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Financial Crises, Dollarization, and Lending of Last Resort in Open Economies†

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Foreign currency debt is considered a source of financial instability in emerging markets. We propose a theory in which liability dollarization arises from an insurance motive of domestic savers. Since financial crises are associated to depreciations, savers ask for a risk premium when saving in local currency. This force makes domestic currency debt expensive, and incentivizes borrowers to issue foreign currency debt. Providing ex post support to borrowers can alleviate the effect of the crisis on savers' income, lowering their demand for insurance, and, surprisingly, it can reduce ex ante incentives to borrow in foreign currency. (*JEL* E21, E42, E44, F34, G01)

Emerging economies are exposed to recurrent episodes of financial instability. This instability has been linked to the presence of debt denominated in foreign currency issued by banks, firms, or households. "Liability dollarization" can amplify the effects of financial crises, as crises are typically associated with currency depreciations, and depreciations increase the real burden of foreign currency debt. This mechanism was first recognized as playing an important role in the East Asian crisis of 1997, and more recently has been a cause for concern in many emerging economies, such as, e.g., Turkey.[1] While we have a good understanding of the mechanisms by which foreign currency debt makes emerging economies more fragile, we still have a relatively limited understanding of the incentives that drive the accumulation of foreign currency debt in the first place.

The first contribution of this paper is to offer a theory of liability dollarization based on the behavior of domestic savers. We argue that an important obstacle to domestic currency borrowing is the unwillingness of domestic savers to save in domestic currency. If savers are concerned about domestic financial instability, they have a preference to hold their savings in foreign currency, a form of insurance,

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[1] See the case study on Turkey in Acharya et al. (2015), which also provides an overall assessment of the risks associated with foreign currency corporate debt in emerging economies.

as financial crises are typically accompanied by domestic depreciation. This demand for insurance implies that domestic currency assets need to pay higher interest rates than those issued in a foreign currency, a force that discourages local borrowers from issuing debt in domestic currency. The second contribution of the paper is to explore the distinct policy implications of this theory. Specifically, we show that ex post government interventions that help distressed borrowers and reduce financial instability can induce the private sector to take *safer* choices ex ante. The reason is that, by reducing savers' demand for insurance, these policies lower the risk premium on domestic currency assets and lead to less foreign currency borrowing. This result runs counter to the standard moral hazard argument that ex post interventions incentivize riskier choices ex ante.

Two empirical observations suggest an important role for domestic savers in understanding liability dollarization.[2] These observations are illustrated in Figure 1. In panel A, we plot the fraction of banks' deposits and banks' loans denominated in a foreign currency for a cross section of emerging economies. The positive correlation in the figure, first documented in De Nicoló, Honohan, and Ize (2003) and Levy Yeyati (2006), shows that countries with a high level of liability dollarization are also countries where domestic agents save more in foreign currency. In panel B, we plot the fraction of banks' deposits denominated in a foreign currency against a measure of deviation from uncovered interest rate parity (UIP) for the same cross section of countries. The positive correlation in panel B shows that local currency bonds in economies with a higher degree of foreign currency savings display a larger positive excess returns over comparable foreign currency bonds, which effectively means that borrowing in foreign currency is relatively cheaper in those countries.[3] Both facts arise in our model due to the incentives of domestic savers to insure against a crisis.

We build a three-period model of a small open economy populated by three groups of agents, domestic consumers, domestic bankers, and risk-neutral foreign investors. Domestic consumers work for domestic firms and save in bonds denominated in domestic and foreign currency. Domestic bankers borrow in domestic and foreign currency and use these resources along with their accumulated net worth to purchase domestic capital, which is used as input in production. The model features two financial frictions: banks face a potentially binding financial constraint, and foreign investors only borrow and lend in foreign currency.

In the intermediate period, our economy is exposed to self-fulfilling crises because of a feedback loop between the exchange rate and banks' net worth. This feedback loop works as in a typical "third-generation" currency crisis model (Krugman 1999). A decline in banks' net worth depresses investment and causes a currency depreciation. The depreciation reduces banks' net worth if banks have foreign currency liabilities. Thus, an economy with enough foreign currency debt is exposed to crises.

[2] In the paper we use "liability dollarization" or "financial dollarization" to identify the presence of foreign currency denominated assets and liabilities. Our main arguments can be applied to euro or yen denominated assets and do not rely on the special role of the dollar in the international financial system.

[3] Burnside, Eichenbaum, and Rebelo (2007) first documented large deviations from UIP for emerging market bonds. Recent work by Dalgic (2018) and Wiriadinata (2019) finds a positive correlation across countries between these UIP deviations and the degree of liability dollarization.

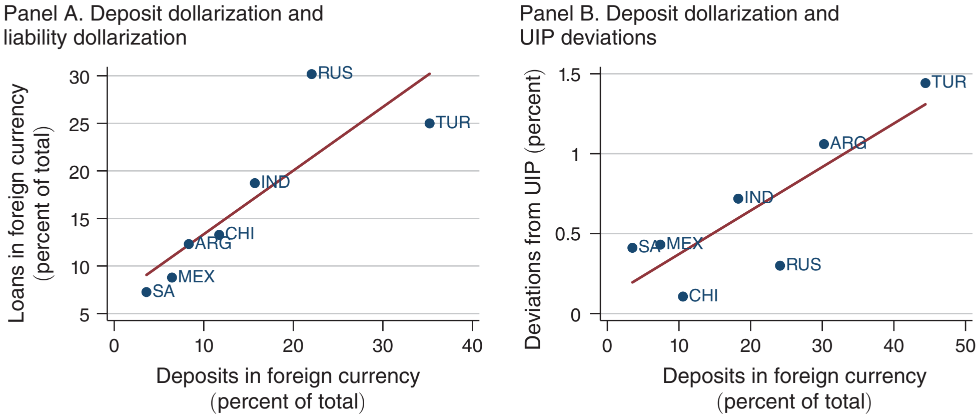

Figure 1. Deposit Dollarization, Liability Dollarization, and UIP Deviations

Notes: Each point in the graph gives a time average of yearly data for the country considered. For panel A, data on foreign currency deposits are obtained from Levy Yeyati (2006), while data on foreign currency loans held by financial institutions are from the IMF. Specifically, we take the ratio between foreign currency denominated loans (*Deposit Takers*, *Foreign-Currency-Denominated Loans*, *National Currency*) and total loans (*Deposit Takers*, *Total Loans*, *National Currency*). Merging the two datasets gives seven observations: Argentina (2005–2008), Chile (2001–2009), Indonesia (2005–2009), Mexico (2005–2008), Russia (2008), South Africa (2008–2009), and Turkey (2005–2009). For panel B, we merge the Levy Yeyati (2006) dataset with the one of Gilmore and Hayashi (2011) which provides UIP deviations for the seven currencies above with respect to the US dollar over the 1997–2009 period.

