value of assets, but also the default risk on dollar and peso contracts.

In the limit when $\delta = 0$, the optimal portfolio coincides with the equilibrium described in the previous subsection, that is, consumers are constrained in their demand for dollar assets ($\lambda_d > 0$). Indeed, in the limit when $\delta = 0$, the first order condition coincides with (2.23):

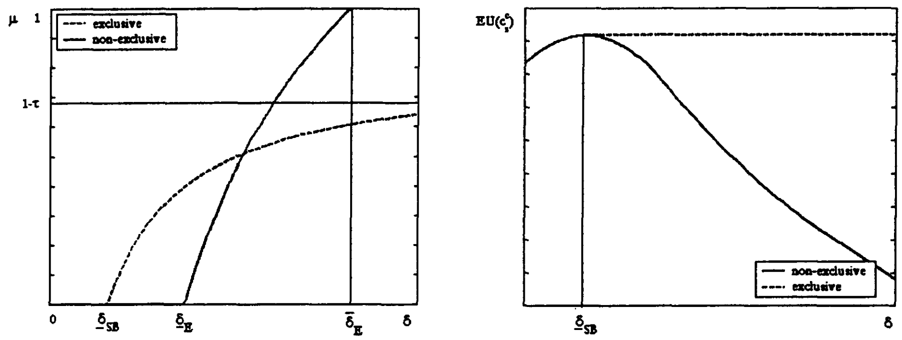
$$\lim_{\delta \to 0^+} foc(\mu|\delta) = -\left[U'(c_B^c) - U'(c_G^c)\right] a_B + U'(c_B^c)\frac{r}{Az} < 0 \tag{2.28}$$

where $r = r_d(\delta = 0) = r_p(\delta = 0)$ satisfies the free entry condition (2.20) and $a_B = a_{B1}(\delta = 0) = a_{B0}(\delta = 0)$.

For low devaluation response, the credit market equilibrium is identical to the one under exclusive contracts. The intuition is simple, for $\delta \leq \underline{\delta}_{SB}$ ($\underline{\delta}_{SB}$ is defined in proposition 1), consumers are constrained in their demand for dollar assets. In both cases, the credit market is fully dollarized ($\mu = 0$) and the interest rate is given by the free entry condition (2.20) for $v_i = 0$. It follows that the probability of default for dollar assets in both cases is also equal.

However, for $\delta > \delta_{SB}$, the optimal allocation requires diversified composition of liabilities. When firms have non-exclusive contractual relationships, they choose extreme currency composition. Therefore, the default risk on dollar assets is excessive relative to consumers' preferences: $a_{B0} < a_{SB}$, where a_{SB} corresponds to the probability of default in the Second Best optimum. This reduces the ability of dollar assets to insure against the aggregate shock. Consumers demand larger quantity of such assets to attain the required level of insurance. Hence, the credit market remains entirely dollarized for higher devaluation response relative to the case with exclusive contracts: $\forall \delta \in [0, \underline{\delta}_E] : \mu(\delta) = 0$, where $\underline{\delta}_E > \underline{\delta}_{SB}$. These results are plotted in figure 2-3.a.

The fact that entrepreneurs cannot commit to diversify the currency composition of debt



a. Optimal Portfolio Composition

b. Consumers' Expected Utility

Figure 2-3: Exclusive and Non-Exclusive Contractual Relationships

is inefficient. Entrepreneurs' expected utility is always given by the free entry condition, irrespectively of the contractual arrangement. However, consumers are worse off in this scenario. Indeed, because the default on dollar assets is above optimum, consumers are underinsured against the aggregate shock.

The magnitude of this inefficiency increases in the size of the devaluation response, following the risk of default of dollar assets. In fact, when δ is sufficiently large, the default risk on dollar assets is so significant that they fail to insure against the aggregate shock. Consequently, there is a large enough exchange rate volatility (which I denote $\overline{\delta}_E$), such that the optimal portfolio is entirely composed of peso assets $(\lambda_p > 0)$. See figure 2-3.a.

In contrast to the case with exclusive contracts, here the magnitude of the devaluation response always has real effects. Figure 2-3.b plots the impact of δ on consumers' expected utility. For $\delta < \underline{\delta}_{SB}$ the contingent value of dollar assets is insufficient to replicate the Second Best contract and consumers are underinsured. Thus, consumers' welfare increases in the devaluation response. For $\delta > \underline{\delta}_{SB}$ the equilibrium with non-exclusive credit contracts departs from the Second Best allocation because dollar assets have reduced insurance capacity. The default risk on dollar assets increases in the volatility of the exchange rate and, consequently, consumers' welfare declines in the size of the devaluation response.

These findings are summarized in the following proposition

Proposition 2 (Non-Exclusive Contracts) *For a set of parameters*

$\{A, z, \tau, K\}$ and a given devaluation schedule $\delta_s \in \{\delta, -\delta\}$, with $\delta \geq 0$, the credit market equilibrium is characterized by:

i) $\{v_i\}_{i=0}^{\mu} = 1$ and $\{v_i\}_{i=\mu}^{1} = 0$

If, evaluated at $\delta = 0$, $[U'(c_B^c) - U'(c_G^c)]\, a_B - U'(c_B^c)\frac{r}{Az} > 0$. Then·

ii) $\forall \delta \leq \underline{\delta}_E : \mu(\delta) = 0$

where $\underline{\delta}_E : \lambda_d(\underline{\delta}_E) = 0$ and $\delta < \underline{\delta}_E : \lambda_d(\delta) > 0$

iii) $\forall \delta \geq \overline{\delta}_E : \mu(\delta) = 1$

where $\overline{\delta}_E : \lambda_p(\overline{\delta}_E) = 0$ and $\delta > \overline{\delta}_E : \lambda_p(\delta) > 0$

2.3.4 Discussion

In the last decade many economies succeeded in controlling inflationary risk. The process of stabilization often involved imposing limitations on the monetary authority's discretion, either because the exchange rate was used as an anchor for prices in the process of disinflation, or because the monetary authority's misconduct and lack of credibility were the main sources of inflationary risk. Therefore, the reduction in monetary policy discretion and inflationary risk were often simultaneous.

The current concern in these economies is not so much with inflationary risk, but with their vulnerability with respect to aggregate shocks –namely sudden stops, changes in the international price of commodities, international interest rates, etc. And, correspondingly, the main factor behind the volatility of consumption is the risk of recessions.

If, as suggested here, insurance against the risk of recession is the motive behind the demand for foreign currency denominated assets, the lack of response of the monetary policy towards the aggregate shock exacerbates the dollarization of the economy. In other words, in economies characterized by their underinsurance against aggregate shocks, we would expect high levels of dollarization to coexist with low volatility of nominal variables.

Moreover, because firms have non-exclusive credit contracts, the currency composition of debt is not contractible. Entrepreneurs pursue an unduly risky currency strategy. In this case, dollarized firms are too exposed to exchange rate volatility.

The natural question that arises from this discussion is related to the role of the monetary authority. Indeed, the devaluation response is the key variable dictating the ability of dollar and peso assets to replicate a complete set of financial instruments. The next section analyzes the optimal devaluation policy in the context of a credit market with non-exclusive contractual relationships.

2.4 Policy Equilibrium

When firms have non-exclusive contractual relationships they cannot commit to diversify the currency composition of their liabilities. In this case, the size of the devaluation response to aggregate shocks always has real effects. For low exchange rate volatility, dollar assets have insufficient contingent value and the optimal trade-off between insurance and maximization of consumption cannot be achieved. On the other hand, a large devaluation response results in excessive default risk on dollar assets. Then, the ability of dollar denominated contracts to insure against the aggregate shock is jeopardized and consumers end up underinsured.

A committed and credible Central Bank that maximizes consumers' welfare can still push the economy towards the Second Best equilibrium. The optimal monetary policy under full commitment results from maximizing consumers' expected utility before the credit contracts are set. Then, the Central Bank chooses δ internalizing its impact on the currency composition of contracts and the equilibrium interest rates:

$$\max_{\delta} EU\left(c_s^c\right)$$

$$s.t.$$

$$\begin{aligned} c_B^c &= \mu a_{B1} R_{pB} + (1-\mu)\, a_{B0} R_{dB} \\ c_B^c &= \mu R_{pG} + (1-\mu)\, R_{dG} \\ K &= E\left(c_{is}^e | v_i = 1, r_p\right) \\ K &= E\left(c_{is}^e | v_i = 0, r_d\right) \end{aligned}$$

where R_{ps} and R_{ds} are the real claims on dollar and peso denominated contracts given by equations (2.14) and (2.15). And a_{B1} and a_{B0} are the probabilities of default on peso and dollar assets.

Under full commitment, the Central Bank can push the economy towards the Second Best equilibrium. If it announces $\delta = \underline{\delta}_{SB}$, the credit market equilibrium is characterized by full dollarization: $\forall i \in [0,1] : v_i = \mu = 0$. At $\mu = 0$ and $\delta = \underline{\delta}_{SB}$, the Second Best allocation is achieved and consumers reach the optimal trade-off between smoothness and maximization of consumption.

However, a time-inconsistent monetary authority will not implement this ex-ante optimal devaluation response. In what follows, I assume that the exchange rate intervention occurs after the credit contracts have been set. Taking the portfolio currency composition and the market interest rates as given, the Central Bank chooses a devaluation response that maximizes consumers' expected utility. Then, the Central Bank will not follow the promised devaluation response $\delta = \underline{\delta}_{SB}$. The Second Best allocation will not be attained as the ex-ante optimal devaluation response is time inconsistent.

The mechanism presented here is in line with the common agency problem developed in Tirole (2003). Government is a common agent of all consumers, and its incentives depend on a representative local investor's portfolio, but not on a single investor's choice. Then, consumers exert externalities on each other through their impact on the Central Bank's incentives.

Definition 2 (Policy Equilibrium) *The Policy (subgame perfect) Equilibrium is a set* $\left\{r_d, r_p, \mu, \{v_i\}_{i=0}^{1}, \delta\right\}$ *such that:*

i) $\left\{r_d, r_p, \mu, \{v_i\}_{i=0}^{1}\right\}$ *is a Domestic Credit Market Equilibrium with non-exclusive contracts given a devaluation schedule* $\delta_s \in \{\delta, -\delta\}$.

ii) The devaluation schedule $\delta_s \in \{\delta, -\delta\}$, *with* $\delta \geq 0$, *maximizes consumers' utility (2.12) subject to their budget constraint, for a given Domestic Credit Market Equilibrium with non-exclusive contracts* $\left\{r_d, r_p, \mu, \{v_i\}_{i=0}^{1}\right\}$.

2.4.1 Optimal Policy

I assume that the Central Bank follows an inflation targeting rule. That is, the Central Bank is committed to a certain expected inflation. Instead, it chooses a devaluation response to the aggregate shock. As it was explained in section 2, devaluation bias does not affect the results presented here but only deviations from expectations. For that reason, I am restricting the analysis to devaluation responses of the form $\delta_s \in \{\delta, -\delta\}$. Moreover, I assume that the Central Bank is constrained to nonnegative devaluation response if the adverse realization of the shock occurs –i.e. $\delta \geq 0$. This is a reduced form of a model where devaluation has, additionally, an expansionary effect on the economy. In the appendix I extend the model to include a devaluation expansionary effect that endogenizes the lower bound for the optimal devaluation in the B-state.

The monetary authority intervenes in the exchange rate market after credit contracts have already been set. Given a credit market equilibrium $\left\{r_p, r_d, \mu, \{v_i\}_{i=0}^{1}\right\}$, the Central Bank chooses $\delta \geq 0$ to maximize consumers' expected utility:

$$\begin{aligned} & \max_{\delta \geq 0} EU\left(c_s^c\right) \\ & s.t. \\ c_B^c &= \mu a_{B1} R_{pB} + (1-\mu)\, a_{B0} R_{dB} \\ c_G^c &= \mu R_{pG} + (1-\mu)\, R_{dG} \end{aligned}$$

where R_{ps} and R_{ds} are the real return on dollar and peso denominated assets, given by equations (2.14) and (2.15). The probabilities of default for peso and dollar assets, a_{B1} and a_{B0}, are given by (2.22) for $v_i = 1$ and $v_i = 0$ respectively.

Devaluation is used to redistribute resources between the corporate sector and consumers across different states of nature. If credit contracts are mainly denominated in pesos, an increase in the devaluation response redistributes –through its effect on the inflation rate– consumers' resources from the B-state to the G-state. This makes consumption schedule more uneven, but increases expected consumption as reduces the corporate sector's default risk. Devaluation has the opposite effect on the schedule of payments of dollar denominated contracts.

Because at the time of the intervention credit contracts have already been set, the devaluation response does not alter the credit market currency composition or the interest rates. However, the Central Bank's optimal policy feeds back into borrowers' and lenders' ex-ante devaluation expectation. This, in turn, determines the currency denomination of contracts and the market interest rates for peso and dollar debt in (2.27). As a result, from an ex-ante perspective, the Central Bank's optimal devaluation response is biased against insurance.

The Central Bank's bias can be seen in the first order condition, evaluated at $\delta = 0$. The first term corresponds to the marginal benefit of improving insurance while the second term is its cost in terms of expected consumption. Indeed, the Central Bank's first order condition departures from the consumers' (equation (2.28)) in its undervaluation of smoothness.

$$foc\,(\delta = 0|\mu) = \left[U'\left(c_B^c\right)a_B - U'\left(c_G^c\right)\right] - U'\left(c_B^c\right)\frac{r}{Az} \tag{2.29}$$

where $r = r_d\,(\delta = 0) = r_p\,(\delta = 0)$ and $a_B = a_{B1}\,(\delta = 0) = a_{B0}\,(\delta = 0)$.

If (2.29) is positive, the policy intervention improves consumers' insurance. However, given the Central Bank's excessive incentive to reduce the number of defaulting firms, the magnitude of the response is insufficient to reach the Second Best allocation. If the market is heavily dollarized, the Central Bank's interior optimum is achieved by increasing the devaluation response, which improves the contingency of dollar assets against the aggregate risk. Improving insurance is not possible when credit contracts are mainly denominated in pesos because the Central Bank is constrained to nonnegative devaluations in the B-state. In this case, the best the monetary authority can do is to minimize the exchange rate volatility and preserve the real value of peso claims.

On the other hand, if (2.29) is negative, the optimal monetary policy lowers the number of defaulting firms. That is, monetary intervention reduces consumers' insurance. Then, the exchange rate volatility is minimized when the credit market is heavily dollarized, in order to avoid the negative effect on firms' balance sheet.[15] The Central Bank's interior optimum is attained if credit contracts are mainly denominated in the domestic currency.[16] That is, a countercyclical monetary policy diminishes peso claims in the B-state. This reduces the default risk, at the expense of lower insurance.

Proposition 3 *For a set of parameters $\{A, z, \tau, K\}$ and a given Credit Market Equilibrium $\left\{r_d, r_p, \mu, \{v_i\}_{i=0}^{1}\right\}$, the optimal devaluation schedule of the form $\delta_s \in \{\delta, -\delta\}$, with $\delta \geq 0$, satisfies:*

[15] For $\mu < \overline{\mu}$, increasing expected consumption would require a revaluation in the B-state. This possibility was ruled out by assumption. The appendix presents an extension with nominal rigidities in which devaluation has an expansive effect on output and the impossibility of revaluation in the B-state arises endogenously.

[16] Qualitatively the same results arise if the Central Bank seeks to minimize the gap between output and an ideal target. The optimal policy is not to float the exchange rate if the corporate sector is heavily dollarized, and the monetary policy is very countercyclical if credit contracts are denominated in pesos.

If (2.29) is positive:

i) $\forall \mu < \underline{\mu} : \delta(\mu) > 0$ *and* $\frac{\partial \delta(\mu)}{\partial \mu} < 0$

ii) $\forall \mu > \underline{\mu} : \delta(\mu) = 0$

where $\underline{\mu} \in (0, 1 - \tau)$ *satisfies* $foc(\delta = 0|\underline{\mu}) = 0$

If (2.29) is negative:

i) $\forall \mu < \overline{\mu} : \delta(\mu) = 0$

ii) $\forall \mu > \overline{\mu} : \delta(\mu) > 0$ *and* $\frac{\partial \delta(\mu)}{\partial \mu} > 0$

where $\overline{\mu} \in (1 - \tau, 1)$ *satisfies* $foc(\delta = 0, \overline{\mu}) = 0$.

Proof. Follows from differentiating $foc(\delta|\mu) = 0$, recognizing that, in the interior CB's optimum, consumption in the two states are independent of $\mu : \frac{\partial c_B^c}{\partial \mu} = \frac{\partial c_G^c}{\partial \mu} = 0$. ■

2.4.2 Policy Equilibrium

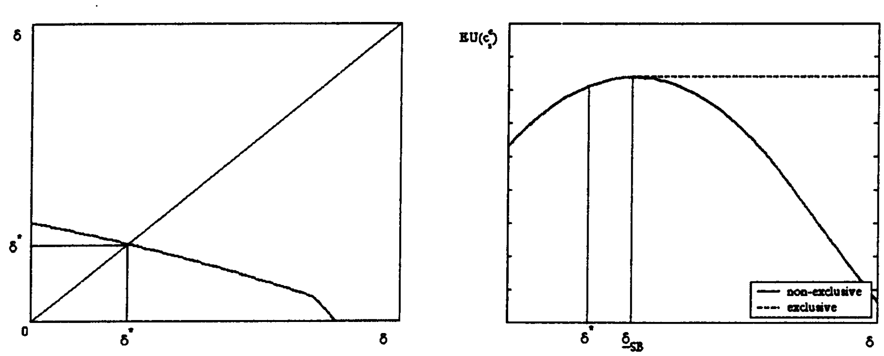
At the time of the monetary intervention, credit contracts have already been set. Then, the degree of dollarization and the market interest rates determine the Central Bank's optimal policy. The ex-post optimal policy feeds back into the credit market expectations and maps into a credit market equilibrium. In the lines of Kydland and Prescott (1977) and Barro and Gordon (1983), the policy equilibrium is the set of fixed points for which the market foreseen devaluation response coincides with the ex-post Central Bank's optimum:

$$\delta^* \left(\mu(\delta^e), r_p(\delta^e), r_d(\delta^e), \{v_i(\delta^e)\}_{i=0}^1 \right) = \delta^e$$

where δ^e corresponds to the market expectations and δ^* is the optimal Central Bank devaluation response. The fixed points correspond to the time consistent Central Bank's policies.

Because at the time of the intervention, the credit contracts have already been set, the Central Bank's incentives are distorted against smoothness of consumption. The quality of the distortion depends on the sign of equation (2.29) and will determine characteristics of the policy equilibrium set.

If (2.29) is positive, the Central Bank improves consumption smoothness by increasing the contingent value of dollar assets. However, because of its bias against insurance, the exchange rate intervention is insufficient to achieve the Second Best allocation. In this case, there is



a. Unique Policy Equilibrium

b. Consumers' Expected Utility

Figure 2-4: Unique Policy Equilibrium

a unique equilibrium characterized by full dollarization of the credit market and positive but suboptimal devaluation response.

Combining propositions 2 and 3, monetary policy reduces the devaluation response in the share of peso denominated contracts and, correspondingly, the credit market becomes more dollarized as the exchange rate volatility decreases. Therefore, the only stable equilibrium involves full dollarization. In that case, because of the Central Bank's lack of commitment, the devaluation response is always suboptimal, that is, $\delta^* < \underline{\delta}_{SB}$ (see figure 2-4).

More interesting is the case in which (2.29) is negative. In this case, the Central Bank pushes the economy towards a reduction of insurance. A complementarity arises between the credit market currency composition, described in proposition 2, and the optimal monetary policy, characterized by proposition 3.

When the credit market is mainly composed of peso assets ($\mu > \overline{\mu}$ in proposition 3), the Central Bank chooses an excessive devaluation response relative to the optimum under full commitment –under full commitment the monetary authority would internalize the negative effect of δ on the equilibrium peso interest rate in (2.27). As a result, consumers exacerbate their preference towards peso denominated contracts. From proposition 2, because dollarized firms cannot bear large exchange rate volatility, the default risk on dollar assets is excessive. The market's reaction is to increase the share of peso denominated assets, reinforcing the motive for a countercyclical monetary policy.

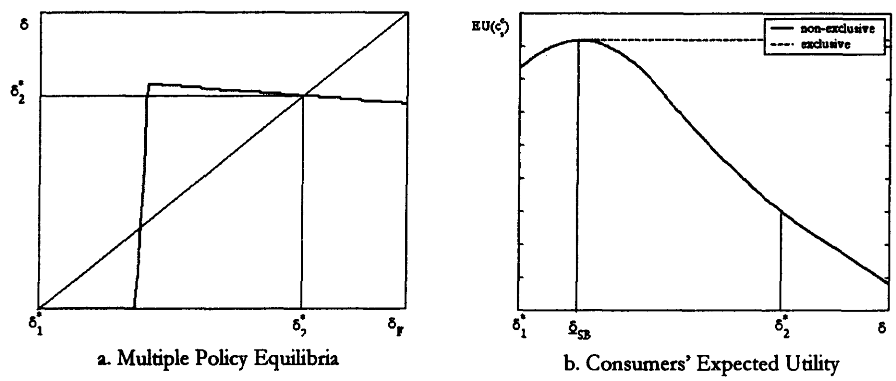


Figure 2-5: Multiple Policy Equilibria

Correspondingly, when the credit market is heavily dollarized ($\mu < \overline{\mu}$ in proposition 3), the Central Bank minimizes the exchange rate volatility, departing from the optimal policy under full commitment –a committed monetary authority would internalize the positive effect of δ on the equilibrium interest rate on dollar debt in (2.27). From proposition 2, the credit market intensifies its degree of dollarization when the devaluation response is low, which exacerbates the monetary lack of response.

As a consequence, there are potentially two stable equilibria: one with low dollarization and excessive exchange rate volatility and another with full dollarization and no devaluation response (see figure 2-5.a).

Consumers are underinsured in both equilibria. However, if the economy is fully dollarized, the Central Bank is constrained in its attempt to further reduce smoothness. On the other hand, when credit contracts are mainly denominated in pesos, the monetary authority succeeds in implementing its unconstrained optimum. That is, the monetary intervention reduces consumers' insurance. In this equilibrium, dollar assets have excessive default risk in the B-state and therefore fail to provide insurance. Moreover, since monetary policy is highly countercyclical, the return on peso assets in the two states is extremely uneven. As a result, consumers are unambiguously better off in the equilibrium with full dollarization (see figure 2-5.b).

These findings are summarized in the following proposition

Proposition 4 *For a set of parameters* $\{A, z, \tau, K\}$*, the Policy Equilibrium satisfies:*

If, evaluated at $\delta = 0, \frac{U'(a_B r)}{U'(r)}\left[a_B - \frac{r}{Az}\right] > 1$, *there is a unique Policy Equilibrium that satisfies:*

i) $\forall\ i \in [0,1] : v_i = \mu = 0$

ii) $\delta^* \in (0, \underline{\delta}_{SB})$

If, evaluated at $\delta = 0$, $a_B < \frac{U'(a_B r)}{U'(r)}\left[a_B - \frac{r}{Az}\right] < 1$, *there are potentially two stable Policy Equilibria:*

i) Full dollarization equilibrium:

$\forall i \in [0,1] : v_i = \mu = 0$

$\delta_1^* = 0$

ii) Low dollarization equilibrium:

$\forall i \in [0,1] : \{v_i\}_{i=0}^{\mu} = 1, \{v_i\}_{i=0}^{\mu} = 0,\ \ \mu \in (1-\tau, 1]$

$\delta_2^* > \underline{\delta}_E$

iii) Full dollarization equilibrium always exists

2.4.3 Discussion

When insurance against the risk of recession is the motive behind dollarization, consumers are better off under full dollarization than with high share of peso denominated contracts. The intuition is simple: if consumers hold peso denominated assets, the monetary authority can pursue a countercyclical policy. The monetary authority has incentives to reduce the number of defaulting firms below the ex-ante consumers' optimum. Hence, the optimal policy increases the volatility of the return on savings. On the other hand, in the full dollar equilibrium, real value of savings is preserved during recessions, when investors value them the most.