The novelty of our paper is to study the ex ante portfolio decisions of consumers and bankers and to ask whether liability dollarization can arise in equilibrium. If crises are possible in the future, consumers have an incentive to save in foreign currency because of the insurance properties discussed above: in a crisis, consumers' income goes down while the foreign currency appreciates. In general equilibrium, this means that the interest rate in domestic currency will be high relative to the interest rate in foreign currency, making foreign currency borrowing relatively cheaper for banks. This mechanism can dominate the banks' own motives to insure against a crisis, leading them to issue more dollar debt.

The interactions just described between the insurance motive of consumers and the risk of future crises can be so strong as to produce multiple equilibria ex ante. In a *safe* equilibrium, consumers are not worried about future crises and are happy to save in domestic currency, banks borrow mostly in domestic currency, the balance sheet effects of currency depreciations are weak, and crises cannot occur. This confirms consumers' expectations. In a *fragile* equilibrium, consumers are worried about future crises and save in foreign currency. Domestic currency funding is more expensive, so banks borrow in foreign currency, the financial sector is more fragile, and crises are possible. Again, consumers' expectations are confirmed. This novel form of multiplicity emphasizes the importance of allowing for endogenous risk premia as determinants of the currency denomination of debt.

We then turn to the analysis of financial stabilization policies and how they affect the incentives to borrow in foreign currency. In particular, we focus on government policies that help banks in distress when a crisis takes place and we study the role of foreign currency reserves in supporting these policies. In our model, the ability of the government to intervene ex post depends on its fiscal capacity. Foreign currency reserves help because they boost the fiscal capacity of the government in the states of the world where financial interventions are needed, that is, when a crisis takes place and the currency depreciates.[4]

Finally, we ask whether the accumulation of reserves, which helps the government stabilize the financial system ex post, leads the private sector to take riskier positions ex ante. Here we obtain a somewhat counterintuitive result. When the government can credibly rule out financial panics, it also reduces the incentives of domestic savers to hold foreign currency assets for precautionary reasons. Through this mechanism, ex post interventions reduce the interest rates in domestic currency, deterring banks from borrowing in foreign currency. In this sense, reserves can play a catalytic role by encouraging virtuous behavior of local borrowers and by promoting financial stability also from an ex ante perspective.

Literature.—Our research is related to several strands of literature. Following the crises of the late 1990s, several authors have developed equilibrium models to explain the joint occurrence of financial and currency crises. The seminal work of Krugman (1999) emphasizes how the feedback between investment demand and the real exchange rate can lead to multiple equilibria when firms/financial institutions have dollar debt. A recent paper that derives multiple equilibria due to the endogenous determination of the real exchange rate in a model with a financial constraint is Schmitt-Grohé and Uribe (2019).[5] Other contributions in this literature include Aghion, Bacchetta, and Banerjee (2001, 2004); Burnside, Eichenbaum, and Rebelo (2001b); Corsetti, Pesenti, and Roubini (1999); and Chang and Velasco (2000, 2001). An important innovation relative to this literature is that we endogenize debt denomination and show how risk premia can lead banks to endogenously choose currency positions that expose an economy to a crisis.

The economic mechanism that produces foreign currency debt in our setting is distinct from other explanations offered in the literature and, in particular, from Schneider and Tornell (2004); Burnside, Eichenbaum, and Rebelo (2001a); and Farhi and Tirole (2012). These papers emphasize the role of bailout guarantees that, coupled with the financial instability typical of emerging markets, can induce the private sector to take excessive risk and borrow in foreign currency.[6] In contrast, we emphasize the portfolio choices of domestic savers and how their demand for safety can, through a general equilibrium mechanism, incentivize local borrowers to issue dollar debt. As explained earlier, our theory has distinctive predictions for the coexistence of asset and liability dollarization and for deviations from uncovered interest parity that finds support in the data. Another key difference lies in the effects of policy: in the moral hazard view, ex post government interventions generate risk

[4]This provides a rationale to the view that emerging market authorities accumulate foreign currency reserves in order to improve financial stability. For example, in a speech as governor of the Bank of England, Mervyn King argued that the buildup of foreign currency reserves allows emerging market authorities to act as "do-it-yourself lenders of last resort in US dollars to their own financial system" (King 2006).

[5]The main difference with our model is that in our model the exchange rate enters the wealth of the bankers due to past borrowing positions, while in their model the exchange rate enters the value of collateral that limits the agents' ability to borrow today.

[6]On the normative side, Caballero and Krishnamurthy (2003) suggests that dollar debt might be excessive relative to the social optimum because of pecuniary externalities.

shifting and lead to more dollar debt; in our theory, these interventions can reduce the degree of financial dollarization in the economy.

Our approach to lending of last resort is close to Gertler and Kiyotaki (2015). In their environment, providing liquidity to the financial sector during a panic has ex ante benefits, and it is always optimal ex post because the government does not face borrowing constraints. The main innovation in our paper relative to their approach is that we explicitly formulate a game between the government and private investors, which embeds equilibrium in goods and asset markets. This allows us to analyze whether off-the-equilibrium-path promises to intervene in a "bad" equilibrium are credible and to discuss how limited fiscal capacity can interfere with lending of last resort policies. Ennis and Keister (2009) and Jeanne and Korinek (2020) also study credibility issues in lending of last resort policies. The former analyzes deposit freezes in the Diamond and Dybvig (1983) model.[7] The latter studies the optimal mix of ex ante and ex post financial interventions in a model with pecuniary externalities. Related to our analysis, they also study multiple equilibria and show that ex post support to financial institutions can reduce the need for ex ante regulation.

A few papers address financial dollarization from a portfolio perspective. In particular, Ize and Levy Yeyati (2003) presents a model that focuses on the effects of the monetary regime, which determines the volatility of inflation and of the nominal exchange rate.[8] Salomao and Varela (2019) builds a partial equilibrium model of the response of domestic borrowers to UIP violations and uses it to generate cross-sectional predictions on the currency composition of debt. Gopinath and Stein (2018) presents a model where the choice of debt denomination comes from a portfolio problem and uses it to study the complementarity between dollar invoicing and financial dollarization in the international monetary system. A distinctive feature of our paper relative to this literature is the focus on the hedging benefits of foreign currency assets against financial instability.

An important literature studies the role of foreign currency reserves as insurance against various types of shocks (Caballero and Panageas 2008; Durdu, Mendoza, and Terrones 2009; Jeanne and Rancière 2011; Bianchi, Hatchondo, and Martinez 2018). Relative to this literature, our focus on the role of reserves in fighting financial panics leads to a distinct set of predictions.[9] In particular, our model can rationalize why reserves across countries are well explained by the size of the financial sector's total liabilities, as shown by Obstfeld, Shambaugh, and Taylor (2010).

Finally, our paper relates to recent research aimed at understanding the patterns of global capital flows and low interest rates in the world economy (Caballero, Farhi, and Gourinchas 2008; Gourinchas and Jeanne 2013; Mendoza, Quadrini, and Ríos-Rull 2009; Maggiori 2017; Farhi and Maggiori 2018). Our paper offers a fully fledged model of financial instability as a cause for increased accumulation of

[7] A different approach to think about the fiscal costs of intervention is to consider the policymaker's uncertainty on whether a crisis is due to illiquidity or insolvency, an approach pursued in Robatto (2019).

[8] Rappoport (2009) adds defaultable debt and optimal monetary policy to the setup of Ize and Levy Yeyati (2003) and obtains the possibility of multiple equilibria due to the endogenous response of monetary policy.

[9] Models that focus on other sources of equilibrium multiplicity are Hur and Kondo (2016) and Hernández (2017).

reserves by emerging economies, and it identifies important differences between the private and the official sector demand for foreign currency.

Layout.—Section I presents the model. We then move on to characterize the equilibria of the model, proceeding backward in time. Section II describes the continuation equilibria from period 1 onward, taking the currency denomination of assets and liabilities as given. Section III studies the optimal portfolio choices of households and banks in the initial period. In Section IV we introduce a government and study lending of last resort, while Section V discusses the role of foreign currency reserves. Section VI concludes. All proofs are in the online Appendix. The online Appendix also contains a case study of Ecuador's financial crisis of 1999, which illustrates well the key mechanisms captured in our model.

I. The Model

We consider a small open economy that lasts three periods, $t = 0,1,2$, populated by two groups of domestic agents, consumers and bankers, who trade with a large number of foreign investors. There are two goods in the economy, a tradable good and a nontradable good.

The model is built around three ingredients. First, in line with standard financial accelerator models, bankers have unique access to a superior technology to accumulate capital, and they finance capital accumulation with debt. Second, debt can be denominated in nontradable or tradable goods, which is meant to capture debt denominated in domestic and foreign currency. This creates the possibility of currency mismatch. Third, consumers supply labor that is combined with capital to produce tradable output. This last assumption introduces a simple macro spillover by which consumers' incomes go down when bankers' capacity to accumulate capital contracts.

We now turn to a detailed description of the environment. The model includes a number of simplifying assumptions. Their role is discussed in detail at the end of the section.

A. *Agents and Their Decision Problems*

Consumers.—Consumers have preferences represented by the utility function

$$E_0 \sum_{t=0}^{2} \beta^t U(c_t),$$

where $U(c_t) = c_t^{1-\gamma}/(1-\gamma)$ and c_t is the Cobb-Douglas consumption aggregator,

$$c_t = \left(c_t^T\right)^{\omega}\left(c_t^N\right)^{1-\omega},$$

c_t^T is consumption of the tradable good, and c_t^N is consumption of the nontradable good.

The tradable good is the numéraire, and p_t denotes the price of the nontradable good. Each period t, consumers supply a unit of labor inelastically at the wage w_t and receive an endowment of nontradable goods $e^N_{c,t}$.

Consumers trade one-period bonds denominated in tradable and nontradable goods, denoted by a^T_t and a^N_t, at the prices q^T_t and q^N_t. As just mentioned, these two bonds represent foreign and domestic currency denominated bonds.[10]

The consumers' budget constraints at dates $t = 0, 1, 2$ are

$$c^T_t + p_t c^N_t + q^T_t a^T_{t+1} + q^N_t p_t a^N_{t+1} \le w_t + p_t e^N_{c,t} + a^T_t + p_t a^N_t. \tag{1}$$

Consumers choose consumption levels and asset positions in order to maximize their utility subject to the budget constraint (19) and the terminal condition $a^N_3 = a^T_3 = 0$.