An important caveat must be made. In an attempt to emphasize the interplay between credit market currency composition and the optimal monetary policy, the framework was simplified to only include agents participating in the domestic financial market. However, concerns regarding dollarization arise from its consequences in terms of output volatility.

In the model presented here, the equilibrium with low dollarization enables the Central Bank to pursue a countercyclical policy, which reduces the impact of aggregate shocks on output. Conversely, in the full dollarization equilibrium, output volatility attains its maximum.

In this case, monetary policy is incapable of reducing the number of defaulting firms.[17]

Although beyond the scope of this paper, there are many welfare losses associated with output volatility, especially related to employment and investment. Not surprisingly, the current debate in many of these countries is centered on the "de-dollarization" dilemma.[18] This model, by explaining the reasons underlying the dollarization of domestic credit contracts, offers some insights to this debate:

1. If, as emphasized here, an insurance motive generates demand for dollar assets, the coupling of low inflationary risk with a large share of dollar liabilities is not surprising. The interplay between the currency denomination of contracts and the optimal devaluation response can explain the persistence in the share of dollar denominated debt.

2. Entrepreneurs have incentives to incur undue currency risk. As long as firms have non-exclusive credit relationships, they cannot commit to diversify the composition of liabilities. Non contractibility of currency denomination of debts underlies the excessive vulnerability of dollarized firms to exchange rate volatility. Moreover, it reduces the ability of dollar assets to hedge against the risk of recession and exacerbates consumers' underinsurance.

3. Monetary policy functions both as an ex-ante incentive device and as an ex-post redistributive tool between consumers and entrepreneurs. The juxtaposition of functions causes the monetary policy's time inconsistency. Although the promise of a countercyclical monetary policy might induce a less dollarized credit market, it is not credible. Once the market is dollarized, the Central Bank will find it optimal to reduce the volatility of the exchange rate.[19] The goal is then to separate these two functions, incorporating in the debate on "de-dollarization" either fiscal considerations aimed to include a different redistributive tool, or corrective distortions in the return on assets so lenders and borrowers internalize the effects of their currency choice.

[17] If the Central Bank's objective function is in terms of the output gap instead of consumers' utility, the policy equilibrium is qualitatively equivalent to the one characterized in proposition 4, for $\frac{U'(a_B r)}{U'(r)}\left[a_B - \frac{r}{Az}\right] \in (a_B, 1)$.

[18] See the Conference on "Financial Dedollarization: Policy Options" Washington: InterAmerican Development Bank, 2003.

[19] See Caballero and Krishnamurthy (2002) for a model in which a countercyclical monetary policy also functions as an ex-ante incentive device and presents similar time inconsistency problems.

2.5 Robustness of the full dollar equilibrium

2.5.1 Persistence in the share of dollar liabilities

The model presented here explains why the share of dollar denominated credit contracts remains high in economies that succeeded in controlling inflation. Moreover, in the context of this framework, it can also be explained why many of these heavily dollarized economies often have a history of important inflationary episodes.

The easiest way to analyze the implications of changes in the inflationary risk is by introducing a mean preserving spread over the inflation rate in (2.11). To focus on pure monetary disturbances, I assume that the relative price of tradables and non-tradables is not affected by the inflationary risk:[20]

$$\begin{aligned} \pi_s &= \tau\delta_s + \varepsilon \\ \delta_s - \pi_s &= (1-\tau)\,\delta_s \\ \varepsilon &: N\left(0, \sigma_\varepsilon^2\right) \end{aligned}$$

Inflationary risk does not affect real returns on dollar assets. They are still given by the real claims on contracts (2.15) and the probability of repayment in the B-state a_{B0}, defined in (2.22) for $v_i = 0$. On the other hand, inflationary risk has an impact on real return on peso assets. Both real claims on contracts and their default risk are affected:

$$R_{ps} = \begin{cases} r_p - \tau\delta - \varepsilon & s = B \\ r_p + \tau\delta - \varepsilon & s = G \end{cases} \tag{2.30}$$

$$\Pr\left(A_{iB} > R_{pB}\right) \equiv a_{B1} = \frac{A - R_{pB} + \varepsilon}{Az} \tag{2.31}$$

A mean preserving spread over inflation increases the demand for dollar denominated assets for any given devaluation response. Indeed, expected return of peso assets decreases in the

[20] Normalizing the mean of the noise to zero is not a crucial assumption as the interest rate in pesos (r_p) collects any expected inflation bias.

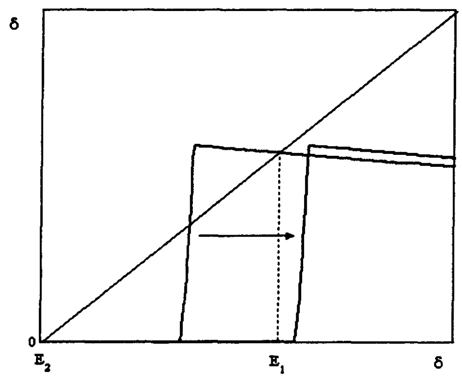


Figure 2-6: Increase in Inflationary Risk

inflationary risk (σ_ε) and its variance is larger. From (2.30) and (2.31):

$$\frac{\partial E\left(\Pr\left(A_{is} > R_{ps}\right) R_{ps}\right)}{\partial \sigma_\varepsilon} < 0$$

$$\frac{\partial Var\left(\Pr\left(A_{is} > R_{ps}\right) R_{ps}\right)}{\partial \sigma_\varepsilon} > 0$$

where $\Pr\left(A_{is} > R_{ps}\right)$ is the probability of repayment of peso assets in the s-state.

The high peso-share equilibrium disappears for large enough inflation variance while the full dollar equilibrium is robust as long as the condition in proposition 4 is satisfied.

An episode of large inflation volatility can trigger a jump into the complete dollarized credit market equilibrium (see figure 2-6). Once the credit contracts are fully denominated in foreign currency, the optimal policy is to reduce the devaluation response to aggregate shocks, which perpetuates consumers' preference towards dollar assets. This equilibrium is stable even if the mean preserving spread over inflation rate disappears or, in other words, reducing inflationary risk will not make the market jump back to the low dollar-share equilibrium.

Summing up, during episodes of high inflationary risk, borrowers and lenders denominate their credit contracts in a more stable unit, typically dollars. However, once inflation is controlled and the countercyclicality of monetary policy is diminished, the motive behind demand for dollar assets changes. Dollar assets are now demanded for their contingency against the risk of recessions. In these economies, characterized by imperfect financial markets, dollar assets are the natural substitute for the missing contracts precisely because dollar instruments are in place from the time of large inflationary risk.

2.5.2 The introduction of CPI-indexed bonds

In the debate on "de-dollarization" it has been often recommended the introduction of CPI-indexed bonds.[21] Indeed, if dollar denominated domestic assets are demanded as an insurance against inflationary risk, consumers should substitute their holdings of dollar denominated assets for CPI-indexed bonds. However, the fact that inflation indexed credit instruments are not demanded over dollar denominated assets suggests that the underlying problem is not fear of surprise inflation. Once inflationary risk is not the main source of volatility in savings, the rationale for holding CPI-indexed bonds is not clear. In particular, if the motive for holding dollar assets is their contingency against real shocks, the effectiveness of CPI-indexed bonds in reducing the level of dollarization is, at best, limited.

In the context of this model, the full-dollarization equilibrium is robust to the introduction of CPI-indexed bonds. Under the same conditions imposed in proposition 4, the optimal portfolio for low devaluation response is again composed of only dollar denominated assets.

Entrepreneurs still choose an extreme currency composition of debt, in this case, either full dollar or full inflation adjustable contracts. In case of the later, entrepreneurs' expected consumption is given by the following expression:

$$\begin{aligned} E\left(c_{is}^{e}|\widetilde{v}_i = 1, r_{cpi}\right) &= \left(1 + a_{cpi,B}\right)\left(A - r_{cpi}\right) + 1/2\left(1 - a_{cpi,B}^{2}\right)Az \\ a_{cpi,B} &= \frac{A - r_{cpi}}{Az} \end{aligned} \quad (2.32)$$

where $\widetilde{v}_i \in [0,1]$ is the share of CPI-indexed debt (respectively $(1-\widetilde{v}_i)$ is the share of dollar denominated liabilities), r_{cpi} is the corresponding interest rate, and $a_{cpi,B}$ is the probability of remaining active in the B-state, which is independent of δ.

The equilibrium interest rate is the one that induces the corporate sector to issue debt according to consumers' demand for dollar and adjustable assets. As long as consumers diversify their portfolio composition, firms with dollar and CPI-indexed debt must coexist. Thus, the

[21] See ibid. conference on "Financial Dedollarization: Policy Options", 2003.

equilibrium interest rate is the one that leaves firms indifferent between the two extremes of debt composition:

$$E\left(c_{is}^{e}|\widetilde{v}_i = 0, r_d\right) = E\left(c_{is}^{e}|\widetilde{v}_i = 1, r_{cpi}\right)$$

Interest rates are equalized when $\delta = 0 : r_d(\delta = 0) = r_{cpi}$ is pinned down from the free entry condition (2.20). Since expected consumption of entrepreneurs with only CPI-indexed debt is not affected by the size of the devaluation response, neither is r_{cpi}:

$$\frac{\partial r_{cpi}}{\partial \delta} = 0 \tag{2.33}$$

Trivially, real claims on these assets are constant. That is, are not affected by surprised inflation. However, the return on CPI-assets is still risky. Adjustable instruments inherit the default risk of the issuing firms: $a_{cpi,B} < 1$.

As in section 3, in the limit when $\delta = 0$, consumers are constrained in their demand for insurance and the credit market is fully dollarized. Using the results derived here for CPI-indexed contracts, consumers maximize (2.12) subject to the following budget constraint:

$$\begin{aligned} c_B^c &= \widetilde{\mu} a_{cpi,B} r_{cpi} + (1 - \widetilde{\mu})\, a_{B0} R_{dB} \\ c_G^c &= \widetilde{\mu} r_{cpi} + (1 - \widetilde{\mu})\, R_{dG} \end{aligned}$$

where $\widetilde{\mu}$ is the share of CPI-indexed instruments, and a_{B0} and R_{ds} are defined as in section 3. The first order condition for low devaluation response coincides with (2.28):

$$\lim_{\delta \to 0^+} foc\left(\widetilde{\mu}|\delta\right) = -\left[U'\left(c_B^c\right) - U'\left(c_G^c\right)\right] a_B + U'\left(c_B^c\right) \frac{r}{Az} < 0$$

where $a_B = a_{B0}(\delta = 0) = a_{B1}(\delta = 0) = a_{cpi,B}$ and $r = r_d(\delta = 0) = r_p(\delta = 0) = r_{cpi}$.

Therefore, under the same condition as in proposition 2, the market is fully dollarized for low devaluation response. Consumers are again constrained in their demand for insurance and thus, the full dollar equilibrium is robust to the introduction of inflation adjustable contracts.

The intuition behind this result is similar to the one presented in the previous section. When the devaluation response is low, consumers do not diversify the currency composition of their portfolio. Again, risk averse consumers prefer dollar denominated assets, for which real claims are negatively correlated with the default risk, over CPI-indexed assets that offer zero correlation with the risk of recessions.

Although, in light of these findings, the introduction of CPI-indexed bonds is not expected to reduce the level of dollarization, it is a useful instrument to prevent the dollarization of the credit market in periods of high inflationary risk.[22] As was analyzed above, large volatility of nominal variables can trigger the dollarization of credit contracts. The full dollarization equilibrium is stable even after inflation is controlled, and robust to the introduction of CPI-indexed instruments. However, inflation indexed instruments can substitute dollar denominated contracts when the motive behind their demand is the fear of inflationary risk. The introduction of these instruments can prevent the economy from abandoning the low dollar equilibrium during periods of large inflationary risk.[23]

2.5.3 Open Capital Account

So far, it has been assumed that local consumers and entrepreneurs can only contract loans in the domestic credit market, which is insulated from international capital flows. This simplification tried to capture the behavior of small investors and firms, for whom the capital account is often closed. The framework of the model is useful for analyzing the implications of opening the capital account for atomistic agents. The complementarity between the residents' portfolio choice and the optimal monetary policy remains, as well as the equilibrium with full dollarization. However, the welfare consequences are very different.

To illustrate this point I assume risk neutral international investors willing to lend at a fixed interest rate equal to r_c –after controlling for default risk– denominated in foreign currency and, conversely, local consumers can also invest abroad at the international interest rate.

Credit Market Equilibrium

The equilibrium interest rate differential between peso and dollar debt in (2.27) is un-

[22] The introduction of adjustable instruments may have downsides in terms of the level of inflation in equilibrium (see, for example, Fisher and Summer (1989)). Still, it is important to consider that the trade-off may involve jumping into dollarization.

[23] For example, Chile's adjustable instruments (Unidad de Fomento) date back to 1967 and were in place during its period of high inflation. This economy succeeded in preserving the credit market largely denominated in local currency. See Herrera and Valdes (2003) for a review on Chilean experience regarding indexation.

changed:

$$E\left(c_{is}^{e}|v_i=1,r_p\right)=E\left(c_{is}^{e}|v_i=0,r_d\right)$$

However, the interest rate level is not pinned down from the free entry condition. Instead, firms are willing to hold debt with local investors as long as the domestic interest rate in dollars is not larger than the one offered by international investors:

$$r_d \leq r_c \frac{2}{(1+a_{B0})} \tag{2.34}$$

Consumers' choice set is composed by domestic assets, denominated in dollars or pesos, and foreign assets. Domestic dollar and peso assets have real claims given by (2.14) and (2.15), with probabilities of default given by (2.22), evaluated at $v_i = 1$ and $v_i = 0$ respectively. Real returns on foreign assets have the following schedule:

$$R_{cs} = \begin{cases} r_c + (1-\tau)\,\delta & s = B \\ r_c - (1-\tau)\,\delta & s = G \end{cases} \tag{2.35}$$

Notice that consumers will never demand dollar denominated domestic assets. Indeed, dollar domestic assets do not provide larger expected return than cross border investments and face higher default risk. In other words, cross border assets are better at providing insurance against the country risk than domestic dollar assets. As a result, firms with peso debt have contracts with local consumers only, while firms with dollar liabilities exclusively contract with foreigners. Equation (2.34) is thus satisfied with equality.

Again, there is a complementarity between consumers' portfolio choice and the optimal monetary policy that results in multiple equilibria.

Policy Equilibrium with fixed exchange rate

When the Central Bank chooses a fixed exchange rate ($\delta = 0$), consumers unambiguously prefer international assets. The first order condition characterizing the optimal portfolio choice is

$$foc\left(\mu|\delta=0\right): -\left(\frac{1-a_B}{1+a_B}\right) r_c \left[U'\left(c_B^c\right)-U'\left(c_G^c\right)\right]=0$$

where $a_B = a_{B1}(\delta = 0) = a_{B0}(\delta = 0)$ is the probability of survival in the B-state for domestic firms with peso ($v_i = 1$) and dollar ($v_i = 0$) denominated debt. The first order condition is then satisfied when $c_B^c = c_G^c = r_c$. As a counterpart, firms rely entirely on foreign investors.

The optimal devaluation rate is thus $\delta = 0$, which allows domestic consumers to perfectly smooth consumption. Consumption schedule is independent of domestic output volatility, which is as large as in the full dollar equilibrium characterized in proposition 4.

Policy Equilibrium with countercyclical monetary policy

When monetary policy is countercyclical, consumers always demand a positive share of peso domestic assets. First, because real return on international assets is risky in terms of domestic prices. Second, because the default risk on peso assets lowers in the devaluation response, so consumers demand less insurance –that is, fewer international assets. And third, because the spread between the international and the domestic currency interest rates is positive –i.e. $(1 + a_{B1}) r_p > 2r_c$.[24]

The optimal portfolio choice can be analyzed in terms of these three features, as appreciated in the consumers' first order condition:

$$foc(\mu|\delta) = -\left[U'(c_B^c) - U'(c_G^c)\right]\delta - U'(c_B^c)(1 - a_{B1}) R_{pB} + \left[U'(c_B^c) + U'(c_G^c)\right](r_p - r_c) = 0$$

The first two terms in $foc(\mu|\delta)$ correspond to the insurance motive behind the optimal portfolio composition: the first term emphasizes the portfolio's currency risk and the second term collects the demand for insurance due to the default risk on domestic assets. The third term represents the demand for domestic assets due to the interest rate differential. Indeed,

[24] Using equations (2.34) and (2.27), it can be shown that for

$$\delta \in B^+(0) : \frac{\partial}{\partial \delta}\left[(1 + a_{B1}) r_p\right] > 0$$

Moreover $\forall \delta : \frac{\partial^2}{\partial \delta^2}\left[(1 + a_{B1}) r_p\right] < 0$.
As long as parameters are such that $\exists \delta_{B1} \in (0,1) : a_{B1}(\delta_{B1}) = 1$,then for $a_{B1} = 1 : r_p > r_c$.
Therefore, for all relevant $\delta : (1 + a_{B1}) r_p > 2r_c$.

because the domestic interest rate is larger than the international, perfect insurance is not optimal and consumers typically prefer an uneven consumption pattern as are compensated with an overall larger expected consumption.

The Central Bank's objective function depends on the consumers' portfolio choice. Without internalizing the effect of the devaluation response on the resulting equilibrium interest rate, the Central Bank overvalues insurance.

$$foc(\delta|\mu) = -[\mu - (1-\tau)]\left[U'(c_B^c) - U'(c_G^c)\right] + U'(c_B^c)\,\mu\left[\frac{\partial a_{B1}}{\partial \delta}\frac{R_{pB}}{Az} + \tau(1-a_{B1})\right] = 0$$

The bias towards insurance can be appreciated in the comparison of the Central Bank's first order condition, $foc(\delta|\mu)$, and the consumers' $foc(\mu|\delta)$. The CB's first order condition collects the devaluation effect on insurance: the CB's $foc(\delta|\mu)$ is parallel to the first two terms in consumers' $foc(\mu|\delta)$. The optimal policy does not take into consideration its effect on the interest rate spread, collected in the last term of consumers' $foc(\mu|\delta)$.[25]

Foreign assets provide the insurance that domestic firms are not able to. Hence, consumers can perfectly hedge against the risk of default independently of the Central Bank's intervention. Instead, the role of the Central Bank is to increase expected consumption. However, a time inconsistent Central Bank will typically try to increase the level of insurance. Indeed, although consumers are able to perfectly smooth consumption, they optimally decide not to in order to enjoy a larger expected consumption.[26] The Central Bank, without internalizing its effect on the equilibrium interest rate, partially undoes consumers' optimal choice and increases consumption smoothness.

From CB's $foc(\delta|\mu)$ and consumers' $foc(\mu|\delta)$, the policy equilibrium for $(1+a_{B1})\,r_p > 2r_c$ is given by $\mu > 1-\tau$ and $\delta_{B1} > \delta > 0$, where δ_{B1} satisfies $a_{B1}(\delta_{B1}) = 1$.[27]

[25] It can be easily verified from consumers' $foc(\mu|\delta)$ and CB's $foc(\delta|\mu)$, that if the uncovered parity condition holded $(r_p(1+a_{B1}) = 2r_c)$, the first best would be attained. That is, the Central Bank optimum is δ such that $a_{B1}(\delta) = 1$ (and $\frac{\partial a_{B1}}{\partial \delta} = 0$). Firms with peso debt have zero default risk so consumers optimal portfolio choice is $\mu = 1-\tau$, which provides perfect hedge against the currency risk.

[26] This result is in line with Holmstrom and Tirole (2002). There, foreign investors are in position to provide insurance to domestic firms when country shocks are idiosyncratic. Still, perfect insurance is not optimal.

[27] Imagine $\mu \leq 1-\tau$. From consumers' $foc(\mu|\delta) : (1+a_{B1})\,r_p > 2r_c \implies c_B^c < c_G^c$.

The equilibrium with countercyclical policy is unambiguously better than the one under fixed exchange rate. Indeed, the fixed exchange rate case was characterized by perfect insurance and $c_B^c = c_G^c = r_c$. An allocation with perfect insurance and fixed consumption pattern with $c_B^c = c_G^c > r_c$ is attainable under any positive devaluation response. So the uneven consumption schedule chosen by consumers is unambiguously superior to the one under fixed exchange rate. Hence, by holding domestic peso assets, consumers provide incentives to the Central Bank to pursue a countercyclical monetary policy and higher utility level is attained.[28]

2.6 Conclusion

After years of high inflationary risk, many developing countries succeeded in stabilizing their monetary variables. Today, these economies' concerns center on underinsurance against aggregate shocks. The main contribution of this paper is to illustrate this topic from the perspective of risk averse residents, whose consumption volatility is mainly driven by the risk of recession. In this framework, dollar assets are demanded as an insurance against real aggregate risks.

Based on the interplay between the currency composition of the credit market and the Central Bank's optimal policy, the model explains persistence in the share of dollar liabilities in economies with low inflationary risk. Indeed, this interplay may result in multiple stable equilibria: an equilibrium with a high degree of dollarization in which the Central Bank minimizes exchange rate volatility; and another in which contracts are mainly denominated in domestic currency and monetary policy is highly countercyclical.

When insurance against the risk of recession is the motive behind dollarization, consumers are better off under full dollarization than with a high share of peso denominated contracts. If the share of peso denominated contracts is large, the optimal policy reduces the number of defaulting firms at the expense of a more volatile return on savings. On the other hand, in the fully dollarized equilibrium, the real value of savings is preserved during recessions, when

From CB's $foc(\delta|\mu)$: $\mu \leq 1-\tau \implies \delta \geq \delta_{B1}$.
From consumers' $foc(\mu|\delta)$: $a_{B1} = 1 \implies \mu > 1-\tau$, which is a contradiction.
Then: $\mu > 1-\tau$.
Follows from CB's $foc(\delta|\mu)$, that as long as $c_B^c < c_G^c$ and $\mu > 1-\tau$, the CB's optimal devaluation response is $\delta < \delta_{B1}$.

[28] In Tirole (2003) domestic investment also functions as a discipline device for the Central Banker, who is only concerned about residents' welfare.

investors value it the most.

An important caveat must be made. In an attempt to emphasize the interplay between credit market currency composition and the optimal monetary policy, the framework was simplified to only include agents participating in the domestic financial market. However, concerns regarding dollarization arise from its negative consequences in terms of output volatility. For that reason, the current debate in many of these countries is centered on the "de-dollarization" dilemma. This model, by explaining the motives underlying the dollarization of domestic credit contracts, offers some insights to this debate:

1. Although an increase in inflationary risk may trigger the dollarization of the credit market, price stabilization will have limited success in reducing it. During episodes of high inflationary risk, borrowers and lenders denominate their credit contracts in a more stable unit, typically dollars. However, once inflation is controlled and the countercyclicality of the monetary policy is diminished, the motive behind the demand for dollar assets changes. Dollar assets are now demanded for their contingent value against the risk of recessions. In these economies, foreign currency denominated assets are the natural substitute for the missing contingent contracts precisely because dollar instruments are in place from the time of large inflationary risk.

2. If dollar assets are demanded for their insurance capacity, the introduction of CPI-indexed bonds will have limited success in reducing the level of dollarization. Adjustable instruments are only useful when inflationary risk is the motive behind the demand for foreign currency denominated contracts. These instruments do not provide any insurance against the risk of recession. Nonetheless, CPI-indexed bonds are useful for preventing the dollarization of the credit market in periods of high inflationary risk.

3. The persistence of the level of dollarization results from the interplay between currency denomination of contracts and a time inconsistent monetary policy. Monetary policy functions both as an ex-ante incentive device and as an ex-post redistributive tool between consumers and entrepreneurs. This juxtaposition of functions causes monetary policy's time inconsistency. The goal is then to separate these two roles, incorporating in the debate on "de-dollarization" either fiscal considerations aimed of including a different re-

distributive tool, or corrective distortions in the return on assets so lenders and borrowers internalize the effects of their currency choice.

Finally, the underlying structure of the model is a useful tool for analyzing the implications of improving access to foreign capital for atomistic consumers and firms, a basic example of which was analyzed in section 5. The complementarity between the Central Bank's optimal policy and the consumers' portfolio choice is still present in the extreme case of perfect access to foreign capital. In this case, foreign instruments can perfectly insure consumers against country risk and consumers are better off if the Central Bank pursues a coutercyclical monetary policy. This is the appropriate framework within which to explore this topic, since it formulates the problem as a trade-off between insurance to consumers against country risk and the vulnerability of a highly dollarized corporate sector. Moreover, under this framework the monetary authority's incentives change according to the nationality of the investors. This paper discussed a particular example. More general applications are a topic for future research.

2.7 Appendix:

2.7.1 Expansionary effect of devaluation

The model can be extended with the introduction of an expansionary effect of devaluation, which provides a motive for devaluing the currency in the adverse state of nature. This way, the restriction imposed in section 4 that constrained the Central Bank from revaluing the currency in the B-state arises endogenously.

Modification to the Basic Framework

I extend the basic framework presented in section 2 with an additional date. At date 0, all contracts are set according to the basic set-up described in section 2. At date 1, after contracts are set, the productive project has an intermediate productive outcome and operational cost, wages.[29] Wages are assumed to be set at date 0 in terms of non-tradable goods. For simplicity, I assume risk neutral workers with a constant opportunity cost in terms of consumption $(w = 1)$.

Each productive unit has then short term and long term outcome (A_{1is} and A_{2is}), a proportion τ of which is tradable, and the rest is non-tradable. The technology is affected by the aggregate shock and a unobservable idiosyncratic sensitivity towards it, as described in (2.2). Total output at date $t \in \{1, 2\}$ is therefore given by $A_{tis} = A_t(1 + a_i z_s)$. In addition to the unit of capital $\left(\overline{k}_0^F = 1\right)$, the productive project requires hiring a date-1 worker.

As before, the firm abandons the market and defaults on its debt if date-2 revenues do not suffice to repay financial debts. This extension introduces another source of default: the firm is forced to abandon the market irrespectively of its overall profits if date-1 revenues do not suffice to cover operational costs. I make parametric assumptions to ensure that in equilibrium firms default in the B-state only: $\min\{A_1 - w, A_2 - r\} > 1/2z \max\{A_1, A_2\}$, where $r = r_d(d = 0) = r_p(d = 0)$.

It can be verified that the goods market is in equilibrium for the same set of prices presented in section 2 and the inflation rate in the s-state, π_s, is given by equation (2.11). Therefore, the firm continues in the market at date 1 in the B-state if $A_{1iB} > w - \tau\delta$.[30] That is, if the

[29] Any nontradable input would suffice to introduce an expansionary effect of devaluation.

[30] As in section 2, the real value the operational cost is approximated for inflation rate close to zero and wages

sensitivity towards the shock is lower than the threshold value a_L:

$$a_i \leq a_L = \frac{A_1 - (w - \tau\delta)}{A_1 z} \tag{2.36}$$

As before, the firm repays its debts date 2 if $a_i \leq a_B(v_i)$, where $a_B(v_i)$ is given by (2.22). The ex-ante probability of repaying financial obligation is therefore given the probability of continuing in both periods:[31]

$$\Pr(repay) = \min\{a_L, a_B(v_i)\}$$

The characterization of the credit market equilibrium when the devaluation schedule is such that the date-2 constraint is binding ($\delta : a_B(v_i) < a_L$) is in line with proposition 4.[32] In what follows, I analyze the case in which the date-1 constraint binds.

Firms' optimal currency composition of liabilities when date-1 constraint is binding

Entrepreneurs choose $v_i \in [0, 1]$ to maximize expected consumption. If the date-1 constraint is binding, the threshold value for continuation at date 1, a_L, is lower than $a_B(v_i)$ and

---

close to one with:

$$\frac{w}{1+\pi_s} \simeq w - \pi_s = w - \tau\delta_s$$

[31]Notice that although a firm i defaults on its debt every time $a_i \geq a_B(v_i)$, its overall profits may still be positive if $a_i \leq a_L$. Firms' idiosyncratic shock is not observable, therefore date-1 profits are also private information. As a result, when the exit decision occurs at date 2, the firm retains date-1 profits.

[32]Without changing qualitatively the results presented in proposition 4, the equilibrium interest rates (before described by (2.27)) are now given by:

$$\begin{aligned}\frac{\partial r_p}{\partial \delta} &= -\tau\frac{1-a_L}{1+a_{B1}} - \tau\frac{1-a_{B1}}{1+a_{B1}} \\ \frac{\partial r_d}{\partial \delta} &= -\tau\frac{1-a_L}{1+a_{B0}} + (1-\tau)\frac{1-a_{B0}}{1+a_{B0}}\end{aligned}$$

determines the probability of remaining active in the two periods.

$$\max_{0\leq v_i\leq 1} E\left(c_{is}^e\right) = a_L \left[E\left(c_{1is}^e \left| c_{1is}^e \geq 0\right.\right) + E\left(c_{2is}^e \left| c_{1is}^e \geq 0\right.\right)\right]$$

$$s.t.$$

$$c_{1is}^e = A_{1is} - (w - \tau\delta_s)$$

$$c_{2is}^e = A_{2is} - (1 - v_i) R_{ds} - v_i R_{ps}$$

The probability of being active in the B-state, captured in (2.36), is independent of the currency composition of debt. Therefore, the entrepreneur's expected consumption is linear in v_i:

$$\frac{\partial E\left(c_{is}^e\right)}{\partial v_i} = a_L \left(r_p - r_d - \delta\right) + \left(r_p - r_d + \delta\right)$$

In equilibrium, entrepreneurs are indifferent in the currency composition of their debt and the expected real claims for dollar and peso debt are equalized. The equilibrium is characterized by the following interest rate differential:

$$r_d - r_p = \frac{1 - a_L}{1 + a_L}\delta \tag{2.37}$$

Entrepreneurs are indifferent in the currency composition of their liabilities and the share of peso denominated debt (v_i) is then determined in equilibrium by investors (consumers):

$$\forall i \in [0,1] : v_i = \mu \tag{2.38}$$

Consumers portfolio choice when date-1 constraint is binding

Consumers choose $\mu \in [0,1]$ to maximize expected utility (2.12) subject to their budget constraint. Real claims on dollar and peso assets are given by (2.14) and (2.15). And, as long as date-1 margin is binding, the probability of default is independent of v_i. Therefore, the probability of default for both assets is equal to a_L. Consumers' budget constraint is therefore given by:

$$\begin{aligned} c_B^c &= a_L\left[\mu R_{pB} + (1-\mu) R_{dB}\right] \\ c_G^c &= \mu R_{pG} + (1-\mu) R_{dG} \end{aligned}$$

Using (2.36) and (2.37), the first order condition for the consumers' maximization problem is:

$$\delta\left[U'\left(c_G^c\right) - U'\left(c_B^c\right)\right] = 0 \tag{2.39}$$

provided that $\mu \in [0,1]$. And, if $foc(\mu = 0|\delta) < 0$ or $foc(\mu = 1|\delta) > 0$, the optimal share of peso assets reaches the constraints $\mu = 0$ and $\mu = 1$ respectively.

As long as the devaluation response is not null, the interior solution for (2.39) implies equalization of marginal utilities $U'\left(c_B^c\right) = U'\left(c_G^c\right)$. If devaluations happen in negative realizations of the aggregate shock ($\delta > 0$), dollar assets have larger real return in the B-state and provide insurance against the default risk.

The interior optimal share of peso assets results from equalizing consumption in both states:

$$\mu = \frac{1+a_L}{4a_L\delta}\left[-\left(1-a_L\right) r_d + \left(1+a_L\right)(1-\tau)\,\delta\right] \tag{2.40}$$

The demand for dollar denominated assets decreases in the devaluation response for two reasons: First, since the default risk decreases in the devaluation response δ, so does the demand for insurance. And second, a larger devaluation response augments the contingent value of dollar assets and a lower quantity of such assets is required to provide the optimal insurance.

The interior solution cannot be achieved for low devaluation responses. If the contingent value of dollar debt is minimal, perfect insurance requires long positions of these assets and the short selling constraint binds. In that case, the share of peso denominated assets reaches its lower bound ($\lim_{\delta\to 0}\mu(\delta) = 0$). Inversely, when the devaluation is large enough as to prevent any firm from defaulting ($a_L = 1$), the optimal currency composition in (2.40) is the one that perfectly hedges against the currency risk, that is, the portfolio composition replicates the participation of tradables and non-tradables in the price index ($\mu = 1-\tau$).

Then, for $\delta_s \in \{\delta, -\delta\}$ such that $\forall v_i \in [0,1] : a_L \leq a_B(v_i)$, the credit market equilibrium is

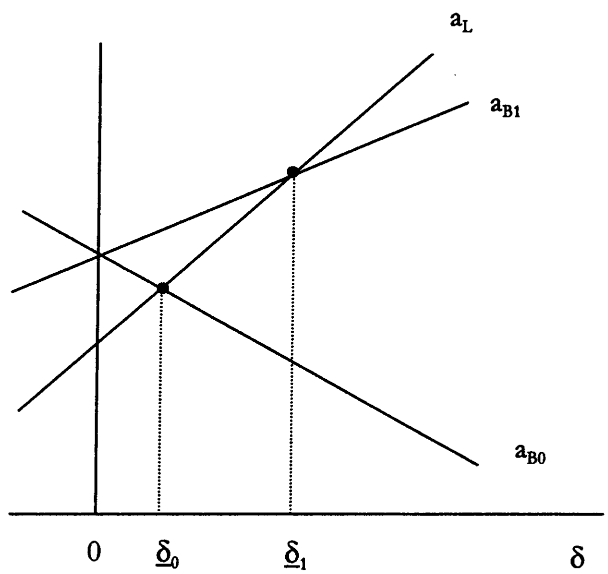


Figure 2-7: Binding Margin for Default

characterized by (2.37), (2.38), and:

$$0 \leq \delta \leq \underline{\delta}_L : \mu(\delta) = 0 \text{ where } \underline{\delta}_L : foc(\mu = 0|\underline{\delta}_L) = 0$$
$$\delta \geq \overline{\delta}_L : \mu(\delta) = 1 - \tau \text{ where } \overline{\delta}_L : \ a_L\left(\overline{\delta}_L\right) = 1$$

Optimal Devaluation Response

The Central Bank maximizes consumers' expected utility by intervening in the currency market at date 1, after all contracts have been set, in line with section 4. The return on assets depends on the binding margin governing the default risk, which is endogenous to the devaluation response (see figure 2-7). When the exchange rate volatility is very large, the balance sheet effect governs the default risk –i.e. $a_{B0} \leq a_L$. When the devaluation response is low, revenues are not sufficient to pay the operational cost and the firm is forced to abandon the market –i.e. $a_L \leq a_{B0}$.

Whenever the date-1 constraint is binding, the optimal monetary policy is to increase the devaluation response. For $\delta \leq \underline{\delta}_L$, an increase in the devaluation response increases both expected consumption and insurance. While for $\delta \geq \underline{\delta}_L$, consumers attain perfect insurance and an increase in the devaluation response raises expected consumption without affecting smoothness. Indeed, as long as the size of the financial obligations is not the motive driving the default decision, there is no trade-off between insurance and maximization of consumption and it is always optimal to reduce the number of firms abandoning the market.

However, once the default is driven by balance sheet considerations, the optimal devaluation response depends dramatically on the currency composition of debt. As explained in section 4, as long as (2.29) is negative, when the credit market is mainly denominated in pesos, the Central Bank finds it optimum to increase the devaluation response. This policy reduces even further date-1 operational cost and the probability of default unambiguously decreases:

$$\delta\left(\mu=1\right)=\max\left\{\underline{\delta}_1,\overline{\delta}_1\right\}$$

where $\underline{\delta}_1 : a_L\left(\underline{\delta}_1\right) = a_{B1}\left(\underline{\delta}_1\right)$ and $\overline{\delta}_1$ is the optimum given that the date-2 constraint is binding –i.e. $\overline{\delta}_1 : foc\left(\overline{\delta}_1|\mu=1\right)=0$ given that $a_{B1}\left(\overline{\delta}_1\right) < a_L\left(\overline{\delta}_1\right)$.

When the credit market is highly dollarized, an increase in the devaluation response has opposite effects on date-1 and date-2 default margins. An increase in the devaluation response reduces date-1 operational cost but increases date-2 financial burden, therefore, the optimal devaluation policy is the one for which the two margins are equivalent:

$$\delta\left(\mu=0\right)=\underline{\delta}_0$$

where $\underline{\delta}_0 : a_L\left(\underline{\delta}_0\right) = a_{B0}\left(\underline{\delta}_0\right)$.

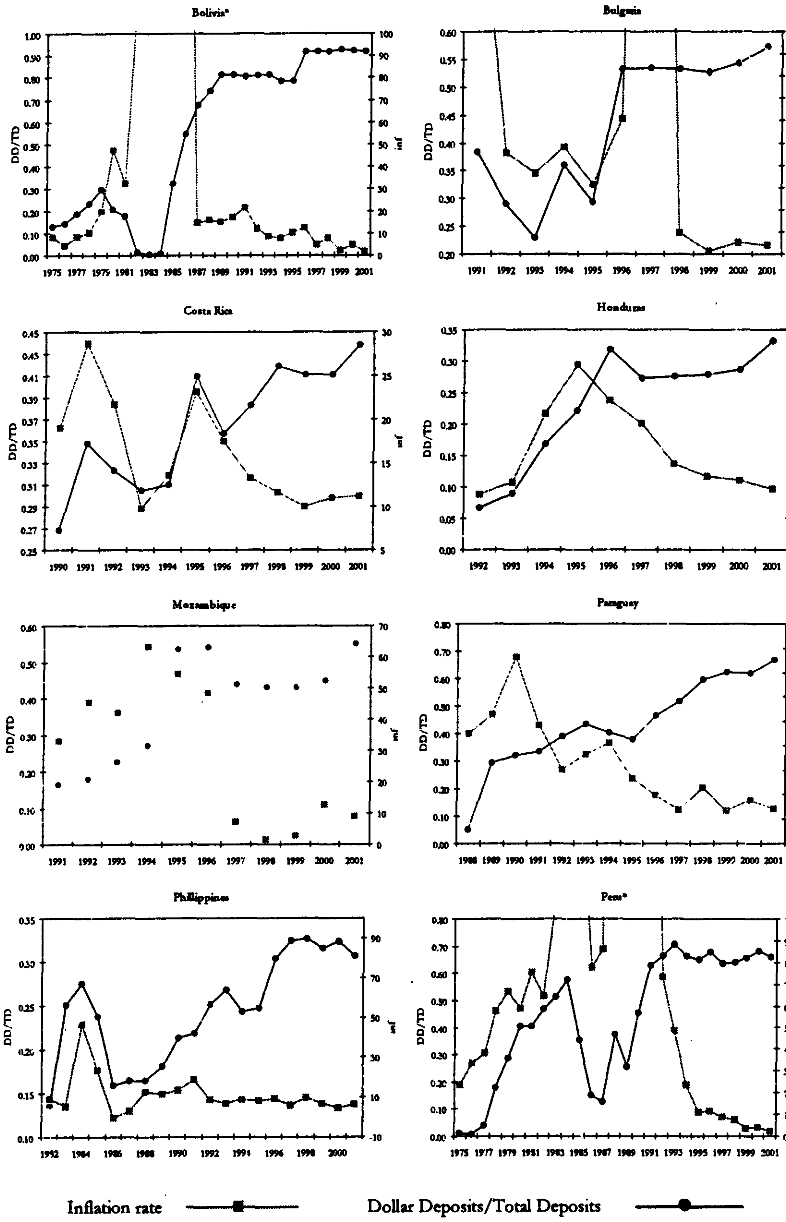
This extension endogenizes a lower bound for the optimal devaluation response: $\delta \geq \underline{\delta}_0$. As long as $\underline{\delta}_0 \in [0, \underline{\delta}_E]$ (see proposition 3), the results presented in the body of the paper hold.

2.7.2 Share of Foreign Currency Denominated Deposits in Domestic Banking Sector

Selected Country	Year	
Angola	2001	81.0%
Argentina	2001	73.7%
Armenia	2001	79.7%
Azerbaijan	2001	81.1%
Belarus	2001	65.9%
Bulgaria	2001	57.1%
Bolivia	2001	91.7%
Congo, Dem. Rep. of	2001	56.8%
China, P.R.: Hong Kong	2001	45.0%
Cambodia	2000	92.5%
Costa Rica	2001	43.8%
Georgia	2001	81.4%
Croatia	2001	71.2%
Haiti	2001	42.5%
Kazakhstan	2001	57.0%
Kyrgyz Republic	2001	65.2%
Lao People's Dem. Rep.	2001	82.9%
Lebanon	2001	69.1%
Lithuania	2001	46.6%
Latvia	2001	43.9%
Mongolia	2001	39.3%
Mozambique	2001	55.1%
Macedonia, FYR	2001	65.4%
Nicaragua	2001	71.1%
Peru	2001	66.0%
Philippines	2001	30.7%
Paraguay	2001	66.9%
Romania	2001	49.0%
Russia	2001	34.3%
Slovenia	2001	36.1%
Sao Tome & Principe	2001	44.4%
Tanzania	2001	32.9%
Turkmenistan	1999	44.7%
Turkey	2001	58.3%
Tajikistan	2000	67.8%
Ukraine	2001	32.4%
Uruguay	2001	84.4%
Vietnam	1998	36.6%
Vanuatu	1999	69.7%
Yemen, Republic of	2001	52.6%
Zambia	2001	42.6%

Sources: Levy-Yeyati (2003) and Arteta (2002, 2003)

2.7.3 Dollarization and Inflation



* Different degrees of legal restrictions to foreign currency denominated deposits were imposed in Peru between 1985 and 1989. Dollar denominated deposits were not allowed in Bolivia between 1982 and 1984.

Sources: Data on inflation from IFS-IMF, data on deposits denomination from Levy-Yeyati (2003) and data on legal restrictions on dollar deposits from Arteta (2002, 2003).

Chapter 3

Idiosyncratic and Aggregate Risk in the Presence of Government's Moral Hazard

3.1 Introduction

Fiscal policy and taxation in particular play an important role in the insurance of local agents against income fluctuations. Government's power to impose taxes is a key tool for optimal redistribution among residents. Indeed, if agents cannot pledge their future income in the financial market, a domestic insurance market cannot privately arise. Local agents rely on government's tax power to diversify their idiosyncratic domestic income risk. Moreover, Government's fiscal policy also plays a role in the international risk sharing. Public debt represents future local tax income. Then, trading public debt in the international financial market allows country risk sharing.

Optimal risk sharing involves foreign investors holding domestic public debt, which introduces government's moral hazard. Because the government prevails local interests over foreign ones, the identity of the bond holders affects the ex-post optimal fiscal policy. This paper looks at how the government's lack of commitment technology affects the capacity of resident agents to optimally diversify risk. I find that government's moral hazard introduces a trade-off between pooling idiosyncratic risk and diversifying aggregate country uncertainty. As a result, local agents face excessive consumption risk.

The model in this paper represents risk averse consumers, who want to diversify domestic idiosyncratic risk and share the aggregate country risk in the international financial market. They are unable to pledge their future random return, which introduces the government's role. The government, who has the tax power, commits on behalf of local agents to deliver the promised goods to the share holders. In other words, domestic and international risk sharing are mediated by government's intervention.

Opening the capital account allows local agents to diversify aggregate country risk but also introduces government's moral hazard. Since taxes are levied exclusively on residents while bond returns are accrued in part by foreign investors, the government has incentives to lower taxes and reduce the return on public debt. Participants in the financial market adjust their demand for domestic bonds according to their credible return. Their equilibrium price also reflects government's future optimal policy. As a result, government's moral hazard does not affect international risk diversification. Domestic and foreign agents minimize aggregate risk at actuarially fair prices. However, government's moral hazard does affect internal tax policy, which is insufficient from an ex-ante point of view. Domestic fiscal policy pools risk suboptimally.

I explore how institutions can be designed as to overcome this moral hazard problem. It is optimal for the government to impose private non-transferable savings account composed of domestic bonds. By forcing residents to hold government bonds, the government restricts itself from expropriating bond holders in the future and can credibly commit to follow a Pareto superior policy. This commitment device is costly: it results in a suboptimal international risk sharing. The first best allocation will not be attained and the optimal restriction results from the trade-off between idiosyncratic and aggregate risk diversification.

I extend the baseline model to an infinitely repeated economy with overlapping generations. I analyze the conditions under which reputation can work as a commitment device for the government. In those cases that it does, the government implements the ex-ante optimal policy under the threat that any deviation will be punished by reversion to the Markov Perfect Equilibrium. The ability to commit depends on the instantaneous gains from deviating from the promised policy, versus the cost in terms of a suboptimal one thereafter. As expected, reputation works as a commitment technology if the government's intertemporal discount is sufficiently high. More interesting, reputation is less likely to support the ex-ante policy in economies with high idiosyncratic risk. When the idiosyncratic risk is higher, the government implements a policy closer to the ex-ante optimal after abandoning the rule. Then, the reversion to the Markov Perfect Equilibrium does not represent a sufficient threat. Along the same lines, imposing minimum requirements of domestic bonds on the pension funds improves fiscal policy, but it may deprive the government from a costless commitment technology.

The model in this paper is related to the literature on sovereign risk and, in particular, to Tirole (2003). As in there, government's moral hazard varies with the proportion of local and foreign investors holding domestic debt. In this paper, I identify a mechanism through which government's actions towards foreign investors also affects local residents: government's suboptimal fiscal policy prevents the diversification of domestic idiosyncratic risk. I find that the relative importance of idiosyncratic and aggregate risks plays a key role in determining the government's optimal fiscal policy.

The rest of the paper is organized as follows. Section 2 describes the static version of the model with a single generation of agents interacting with the government for two periods. I characterize here the commitment problem of the government and provide rationality for the use of minimum requirements on bond holdings as a commitment device. In section 3, I extend the basic static framework into a dynamic economy. I characterize the stationary Markov Perfect Equilibrium and analyze the conditions under which reputation can work as a commitment device for the implementation of the ex-ante optimal fiscal policy. Finally, section 4 concludes.