Bankers.—Bankers are risk-neutral agents and consume only tradable goods at date 2. Bankers own banks. Banks hold physical capital k_t, which is used as an input in the production of tradable goods and yields the rental rate r_t. Banks have access to a linear technology to convert one unit of tradable goods into one unit of capital and vice versa. Capital fully depreciates at the end of each period. Banks also receive a nontradable endowment each period $e^N_{b,t}$. On the liability side, banks issue tradable and nontradable denominated bonds, denoted, respectively, by b^T_t and b^N_t. The banks' net worth at the beginning of each period is

$$n_t = r_t k_t - b^T_t + p_t\left(e^N_{b,t} - b^N_t\right). \tag{2}$$

The banks' budget constraints at $t = 0, 1$ are

$$k_{t+1} = n_t + q^T_t b^T_{t+1} + q^N_t p_t b^N_{t+1}. \tag{3}$$

At $t = 2$ the bankers consume n_2. We introduce a financial friction that bounds the bankers' ability to raise external finance. Specifically, we assume that at the beginning of period $t+1$, after renting the capital stock, the banker can default on its debt and use the bank's resources to consume or start a new bank. We assume that diversion entails the cost $\theta_{t+1} k_{t+1}$, where $\theta_{t+1} \in [0,1]$. This friction limits the amount of borrowing that the bankers can do at time t. Specifically, in every state of the world, the banks' liabilities need to be bounded by $\theta_{t+1} k_{t+1}$,[11]

$$b^T_{t+1} + p_{t+1} b^N_{t+1} \le \theta_{t+1} k_{t+1}. \tag{4}$$

[10] Currency denomination can be modeled in other ways, for example, by denominating domestic bonds in terms of the domestic consumption basket, or by introducing explicitly nominal variables and making assumptions about monetary policy. For our purposes here, simply denominating bonds in tradables and nontradables makes the analysis more transparent.

[11] This equation follows from the banker's participation constraint, $r_{t+1} k_{t+1} + p_{t+1} e^N_{b,t} - \theta_{t+1} k_{t+1} \le r_{t+1} k_{t+1} + p_{t+1} e^N_{b,t} - b^T_{t+1} - p_{t+1} b^N_{t+1}$, which gives (4).

Bankers choose $\{k_{t+1}, b_{t+1}^T, b_{t+1}^N\}$ to maximize the expected value of n_2, subject to the law of motion for net worth (2), the budget constraint (3), the collateral constraint (4), and the terminal condition $b_3^T = b_3^N = 0$.

Production.—Consumers own two types of firms. Tradable goods firms produce tradable goods using capital and labor according to the production function

$$y_t^T = K_t^{\alpha} L_t^{1-\alpha}, \tag{5}$$

where K_t and L_t are capital and labor inputs.

Next, there are firms that produce capital $\tilde{k}_t$ using a linear technology that requires $\phi > 1$ units of tradable goods per unit of capital. Since the latter technology is inferior to the banks' technology, these firms will only be active when banks' capital is low enough, as we will see shortly.

Both types of firms owned by consumers run constant returns to scale technologies, so their profits will be zero in equilibrium and can be omitted from the consumers' budget constraints.

We assume that the total endowment of nontradable goods is constant over time,

$$e_{c,t}^N + e_{b,t}^N = e^N.$$

To simplify some expressions, we assume throughout that $e_{b,2}^N = 0$.

Foreign investors.—Foreign investors are risk neutral and consume only tradable goods. Their discount factor is β. An important restriction in our model is that foreign investors can only purchase tradable denominated bonds, denoted by $\{a_t^{T*}\}$.

B. *Equilibrium*

There are no fundamental shocks in the economy, but given the possibility of multiple equilibria, we introduce a sunspot variable ζ realized at $t = 1$, with a uniform distribution on $[0,1]$, and use this sunspot as a selection device when multiple equilibria are possible at $t = 1$. For ease of notation, we will mostly leave implicit the dependence of variables dated $t = 1, 2$ on the sunspot realization.[12]

DEFINITION 1: *A competitive equilibrium is a vector of prices* $\{p_t, r_t, w_t, q_t^T, q_t^N\}$, *households' choices* $\{c_t^T, c_t^N, a_{t+1}^T, a_{t+1}^N\}$, *bankers' choices* $\{k_{t+1}, b_{t+1}^T, b_{t+1}^N\}$, *firms' choices* $\{K_t, L_t, \tilde{k}_t\}$, *and foreign investors' choices* $\{a_t^{T*}\}$ *such that all choices are individually optimal and all markets clear*,

$$c_t^N = e^N, \quad a_t^T + a_t^{T*} = b_t^T, \quad a_t^N = b_t^N, \quad K_t = k_t + \tilde{k}_t.$$

[12] We only introduce a sunspot at $t = 1$ because, conditional on past state variables, no multiplicity can arise at $t = 2$, and we do not need to specify how multiplicity is resolved at $t = 0$, given that no previous decision relies on that equilibrium selection.

C. *Discussion of Assumptions*

Let us briefly discuss some simplifying assumptions made in the model.

First, banks directly hold physical capital, rather than making loans. This is a common simplification in the financial accelerator literature. In terms of capturing the problem of liability dollarization, this assumption treats situations in which banks' balance sheets are explicitly mismatched in the same way as situations in which they are only implicitly mismatched, as happens, for example, when banks lend in dollars to domestic firms, who are then more likely to default in the event of a depreciation.[13]

Second, foreign investors in the model cannot purchase local currency (nontradable) claims issued by domestic agents. As we will discuss in more details in Section IIIE, this assumption plays an important role in our theory. Because of market clearing, bankers can issue nontradable claims only to domestic consumers. Thus, the portfolio choices of domestic savers affect, in equilibrium, the bankers' decision regarding the denomination of their liabilities. Our results, however, do not require this stark form of segmentation: in Section IIIE we discuss an extension of the model where we allow risk-averse foreign investors to participate in the market for local currency claims and show that the main results of our analysis survive.

Third, we are assuming a fixed supply of nontradable goods, partly held by bankers. The fact that bankers' revenues are partly denominated in nontradables implies that their net worth falls when the real exchange rate depreciates if and only if $e_{b,t}^N > b_t^N$. This feature is important for the analysis that follows, and it can also be derived in versions of the model where the production of nontraded goods is endogenized.[14]

D. *Road Map*

In the next two sections, we analyze the model in two steps, moving backward in time. First, we analyze the equilibrium in the last two periods, taking as given assets and liabilities from the previous period. We call this a *continuation equilibrium* and show that, for some initial conditions, multiple continuation equilibria are possible. In our second step, we go back to date 0 and complete our equilibrium characterization, focusing on the endogenous denomination of assets and liabilities and on whether the economy can settle on portfolios that produce multiple continuation equilibria.