3.2 Static Framework

The model presented here describes a world with two countries: home and abroad. Each country is populated by a unit measure of consumers, alive for two periods. Agents have

CARA preferences over consumption at time 1 and 2:

$$\begin{aligned} U &= u(c_1) + \beta E u(c_2) \\ u(c) &= -\frac{1}{\gamma} e^{-\gamma c} \end{aligned} \tag{3.1}$$

There is a single good, used as numeraire, which is received by agents as endowment in the first and second periods. At date 1, domestic endowment is a deterministic amount w_1 (w_1^* for foreigners), while endowment in the second period is uncertain: each resident agent $i \in [0,1]$ receives $w_{is} = w_s + \varepsilon_i$ units of goods in the second period (foreign agents get w_s^*). The aggregate risk is given by the realization of (w_s, w_s^*), while ε_i corresponds to pure idiosyncratic domestic risk:

$$\begin{aligned} (w_s, w_s^*) &: N\left(\overline{w}, \overline{w}^*; \sigma^2, \sigma^{*2}, \sigma_{fd}\right) \\ \varepsilon_i &: iid.N\left(0, \sigma_i^2\right) \end{aligned} \tag{3.2}$$

At date 1, before the realization of the aggregate and idiosyncratic shocks, agents make their consumption/saving decision and choose their portfolio allocation. Each agent i can save in three ways: shares of future domestic endowment of each domestic agent j ($B_{id,j}$), a share of future foreign endowment (B_{if}), and a riskless storage technology that transform one unit of date-1 good into $1+r$ units of date-2 good (B_{i0}). That is, the strategy of each local agent $i \in [0,1]$ is a vector $\mathcal{B}_i = \left\{B_{i0}, \langle B_{id,j}\rangle_{j=0}^{1}, B_{if}\right\} \in \mathbb{R}_+^3$, while for each foreign agent is $\mathcal{B}^* = \left\{B_0^*, \left\langle B_{d,j}^*\right\rangle_{j=0}^{1}, B_f^*\right\} \in \mathbb{R}_+^3$.

Finally, to assure a constant consumption schedule, I assume that $\beta = \frac{1}{1+r}$.

3.2.1 Optimal allocation

As a benchmark, I characterize here the financial market equilibrium that corresponds to the first best allocation. In this frictionless economy foreign and domestic agents are able to sell (and buy) their future endowments in the financial market.

In period 1, each local agent $i \in [0,1]$ receives her date-1 endowment w_1 and sells her future endowment w_{is} at a market price p_{id}. She consumes an amount c_{i1} and buys shares of foreign and domestic (from each local agent $j \in [0,1]$) endowments. The remaining resources are invested in the riskless technology. At date 2, and in each state of nature s, the agent consumes c_{is} according the the return on her assets: shares on foreign and domestic (from each agent $j \in [0,1]$) endowments have returns w_s^* and w_{js} respectively; and the return on the storage technology is $1+r$.

Therefore, financial market equilibrium consistent with the first best allocation is defined as follows:

Definition 3 *The first best financial market equilibrium is a combination of strategies and market prices* $\left\{\langle\mathcal{B}_i\rangle_{i=0}^1, \mathcal{B}^*, \langle p_{id}\rangle_{i=0}^1, p_f\right\}$ *such that:*

(i) $\mathcal{B}_i = \left\{B_{i0}, \langle B_{id,j}\rangle_{j=0}^1, B_{if}\right\} \in \mathbb{R}_+^3$ *maximizes (3.1) subject to:*

$$c_{i1} + B_{i0} + \int_0^1 B_{id,j}p_{jd}dj + B_{if}p_f = w_1 + p_{id}$$

$$c_{is} = B_{i0}(1+r) + \int_0^1 B_{id,j}w_{js}dj + B_{if}w_s^*$$

(ii) $\mathcal{B}^* = \left\{B_0^*, \left\langle B_{d,j}^*\right\rangle_{j=0}^1, B_f^*\right\} \in \mathbb{R}_+^3$ *maximizes (3.1) subject to:*

$$c_1^* + B_0^* + \int_0^1 B_{d,j}^*p_{jd}dj + B_f^*p_f = w_1^* + p_f$$

$$c_s^* = B_0^*(1+r) + \int_0^1 B_{d,j}^*w_{js}dj + B_f^*w_s^*$$

(iii) And $\left\{\langle p_{id}\rangle_{i=0}^1, p_f\right\}$ *are such that the market clearing conditions are satisfied:*

$$j \in [0,1]: \quad \int_0^1 B_{id,j}di + B_{d,j}^* = 1$$

$$B_f + B_f^* = 1$$

Since idiosyncratic risk is perfectly diversifiable, the price of individual domestic endowments w_{is} is identical for all $i \in [0,1]: p_{id} = p_d$. Therefore, all domestic agents are ex-ante identical. Moreover, the optimal allocation on risky assets is independent of the level of wealth. It follows that all agents (foreign and domestic) have the same optimal portfolio, characterized by the following first order conditions:

$$foc\,(B_d) \quad : \quad -p_d + \beta \left[\overline{w} - \gamma \left(B_d \sigma^2 + B_f \sigma_{fd}\right)\right] = 0 \tag{3.3}$$

$$foc\,(B_f) \quad : \quad -p_f + \beta \left[\overline{w}^* - \gamma \left(B_f \sigma^{*2} + B_d \sigma_{fd}\right)\right] = 0 \tag{3.4}$$

where $B_d = \int_0^1 B_{d,j} dj$ is the perfectly diversified domestic asset. Finally, because the intertemporal discount is the reciprocal of the return on the risk-free asset, the optimal demand for risk-free assets equalizes marginal utilities of consumption over time:

$$foc\,(B_0) : -U'\left(c_1\right) + EU'\left(c_{is}\right) = 0 \tag{3.5}$$

where for $c_1 = c_{i,1}$ for all i.

Combining the first order conditions with the market clearing conditions, the decentralized equilibrium that corresponds to the first best allocation is given by the following portfolio composition and prices:

$$B_d = B_d^* = \frac{1}{2} \tag{3.6}$$

$$B_f = B_f^* = \frac{1}{2} \tag{3.7}$$

$$p_f = \beta \left[\overline{w}^* - \frac{\gamma}{2}\left(\sigma^{*2} + \sigma_{fd}\right)\right] \tag{3.8}$$

$$p_d = p_{id} = \beta \left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right] \tag{3.9}$$

Welfare depends on preferences and the country-endowment distribution:

$$U = (1+\beta)\, u\left(c_1\right)$$

$$where \quad : \quad c_1 = \frac{1}{1+\beta}\left[w_1 + \beta \overline{w} - \beta \frac{\gamma}{2} Var\left(c_{is}\right) - \beta \frac{\gamma}{4}\left(\sigma^2 - \sigma^{*2}\right)\right] \tag{3.10}$$

$$U^* = (1+\beta)\, u\left(c_1^*\right)$$

$$where \quad : \quad c_1^* = \frac{1}{1+\beta}\left[w_1^* + \beta \overline{w}^* - \beta \frac{\gamma}{2} Var\left(c_s^*\right) - \beta \frac{\gamma}{4}\left(\sigma^{*2} - \sigma^2\right)\right] \tag{3.11}$$

$$Var\left(c_s^*\right) = Var\left(c_{is}\right) = \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right) \tag{3.12}$$

As expected, consumption of both foreign and local agents increase in the agents' discounted expected total endowment. The covariance matrix affects consumption in two ways. First, precautionary savings increase with non-diversifiable risk –i.e. $Var(c_s)$ –. Since both local and foreign investors hold the same amount of risky assets, the variance of domestic and foreign consumption is identical. And second, through its effect on prices, residents' consumption decreases on σ^2, since residents are net suppliers of domestic assets, and increases in σ^{*2}, because that reduces the price of the asset for which residents are net demanders. The symmetric opposite characterizes foreign agents' consumption.

3.2.2 Imperfect Financial Market

Because atomistic agents have no power to levy taxes, consumers cannot commit at time 1 to share their future endowment with other agents. However, the government has that tax power; that is, it can expropriate local agents of their endowment and commit on their behalf to deliver the date-2 domestic endowment to the share holders. In effect, a government intervention can replicate the first best allocation.

The government issues a state-contingent bond that pays R_s at time 2. It taxes residents at time 1 and 2, with a tax rate τ_1 and τ_2 chosen before the shocks are realized. The storage technology is also available for the government: it can transform a unit of date-1 good into $(1+r)$ units of date-2 goods. So the government chooses the policy $\mathcal{P} = \{\tau_1, \tau_2, R_s\} \in \mathbb{R}^3$ to maximize (3.1) subject to date 1 and date 2 budget constraints:

$$t = 1 : 0 \leq \tau_1 w_1 + p_d \tag{3.13}$$

$$t = 2 : R_s = \tau_2 w_s + (\tau_1 w_1 + p_d)(1+r) \tag{3.14}$$

The law of large number holds, so the return on government bonds is only contingent on the aggregate risk.

For simplicity, I introduce this lack of commitment to domestic agents only. The return on foreign bonds is still given by w_s^* in period 2 and state s.

In this section I first characterize the financial market equilibrium for a given policy vector $\{\tau_1, \tau_2, R_s\}$. Then, I analyze the optimal government intervention. A credible government that maximizes residents' welfare can achieve the first best allocation. In this case, the government chooses the policy internalizing its effect on the equilibrium level of consumption. However, without a commitment device, the government has incentives to deviate from the ex-ante optimal rule. If date-2 tax rate τ_2 is chosen after date-1 financial decisions are set, the government has incentives to impose a sub-optimal (from an ex-ante point of view) tax policy. Because domestic bonds are hold both by local and foreign investors, the government has incentives to reduce ex-post the return on bonds and lower the domestic tax burden accordingly. This policy is inefficient and results in an imperfect diversification of domestic idiosyncratic risk.

3.2.3 Financial Market Equilibrium

As has been described above, the strategy of each local agent consist of three actions $\mathcal{B} = \{B_d, B_f, B_0\} \in \mathbb{R}_+^3$ –correspondingly, the strategy of a foreign investors is $\mathcal{B}^* = \left\{B_d^*, B_f^*, B_0^*\right\} \in \mathbb{R}_+^3$ –. The financial market equilibrium for a given policy $\mathcal{P} = \{\tau_1, \tau_2, R_s\}$ is defined as follows:

Definition 4 *For a given policy $\mathcal{P} = \{\tau_1, \tau_2, R_s\}$ that satisfies (3.13) and (3.14), a financial market equilibrium is a combination of strategies and market prices $\{\mathcal{B}, \mathcal{B}^*, p_d, p_f\}$ such that:*

(i) $\mathcal{B} = \{B_0, B_d, B_f\} \in \mathbb{R}_+^3$ maximizes (3.1) subject to:

$$c_1 + B_0 + B_d p_d + B_f p_f = w_1 (1 - \tau_1) \tag{3.15}$$

$$c_{is} = (1 - \tau_2) w_{is} + B_0 (1 + r) + B_d R_s + B_f w_s^* \tag{3.16}$$

(ii) $\mathcal{B}^* = \left\{B_d^*, B_f^*, B_0^*\right\} \in \mathbb{R}_+^3$ maximizes (3.1) subject to:

$$c_1^* + B_0^* + B_d^* + B_f^* p_f = w_1^* + p_f \tag{3.17}$$

$$c_s^* = B_0^* (1 + r) + B_d^* R_s + B_f^* w_s^* \tag{3.18}$$

(iii) The equilibrium prices $\{p_d, p_f\}$ are such that the market clearing conditions are satisfied:

$$B_d + B_d^* = 1 \tag{3.19}$$

$$B_f + B_f^* = 1 \tag{3.20}$$

The first order conditions that characterize the optimal demands for domestic and foreign assets are, for local investors:

$$foc(B_f) \;:\; -p_f + \beta\left[\overline{w}^* - \gamma\left\{B_f\sigma^{*2} + [1-\tau_2(1-B_d)]\,\sigma_{fd}\right\}\right] = 0 \tag{3.21}$$

$$foc(B_d) \;:\; -p_d + \beta\left[\overline{R} - \gamma\tau_2\left\{[1-\tau_2(1-B_d)]\,\sigma^2 + B_f\sigma_{fd}\right\}\right] = 0 \tag{3.22}$$

and for foreign investors:

$$foc\left(B_f^*\right) \;:\; -p_f + \beta\left[\overline{w}^* - \gamma\left\{B_f^*\sigma^{*2} + B_d^*\tau_2\sigma_{fd}\right\}\right] = 0 \tag{3.23}$$

$$foc(B_d^*) \;:\; -p_d + \beta\left[\overline{R} - \gamma\tau_2\left\{B_d^*\tau_2\sigma^2 + B_f^*\sigma_{fd}\right\}\right] = 0 \tag{3.24}$$

where $\overline{R}$ corresponds to the expected return on domestic bonds $\overline{R} = \int_{-\infty}^{\infty} R_s f(w_s)\,dw_s$.

The optimal exposure to risk is independent of the wealth level. Thus, domestic and foreign agents will have the same exposure to domestic and foreign uncertainty in equilibrium, as in the first best allocation. From (3.21) and (3.23), domestic and foreign consumers face foreign risk in the amount B_f and B_f^* respectively. Then, the credit market equilibrium satisfies the market clearing condition (3.20) and $B_f = B_f^*$, which implies that the demand for foreign shares is equal to the first best equilibrium:

$$B_f = B_f^* = \frac{1}{2} \tag{3.25}$$

In the case of domestic risk, the total holdings of future domestic endowment is not equal to the demanded domestic contingent bond. From (3.22), residents not only hold domestic endowment in the amount $B_d\tau_2$, they also have an amount $(1-\tau_2)$ of their own risky endowment. Therefore, residents' total exposure to domestic risk is $[1-\tau_2(1-B_d)]$, while foreigners' is only given by their share of domestic bonds: $B_d^*\tau_2$. As a result, the market for domestic shares is in equilibrium when (3.19) is satisfied and $B_d^*\tau_2 = [1-\tau_2(1-B_d)]$, which implies:

$$B_d = \frac{2\tau_2 - 1}{2\tau_2} \qquad\qquad B_d^* = \frac{1}{2\tau_2} \tag{3.26}$$

Residents' demand for domestic bonds increases in the tax rate τ_2. A larger tax rate decreases residents' exposure to their own endowment risk, which has a sovereign risk component –i.e. $Var(w_{is}) = \sigma_i^2 + \sigma^2$–. Then, residents are willing to hold more domestic bonds when the exposure to their own endowment risk is lower. In the case of foreign investors, their demand of domestic bonds lowers in τ_2, since higher tax rate increases the variance of domestic bonds.

The equilibrium prices that sustain the market allocations are:

$$p_d = \beta\left[\overline{R} - \frac{\gamma}{2}\tau_2\left(\sigma^2 + \sigma_{fd}\right)\right] \quad (3.27)$$

$$p_f = \beta\left[\overline{w}^* - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right] \quad (3.28)$$

where $\overline{R}$ denotes the expected return on domestic asset.

Finally, since the return on the risk-free asset is the reciprocal of the intertemporal discount rate, condition (3.5) is again satisfied for all agents.

3.2.4 Ex-ante optimal government intervention

The first best allocation can be attained if the government can credibly commit to follow the ex-ante optimal policy. That is, the government chooses a policy $\mathcal{P} = \{R_s, \tau_1, \tau_2\} \in \mathbb{R}^3$ that maximizes :

$$\max_{\{R_s,\tau_1,\tau_2\}} u(c_1) + \beta E u(c_{is})$$

$$s.t.$$

$$CE(c_{is}) = c_1 \quad (3.29)$$

$$c_1 = \frac{1}{1+\beta}\left[w_1 + \beta\overline{w} - \beta\frac{\gamma}{2}Var(c_{is}) - \beta\frac{\gamma}{4}\left(\sigma^2 - \sigma^{*2}\right)\right] \quad (3.30)$$

$$where: Var(c_{is}) = \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right) + (1-\tau_2)^2\sigma_i^2$$

Budget Constraints (3.13) and (3.14)

where, $CE(c_{is})$ denotes for Certainty Equivalent of c_{is}. Combining (3.5), (3.25)-(3.28), and (3.15)-(3.16), the equations (3.30) and (3.29) correspond to the equilibrium consumption schedule for residents given a policy vector $\{R_s, \tau_1, \tau_2\}$.

The ex-ante optimal tax schedule is therefore:

$$\begin{aligned}\tau_2 &= 1 \\ \tau_1 w_1 &= -\beta\left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right]\end{aligned}$$

The optimal tax rate at date 2 prevents residents from facing any idiosyncratic risk. And government's transfers to the residents at date 1 correspond to the discounted certainty equivalent of date 2-tax revenues. The first best allocation is attained.

The expected return on domestic bonds $\overline{R}$ (and therefore the optimal government's investment in the storage technology) is undetermined. It does not affect the covariance matrix, which only depends on the policy choice τ_2, and it is fully accounted for in the equilibrium price (3.27). Summarizing, since agents and the government have the same storage technology, changes in $\overline{R}$ do not alter the consumption schedule in (3.30) and (3.29).

3.2.5 Time inconsistent Government

The ex-ante government policy leads the economy to the first best allocation. However, this policy may not be optimal ex-post because, once investment decisions have been made, a lower date-2 tax rate τ_2 can increase local agents' expected consumption by expropriating foreign investors. Here, the government chooses date-2 tax rate τ_2 –and therefore the return on domestic shares- after the portfolio choice is set and before the realization of the shocks. The policy equilibrium is defined as follows:

Definition 5 *Policy Equilibrium is a combination of strategies and market prices* $\{\mathcal{P}, \mathcal{B}, \mathcal{B}^*, p_d, p_f\}$ *such that:*

(i) $\{\mathcal{B}, \mathcal{B}^*, p_d, p_f\}$ *is a Financial Market Equilibrium given* $\mathcal{P} = \{\tau_1, \tau_2, R_s\}$

(ii) τ_1 *maximizes government's objective at time 1:* $u(c_1) + \beta E u(c_{is})$ *given the budget constraint (3.13)*

(iii) $\{\tau_2, R_s\}$ *maximizes government's objective at time 2:* $Eu(c_{is})$*, given* $\{\mathcal{B}, \mathcal{B}^*, p_d, p_f\}$ *and subject to the budget constraint (3.14).*

The policy equilibrium is characterized by backwards induction. At date 2, for a given financial market equilibrium $\{\mathcal{B}, \mathcal{B}^*, p_d, p_f\}$ and date-1 policy τ_1, the government chooses $\{R_s, \tau_2\} \in$

$\mathbb{R}^2$ to maximize

$$\begin{aligned} & \max_{\{\tau_2, R_s\}} EU(c_{is}) \\ & s.t. \\ R_s &= \tau_2 w_s + (\tau_1 w_1 + p_d)(1+r) \\ c_{is} &= w_{is}(1-\tau_2) + B_0(1+r) + B_d R_s + B_f w_s^* \end{aligned} \tag{3.31}$$

At the time of choosing $\{R_s, \tau_2\}$ investors already made their financial decisions and agreed on a price for domestic bonds. Then, the policy does not alter the holdings of domestic bonds or its price. In other words, the government chooses its policy without internalizing its effect on already taken financial decisions. Therefore, it maximizes the ex-post consumption level in (3.31), instead of the equilibrium consumption level in (3.30). However, the government's optimal policy feeds back into investors' expectation. As a result, from an ex-ante perspective, the government's optimal tax rate is suboptimal and results in a suboptimal diversification of domestic risk.

The first order condition that characterizes the optimal date-2 tax rate and the return on the domestic asset is:

$$-(1-B_d)\overline{w} + \gamma \left\{ \begin{array}{c} (1-\tau_2)\sigma_i^2 \\ +[1-\tau_2(1-B_d)](1-B_d)\sigma^2 \\ +(1-B_d)B_f\sigma_{fd} \end{array} \right\} = 0 \tag{3.32}$$

The return on assets R_s is financed through taxes. While taxes are levied entirely on residents, the return on assets goes to share holders, which only a proportion B_d are residents. Therefore, expected consumption of residents decreases on τ_2 in an amount $(1-B_d)\overline{w}$, which corresponds to the first term in equation (3.32). The government, who does not consider foreigners' utility in its welfare objective, has incentives to reduce taxes and return on domestic asset. However, the optimal tax rate and return on domestic asset will not be zero. Because domestic government bonds are used to diversify aggregate and idiosyncratic risk, a time-inconsistent government will still find it optimal to tax residents and pay a positive return on domestic shares. An increase in τ_2 reduces the variance of consumption, as can be observed in the second term in (3.32).

The optimal date-2 tax rate as a function of residents' portfolio is presented in equation (3.33). It is a positive function of residents' holdings of domestic assets and the variance of both aggregate and idiosyncratic risk:

$$\tau_2 = 1 - (1 - B_d) \frac{\overline{w} - \gamma \left[B_d \sigma^2 + B_f \sigma_{fd} \right]}{\gamma \left[(1 - B_d)^2 \sigma^2 + \sigma_i^2 \right]} \tag{3.33}$$

Domestic bonds are not only used for international risk diversification, they also play a key role in the domestic financial system: since agents cannot commit their future endowment, they use government bonds to diversify the idiosyncratic risk. As a result, the larger the diversifiable risk, the lower the time inconsistency problem of the government. Indeed, in the limit of infinite idiosyncratic risk, the optimal tax rate coincides with the ex-ante optimum: $\lim_{\sigma_i^2 \to \infty} \tau_2 = 1$.

The ex-post optimal policy $\{\tau_2, R_s\}$ feeds back into the agents expectation and the resulting market equilibrium at date 1. The policy equilibrium is the set of fix points for which the market's foreseen policy coincides with the ex-post government optimum. Combining (3.26) and (3.25) with (3.33), the equilibrium date-2 tax rate is implicitly defined by:

$$\tau_2 (1 - \tau_2) = \frac{\overline{w} - \frac{\gamma}{2} \left(\sigma^2 + \sigma_{fd} \right)}{2 \gamma \sigma_i^2} \tag{3.34}$$

In order to assure an interior solution to the problem, I make the following parametric assumption:

$$\frac{\gamma}{2} \left(\sigma_i^2 + \sigma^2 + \sigma_{fd} \right) \geq \overline{w} \tag{3.35}$$

This assumption assures that there are values of τ_2 such that the benefits from retaining all the domestic endowment are lower than its cost in terms of variance of consumption. In particular, when $\tau_2 = \frac{1}{2}$, the government increases welfare by rising taxes and reducing consumption risk. It follows that the stable equilibrium corresponds to the positive root of (3.34) and the optimal date-2 tax rate is positive but lower than the ex-ante best policy: $\tau_2 \in \left[\frac{1}{2}, 1\right]$.

As in the ex-ante optimal policy, the expected return on the domestic bonds is undetermined as long as the budget constraint (3.13) is satisfied: $\overline{R} \geq \tau_2 \overline{w}$. Finally, combining (3.27) and

(3.14), the date-1 transfer to the residents is also lower than the ex-ante optimal policy:

$$\tau_1 w_1 = -\beta \tau_2 \left[\overline{w} - \frac{\gamma}{2} \left(\sigma^2 + \sigma_{fd} \right) \right] \tag{3.36}$$

The equilibrium price for domestic bonds at date 1 takes into account the future optimal government response. In other words, the price incorporates the future incentive of the government to decrease taxes and reduce payments to share holders. As a result, date-1 revenues from selling the domestic bond are also reduced and so are the transfers to local agents. For that reason, the time inconsistency of the government does not affect expected consumption of residents or foreign investors. Moreover, the international risk diversification is not affected by the suboptimal tax rate. Both foreign and resident investors adjust their demand for domestic bonds according to the after-tax covariance matrix. Total exposure to aggregate risk coincides with the first best allocation in (3.10) and (3.11).

However, the government distortion does have welfare implications. Residents' utility is still given by $U = (1+\beta) u(c_1)$, but the variance of consumption for residents is now higher than in the first best allocation (3.12):

$$Var(c_{is}) = \frac{1}{4} \left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd} \right) + (1-\tau_2)^2 \sigma_i^2$$

Because domestic bonds are also used to diversify the domestic idiosyncratic risk, residents face an excessive volatility of consumption relative to the ex-ante optimal one. The incentive of the government to expropriate foreign share holders has a negative impact on the domestic financial system, which is unable to diversify the idiosyncratic endowment risk. The suboptimal tax rate has no effect on foreign investors' welfare, which is still characterized by equation (3.11) and (3.12).