II. Continuation Equilibria: Financial Crises

In this section, we look at continuation equilibria, that is, equilibria that arise at dates $t = 1, 2$, for given initial asset positions $\left\{a_1^T, a_1^N, b_1^T, b_1^N, K_1\right\}$. Let us restrict attention to initial positions that satisfy the following assumption.

[13] The case study of Ecuador in online Appendix Section C discusses one such example.

[14] For example, we could allow nontradable goods to be produced using a Cobb-Douglas technology in capital and labor and assume that the capital used in this sector is in fixed supply and endowed to the bankers. This extension retains most of the tractability of our model and delivers the core results.

ASSUMPTION 1: *Initial positions satisfy the following inequalities:*

$$a_1^N = b_1^N \leq e_{b,1}^N, \quad b_1^T \leq \theta_1 K_1, \quad \alpha K_1^{\alpha-1} \geq 1/\beta. \tag{6}$$

The first inequality means that banks have a nonnegative net position in nontradables, so a real exchange rate appreciation (higher p_1) increases banks' net worth and leads to (weakly) higher investment. We focus on initial asset positions that satisfy this inequality because, as we will see, this is the interesting case that can potentially produce multiple equilibria. The next two inequalities are necessary conditions for bankers' optimality at date 0 and must be satisfied in any competitive equilibrium.[15] Combining these three inequalities we can show that banks' net worth is always positive,

$$n_1 = \alpha K_1^\alpha - b_1^T + p_1\left(e_{b,1}^N - b_1^N\right) > \theta_1 K_1 - b_1^T \geq 0.$$

We characterize continuation equilibria using two relations. The first is an equilibrium condition in the nontradable goods market. The second is an equilibrium condition in the capital market.

A. *Nontradable Goods Market*

Simple derivations, presented in the online Appendix, show that the price of nontradable goods is constant in periods $t = 1,2$ and is determined by the market clearing condition

$$\frac{1}{p}\frac{1-\omega}{1+\beta}\left[a_1^T + pa_1^N + w_1 + \beta w_2 + p\left(e_{c,1}^N + \beta e^N\right)\right] = e^N, \tag{7}$$

where p denotes the constant price of nontradables in $t = 1,2$. The left-hand side of this equation is the demand for nontradables: consumers spend a fraction $(1-\omega)/(1+\beta)$ of their lifetime wealth on nontradable goods, and their wealth is equal to their financial wealth plus the present value of their labor income and nontradable endowments.[16] The right-hand side of the equation is just the total supply of nontradables. Profit maximization and labor market clearing imply that wages are $w_t = (1-\alpha)K_t^\alpha$. So we can rearrange the equation above to express p as a function of K_2:

$$p = \mathcal{P}(K_2) \equiv (1-\omega)\frac{(1-\alpha)\left(K_1^\alpha + \beta K_2^\alpha\right) + a_1^T}{\omega(1+\beta)e^N + (1-\omega)\left(e_{b,1}^N - a_1^N\right)}. \tag{8}$$

Because initial positions satisfy $a_1^N \leq e_{b,1}^N$, the denominator in (8) is positive and the nontradable goods market clears at a finite price p.

[15] The inequality $b_1^T \leq \theta_1 K_1$ is a necessary condition for the collateral constraint (4) at $t = 0$, while $\alpha K_1^{\alpha-1} \geq 1/\beta$ is a necessary condition for banks' optimal choice of K_1 at date 0.

[16] The real interest rate is $1/\beta$ due to the presence of international investors with linear preferences.

Equation (8) defines an increasing and concave relation between p and K_2. More capital invested in the tradable sector leads to higher wages in period 2, higher consumers wealth, and higher demand for nontradables. This leads to a real appreciation (higher p). This mechanism is a version of the Balassa-Samuelson effect.

B. *Capital Market*

In the capital market, three configurations are possible.

First, banks' net worth may be large enough that the collateral constraint is slack. In this case, banks' optimality requires $\beta r_2 = 1$. Substituting the rental rate $r_2 = \alpha K_2^{\alpha-1}$ and solving, we get the first-best level of capital

$$K_2 = K^* \equiv (\alpha\beta)^{\frac{1}{1-\alpha}}.$$

Given that banks can borrow at most $\beta\theta_2 k_2$, this case arises if banks' net worth satisfies $n_1 \geq (1 - \beta\theta_2)K^*$.

A second scenario arises if the banks' collateral constraint is binding, but there is no investment in the inferior capital accumulation technology controlled by the consumers. In this case, the level of K_2 can be derived from the bankers' budget constraint:

$$K_2 = \frac{1}{1 - \beta\theta_2} n_1.$$

To ensure that banks want to invest in capital and that the inferior technology is not in use, K_2 must satisfy the inequalities

$$1 \leq \beta r_2 = \beta\alpha K_2^{\alpha-1} \leq \phi.$$

In the third scenario, the bankers' net worth is so low that there is positive investment in the inferior technology. Optimality for the firms running this technology requires $\beta r_2 = \phi$, which yields the aggregate capital stock

$$K_2 = \underline{K} \equiv (\alpha\beta/\phi)^{\frac{1}{1-\alpha}}.$$

This case arises if bank's net worth satisfies $n_1 \leq (1 - \beta\theta_2)\underline{K}$. In this case, banks' investment is $k_2 = n_1/(1 - \beta\theta_2)$, and investment in the inferior technology is $\tilde{k}_2 = \underline{K} - k_2 > 0$.

To complete the analysis of the capital market, notice that the banks' net worth from equation (2) is a linear function of the price of nontradable goods:

$$n_1 = N(p) \equiv \alpha K_1^{\alpha} - b_1^T + p\left(e_{b,1}^N - b_1^N\right).$$

Combining this relation with the analysis of the three cases discussed above, we obtain the following schedule:

$$K_2 = \mathcal{K}(p) \equiv \begin{cases} K^{\star} & \text{if } N(p) \geq (1-\beta\theta_2)K^{*} \\ \underline{K} & \text{if } N(p) < (1-\beta\theta_2)\underline{K} \\ \frac{1}{1-\beta\theta_2}N(p) & \text{otherwise.} \end{cases} \tag{9}$$

C. *Multiple Equilibria*

Continuation equilibria can be found looking for pairs $(\hat{K}_2, \hat{p})$ that satisfy $\hat{p} = \mathcal{P}(\hat{K}_2)$ and $\hat{K}_2 = \mathcal{K}(\hat{p})$. Using the properties of these two schedules, we can then prove the following.