These findings are summarized by the following proposition

Proposition 5 *For a given date-1 domestic and foreign endowment* $\{w_1, w_1^*\}$ *and date-2 risky endowment* $\{w_{is}, w_s^*\}$ *with distributions defined in (3.2) and (3.35), the policy equilibrium is characterized by:*

(i) Sub-optimal tax on risky local endowment: $\tau_2 \in \left(\frac{1}{2}, 1\right)$ *with* $\frac{\partial \tau_2}{\partial \sigma^2} > 0$, $\frac{\partial \tau_2}{\partial \sigma_i^2} > 0$, *and* $\lim_{\sigma_i^2 \to \infty} \tau_2 = 1$

(ii) Excessive volatility of local consumption:

$$c_1 = CE\left(c_{is}\right) = \frac{1}{1+\beta}\left\{w_1 + \beta\overline{w} - \beta\frac{\gamma}{2}Var\left(c_{is}\right) - \beta\left(\sigma^2 - \sigma^{*2}\right)\right\}$$
$$where: Var\left(c_{is}\right) = \left(1-\tau_2\right)^2\sigma_i^2 + \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right)$$

(iii) Foreign agent's consumption at its first best level:

$$c_1^* = CE\left(c_s^*\right) = \frac{1}{1+\beta}\left\{w_1^* + \beta\overline{w}^* - \beta\frac{\gamma}{2}Var\left(c_s^*\right) - \beta\left(\sigma^{*2} - \sigma^2\right)\right\}$$
$$where: Var\left(c_s^*\right) = \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right)$$

3.2.6 Commitment Device

The ex-ante optimal policy enables the financial market to replicate the first best allocation. However, the government cannot credibly commit to follow it. This distortion arises because the government prevails domestic interests over foreign ones and, if anticipated, ends up reducing residents' welfare. The first best allocation will not be attained in this economy. Nevertheless, the government can credibly commit to follow a superior policy by forcing residents to hold domestic bonds above their individual optimal level. A Pareto better allocation is attained if the government gives part of the date-1 transfer in the form of non-transferable individual domestic-bond accounts.

From equation (3.33), the optimal date-2 tax rate increases with the holdings of domestic bonds by the representative local agent. However, the portfolio of a single investor does not affect government's incentives. That is, the individual optimum B_d in equation (3.26) does not internalize its effect on government's incentives.[1] Then, giving part of the initial transfer to local investors in the form of domestic bonds is a Pareto improvement. Or, in other words, the government uses date-1 transfer to residents as a commitment device for a better policy in period 2. Needless to say, that policy will have an impact only if those accounts are nontransferable and the amount transferred is above the privately chosen B_d in (3.26). Then, government's policy is a vector $\mathcal{P} = \left\{\overline{B}_d, \tau_1, \tau_2, R_s\right\} \in \mathbb{R}^4$, where $\left\{\overline{B}_d, \tau_1\right\}$ are chosen at date 1, while $\left\{\tau_2, R_s\right\}$ are

[1] This mechanism is in the lines of Tirole (2003): local investors exert externalities on each other through their impact on the government's incentives.

decided at date 2.

At date 1, the government chooses $\left\{\overline{B}_d, \tau_1\right\}$ that maximizes ex-ante residents' welfare, taking into account its own ex-post incentives to impose a suboptimal tax rate τ_2

$$\max_{\left\{\overline{B}_d, \tau_1\right\}} \left\{u\left(c_1\right) + \beta E\left(c_{is}\right)\right\}$$

$s.t.$

$\left\{\mathcal{B}, \mathcal{B}^*, p_d, p_f\right\}$ is a Financial Market Equilibrium for $\mathcal{P} = \left\{\overline{B}_d, \tau_1, \tau_2, R_s\right\}$

$$\tau_2 = 1 - \left(1 - \overline{B}_d\right) \frac{\overline{w} - \gamma\left[\overline{B}_d \sigma^2 + B_f \sigma_{fd}\right]}{\gamma\left[\left(1 - \overline{B}_d\right)^2 \sigma^2 + \sigma_i^2\right]} \tag{3.37}$$

Budget Constraints (3.13) and (3.14)

For a given $\mathcal{P} = \left\{\overline{B}_d, \tau_1, \tau_2, R_s\right\}$ the financial market equilibrium is characterized by:

$$p_d = \beta\left[\overline{R} - \frac{\gamma}{2}\tau_2\left(\sigma_{fd} + \sigma^2\right)\right] + \beta\left(\overline{B}_d - B_d\right)\gamma\tau_2^2\sigma^2\left(1 - \rho^2\right) \tag{3.38}$$

$$p_f = \beta\left[\overline{w}^* - \frac{\gamma}{2}\left(\sigma^{*2} + \sigma_{fd}\right)\right] \tag{3.39}$$

$$B_f = \frac{1}{2} - \frac{\sigma_{fd}}{\sigma^{*2}}\tau_2\left(\overline{B}_d - B_d\right) \tag{3.40}$$

where B_d is the privately optimum holding of domestic asset in (3.26), while $\overline{B}_d$ is the amount transferred by the government. Foreign holdings of assets are $B_d^* = 1 - \overline{B}_d$ and $B_f^* = 1 - B_f$.

The transfer of domestic bonds to the local agents affects the price of the bonds in two opposite ways. First, as expected, the policy increases their demand and, as a result, the price rises with $\overline{B}_d$ –computed in the second term in (3.38). And second, because higher local holdings of domestic bonds $\overline{B}_d$ result in a larger date-2 tax rate τ_2, the variance of the return on domestic bonds increases. This affects negatively the price of domestic bonds. Notice from (3.39) that the price of foreign bonds is not affected by the local policy.

The existence of individual domestic-bond accounts also affects the demand for foreign bonds, since the diversification strategy is altered (see (3.40)). The sign of this effect depends on the sign of the covariance between foreign and domestic endowment risks.

The optimal date-1 transfer of domestic bonds is $\overline{B}_d$ that satisfies the following first order equation:

$$\left[\frac{\partial c_1}{\partial \overline{B}_d}+\frac{\partial c_1}{\partial \tau_2}\frac{\partial \tau_2}{\partial \overline{B}_d}\right]+\frac{\partial c_1}{\partial B_f}\left[\frac{\partial B_f}{\partial \overline{B}_d}+\frac{\partial B_f}{\partial \tau_2}\frac{\partial \tau_2}{\partial \overline{B}_d}\right]+\frac{\partial c_1}{\partial p_d}\left[\frac{\partial p_d}{\partial \overline{B}_d}+\frac{\partial p_d}{\partial \tau_2}\frac{\partial \tau_2}{\partial \overline{B}_d}\right]=0$$

Notice from (3.22), that $\frac{\partial c_1}{\partial \overline{B}_d}$ corresponds to the first order condition for the individual local agent, which is zero for $\overline{B}_d = B_d$ and negative for $\overline{B}_d > B_d$. Also, since agents can freely choose the amount of foreign bonds, it follows that $\frac{\partial c_1}{\partial B_f} = foc(B_f)$ is equal to zero. Finally, the ex-post optimal tax level τ_2 satisfies the first order condition (3.32) and therefore: $\frac{\partial c_1}{\partial \tau_2} = -\beta\frac{\gamma}{2}\frac{\partial Var(c_{is})}{\partial \tau_2} = \beta\left(1-\overline{B}_d\right)\overline{w}$.

Replacing, the first order condition for $\overline{B}_d$ is:

$$\begin{aligned} foc\left(\overline{B}_d\right) &= foc_{ind}\left(\overline{B}_d\right)+\beta\left(1-\overline{B}_d\right)\gamma\tau_2^2\sigma^2\left(1-\rho^2\right) \\ &\quad +\beta\left(1-\overline{B}_d\right)\left[\overline{w}-\frac{\gamma}{2}\left(\sigma_{fd}+\sigma^2\right)+2\gamma\tau_2\left(\overline{B}_d-B_d\right)\sigma^2\left(1-\rho^2\right)\right]\frac{\partial \tau_2}{\partial \overline{B}_d}=0 \end{aligned}$$

where $foc_{ind}\left(\overline{B}_d\right)$ corresponds to the individual first order condition in (3.22), evaluated at the government's optimum $\overline{B}_d$ and $\frac{\partial \tau_2}{\partial \overline{B}_d} > 0$.[2]

It follows that the optimal $\overline{B}_d$ is larger than the private optimum B_d but allows some international diversification: $\overline{B}_d \in (B_d, 1)$.[3] Since foreign investors still hold some domestic bonds, the date-2 tax rate is bellow its first best level. The first best tax level ($\tau_2 = 1$) is not optimal. From equation (3.37), that would require residents to hold the entire supply of domestic bond $\left(\overline{B}_d = 1\right)$. In that case, the idiosyncratic risk would be perfectly diversified, but there would be suboptimal international risk sharing.

Summarizing, it is optimal for the government to impose private non-transferable savings account composed of domestic bonds. By forcing residents to hold public bonds, the government restricts itself from expropriating bond holders in the future and can credibly commit to follow a Pareto better policy. This commitment device is costly: it results in a suboptimal international

[2] Replacing (3.40) in (3.37), follows that the ex-post optimal tax-rate is a function of $\overline{B}_d$ only: $\tau_2 = 1-\left(1-\overline{B}_d\right)\frac{\overline{w}-\frac{\gamma}{2}\left(\sigma^2+\sigma_{fd}\right)-\gamma\left(\overline{B}_d-\frac{1}{2}\right)\sigma^2\left(1-\rho^2\right)}{\gamma\left[\left(1-\overline{B}_d\right)^2\sigma^2\left(1-\rho^2\right)+\sigma_i^2\right]}$. The tax rate τ_2 is a positive function of $\overline{B}_d$: $\frac{\partial \tau_2}{\partial \overline{B}_d} = \frac{\tau_2\left(1-\overline{B}_d\right)^2\sigma^2\left(1-\rho^2\right)+(1-\tau_2)\sigma_i^2}{\left(1-\overline{B}_d\right)\left[\left(1-\overline{B}_d\right)^2\sigma^2\left(1-\rho^2\right)+\sigma_i^2\right]} > 0$

[3] For $\overline{B}_d = B_d : foc\left(\overline{B}_d\right) = \beta\left(1-B_d\right)\left[\gamma\tau_2^2\sigma^2\left(1-\rho^2\right)+\left[\overline{w}-\frac{\gamma}{2}\left(\sigma_{fd}+\sigma^2\right)\right]\frac{\partial \tau_2}{\partial B_d}\right] > 0$

For $\overline{B}_d = 1 : foc_{ind}\left(\overline{B}_d\right) = foc\left(\overline{B}_d\right) < 0$. It follows that $\overline{B}_d \in (B_d, 1)$.

risk sharing. As a result, agents will face lower idiosyncratic risk but the first best allocation will not be attained. The optimal restriction results from the trade-off between idiosyncratic and aggregate risk diversification.

3.3 Dynamic Model

In this section I extend the baseline model to an infinitely repeated economy. Based on the previous static framework, I develop an overlapping generation model with zero population and economic growth. The government is an infinitely lived agent, who internalizes the future benefits of implementing the ex-ante optimal policy.

I analyze the conditions under which "reputation" can work as a commitment device. In those cases where it does, the government implements the ex-ante optimal policy under the threat that any deviation will be punished by reversion to the Markov Perfect Equilibrium. Then, the economy attains its first best allocation. That is, residents diversify the domestic idiosyncratic risk and minimize the aggregate risk by holding the international portfolio of assets.

I characterize in this section the stationary Markov Perfect Equilibrium and analyze the cases in which the reversion to such equilibrium represents a sufficient threat.

3.3.1 Dynamic Environment

At each moment in time $t = 1, 2, 3...$, two generations coexist in the local economy: a unit mass of young agents with endowment w_1, who consume an amount $c_{1,t}$; and a unit mass of old agents with a random endowment $w_{is,t}$, who consume $c_{is,t}$. The state of the economy at each time t is given by the old investors' assets and the government's storage of goods $\left\{\mathcal{B}_{t-1}, \mathcal{B}^*_{t-1}, a_{t-1}\right\}$, where a_t corresponds to the government's investment in the storage technology, with a riskless return $(1+r)$.

As in the static framework, young and old residents at time t consume according to (3.41) and (3.42) respectively:

$$c_{1,t} + B_{0,t} + B_{d,t}p_{d,t} + B_{f,t}p_{f,t} = (1 - \tau_{1,t})\, w_1 \tag{3.41}$$

$$c_{is,t} = (1 - \tau_{2,t})\, w_{is,t} + B_{0,t-1}\,(1 + r) + B_{d,t-1}R_{s,t} + B_{f,t-1}w^*_{s,t} \tag{3.42}$$

Similarly, young and old foreign investors at time t consume:

$$c^*_{1,t} + B^*_{0,t} + B^*_{d,t}p_{d,t} + B^*_{f,t}p_{f,t} = w^*_1 + p^*_{f,t} \tag{3.43}$$

$$c^*_{s,t} = w^*_{s,t} + B^*_{0,t-1}\,(1 + r) + B^*_{d,t-1}R_{s,t} + B^*_{f,t-1}w^*_{s,t} \tag{3.44}$$

Notice that the generation born at time t is affected by the policy actions $\{\tau_{1,t}, \tau_{2,t+1}, R_{s,t+1}\}$.

Similar to the static case, the government has a period by period budget constraint. Differently, at each time t, government resources combine taxes levied to young and old agents, and revenues from selling the domestic bond.

$$\begin{aligned} R_{s,t} + a_t &\geq \tau_{2,t}w_{s,t} + \tau_{1,t}w_1 + p_{d,t} + a_{t-1}\,(1 + r) \\ a_t &\geq 0 \end{aligned} \tag{3.45}$$

3.3.2 Financial Market Equilibrium

As in the static framework, the strategy of each local agent born at time t consists of three actions $\mathcal{B}_t = \{B_{d,t}, B_{f,t}, B_{0,t}\} \in \mathbb{R}^3_+$ –correspondingly, the strategy of a foreign investors is $\mathcal{B}^*_t = \left\{B^*_{d,t}, B^*_{f,t}, B^*_{0,t}\right\} \in \mathbb{R}^3_+$ – . The financial market equilibrium is defined for a given policy path $\{\mathcal{P}_t\}^{\infty}_{t=t_0}$, where $\mathcal{P}_t = \{\tau_{1,t}, \tau_{2,t}, R_{s,t}, a_t\}$.

Definition 6 *For a given policy path $\{\mathcal{P}_t\}^{\infty}_{t=1}$ such that for all t (3.45) is satisfied, a Financial Market Equilibrium is a combination of strategies and market prices $\{\mathcal{B}_t, \mathcal{B}^*_t, p_{d,t}, p_{f,t}\}$ such that:*

(i) $\mathcal{B}_t = \{B_{d,t}, B_{f,t}, B_{0,t}\}$ maximizes $u\,(c_{1,t}) + \beta E u\,(c_{is,t+1})$ subject to (3.41) and (3.42)

(ii) $\mathcal{B}^*_t = \left\{B^*_{d,t}, B^*_{f,t}, B^*_{0,t}\right\}$ maximizes $u\left(c^*_{1,t}\right) + \beta u E\left(c^*_{s,t+1}\right)$ subject to (3.43) and (3.44)

(iii) Market clearing conditions are satisfied:

$$B_{d,t} + B_{d,t}^{*} = 1 \tag{3.46}$$

$$B_{f,t} + B_{f,t}^{*} = 1 \tag{3.47}$$

As in the static framework, agents live for only two periods, so the financial market equilibrium at each time t is analog to the static case:

$$\begin{array}{ll} B_{d,t} = \dfrac{2\tau_{2,t+1} - 1}{2\tau_{2,t+1}} & B_{d,t}^{*} = \dfrac{1}{2\tau_{2,t+1}} \\ B_{f,t} = \dfrac{1}{2} & B_{f,t}^{*} = \dfrac{1}{2} \end{array} \tag{3.48}$$

Similarly, the equilibrium prices are:

$$p_{f,t} = \beta\left[\overline{w}^{*} - \frac{\gamma}{2}\left(\sigma^{*2} + \sigma_{fd}\right)\right] \tag{3.49}$$

$$p_{d,t} = \beta\left[\overline{R}_{t+1} - \frac{\gamma}{2}\tau_{2,t+1}\left(\sigma^{2} + \sigma_{fd}\right)\right] \tag{3.50}$$

The existence of a storage technology assures that for each generation, the consumption schedule satisfies (3.5). Then, replacing in the budget constraints (3.41) and (3.42), the consumption schedule for each generation born at time t is:

$$c_{1,t} = \frac{1}{1+\beta}\left\{w_1 + \beta\overline{w} - \beta\frac{\gamma}{4}\left(\sigma^2 - \sigma^{*2}\right) - \beta\frac{\gamma}{2}Var\left(c_{is,t+1}\right) + T_t\right\} \tag{3.51}$$

$$where: \begin{cases} Var\left(c_{is,t+1}\right) = \left(1 - \tau_{2,t+1}\right)^2 \sigma_i^2 + \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right) \\ T_t = -\tau_{1,t}w_1 - \beta\tau_{2,t+1}\left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right] \end{cases}$$

$$c_{1,t} = CE\left(c_{is,t+1}\right) \tag{3.52}$$

where $CE\left(c_{is,t+1}\right)$ denotes for the Certainty Equivalent of $c_{is,t+1}$, and T_t is the net transfer received by the generation born at time t. In the static framework, with only one generation alive, the net transfer is necessarily zero. That is, the resources received when young are equal to the discounted certainty equivalent of future tax payments (see equation (3.36)). This is not necessarily the case in the dynamic framework.

3.3.3 Ex-ante Optimal Policy

If local agents could sell their future endowment, the decentralized equilibrium would be a repeated version of the static equilibrium presented in section 2.2. That is, prices would be constant over time and each generation born at time t would have the same consumption schedule and portfolio composition as in the decentralized equilibrium characterized by equations (3.6)-(3.12). As in the static framework, a credible government can replicate this first best allocation for the case where agents cannot pledge their future endowment. The ex-ante optimal policy is a path $\{\mathcal{P}_t\}_{t=1}^{\infty}$ with $\mathcal{P}_t = \{\tau_{1,t}, \tau_{2,t}, R_{s,t}, a_t\} \in \mathbb{R}^4$ that maximizes

$$\max_{\{\mathcal{P}_t\}_{t=1}^{\infty}} \sum_{t=1}^{\infty} \beta^{t-1} \left[u\left(c_{1,t}\right) + \beta E u\left(c_{is,t+1}\right)\right]$$

$$s.t.$$

$$R_{s,t} + a_t = \tau_{1,t} w_1 + \tau_{2,t} w_{s,t} + p_{d,t} + a_{t-1}\left(1+r\right) \tag{3.53}$$

$$(3.50), (3.51), \ and \ (3.52)$$

The ex-ante optimal policy leads the economy towards the first best risk diversification. That is, the idiosyncratic risk is diversified away and the aggregate risk is minimized:

$$\forall t : \tau_{2,t} = 1 \tag{3.54}$$

Since the intertemporal preference is the reciprocal of the return on the riskless technology, the utility is constant across generations:

$$u'\left(c_{1,t}\right) = Eu'\left(c_{is,t}\right) = u'\left(c_{1,t-1}\right) \tag{3.55}$$

Then, at any time t, the optimal transfer to the young agents is:

$$\tau_{1,t} w_1 = -a_0 r - \beta\left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right] \tag{3.56}$$

where a_0 corresponds to the government's initial holdings of assets in storage. Then, the net transfer to the young generation $T_t = -\tau_1 w_1 - \beta\left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right]$ is equal to the flow of returns on government's assets: $a_0 r$.

Again, the level of expected return on the domestic asset $\overline{R}_t$ is undetermined, together with the government's storage in the riskless technology, and does not affect agents' welfare:

$$\overline{R}_t = (a_{t-1} - a_0)(1 + r) + \overline{w} \tag{3.57}$$

At each period t, the government gets $a_{t-1}(1+r)$ from its investment in the storage technology. An amount $(a_t - a_0)(1+r)$ is assigned to debt payments, $a_{0-1}r$ is transferred to the young, and the remaining a_{0-1} is reinvested.

3.3.4 Markov Perfect Equilibrium

A time inconsistent government cannot commit to follow the ex-ante optimal dynamic policy. Instead, it has incentives to impose a suboptimal tax on old residents and, by doing so, it prevents residents from fully diversifying the idiosyncratic risk. Moreover, in the dynamic framework, a new distortion arises: a time inconsistent government has incentives to redistribute resources across generations.

For each t, the timing of each stage-game is the following:

1. Local and foreign young agents choose strategies $\mathcal{B}_t = \{B_{d,t}, B_{f,t}, B_{0,t}\} \in \mathbb{R}^3_+$ and $\mathcal{B}^*_t = \left\{B^*_{d,t}, B^*_{f,t}, B^*_{0,t}\right\} \in \mathbb{R}^3_+$. The government implements a policy vector $\mathcal{P}_t = \{\tau_{1,t}, \tau_{2,t}, R_{s,t}, a_t\}$.
2. The aggregate and idiosyncratic shocks are realized: $\left\{w_{s,t}, w^*_{s,t}, \{\varepsilon_{i,t}\}^1_{i=0}\right\}$.
3. Consumption takes place: $\left\{c_{1,t}, \{c_{is,t}\}^1_{i=0}\right\}$

I characterize here the stationary Markov Perfect Equilibrium (MPE) for the dynamic game described above. In this type of equilibria, strategies can only be contingent on the payoff-relevant state of the world and the prior actions taken within the same period. The Markov Perfect Equilibrium for this economy is defined as follows:

Definition 7 *For a given state $\{\mathcal{B}_0, a_0\}$, a stationary Markov Perfect Equilibrium is a combination of strategies and market prices $\{\mathcal{P}_t, \mathcal{B}_t, \mathcal{B}^*_t, p_{d,t}, p_{f,t}\}^\infty_{t=1}$ such that the three strategies are best responses to the other three, and the asset markets clear. That is:*

(i) for all $t = 1, 2, 3...$, $\{\mathcal{B}_t, \mathcal{B}^*_t, p_{d,t}, p_{f,t}\}$ is a Financial Market Equilibrium given $\{\mathcal{P}_t\}^\infty_{t=1}$

(ii) for all $t = 1, 2, 3...$, $\mathcal{P}_t$ *satisfies*

$$W(\mathcal{B}_{t-1}, a_{t-1}) = \max_{\mathcal{P}_t} \{u(c_{1,t}) + Eu(c_{is,t}) + \beta EW(\mathcal{B}_t, a_t)\}$$

$$s.t.$$

$$(3.45), (3.41), and\ (3.42)$$

$$\lim_{T\to\infty} \sum_{t=1}^{T} \beta^t \left\{\tau_{1,t} w_1 + \beta \tau_{2,t} \left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right]\right\} + a_0 \geq 0 \tag{3.58}$$

(iii) the allocation is stationary: for all $t = 1, 2, 3... : c_{1,t} = c_1$ *and* $E(c_{is,t}) = E(c_{is})$

The government has incentives to transfer resources from the old to the new generations. For that reason, I restrict, in the limit, the budget constraint of the government. Condition (3.58) requires that transfers to the young generation are financed out of taxes on residents or initial government's savings. In other words, under condition (3.58) no bubble arises.