PROPOSITION 1: *Suppose initial asset positions* $\{a_1^T, a_1^N, b_1^T, b_1^N, K_1\}$ *satisfy* (6). *Then a continuation equilibrium exists and there are at most three continuation equilibria. If there are multiple equilibria, the equilibrium with the lowest price always has* $K_2 = \underline{K}$.

Figure 2 plots two examples of the schedules $\mathcal{P}$ and $\mathcal{K}$ in the (K_2, p) space. As explained earlier, the schedule $\mathcal{P}$ is increasing and concave in K_2 because of the Balassa-Samuelson effect, while the $\mathcal{K}$ schedule is weakly increasing in p because banks' net worth is positively affected by an exchange rate appreciation when $e_{b,1}^N > b_1^N$. An equilibrium corresponds to a point where the two schedules intersect. In panel A there is a unique equilibrium. In panel B there are three equilibria, at points A, B, and C. In equilibrium A, banks are unconstrained. In equilibria B and C, however, the collateral constraint binds. From now on, whenever there are three equilibria as in panel B, we will rule out the unstable intermediate equilibrium B and focus on the two stable equilibria A and C.

Equilibrium multiplicity comes from the positive feedback between banks' investment and the real exchange rate: when $e_{b,1}^N > b_1^N$, an exchange rate depreciation causes a reduction in banks' net worth; this causes lower investment, lower second period wages, and lower lifetime wealth for consumers; finally, this causes a low demand for nontradables, producing a lower equilibrium value of p.

Whenever multiple equilibria are possible, we interpret the "bad" equilibrium with low p and K_2 as a financial crisis and obtain a number of predictions about the behavior of consumption, investment, the exchange rate and the current account in those events. In the next sections, when multiplicity is present, we will use the sunspot ζ to select the continuation equilibrium.[17]

[17] To make equilibrium selection less arbitrary, it may be possible to extend the model by introducing fundamental shocks and imperfect information about fundamentals, and obtain equilibrium selection based on a public signal received by the agents, which would be correlated with fundamentals.

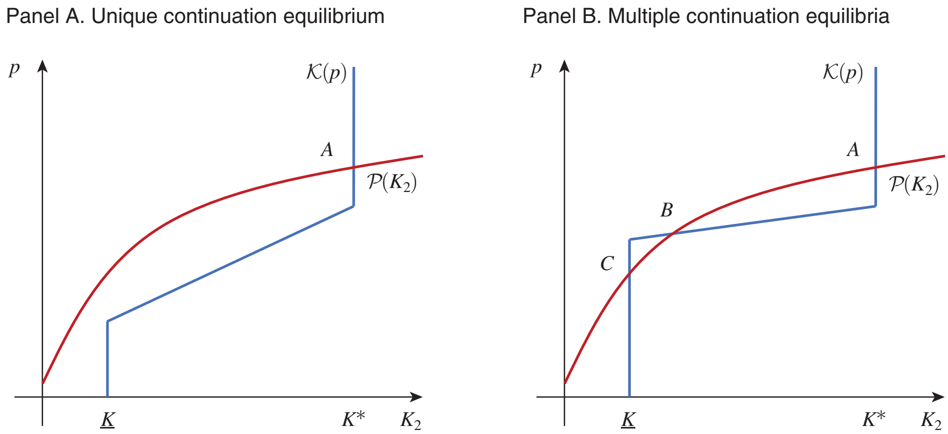

Figure 2. Continuation Equilibria

PROPOSITION 2: *If there are three equilibria and we compare the two stable ones, we obtain the following predictions:*

(*i*) *Investment and consumption are lower in the crisis equilibrium;*

(*ii*) *The real exchange rate is more depreciated in the crisis equilibrium;*

(*iii*) *The current account balance is higher in the crisis equilibrium;*

(*iv*) *The utility of consumers is lower in the crisis equilibrium. If the following sufficient condition is satisfied,*

$$(1-\beta\theta_2)\,\phi^{\frac{1}{1-\alpha}} > \phi - \beta\theta_2, \tag{10}$$

the utility of bankers is also lower in the crisis equilibrium.

The improvement in the current account shows that the domestic banking crisis is associated with a capital flight. The capital flight has two aspects: the contraction in investment is driven by the reduction in banks' net worth, while the contraction in consumption is driven by lower future wages. The recent literature includes papers that emphasize financial constraints (Mendoza 2010) and lower future income growth (Aguiar and Gopinath 2007) as causes of capital account reversals in emerging markets. Here both mechanisms are active.

The proposition shows that the equilibria are Pareto ranked, as both consumers and bankers get lower utility in the crisis equilibrium, while international investors are indifferent. On the consumers' side, welfare is lower because of lower capital accumulation and hence lower future real wages. On the bankers' side, the effects are more subtle because the rate of return on banks' net worth is actually higher in the low-p equilibrium. However, net worth itself is lower. The proposition gives a sufficient condition under which the latter effect dominates. International investors are indifferent because they get zero surplus in both equilibria.

Multiple Pareto-ranked continuation equilibria arise because of externalities that operate through the real exchange rate and the wage. Consider the economy at the bad continuation equilibrium and suppose that we introduce a proportional subsidy τ on the purchase of nontradable goods, financed via a lump-sum tax levied on consumers. A positive subsidy increases the demand for nontradables goods and increases the real exchange rate. This redistributes resources at date 1 from consumers, who are net buyers of nontradables, to bankers, who are net sellers.[18] Because bankers are constrained, this redistribution increases investment, increases second period wages w_2, and reduces the rental rate of capital r_2, which generates a reallocation from bankers to consumers in period 2. Summing up, a combination of pecuniary externalities allows bankers to obtain more resources in period 1, and to transfer them back to consumers in period 2. This produces efficiency gains for the economy as a whole, as it helps relax the bankers' financial constraints. It can also be shown that these efficiency gains are distributed so that both consumers and bankers benefit from them.[19]

D. *Debt Denomination and Equilibrium Multiplicity*

What is the role of debt denomination in exposing the economy to equilibrium multiplicity?

Proposition 1 shows that to have multiple equilibria there must exist an equilibrium in which the inferior technology is employed, $K_2 = \underline{K}$. The existence of such equilibrium requires the following inequality to hold:

$$\underline{K} > \frac{1}{1-\beta\theta_2}\left[\alpha K_1^\alpha - b_1^T + \mathcal{P}(\underline{K})\left(e_{b,1}^N - b_1^N\right)\right]. \tag{11}$$

The other two equilibria are present if and only if the following condition is also satisfied:

$$K_2 < \frac{1}{1-\beta\theta_2}\left[\alpha K_1^\alpha - b_1^T + \mathcal{P}(K_2)\left(e_{b,1}^N - b_1^N\right)\right] \tag{12}$$

for some $K_2 \in (\underline{K}, K^*]$. The last two conditions thus provide necessary and sufficient conditions for the existence of three continuation equilibria.

Panel A of Figure 3 helps us to understand these conditions in the simple case in which (12) is satisfied at K^*. Inequality (11) requires that banks have insufficient net worth to buy the capital stock $\underline{K}$ when the exchange rate is $\underline{p} = \mathcal{P}(\underline{K})$, so that the inferior technology is employed. Inequality (12) at K^* requires that at the

[18] The intertemporal budget constraint of the consumers can be written as $c^T(1+\beta) \leq a_1^T + w_1 + \beta w_2 - p\left(e_{b,1}^N - b_1^N\right)$. A unit increase in p reduces consumers' life-time resources by $e_{b,1}^N - b_1^N > 0$ and increases n_1 by the same amount.

[19] The argument described is correct if the increase in p_1 is large enough that bankers are able to increase k_2 above $\underline{K}$, so as to have positive effects on wages in period 2. A small subsidy would not be Pareto improving in our model. A full discussion of this issue is in the proof of Lemma A-4 in the online Appendix.

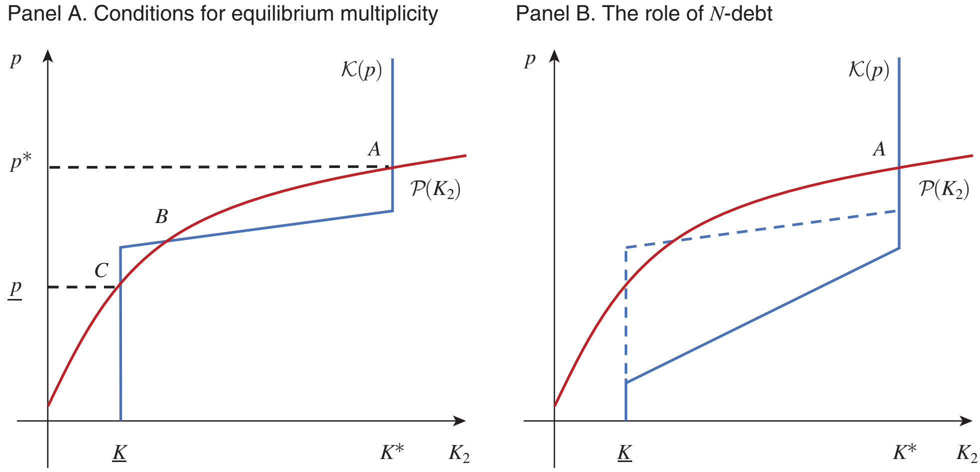

Figure 3. Debt Denomination and Multiple Equilibria

appreciated exchange rate $p^* = \mathcal{P}(K^*)$, banks have enough net worth to finance the first-best capital level K^*. Given that $K^* > \underline{K}$, in order for both conditions to be satisfied, we need the banks' net worth to be sufficiently sensitive to the exchange rate, which can only be the case if $e_{b,1}^N - b_1^N$ is large enough. In particular, it is immediate to see that both conditions can never be satisfied if $e_{b,1}^N = b_1^N$. In that case, the $\mathcal{K}$ schedule is a vertical line and multiplicity is impossible.

To further illustrate this idea, panel B of Figure 3 shows what happens if we start from the economy in panel A and we reduce b_1^T and increase b_1^N while leaving the value of total bank debt unchanged at the good equilibrium (that is, keeping constant $b_1^T + \mathcal{P}(K^*)\, b_1^N$). Since the bank net exposure is lower, the schedule $\mathcal{K}$ shifts downward for all $K_2 < K^*$, and, for b_1^N large enough, the bad equilibrium disappears.

Since mismatch is crucial for the presence of multiplicity, our next question is: why would banks choose a liability composition at date 0 that exposes them to the possibility of crises at date 1? This is the question we address in the next section.

III. Dollarization and Fragility

We now go back to date 0 and study the equilibrium determination of banks' and consumers' assets and liabilities. Our main objective is to show that even though banks can choose ex ante whether to denominate their debt in tradables or nontradables, this does not rule out the possibility of multiple continuation equilibria. That is, even though currency mismatch in banks' balance sheets opens the door to "bad" Pareto-dominated equilibria, banks do not necessarily have sufficient ex ante incentives to reduce their exchange rate exposure.

From now on, whenever we say an "equilibrium" of the model, we are referring to an equilibrium of the whole three-period model, as opposed to a continuation equilibrium that starts in period 1. We will use the following terminology. We say that an equilibrium is "fragile" if it features multiple continuation equilibria that happen with positive probability at $t = 1$. We say that an equilibrium is "safe" if the equilibrium values of $\{a_1^T, a_1^N, b_1^T, b_1^N, K_1\}$ are such that there is a unique continuation equilibrium. Notice that the requirement for a safe equilibrium is not just that a single continuation equilibrium is selected with probability 1 at $t = 1$, but also that no other continuation equilibrium exists.