I guess the following equation for the government's future policy:

$$\overline{R}_{t+1} = (a_t - a_0)(1 + r) + \beta \tau_{2,t+1} \overline{w} + \frac{1 - B_d}{B_d} (\tau_{1,t} w_1 - \tau_1^* w_1)(1 + r) \tag{3.59}$$

Combining (3.50) and (3.59), the resulting financial market equilibrium price for the domestic bond is:

$$p_{d,t} = a_t - a_0 + \beta \tau_{2,t+1} \left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right] + \frac{1 - B_d}{B_d} [\tau_{1,t} w_1 - \tau_1^* w_1] \tag{3.60}$$

The optimal tax rate on the old residents' endowment is suboptimal relative to the ex-ante optimum. Again, the tax rate corresponds to the optimal trade-off between variance and expected consumption. The reaction function describing the optimal tax level $\tau_{2,t}$ is identical to the static one:

$$\tau_{2,t} = 1 - (1 - B_{d,t-1}) \frac{\overline{w} - \gamma\left[B_{d,t-1}\sigma^2 + B_{f,t-1}\sigma_{fd}\right]}{\gamma\left[(1 - B_{d,t-1})^2 \sigma^2 + \sigma_i^2\right]} \tag{3.61}$$

Combining (3.48) and (3.61), the MPE tax level and holdings of domestic assets by residents are constant over time and identical to the static equilibrium in (3.34) and (3.26). For all

$t = 1, 2, 3, ...$

$$\begin{aligned} \tau_{2,t} &= \tau_2 : \tau_2 (1 - \tau_2) = \frac{\overline{w} - \frac{\gamma}{2} \left(\sigma^2 + \sigma_{fd}\right)}{2\gamma\sigma_i^2} \\ B_{d,t} &= B_d = \frac{2\tau_2 - 1}{2\tau_2} \end{aligned} \tag{3.62}$$

The optimal transfer to young residents satisfies the following condition:

$$u'(c_{1,t}) w_1 = Eu'(c_{is,t}) B_{d,t-1} \left[w_1 + \frac{\partial p_{d,t}}{\partial \tau_1} \right] \tag{3.63}$$

The first term in (3.63) corresponds to the marginal benefit of increasing the transfer to the young, while the second term is its marginal cost in terms of reducing the payments to the bond holders. Everything else constant, a unit of extra consumption to the young generation implies a reduction in today's payments to the elderly. However, because this payments take the form of returns on domestic bonds, this reduction only affects residents in a proportion $B_{d,t-1}$, while the remaining $(1 - B_{d,t-1})$ affects foreign investors not taken into account in the government's objective function. Then, if the price of future bonds did not react to current transfer to the young generation, the government would have incentives to redistribute resources from the elderly to the young above the ex-ante optimal.

In the stationary MPE, the price reaction in (3.60) exactly offsets government's incentives to redistribute resources across generations and the level of utility is constant. A constant utility over time together with a constant tax on old residents' endowment implies that for all t, the tax on the young generation is also constant: $\tau_{1,t} w_1 = \tau_1 w_1$.

The price on domestic bonds increases with current tax burden on the young generations. The intuition is simple: any increase in the transfer to young residents is permanent over time and implies a reduction on future payments to domestic bond holders, which results in a lower price. Notice that the incentives of the government to redistribute resources to the young generation decreases in the share of domestic bonds held by residents. Indeed, in the limit of $B_d = 1$, the price of the domestic bond does not react to current taxes and the government has no incentives to further reduce payments.

From (3.58), the resulting MPE is characterized by a constant level of utility over time, which requires constant transfers. The transfer to each young generation is given by the certainty equivalent of their future tax payments when old, and the flow of interest on the initial government's savings:

$$\tau_{1,t} w_1 = \tau_1^* w_1 = -a_0 r - \beta \tau_2 \left[\overline{w} - \frac{\gamma}{2} \left(\sigma^2 + \sigma_{fd} \right) \right] \tag{3.64}$$

Finally, replacing the optimal tax schedule on (3.59), the government's choice of expected return on bonds is given by (3.59). Payments to bond holders are financed out of taxes on old generation's endowment and out of government's return on savings. At each period t, government's revenues from its investment in the storage technology are $a_{t-1}(1+r)$. An amount $(a_t - a_0)(1+r)$ is assigned to debt payments, $a_{0-1} r$ is transferred to the young, and the remaining a_{0-1} is reinvested. The MPE expected return on domestic bonds is again undetermined, together with the optimal level of government's storage, and does not affect agents' utility but only the price level.

$$\overline{R}_t = (a_{t-1} - a_0)(1+r) + \tau_2 \overline{w} \tag{3.65}$$

Welfare value for the government is only affected by its initial wealth and the endowment distribution:

$$\begin{aligned}
& W\left(\mathcal{B}_{t_0-1}, a_{t_0-1}\right) = u\left(c_1\right) \frac{2}{(1-\beta)} \\
& where: \\
& c_1 = \frac{1}{1+\beta} \left[w_1 + \beta \overline{w} + a_0 r - \beta \frac{\gamma}{4} \left(\sigma^2 - \sigma^{*2} \right) - \beta \frac{\gamma}{2} Var\left(c_{is}\right) \right] \\
& Var\left(c_{is}\right) = \left(1 - \tau_2\right)^2 \sigma_i^2 + \frac{1}{4} \left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd} \right)
\end{aligned}$$

These findings are summarized as follows:

Proposition 6 *For a given domestic and foreign endowment* $\{w_1, w_1^*, w_{is}, w_s^*\}$ *with distributions defined in (3.2) and (3.35), the policy (stationary Markov Perfect) equilibrium is characterized by:*

(i) Sub-optimal tax on risky local endowment: $\tau_2 \in \left(\frac{1}{2}, 1\right)$ *with* $\frac{\partial \tau_2}{\partial \sigma^2} > 0$, $\frac{\partial \tau_2}{\partial \sigma_i^2} > 0$, *and* $\lim_{\sigma_i^2 \to \infty} \tau_2 = 1$

(ii) Excessive volatility of local consumption:

$$c_1 = CE(c_{is}) = \frac{1}{1+\beta}\left\{w_1 + \beta\overline{w} + a_0 r - \beta\frac{\gamma}{2}Var(c_{is}) - \beta\left(\sigma^2 - \sigma^{*2}\right)\right\}$$
$$where: Var(c_{is}) = (1-\tau_2)^2\sigma_i^2 + \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right)$$

(iii) Foreign agent's consumption at its first best level:

$$c_1^* = CE(c_s^*) = \frac{1}{1+\beta}\left\{w_1^* + \beta\overline{w}^* - \beta\frac{\gamma}{2}Var(c_s^*) - \beta\left(\sigma^{*2} - \sigma^2\right)\right\}$$
$$where: Var(c_s^*) = \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right)$$

(iv) Price for domestic bonds reacts negatively to current transfers to the young generation: $\frac{\partial p_{d,t}}{\partial(-\tau_1 w_1)} = -\frac{1-B_d}{B_d} < 0$

3.3.5 Equilibrium with Reputation

I analyze in this section the conditions under which reputation can work as a commitment device. Here, I allow strategies to be contingent not only on actions taken within the same period, but also on the history of strategies. The optimal policy rule that the government can credibly commit to follow is given by the following program:

$$\max_{\{\mathcal{P}_t'\}_{t=0}^{\infty}} \sum_{t=0}^{\infty}\beta^t\left[u(c_{1,t}) + \beta Eu(c_{is,t+1})\right]$$
$$s.t.$$
$$R_{s,t} + a_t = \tau_{1,t}w_1 + \tau_{2,t}w_{s,t} + p_{d,t} + a_{t-1}(1+r)$$
$$(3.50), (3.48), (3.51), \ and \ (3.52)$$
$$\forall t: W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}_{t'}\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t-1}\right) \geq W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}_{t'}'\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t-1}\right)$$

The policy rule $\{\mathcal{P}_{t'}\}_t^{\infty}$ maximizes the ex-ante welfare subject to $\{\mathcal{B}_t, \mathcal{B}_t^*, p_{d,t}, p_{f,t}\}$ being a financial market equilibrium for every t, given the history of government's policy $\{\mathcal{P}_{t'}\}_0^{t-1}$. And, at each moment t, the incentive compatibility constraint is satisfied. That is, the government has incentives to follow the promised rule $\{\mathcal{P}_{t'}\}_t^{\infty}$ instead of implementing the MPE policy $\{\mathcal{P}_{t'}'\}_t^{\infty}$.The reversion to the Markov Perfect Equilibrium is used as a threat to sustain the ex-ante policy rule. The ability to commit depends on the instantaneous gains from deviating from the promised rule, versus the cost in terms of a suboptimal policy thereafter. Then, if the reversion to the MPE does not represent a sufficient threat, reputation cannot constitute a commitment technology.

The ex-ante optimal policy rule is $\{\mathcal{P}_{t'}\}_t^\infty$ such that $\mathcal{P}_t = \{\tau_{1,t}, \tau_{2,t}, R_{s,t}, a_t\}$ satisfies (3.54)-(3.57). So, if the government follows the ex-ante optimal rule, residents' portfolio is, in equilibrium, $\mathcal{B}^F = \left\{B_0^F, B_d^F, B_f^F\right\}$ such that:

$$\begin{aligned} B_d^F &= B_f^F = \frac{1}{2} \\ B_0^F &: c_{1,t} = E\left(c_{is,t+1}\right) \end{aligned}$$

The welfare value for the government if following the rule is:

$$\begin{aligned} & W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}_{t'}\}_t^\infty \,|\, \{\mathcal{P}_{t'}\}_0^{t-1}\right) = u\left(c_1^F\right)\frac{2}{1-\beta} \\ & where: \\ & c_1^F = \frac{1}{1+\beta}\left[w_1 + \beta\overline{w} + a_0 r - \beta\frac{\gamma}{2}Var\left(c_{is}^F\right) - \beta\frac{\gamma}{4}\left(\sigma^2 - \sigma^{*2}\right)\right] \\ & Var\left(c_{is}^F\right) = \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right) \end{aligned} \tag{3.66}$$

If the government abandons the rule, it succeeds in surprising the market for one period. After that, the economy goes back to its Markov Perfect Equilibrium described previously. In that case, welfare value for the government is:

$$\begin{aligned} & W\left(\mathcal{B}_{t_D-1}, a_{t_D-1}, \{\mathcal{P}'_{t'}\}_{t_D}^\infty \,|\, \{\mathcal{P}_{t'}\}_0^{t_D-1}\right) = \max_{\mathcal{P}'_t}\left\{u\left(c_{1,t}\right) + Eu\left(c_{is,t}\right) + \beta EW\left(\mathcal{B}_t, a_t\right)\right\} \\ & s.t. \\ & (3.60), (3.48), (3.51), \ and \ (3.52) \\ & \{\mathcal{B}_{t_D-1}, a_{t_D-1}\} \text{ correspond to } \mathcal{B}^F, a^F \\ & \lim_{T\to\infty}\sum_{t=t_D+1}^{T}\beta^{t-t_D}\left\{\tau_{1,t}w_1 + \beta\tau_{2,t}\left[\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)\right]\right\} + a_D \geq 0 \end{aligned}$$

where t_D is the time of abandoning the rule, and a_D corresponds to government's asset at that time.

When residents expect the government to follow the rule, their holdings of domestic bonds are larger than in the MPE ($B_d^F > B_d$). Therefore, at the time of deviating, the optimal tax rate is higher than the MPE tax rate in (3.62). In other words, since residents' exposure to domestic risk is above the MPE levels, the government implements a tax rate τ_2^D higher than the MPE tax rate τ_2:

$$t = t_D : \tau_{2,t} = \tau_2^D = 1 - \frac{1}{2}\frac{\overline{w} - \frac{\gamma}{2}\left(\sigma^2 + \sigma_{fd}\right)}{\gamma\left(\frac{1}{4}\sigma^2 + \sigma_i^2\right)} \tag{3.67}$$

Residents adjust their holdings of bonds as soon as the government deviates from the promised rule. From then on, both the tax rate and the portfolio choice are consistent with the MPE described above:

$$\begin{aligned} t &> t_D : \tau_{2,t} = \tau_2 < \tau_2^D \\ t &\geq t_D : B_{d,t} = B_d = \frac{2\tau_2 - 1}{2\tau_2} \end{aligned}$$

where τ_2 corresponds to the MPE tax rate in equation (3.62)).

Deviating from the rule is not neutral over generations. The immediate gains from surprising the market will be spread over time but still, the initial old generation will be the most benefited from the departure. As before, the government has incentives to redistribute in favor of the young: increasing the transfer $(-\tau_1 w_1)$ implies a one-to-one increase in young residents' consumption and a reduction of only B_d^F in old residents'. However, the negative reaction of the price level more than offsets this effect. From equation (3.60)), the price of domestic bonds at the time of deviation decreases in $\frac{1-B_d}{B_d}$ for every dollar transferred to the young. Because the price reflects the future performance of the domestic bond, its elasticity towards current transfer depends on B_d, the future holdings of the asset, which is lower than its current level, B_d^F. Therefore, the optimal transfer $(-\tau_{1,t} w_1)$ to the young generation satisfies the following condition:

$$\begin{aligned} t &= t_D : u'\left(c_{1,t}\right) = Eu'\left(c_{is,t}\right)\frac{B_d^F}{B_d} \\ t &> t_D : u'\left(c_{1,t}\right) = Eu'\left(c_{is,t}\right) \end{aligned} \tag{3.68}$$

The resulting payment to bond holders is:

$$
\begin{aligned}
t &= t_D : \overline{R}_t = (a_F - a_D)(1+r) + \tau_2^D \overline{w} \\
t &> t_D : \overline{R}_t = (a_{t-1} - a_D)(1+r) + \tau_2 \overline{w}
\end{aligned}
\tag{3.69}
$$

At the time of abandoning the rule, the government succeeds in surprising the financial market. It does so by deviating from the promised tax τ_2 and by altering the amount of government's savings designated to pay its debt. The government transfers $a_D r$ to the young (different from $a_0 r$ under the rule), and assigns $(a_F - a_D)(1+r)$ to debt payments instead of $(a_F - a_0)(1+r)$ committed under the rule.

The welfare value of the government if deviating is:

$$
W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}'_{t'}\}_{t_D}^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t_D-1}\right) = u(c_1)\left[\frac{2}{(1-\beta)} - \frac{(1-\tau_2)}{\tau_2}\right] \tag{3.70}
$$

$$
\begin{aligned}
&where: \\
&c_1 = \frac{1}{1+\beta}\left[w_1 + \beta\overline{w} + a_D r - \beta\frac{\gamma}{4}\left(\sigma^2 - \sigma^{*2}\right) - \beta\frac{\gamma}{2} Var(c_{is})\right] \\
&Var(c_{is}) = (1-\tau_2)^2 \sigma_i^2 + \frac{1}{4}\left(\sigma^2 + \sigma^{*2} + 2\sigma_{fd}\right)
\end{aligned}
\tag{3.71}
$$

where a_D is defined implicitly by (3.68), (3.71) and (3.69).

The instantaneous benefit from deviating can be observed in the second term in (3.70). Part of the gains from expropriating bond holders is shared with future generations, who are the beneficiaries of the flows of interests on a_D, as can be observed in (3.71). However, future generations will be jeopardized with suboptimal diversification of idiosyncratic risk.

The ability to commit to the ex-ante rule depends on the instantaneous gains from surprising the market, versus the cost in terms of a suboptimal policy thereafter. As expected, reputation works as a commitment technology if the intertemporal discount is sufficiently high (see figure 1.a.). In the limit of $\beta = 1$ (or equivalently $r = 0$), government's flow of return on a_D has no effect on consumption ($\lim_{\beta\to1} a_D r = 0$). It follows that the $\lim_{\beta\to1} c_1 < c_1^F$ and therefore:

$$
\lim_{\beta\to1} \frac{W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}'_{t'}\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t-1}\right)}{W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}_{t'}\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t-1}\right)} = \frac{u(c_1)}{u\left(c_1^F\right)} > 1
$$

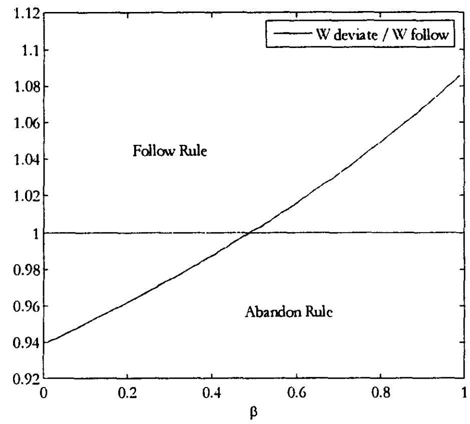


Figure 1.a

More interesting, reputation is less likely to support the ex-ante rule in economies with high idiosyncratic risk. When the idiosyncratic risk is higher, the government implements a policy closer to the ex-ante optimal after abandoning the rule. Then, the reversion to the Markov Perfect Equilibrium does not represent a sufficient threat. Indeed, the higher is σ_i^2, the larger is the tax rate on the risky endowment (τ_2) and residents' holding of domestic bond (B_d). The improvement in the optimal policy more than compensates the increase in the idiosyncratic risk and residents end up facing a lower variance of consumption:

$$\frac{\partial Var\left(c_{is}\right)}{\partial \sigma_i^2} = \frac{\partial\left[\left(1-\tau_2\right)^2 \sigma_i^2\right]}{\partial \sigma_i^2} = -\frac{\left(1-\tau_2\right)^2}{\left(2\tau_2-1\right)}$$

Then, if the government is indifferent between following the rule or deviating, an increase in the idiosyncratic risk will make the rule less attractive. [4] Figure 2.b. shows the case where such point of indifference exists, contrary to Figure 2.a. where pre-commitment is possible for all values of σ_i^2.

In the limit of infinite idiosyncratic variance, the optimal policy without commitment tech-

[4] If a point of indifference exists. At that point, the direct effect of an increase in the idiosyncratic risk (keeping a_D constant) on the welfare value after abandoning the rule is:

$$\frac{\partial W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}'_{t'}\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_{t_0}^{t-1}\right)}{\partial \sigma_i^2} = \frac{\gamma}{2} u'\left(c_1\right)\left(1-\tau_2\right)^2\left[\frac{\beta}{1-\beta}\frac{1}{2\tau_2-1} - \frac{B_d}{B_d^F}\frac{\left(1-\tau_2^D\right)^2}{\left(1-\tau_2\right)^2}\right]$$

which is positive for $\beta > 0.5$. Making a_D endogenous can only increase the welfare value even further nology coincides with the ex-ante optimal. As a result, the incentive compatibility constraint is satisfied with equality, as shown in Figure 2.a and 2.b..

$$\lim_{\sigma_i^2 \to \infty} \frac{W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}'_{t'}\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t-1}\right)}{W\left(\mathcal{B}_{t-1}, a_{t-1}, \{\mathcal{P}_{t'}\}_t^{\infty} \mid \{\mathcal{P}_{t'}\}_0^{t-1}\right)} = 1$$

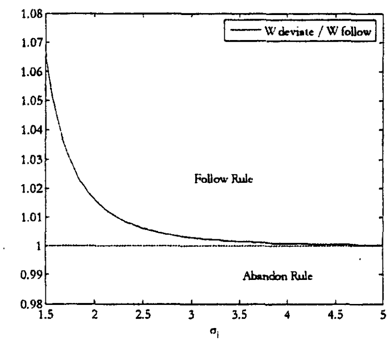


Figure 2.a.

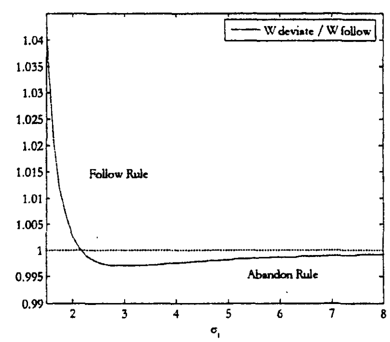


Figure 2.b

These findings are summarized in the following proposition:

Proposition 7 *The threat of a reversion to the stationary Markov Perfect Equilibrium can sustain the ex-ante optimal policy if*

$$u\left(c_1^F\right)\frac{2}{(1-\beta)} \geq u\left(c_1\right)\left[\frac{2}{(1-\beta)} - \frac{(1-\tau_2)}{\tau_2}\right] \tag{3.72}$$

where c_1^F is defined as in (3.66), c_1 as in (3.71), and a_D is implicitly given by (3.68).

At a point where (3.72) is satisfied with equality, a higher β increases the cost of the reversion to the stationary MPE, while a rise in σ_i^2 reduces it.

Summarizing, when the idiosyncratic risk is high, reputation is less lickely to work as a commitment device for the implementation of the ex-ante optimal policy and the economy will not attain the first best allocation. Along the same lines, transfer to young residents in the form of domestic bonds improves fiscal policy. But, as a downside, they reduce the effectiveness of the reversion to the Markov Perfect Equilibrium as a threat and may deprive the government from a costless commitment technology.

3.4 Conclusions

Fiscal policy plays a double role in terms of risk diversification: government's bonds are used for international risk sharing, while taxes are key to pool domestic idiosyncratic risk. If the government can pre-commit to follow the ex-ante optimal policy, there is no trade-off between these two roles. The ex-ante optimal fiscal policy succeeds in perfectly diversifying domestic idiosyncratic risk and local investors minimize their exposure to aggregate risk by holding the optimal international portfolio.

However, when the policymaker lacks the ability to commit, there is a tension between pooling idiosyncratic risk and holding a diversified interantional portfolio. If a large proportion of government debt is held by domestic investors, the government, who prevails local interests over foreign ones, will be able to commit to a higher return on its debt. On the other hand, whenever foreign investors hold government bonds, the fiscal policy will be suboptimal, and the domestic idiosyncratic risk will not be perfectly diversified.

This result provides a rationality for restricting the portfolio choice of pension funds, with minimum requirements of government bonds. This restriction results in a superior fiscal policy and better diversification of the idiosyncratic risk. However, as a downside, it implies a suboptimal international risk sharing. Moreover, these restrictions reduce the effectiveness of reputation as a commitment device for implementing the ex-ante best policy.

Chapter 4

Investor Protection and Domestic Participation in the Financial Market

4.1 Introduction

The quality of countries' institutions governing financial markets has a strong impact on the ability of those economies to attract investment. Despite the breath of evidence documenting this fact,[1] and the broad consensus on the need of increasing investor protection and the overall quality of the institutional environment in which financial transactions occur, the question of why inefficient institutions exist in the first place has not been resolved.[2]

One way of formalizing weak institutions is to assume that governments cannot commit to policies. Instead, only policies that are ex-post optimal can be credibly implemented. As a result, emerging markets must function in poor institutional environments, face high sovereign risk, and must resort to very costly commitment devices that are sub-optimal from an ex-ante

[1]For a review of theoretical and empirical research on the link between law, financial developtment and investment, see Beck et al. (2000, 2004) and Levine (2004).

[2]La Porta et al. (1997, 1998) find that the level of financial develpment varies signifiatively across countries. La Porta et al. (1997) stress that historically-determined differences in legal tradition shape the laws governing financial transactions. Pagano and Volpin (2001) and Rajan and Zingales (2003) focus on how political economy forces shape national policies.

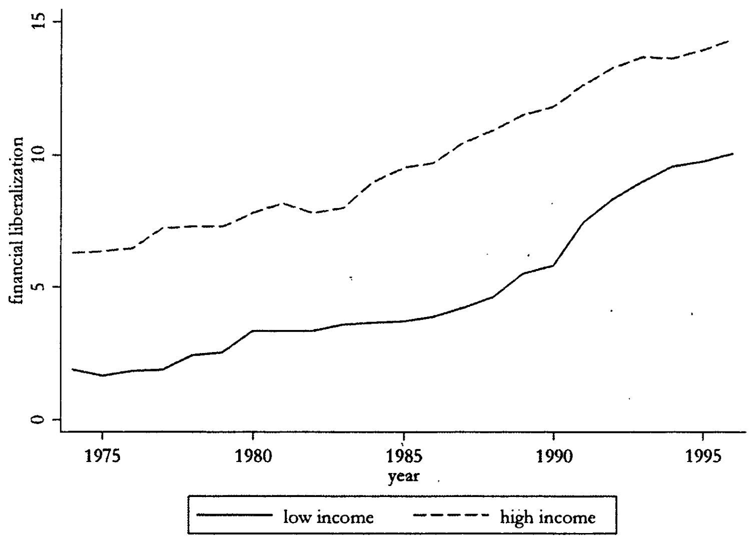
perspective. This paper looks at how the government's lack of commitment technology affects policy decisions towards investor protection –i.e. bankruptcy laws. In particular, it shows that the interaction between wealth distribution and international integration will affect investor protection and, consequently, the domestic level of investment.

The government's objective function weights agents' utilities independently of their wealth. The optimal level of investor protection depends on the number of financiers relative to entrepreneurs affected by the policy. If the capital account is closed, the incentives to impose a superior level of investor protection are higher in economies with an even income distribution. In unequal economies, the supply of investment funds will be concentrated among a small group of wealthy investors with low weight in the government's objective function. In that case, the number of financiers relative to entrepreneurs is low and the government has incentives to benefit the later, which, from an ex-post perspective, implies a reduction in investor protection. Those economies will be characterized by low level of investment.

When the capital account is open, this conclusion may be reversed. In economies with low income per capita, foreign capital inflows crowd out local investors. In poor but equally distributed economies, lenders are mainly foreign. The government, who does not consider foreigners in its objective function, will reduce investor protection in an attempt to redistribute resources from foreign lenders to local borrowers. In poor economies, the number of resident financiers increases if there is at least a small share of wealthy investors able to compete with foreign lenders in the local market. Therefore, investor protection will be higher in unequal economies.

On the other hand, in rich economies, income per capita is high enough so the average local investor finds it optimal to participate in the financial market. Therefore, the number of local participants and the optimal level of investor protection are higher in economies with an even wealth distribution. Moreover, in rich economies, with large domestic financial markets, the proportion of foreign to domestic capital is low. As a result, the government will have incentives to maintain high level of investor protection after the capital account liberalization. The gains from integrating the financial system are larger in this case.

The predictions of this model are consistent with some stylized facts concerning the institutions governing financial markets. First, as shown in Figure 4-1, high income countries have a more liberalized financial market. Second, as represented in Figure 4-2, in economies with low income per capita, unequal distribution –i.e. high Gini coefficient- is correlated with higher financial liberalization. However, that pattern is reversed for high income economies, were economies with low Gini coefficient tend to show higher levels of financial liberalization.[3]



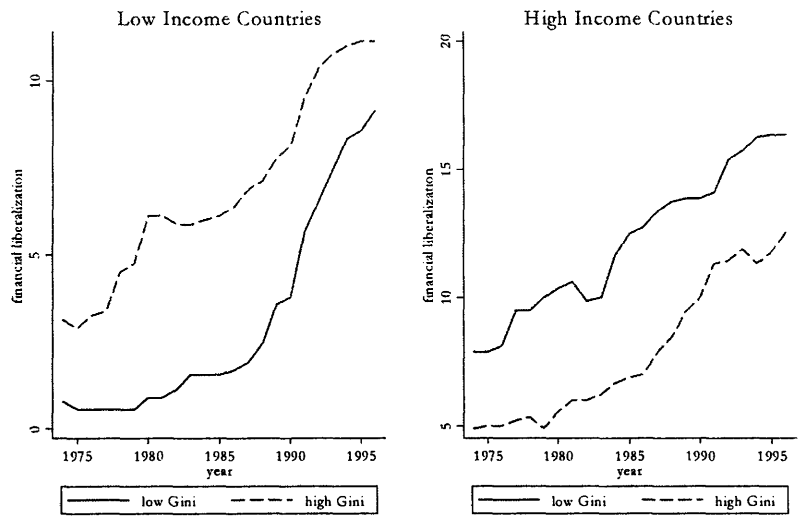
Source: Index of financial liberalization from Abiad and Mody (2003): 0-17 where 17 corresponds to the maximum level of financial liberalization. GDP per capita from WDI

Note: The threshold for low and high income countries corresponds to the simple average of income per capita in 1974.
Low income countries are: Bangladesh, Chile, Colombia, Egypt, Ghana, India, Indonesia, Sri Lanka, Morocco, Malaysia, Nepal, Pakistan, Peru, Philippines, Thailand, Turkey and Zimbabwe.
High income countries are: Argentina, Australia, Brazil, Canada, Germany, France, Korea, Israel, Italy, Japan, Mexico, New Zealand, United Kingdom, United States, South Africa, and Venezuela.

Figure 4-1: Financial Liberalization and Income Level

The model developed in this paper has three building blocks. First, investors and entrepreneurs share risk in a small open economy subject to a productivity shock. I simplify the analysis by assuming that investors are risk averse and entrepreneurs are risk neutral. Entrepreneurs can therefore provide some insurance to investors, up to the limit imposed by the return on productive projects. That is, the efficient credit arrangement minimizes entrepreneurs' con-

[3]The index of financial liberalization presented in these figures was developed by Abiad and Mody (2003) and accounts for regulation, investor protection, and financial integration.



Source: Index of financial liberalization from Abiad and Mody (2003): 0-17 where 17 corresponds to the maxim level of financial liberalization. GDP per capita from WDI. Gini coefficients from Deininger and Squire (1996).

Note: The threshold corresponds to the simple average of Gini coefficient in 1974.
Countries with low Gini coefficient and low income level: Bangladesh, Egypt, Ghana, India, Indonesia, Morocco Nepal, Pakistan, and Thailand.
Countries with high Gini coefficient and low income level: Chile, Colombia, Sri Lanka, Malaysia, Peru, Philippin Turkey, and Zimbabwe.
Countries with low Gini coefficient and high income level: Argentina, Australia, Canada, Germany, Japan, New Zealand, United Kingdom, and United States.
Countries with high Gini coefficient and high income level: Brazil, France, Israel, Italy, Korea, Mexico, Singapoı Venezuela, South Africa.

Figure 4-2: Financial Liberalization and Income Distribution sumption in the low-productivity state. However, credit contracts promise a non-contingent payment, which is only going to be honored in the non-defaulting state. In bad realization of the productivity shock, the payment to the financiers depends on the bankruptcy law imposed by the government. Or, in other words, the insurance component of credit contracts is mediated by government's policy. Higher level of investor protection increases the capacity of the entrepreneurs to provide insurance and boost aggregate investment.

Second, there is an access cost to the domestic financial system. This is to account for the fact that in emerging economies there is a share of the population that does not participate in formal credit transactions. Then, income distribution will determine the number and the average wealth of those who participate. If the financial market is closed to international transactions, the expected return on the loans that clears the market will be high enough so that local investors participate. If the capital account is open, this need not be the case. The expected return that clears the market may low such that local investors do not find it optimal to pay the access cost. In that case, most of the financing is provided by foreign investors.

Finally, the government lacks the ability to commit to the ex-ante optimal policy. Instead, it will be tempted to use investor protection laws as a tool for redistribution between borrowers and lenders. Government's objective function weights individual utilities independently of their wealth. Therefore, for the same investment level, the policy will be different depending on the number of local investors participating in the financial market.

This model builds on the literature on the political economy of finance, where the influence of private interests affects financial development. As Rajan and Zingales (2003), I emphasize the influence of incumbent interests (entrepreneurs and financiers in the financial system) on the institutional differences across countries. Here, incumbents do not affect the political outcome through lobby or economic interest groups. Instead, the government maximizes entrepreneurs and financiers' welfare independently of their wealth. The model in this paper is also related to Tirole (2003). As in there, I relate government's moral hazard and access to international capital markets to the quality of the institutions governing financial markets. Moreover, I interact these features with country specific characteristics such as wealth level and distribution. I find that these characteristics play a key role in determining the effect of openness on the level of investor protection.

The rest of the paper is organized as follows. Section 2 describes the economic environment. Section 3 solves the credit market equilibrium with closed capital account for a given government's policy. Section 4 endogenizes the level of investor protection. Section 5 solves the credit market equilibrium after opening the capital account and the following section closes the model endogenizing the level of investor protection in the integrated financial market. Section 6 concludes.

4.2 Environment

The model describes a 2-period small economy populated by a large number of investors and entrepreneurs. Consumption takes place at date 2. Entrepreneurs are risk neutral with expected utility $E\left(c^E\right)$. Consumers/investors have risk averse preferences over date 2-consumption:

$$u\left(c_i^C\right) = \ln\left(c_i^C\right) \tag{4.1}$$

They are characterized by their initial wealth $W_i : U\left[\underline{W}, \overline{W}\right]$.

Entrepreneurs have no initial resources and, at date 1, have access to two technologies: either they home-produce an amount k_j units of goods at time 2, or they can undertake a risky project. The return of the home-production is distributed uniformly across entrepreneurs:

$$k_j : U\left[0,1\right]$$

The risky project requires a unit of initial investment and has a random return R_s at date 2, which follows the aggregate state of the economy $s \in \{L, H\}$. Productivity follows a symmetric binomial distribution:

$$\begin{aligned} R_s &= \{R_L, R_H\} \\ \Pr &= 1/2 \end{aligned}$$

Debt contracts are set at date 1, before the productivity shock is realized. The contract with domestic firms specifies a date 2 repayment (P). In case of default, there is a share α of project's revenues that goes to the financier, while the rest is held by the entrepreneur. The parameter α can be interpreted generally as bankruptcy laws. It is going to be endogenized in section 4. Entrepreneurs are risk neutral, so their utility is given by:

$$E\left(c_{js}^{E}\right) = \begin{cases} k_j & \text{if home-production} \\ E\left(R_s - N_s\right) & \text{if risky project} \end{cases} \tag{4.2}$$

$$where \quad : \quad N_s = \min\left\{\alpha R_s, P\right\}$$

Entrepreneurs' strategy consists of a single binary variable choice: participate or not in the risky project. A risk neutral entrepreneur will undertake the project if its expected return is higher than the home-production's. That is, all entrepreneurs with $k_j \leq k^*$ will require finance for the investment project, where k^* is defined as:

$$k^* = E\left(R_s - N_s\right) \tag{4.3}$$

I assume now (and check the conditions later) that $\alpha R_L < P < \alpha R_H$. Then: $N_L = \alpha R_L$ and $N_H = P$.

At date 1, consumers can invest in the domestic risky project through the domestic financial market, or storage with zero net return. There is a fixed cost τ to access the financial market. This is to capture for the fact that, in emerging economies, there is an important share of the population that does not have access to the financial sector. Storage, on the other hand, does not involve any cost.

The strategy of each investor with W_i consists of a variable μ_i, the share of wealth invested in domestic projects, that maximizes expected utility (??):

$$\max_{\{\mu_i\}} Eu\left(c_{is}^{C}\right)$$
$$s.t.$$
$$c_{is}^{C} = \left[\mu_i N_s + (1-\mu)\right]\left[W_i - \mathbf{1}\left(\mu_i > 0\right)\tau\right] \tag{4.4}$$

The access cost to the financial market is only paid if the investor has positive amount of these assets, which is illustrated by the indicator function $\mathbf{1}\left(\cdot\right)$.

4.3 Credit Market Equilibrium

The credit market equilibrium is defined as follows:

Definition 8 *For given parameters* $\{\alpha, \tau\}$ *the credit market equilibrium is a vector* $\left\{k^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P\right\}$ *such that:*

i) For a given P, k^* *satisfies the free entry condition (4.3)*

ii) For a given P, *each investor with* $W_i \in [\underline{W}, \overline{W}]$ *chooses* μ_i *that maximizes (4.1) subject to (4.4)*

iii) P *is such that the credit market clears:*

$$k^* = \int_{\underline{W}}^{\overline{W}} \mu_i (W_i - \tau) f(W_i) \, dW_i$$

The strategy that maximizes (4.1) subject to (4.4) is the following: all consumers with $W_i < W^*$ will find it optimum not to participate in the financial market $\mu_i = 0$ (see Figure 4-3). For those with wealth higher than W^* the optimal investment in the risky project is a constant share $\mu_i = \mu$ of their wealth, where W^* and μ satisfy the following:

$$\mu = \frac{(P-1) - (1 - \alpha R_L)}{2(P-1)(1 - \alpha R_L)} \tag{4.5}$$

$$\ln\left(\frac{W^*}{W^* - \tau}\right) = E \ln(\mu N_s + (1 - \mu)) \tag{4.6}$$

The market clears when credit contracts stipulate P (the payment in the non-defaulting state) such that the demand of investment funds k^* equals the supply, which is given by the share μ of the portfolio lent to entrepreneurs and the size of the financial market W_{FM}:

$$k^* = \mu W_{FM} \tag{4.7}$$

$$where : W_{FM} = E(W - \tau | W > W^*) \Pr(W > W^*) \tag{4.8}$$

The level of investment increases in α, the share of production that corresponds to the financiers in case of default. The intuition is simple. Entrepreneurs are risk neutral while financiers are risk averse. Therefore, in a frictionless economy, the optimal credit contract

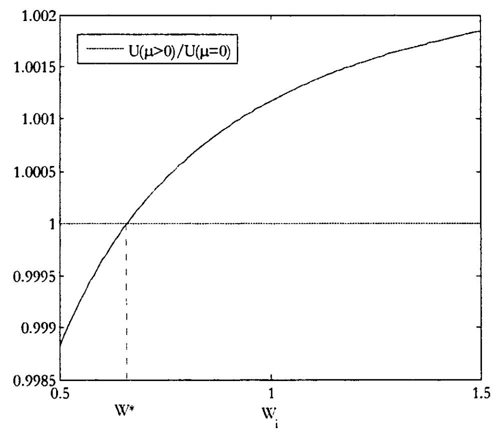


Figure 4-3: Utility of participants and non-participants in the financial market

would minimize entrepreneurs' consumption in the bad state so to provide the maximum level of insurance to the investors. Here, debt contracts stipulate a non-contingent payment P. The payment to the financiers in case of default depends on α. Therefore, a large α improves the insurance component of the credit arrangements and brings the economy closer to its first best allocation.

Indeed, a larger α increases the payments to the financiers in the low productivity state. And, because investors are risk averse, they value the return in the bad state more than in the good one. Therefore, if α is larger, they are willing to accept lower expected return from the loan. That is, the level of P required to keep μ constant decreases in αR_L more than proportionally:

$$\left.\frac{\partial P}{\partial \alpha}\right|_{\mu=\overline{\mu}} = -R_L \frac{(P-1)^2}{(1-\alpha R_L)^2} < -R_L \tag{4.9}$$

Entrepreneurs, on the other side, maximize expected profits which only depends on their expected payments to the financiers:

$$\left.\frac{\partial P}{\partial \alpha}\right|_{k^*=\overline{k^*}} = -R_L \tag{4.10}$$

There is an additional effect of α on the supply of investment funds. Because changes in α and P affect the expected utility of those agents who participate in the domestic financial

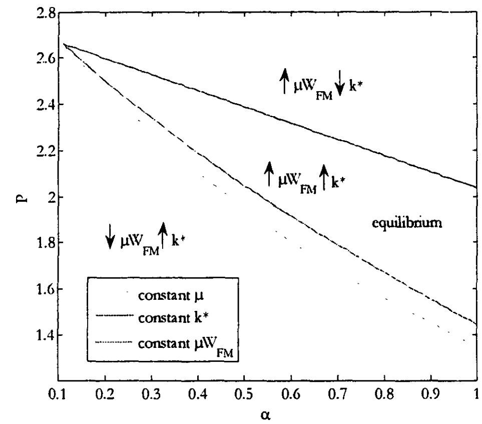


Figure 4-4: Investment level and α

system, an increase in α also has an impact in W_{FM}. The effect of α on the size of the financial market is ambiguous, however, it can never be the case that the change in W_{FM} totally compensates the mentioned effect of α on k^* and μ.[4]

Figure 4-4 illustrates the schedules (P, α) such that the demand (k^*) and the supply (μW_{FM}) of investment funds are constant. Any point above the schedule $(P, \alpha)\,|_{\mu W_{FM}=\overline{\mu W}_{FM}}$ is characterized by higher supply, while any point above the schedule $(P, \alpha)\,|_{k^*=\overline{k}^*}$ corresponds to lower demand of investment funds. The equilibrium lays between the two curves: as α increases the expected payment $E(N_s)$ decreases and, therefore, aggregate investment is higher.

The existence of the entry cost τ makes wealth distribution relevant when analyzing aggregate investment level. I define $\omega = \overline{W} - E(W) = E(W) - \underline{W}$. Then, the direct effect of a

[4] To see this, suppose that an increase in α did not provoke a rise in the level of investment (k^*). Then, the schedule (P, α) would be characterized by equation (4.10). However, if that was the case, the utility of those who participate in the financial sector would unambiguously increase in α:

$$\left.\frac{dEu\left(c_{is}^F|\mu > 0\right)}{d\alpha}\right|_{k^*=\overline{k}^*} = \frac{\mu R_L}{2}\left[\frac{1}{1-\mu(1-\alpha R_L)} - \frac{1}{1+\mu(P-1)}\right] > 0$$

In that case, the number of participants in the financial market should increase –i.e. $\left.\frac{dW^*}{d\alpha}\right|_{k^*=\overline{k}^*} < 0$– and therefore, there should be an excess of supply of investment funds, which is a contradiction.

Concluding: even if the number of participants in the financial market decreases with α, it has to be that $\frac{\partial P}{\partial \alpha} < \frac{\partial P}{\partial \alpha}\big|_{k^*=\overline{k^*}}$. This implies that the equilibrium investment level rises in α.

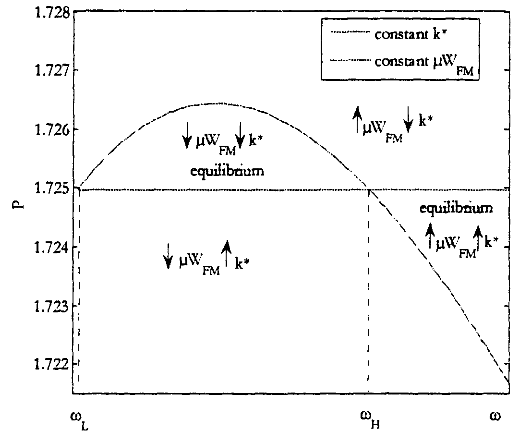


Figure 4-5: Investment and wealth distribution

mean preserving spread on the size of the financial market is the following:

$$\frac{\partial W_{FM}}{\partial \omega} = \frac{1}{4}\left(1 - \frac{E\left(W\right)^2 - W^{*2}}{\omega^2}\right)$$

$$\lim_{\omega \to 0} \frac{\partial W_{FM}}{\partial \omega} = -\infty \qquad \lim_{\omega \to \infty} \frac{\partial W_{FM}}{\partial \omega} = \frac{1}{4}$$

When wealth distribution is perfectly even ($\omega = 0$), P is such that all of investors participate in the financial market: $\forall i : W_i = W \geq W^*$. The size of the market attains its maximum in that case and any mean preserving spread reduces investment. On the other hand, when the wealth distribution is very uneven, only the wealthiest participate. A mean preserving spread, in that case, increases the size of the financial market because the expected wealth of those rich enough to participate increases.

Following the effect of ω on W_{FM}, the relation between ω and the level of investment is ambiguous, and depends on the initial wealth distribution, as can be observed in Figure 4-5. The figure shows two credit market equilibria: in the one that corresponds to a low inequality (ω_L), a mean preserving spread reduces the investment level; in the one that corresponds to high inequality (ω_H) a further increase in ω increases investment.

These findings are summarized in the following proposition:

Proposition 8 *For a given set of parameters* $\{\alpha, \tau\}$, *the Credit Market Equilibrium is characterized by*

i) All investors with $W_i \geq W^*$ *lend a share* $\mu > 0$. *Investors with* $W_i < W^*$ *choose* $\mu = 0$.

ii) All entrepreneurs with $k_j \leq k^*$ *demand finance. Entrepreneurs with* $k_j > k^*$ *choose home-production*

iii) An increase in α *increases the level of investment:*

$$\frac{\partial k^*}{\partial \alpha} > 0$$

iv) Investment decreases in ω *if the original distribution is even. The opposite occurs with original uneven distribution:*

$$\lim_{\omega \to 0} \frac{\partial k^*}{\partial \omega} < 0 \qquad \lim_{\omega \to \infty} \frac{\partial k^*}{\partial \omega} > 0$$

v) The number of participants and the size of the financial sector attain their maximum when $\omega = 0$*:*

$$0 = \arg\max_{\omega} W_{FM} \qquad \underline{W} \geq W^* \, (\omega = 0)$$

4.4 Policy Equilibrium

The government impacts the financial market by affecting the environment in which credit contracts are set. I assume that the government can choose the level of investor protection α, for example, by modifying bankruptcy laws. This is in line with Tirole (2003), where private credit agreements depend both on the parties involved in the arrangement and the government, with whom investors and entrepreneurs do not contract.

The government chooses α (the share of the project's revenues that corresponds to the financier in case of default) after credit contracts are set. That is, the government lacks the ability to commit and can only credibly implement the ex-post optimal policy. The ex-post optimal policy feeds back into date-1 expectations and Credit Market Equilibrium. Entrepreneurs and investors set their credit contracts accordingly.

The equilibrium is defined as follows:

Definition 9 *Given a set of parameters* $\{\tau, \theta\}$*, the Policy Equilibrium is a vector* $\left\{\alpha, k^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P\right\}$ *such that:*

i) $\left\{k^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P\right\}$ *is a Credit Market Equilibrium given* α

ii) α *maximizes government's welfare function given* $\left\{k^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P\right\}$*:*

$$\max_{\alpha\in[0,1]} \theta \int_{\underline{W}}^{\overline{W}} Eu\left(c_{is}^{C}\right) f\left(W_i\right) dW_i + (1-\theta) \int_0^1 E\left(c_{js}^{E}\right) f\left(k_j\right) dk_j$$
$$s.t.$$
$$(4.2), (4.4)$$

where θ *and* $(1-\theta)$ *correspond to the weights the government assigns to consumers and entrepreneurs respectively.*

Combining (4.4), (4.6), (4.2), and (4.3), the welfare of consumers and entrepreneurs are given by:

$$\int_{\underline{W}}^{\overline{W}} Eu\left(c_{is}^{C}\right) dW_i = \int_{\underline{W}}^{W^*} Eu\left(W_i\right) f\left(W_i\right) dW_i + \int_{W^*}^{\overline{W}} Eu\left(\rho_s\left(W_i-\tau\right)\right) f\left(W_i\right) dW_i$$
$$where : \rho_s = \mu N_s + (1-\mu)$$
$$\int_0^1 E\left(c_{js}^{E}\right) dk_j = \int_0^{k^*} E\left(R_s - N_s\right) f\left(k_j\right) dk_j + \int_{k^*}^1 k_j f\left(k_j\right) dk_j$$

Taking P, k^* and W^* as given, the optimal $\alpha \in [0,1]$ satisfies the following first order condition:

$$foc\left(\alpha\right) : \theta \frac{\mu}{\rho_L} \Pr\left(W_i > W^*\right) - (1-\theta) \Pr\left(k_j < k^*\right) = 0 \tag{4.11}$$

As expected, the higher is θ, the larger is the optimal α. As discussed in the previous section, a larger α increases the equilibrium investment level. In other words, aggregate investment will be higher, the larger the weight the government assigns to investors in its objective function.

The Policy Equilibrium is represented in Figure 4-6. Different foreseen policies imply different Credit Market Equilibria $\left\{k^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P\right\}$, which determines an ex-post government's policy α. The rational expectation equilibrium corresponds to the intersection with the 45 degree line, in which the foreseen α is equal to the ex-post optimal.

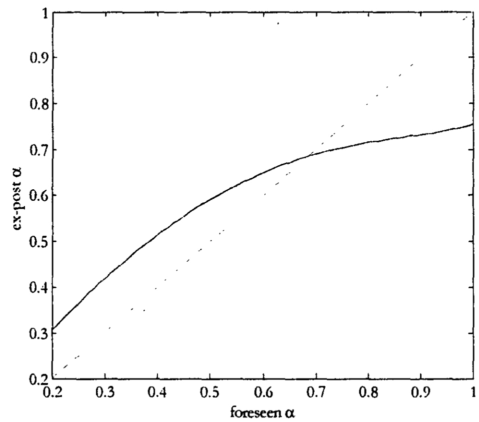


Figure 4-6: Policy Equilibrium

The government weights investors and entrepreneurs' utilities independently of their wealth. Then, the optimal policy α depends on the number of investors to entrepreneurs participating in the financial market. Since the number of investors and the level of investment change with the wealth distribution, so is the optimal α. Indeed, combining (4.11) with (4.7) and (4.8), the optimal policy α decreases in ω :

$$\alpha = \left\{ \frac{\theta}{1-\theta} \frac{2}{[E(W) + \omega + W^*]} - (1-\mu) \right\} \frac{1}{\mu R_L} \tag{4.12}$$

As explained in the previous section, the number of consumers participating in the financial market attains its maximum when the wealth distribution is perfectly even $\omega = 0$. Correspondingly, the equilibrium policy α also attains its maximum in that case (see equation (4.12)). An increase in ω reduces the ratio of investors to entrepreneurs. The intuition is simple. A mean preserving spread reduces the participation of the least wealthy investors and increases the resources of those rich enough to remain. In other words, it results in wealthier, but fewer, investors financing productive projects. The ratio of financiers to entrepreneurs decreases and the government finds it optimal to favor the later, which, from a date-2 perspective, implies in a lower α.

These findings are summarized in the following proposition:

Proposition 9 *In equilibrium, the policy α decreases in ω:*

$$\lim_{\omega \to 0} \frac{\partial \alpha}{\partial \omega} < 0$$

4.5 Open Financial Market

This section analyzes the effects of opening the financial market. Local investors are now able to invest abroad on a risk free asset with a return higher than the storage asset: $r > 1$. Respectively, foreign investors are allowed to invest in local projects. Again, the access cost to the financial market is a parameter τ. For simplicity, I assume there is no extra cost to access to the international financial market. Those consumers who pay τ participate in the internationally integrated financial market. Otherwise, they invest in the storage asset. The credit market equilibrium is now defined as follows:

Definition 10 *For given parameters $\{\alpha, \tau, r\}$ the credit market equilibrium is a vector $\left\{k_o^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P, \mu_f\right\}$ such that:*

i) For a given P, k_o^* satisfies the free entry condition (4.3)

ii) For a given P, each local investor with $W_i \in \left[\underline{W}, \overline{W}\right]$ chooses μ_i that maximizes (4.1) subject to

$$c_{is}^C = \mathbf{1}(\mu_i > 0)\left[\mu_i N_s + (1-\mu_i) r\right]\left[W_i - \tau\right] + \left[1 - \mathbf{1}(\mu_i > 0)\right] W_i \qquad (4.13)$$

iii) For a given P, each foreign investor with $W = W_f$ chooses μ_f that maximizes (4.1) subject to

$$c_s^F = \left[\mu_f N_s + \left(1 - \mu_f\right) r\right]\left[W_f - \tau\right]$$

iv) P is such that the credit market clears:

$$k_o^* = \int_{\underline{W}}^{\overline{W}} \mu_i \left(W_i - \tau\right) dW_i + \mu_f \left(W_f - \tau\right)$$

The strategy that maximizes (4.1) subject to (4.13) is the following: all investors with $W_i < W_o^*$ will find it optimum not to participate in the financial market. For those with $W_i \geq W_o^*$ the optimal investment in the risky project is a constant share $\mu_i = \mu_o$ of their wealth, where W_o^* and μ_o satisfy the following:

$$\mu_o = \frac{(P-r)-(r-\alpha R_L)}{2(P-r)(r-\alpha R_L)} \tag{4.14}$$

$$\ln\left(\frac{W_o^*}{W_o^*-\tau}\right) = E\ln\left(\mu_o N_s + (1-\mu_o)r\right) \tag{4.15}$$

The share invested in domestic projects is invariant to wealth level. Therefore, foreign investors' portfolio choice is identical to the local investors': $\mu_f = \mu_o$.

The market clears when the credit contracts stipulate P (the payment in the non-defaulting state) such that the demand of investment funds k^* equals the supply, which is given by the share μ_o of the portfolio invested in the risky project and the size of the financial market W_{FM}:

$$k_o^* = \mu_o W_{FM} \tag{4.16}$$

$$where \; : \; W_{FM} = E\left(W-\tau | W > W_o^*\right)\Pr\left(W > W_o^*\right) + \left(W_f - \tau\right) \tag{4.17}$$

Notice that the size of the financial market is unambiguously larger when foreign investors are allowed to participate. For that reason, the equilibrium expected return on the domestic loans is lower than in the closed economy described before:

$$\frac{\partial P}{\partial W_f} = -\frac{2\mu_o (P-r)^2}{(P-r)^2 + W_{FM}} < 0 \tag{4.18}$$

The effect of openness on the number of local investors is ambiguous. On one hand, gaining access to the international market provides the opportunity of investing in a superior riskless asset. Indeed, the international asset has a certain return $r > 1$, superior to the storage technology and, from equation (4.15): $\frac{\partial W_o^*}{\partial r} < 0$. But, on the other hand, according to equation (4.18), the entry of foreign investors lowers the return on domestic risky assets and therefore reduces the attractiveness of participating. Figure 4-7 illustrates this trade-off. When the international interest rate is high, local investors will profit from opening the market. The contrary occurs if the international interest rate is low. Similarly, if the capital inflows are negligible, the negative effect on P is small. In that case, local investors are unambiguously better off after opening the financial market and increase their participation.

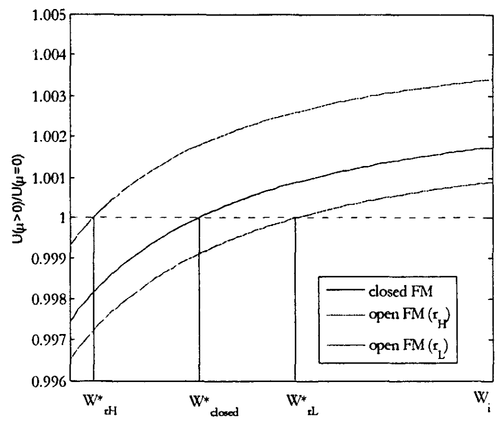


Figure 4-7: Utility of participants and non-participants in the financial market.

The reciprocal characterizes the level of investment: it decreases in the international r and increases with the size of the capital inflows. A larger international interest rate reduces the share of portfolio dedicated to loans:

$$\frac{\partial \mu_0}{\partial r} = -\frac{(P-r)^2 + (r-\alpha R_L)^2}{2\,(P-r)^2\,(r-\alpha R_L)^2}$$

And, if capital inflows are important, the equilibrium payment P is lower and investment level is therefore larger (see equation (4.18)). The relation between the size of foreign capital inflows and investment is represented in Figure 4-8. The level of investment increases after opening the financial market if foreign capital inflows are large and the return on the international riskless asset is low.

$$\lim_{W_f \to 0} W_o^* < W^* \qquad \lim_{W_f \to 0} k_o^* < k^*$$

$$\lim_{r \to 1} W_o^* > W^* \qquad \lim_{r \to 1} k_o^* > k^*$$

where W_o^* and k_o^* correspond to the open financial market, while W^* and k^* to the closed economy.

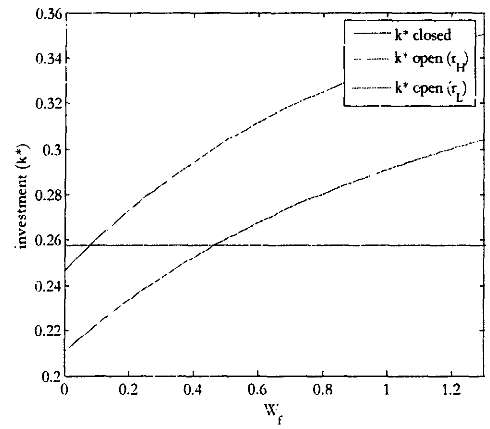


Figure 4-8: Investment and foreign capital inflows

The effect of domestic wealth distribution on investment depends crucially on the level of domestic wealth relative to foreign capital inflows.

$$\frac{\partial W_{FM}}{\partial \omega} = \frac{1}{4}\left(1 - \frac{E(W)^2 - W_o^{*2}}{\omega^2}\right)$$

where $\omega = 1/2\left(\overline{W} - \underline{W}\right)$.

When foreign capital inflows are small relative to the size of the domestic market, the relationship between wealth distribution and investment is similar to the closed credit market equilibrium characterized in proposition 1: the maximum participation in the financial market is attained when wealth distribution is even.

On the other hand, if the inflows of foreign capital are relatively large, the proportion of local investors that participate in the financial market is larger in unequal societies.

To understand the intuition, it is better to focus in the limit case of equal domestic wealth distribution $\cdot\ \forall i : W_i = E(W)$. In the closed economy, the equilibrium payment P is such that all of local investors participate: $W^* \leq E(W)$. Then, for a given average domestic wealth, the financial market attains its maximum size in the limit of equal wealth distribution. In an open economy, the equilibrium P does not guarantee the participation of local investors in the financial market. In fact, if a poor economy receives large capital inflows, the equilibrium

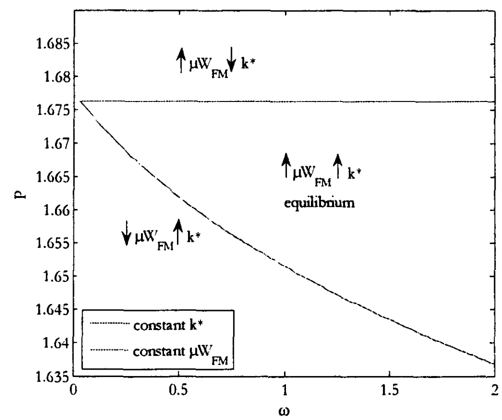


Figure 4-9: Investment and wealth distribution in an open economy

payment P may drop so that no local investor participates in the financial system: $W_o^* > E(W)$. In this case, from equation (4.19), the number of local investors increases in ω.

$$\frac{\partial \Pr(W > W_o^*)}{\partial \omega} = \frac{W_o^* - E(W)}{2\omega^2} \tag{4.19}$$

If local wealth is low so that $W_o^* > E(W)$, wealth inequality implies that there is at least a group of rich local agents are able to compete with foreign investors in the financial market. In that case, aggregate investment, local participation, and the size of the financial market increase in ω.

This example is illustrated in Figure 4-9. A mean preserving spread increases the size of the financial market. Therefore, the schedule $(P, \omega)|_{\mu W_{FM} = \overline{\mu W}_{FM}}$ is downward slopping: if ω increases, a constant supply of investment funds requires a lower P. The equilibrium investment level lays between the two curves, and increases with ω.

Finally, as in the closed economy, the level of investment increases in α.

These results are summarized in the following proposition:

Proposition 10 *For a given set of parameters $\{\alpha, \tau\}$, the Credit Market Equilibrium is characterized by:*

i) All investors with $W_i \geq W_o^*$ participate in the financial market.

$$\lim_{W_f \to 0} W_o^* < W^* \qquad \lim_{r \to 1} W_o^* > W^*$$

ii) All entrepreneurs with $k_j \leq k_o^*$ demand finance. Entrepreneurs with $k_j > k_o^*$ choose home-production.

$$\lim_{W_f \to 0} k_o^* < k^* \qquad \lim_{r \to 1} k_o^* > k^*$$

iii) If $E(W_i) > W_o^*$, ω decreases investment if the original distribution is very even, and increases otherwise:

$$\lim_{\omega \to 0} \frac{\partial k_o^*}{\partial \omega} < 0 \qquad \lim_{\omega \to \infty} \frac{\partial k_o^*}{\partial \omega} > 0$$

iv) If $E(W_i) < W_o^*$, investment increases in ω for all original wealth distribution.

4.6 Policy Equilibrium in an Open Financial Market

The government chooses α (the share of the projects's revenues that corresponds to the financier in case of default) after credit contracts are set. As in the closed economy, if the government decides to favor the entrepreneurs, it will implement a lower α, which will result in a lower investment level. When the market is open to international capital inflows, a new effect is introduced. The government, who only considers local investors and entrepreneurs in its objective function, will use α to redistribute resources from foreigner lenders to local borrowers. This ex-post optimal policy is foreseen by the participants in the financial market and will end up reducing the equilibrium level of investment. The benefits from opening the market are therefore reduced.

Definition 11 *Given a set of parameters $\{\theta, \tau, r\}$, the Policy Equilibrium is a vector $\left\{\alpha, k_o^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P, \mu_f\right\}$ that satisfies:*

i) $\left\{k_o^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P, \mu_f\right\}$ is a Credit Market Equilibrium given α

ii) α *maximizes government's welfare function given* $\left\{k_o^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P, \mu_f\right\}$*:*

$$\max_{\alpha\in[0,1]} \theta \int_{\underline{W}}^{\overline{W}} Eu\left(c_{is}^C\right) f\left(W_i\right) dW_i + (1-\theta) \int_0^1 E\left(c_{js}^E\right) f\left(k_j\right) dk_j$$
$$s.t.$$
$$(4.13), (4.4)$$

Combining (4.13), (4.15), (4.2), and (4.3), the welfare of consumers and entrepreneurs are given by:

$$\int_{\underline{W}}^{\overline{W}} Eu\left(c_{is}^C\right) dW_i = \int_{\underline{W}}^{W_o^*} Eu\left(W_i\right) f\left(W_i\right) dW_i + \int_{W_o^*}^{\overline{W}} Eu\left(\rho_s\left(W_i - \tau\right)\right) f\left(W_i\right) dW_i$$

$$where: \rho_s = \mu_o N_s + (1-\mu_o) r$$

$$\int_0^1 E\left(c_{js}^E\right) dk_j = \int_0^{k_o^*} E\left(R_s - N_s\right) f\left(k_j\right) dk_j + \int_{k_o^*}^1 k_j f\left(k_j\right) dk_j$$

Taking P, k_o^* and W_o^* as given, the optimal $\alpha \in [0,1]$ satisfies the following first order condition:

$$foc\left(\alpha\right): \theta\frac{\mu_o}{\rho_L} \Pr\left(W_i > W_o^*\right) - (1-\theta)\Pr\left(k_j < k_o^*\right) = 0$$

As in the closed economy, the government implements a larger α if the number of local investors is larger –i.e. $\Pr\left(W_i > W_o^*\right)$-. And the ex-post optimal α decreases in the number of entrepreneurs –i.e. $\Pr\left(k_j < k_o^*\right)$ – .

The Policy Equilibrium is represented in Figure 4-10. Different foreseen policies imply different Credit Market Equilibria $\left\{k_o^*, \{\mu_i\}_{\underline{W}}^{\overline{W}}, P, \mu_f\right\}$, which determines an ex-post government's policy α. The rational expectation equilibrium corresponds to the intersection with the 45 degree line, in which the foreseen α is equal to the ex-post optimal.

Combining (4.17), (4.16), and the fact that $\Pr\left(k_j < k_o^*\right) = k_o^*$, in equilibrium the policy α satisfies:

$$\alpha = \left\{\frac{\theta}{(1-\theta)}\frac{\Pr\left(W > W_o^*\right)}{W_{FM}} - (1-\mu_o) r\right\}\frac{1}{\mu_o R_L} \qquad (4.20)$$

The equilibrium policy α increases in the proportion of local investors relative to the size of the financial market. For that reason, an increase in capital inflows results unambiguously in

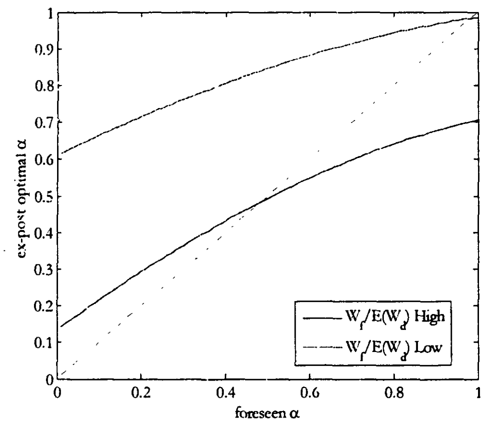


Figure 4-10: Policy Equilibrium and foreign capital inflows

lower α:

$$\frac{\partial \alpha}{\partial W_f} = \left\{ -\frac{\theta}{(1-\theta)} \frac{\Pr(W > W_o^*)}{W_{FM}^2} \frac{\partial W_{FM}}{\partial W_f} + \frac{\theta}{(1-\theta)} \frac{1}{W_{FM}} \frac{\partial \Pr(W > W_o^*)}{\partial W_f} + (r - \alpha R_L) \frac{\partial \mu_o}{\partial W_f} \right\} \frac{1}{\mu_o R_L} \quad (4.21)$$

First, when foreign capital inflows increase, the number of local entrepreneurs that access to credit increases. While foreign investors do not enter in the government's objective function, local entrepreneurs do. The government will therefore reduce α to protect domestic borrowers. This effect corresponds to the first term in equation (4.21). Second, foreign capital inflows tend to crowd out local investors. Since an increase in W_f reduces the return on domestic loans (see equation (4.18)), fewer local investors will pay the access cost. This effect is represented in the second term in equation (4.21).[5] And finally, foreign capital inflows result in lower portfolio share dedicated to risky projects, which is collected in the last term in equation (4.21).[6]

Notice that the negative effect of foreign capital inflows on α is lower when the original size of the financial market is large. So economies a with bigger financial market will tend to

[5] $\frac{\partial \Pr(W > W_o^*)}{\partial W_f} = \frac{\partial \Pr(W > W_o^*)}{\partial W_o^*} \frac{\partial W_o^*}{\partial P} \frac{\partial P}{\partial W_f} < 0$

[6] $\frac{\partial \mu_o}{\partial W_f} = \frac{\partial \mu_o}{\partial P} \frac{\partial P}{\partial W_f} < 0$

preserve higher α after the integration with the international market. The resulting level of investment will be higher in those economies.

$$\lim_{W_{FM}\to\infty} \frac{\partial \alpha}{\partial W_f} = 0 \qquad \frac{\partial^2 \alpha}{\partial W_f \partial W_{FM}} < 0$$

The effect of wealth distribution on the equilibrium policy α depends crucially on the ratio of the capital inflows to local wealth. Combining equations (4.20) and (4.19), the effect of ω on α is the following

$$\frac{\partial \alpha}{\partial \omega} = \frac{\theta}{1-\theta} \frac{1}{\mu_o R_L} \left\{ \frac{W_f}{W_{FM}^2} \frac{W_o^* - E(W)}{2\omega^2} - \frac{\Pr(W > W_o^*)^2}{2W_{FM}} \right\} \tag{4.22}$$

The second term in equation (4.22) corresponds to the increase in the number of entrepreneurs when the upper tail of the distribution (who already participate in the financial sector) gets richer and increase their lending. Any increase in the number of entrepreneurs negatively affects α.

The first term in equation (4.22) represents the change in the number of local investors. From equation (4.19), if the ratio of capital inflows to domestic wealth is small such that $W_o^* < E(W)$, a mean preserving spread reduces the participation of local investors. In that case, this term is negative. Unambiguously, the equilibrium policy α lowers in ω:

$$\frac{\partial \alpha}{\partial \omega} < 0$$

On the other hand, if that ratio of capital inflows to domestic wealth is small such that $W_o^* > E(W)$, from equation (4.19), a mean preserving spread increases the number of local financiers and incentives the government to increase α. The first term in (4.22) is positive in this case.

The effect of ω on α is ambiguous when $W_o^* > E(W)$, and depends on the original wealth distribution. When the wealth distribution is even, no local investors participate in the financial market and the equilibrium policy attains its minimum when $\omega = 0$. Any increase in ω implies a higher equilibrium policy α. On the other hand, if ω is large, the effect of a mean preserving spread increases the ratio of entrepreneurs to local financiers. The government reduces investor

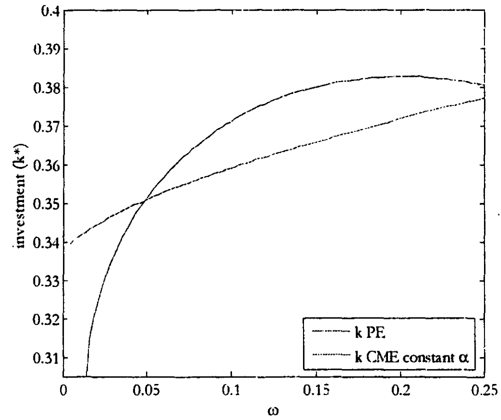


Figure 4-11: Investment and wealth distribution

protection in that case.

$$\lim_{\omega \to 0} \frac{\partial \alpha}{\partial \omega} > 0 \qquad \lim_{\omega \to \infty} \frac{\partial \alpha}{\partial \omega} < 0$$

Figure (4-11) plots aggregate investment as a function of ω for the case where $W_o^* > E(W)$. As explained in the previous section, for a constant α, the level of investment increases in ω. Once α is endogenized, aggregate investment attains its maximum for intermediate values of ω.

These findings are summarized in the following proposition:

Proposition 11 *In equilibrium, the policy α is characterized by*

i) The policy α decreases in W_f

$$\frac{\partial \alpha}{\partial W_f} < 0$$

ii) The negative effect of W_f on α is lower when the size of the financial market is larger.

$$\lim_{W_{FM} \to \infty} \frac{\partial \alpha}{\partial W_f} = 0 \qquad \frac{\partial^2 \alpha}{\partial W_f \partial W_{FM}} < 0$$

iii) If the ratio W_f to $E(W)$ is small enough so that $E(W) > W_o^*$, then

$$\frac{\partial \alpha}{\partial \omega} < 0$$

iv) If the ratio W_f to $E(W)$ is large enough so that $E(W) < W_o^*$, then:

$$\lim_{\omega \to 0} \frac{\partial \alpha}{\partial \omega} > 0 \qquad \lim_{\omega \to \infty} \frac{\partial \alpha}{\partial \omega} < 0$$

4.7 Conclusions

The model presented in this paper analyzes the change in the economic environment after capital account liberalization. The existence of foreign investors exacerbates government's moral hazard. In particular, since the government does not consider foreign investors in its objective function, it will tend to reduce the level of investor protection in an attempt to favor local borrowers. However, in doing so, the government also affects the welfare of local investors. Therefore, the optimal level of investor protection is a function of the ratio of local to foreign financiers participating in the domestic financial sector, which depends on level and distribution of income in the economy.

In economies with high income per capita, the participation of local investors in the domestic financial market is large. The government finds it optimal to maintain high levels of investor protection even if the capital account is open to foreign capitals. Furthermore, the participation of local investors is higher when the income distribution is even. The government's moral hazard that results from opening the capital account attains its minimum in that case. Therefore, higher investor protection and international integration are associated with economies with more even income distributions. These findings are consistent with the fact that even income distributions and financial liberalization are positively correlated in rich economies.

On the other hand, in poor economies capital inflows are large relative to the size of the domestic financial market. The ratio of local entrepreneurs to local investors is high and the government finds it optimal to set low levels of investor protection. Moreover, in poor economies large capital inflows tend to crowd-out local investors, which reinforces government's incentives to set a low level of investor protection. The crowding out effect is larger in poor economies with an even wealth distribution. This finding is consistent with the fact that, among poor countries, those with unequal income distributions show a higher level of financial liberalization.

The model presented in this paper also analyzes the impact of capital account liberalization on the level of domestic investment and welfare of local investors. Financial integration enables the entry of foreign capital, which reduces the cost of finance for local entrepreneurs and results in a larger aggregate investment. However, foreign capital inflows crowd out local investors. The entry of foreign investors ends up reducing the equilibrium return on domestic assets and fewer local agents will participate in the financial market. If this crowding-out effect is important, the welfare of local investors is reduced with the financial integration.

International integration also opens diversification opportunities to local investors. This new investment opportunity increases investors' welfare. However, it also reduces the optimal share invested in local projects. If the attractiveness of international assets is large, aggregate investment could be lower after the integration.

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