Our argument in this section is constructive. First, we show how to construct examples of fragile equilibria. Second, we show that given an economy with a fragile equilibrium, the same economy also admits a safe equilibrium. In Section IIID, we use a numerical example to illustrate our argument and provide intuition. Readers less interested in the formal steps can skip directly to the example.

A. *Portfolio Choice*

Consider first the portfolio decision problem of consumers and banks at date 0. Consumers' optimization gives the following first-order conditions for a_1^T and a_1^N:

$$q_0^T \lambda_{c,0} = \beta E[\lambda_{c,1}], \qquad q_0^N \lambda_{c,0} = \beta E\left[\frac{p_1}{p_0}\lambda_{c,1}\right], \tag{13}$$

where

$$\lambda_{c,t} = \left(c_t^T\right)^{\omega(1-\gamma)-1}$$

is the consumers' marginal utility of wealth (in tradables).

On the banks' side, we will focus on cases in which the collateral constraint is slack at time 0, which can be guaranteed by setting $\theta_1 = 1$. The banks' first-order conditions for b_1^T and b_1^N, then, take a similar form,

$$q_0^T \lambda_{b,0} = E[\lambda_{b,1}], \qquad q_0^N \lambda_{b,0} = E\left[\frac{p_1}{p_0}\lambda_{b,1}\right],$$

and the bankers' marginal utility at $t = 1$ is

$$\lambda_{b,1} = \frac{r_2 - \theta_2}{1 - \beta\theta_2}.$$

To interpret the last expression notice that a unit of tradables at $t = 1$ can be levered by the banker to purchase $1/(1 - \beta\theta_2)$ units of capital. The payoff from such investment at $t = 2$, net of debt repayments, is $r_2 - \theta_2$. So we get a return of $(r_2 - \theta_2)/(1 - \beta\theta_2)$ per unit of tradable at $t = 1$, which the banker can consume in the last period. Because the utility of the banker is linear in consumption, this expression is also the marginal utility at $t = 1$. The expression is also valid if $r_2 = 1/\beta$ and banks are unconstrained. Then the expression boils down to $\lambda_{b,t} = 1/\beta$, as the return per unit of net worth is simply the interest rate $1/\beta$.

It is useful to remark that when multiple equilibria are possible, the bankers' marginal utility is higher in the bad continuation equilibrium, because in that equilibrium capital is scarcer and yields a higher rate of return. Therefore, even though bankers are risk neutral, they still value resources in the bad continuation equilibrium more. This leads to a hedging motive that commonly arises in general equilibrium models with financial constraints, as pointed out, for example, in Rampini and Viswanathan (2010).

B. *Fragile Equilibrium*

Take a vector of date 1 initial positions $\{a_1^T, a_1^N, b_1^T, b_1^N, K_1\}$ such that multiple continuation equilibria are possible. Suppose now that we want to construct an equilibrium in which the two stable continuation equilibria occur with positive probability. Given that the price p_1 is different in the two equilibria and there are only two payoff-relevant states of the world at $t = 1$, domestic consumers and bankers have sufficient instruments to achieve perfect risk sharing. This means that the portfolio conditions derived above can be satisfied if and only if the marginal utilities of wealth of consumers and bankers are equalized across states of the world, using the appropriate Pareto weights. That is, the portfolio conditions can be satisfied if and only if there is a $\Phi > 0$, such that

$$(c_1^T)^{\omega(1-\gamma)-1} = \Phi \frac{r_2 - \theta_2}{1 - \beta\theta_2} \tag{14}$$

in both the good and the bad continuation equilibria.

Can we construct an equilibrium in which the last condition is satisfied? The answer is yes because both the consumers' and the bankers' marginal utilities of wealth are higher if the bad equilibrium is realized. Building on this intuition, the next proposition shows how to construct a fragile equilibrium and what conditions are required for the construction.

For simplicity, we focus on constructing fragile equilibria in which nontradable positions are exactly zero and in which, as mentioned above, $\theta_1 = 1$, so that the collateral constraint is slack in period 0 and $K_1 = K^*$. We use the superscripts G and B to denote variables in the good and in the bad continuation equilibria.

PROPOSITION 3: *Fix all the model parameters except γ and the initial asset positions at $t = 0$. Take a vector of date 1 initial positions $\{a_1^T, a_1^N, b_1^T, b_1^N, K_1\}$, with*

$$a_1^N = b_1^N = 0, \quad K_1 = K^*, \quad b_1^T \leq K_1.$$

Suppose that, given these positions, there are two continuation equilibria that satisfy

$$\left(\frac{w_1 + \beta w_2^B + a_1^T}{w_1 + \beta w_2^G + a_1^T}\right)^{\omega-1} < \frac{r_2^B - \theta_2}{r_2^G - \theta_2}. \tag{15}$$

Then there exist a coefficient of relative risk aversion γ and date 0 initial positions $\{a_0^T, a_0^N, b_0^T, b_0^N, K_0\}$ that generate a fragile equilibrium in which the two continuation equilibria above are realized with positive probability.

The proof of this proposition relies on the fact that continuation equilibria can be constructed independently of γ, because the schedules $\mathcal{P}$ and $\mathcal{K}$ do not depend on that parameter. Then γ can be chosen to ensure that the two continuation equilibria are consistent with ex ante optimality. The role of condition (15) is discussed in the proof of the proposition in the online Appendix.

Proposition 3 relies on making the consumers sufficiently risk averse to match the bankers' hedging motive. This logic can also be turned around, and we can show that if consumers' risk aversion is low enough, then the economy cannot feature a fragile equilibrium. The next proposition provides a result along these lines.

PROPOSITION 4: *Suppose consumers' risk aversion satisfies*

$$\gamma < 1 + \frac{\beta(1-\alpha) - (\phi - \beta\theta_2)}{\omega(\phi - \beta_2\theta_2)}.$$

Then there exists no fragile equilibrium with $a_1^T \geq 0$.

C. *Safe Equilibrium*

Suppose we have constructed an economy with a fragile equilibrium following the steps in Proposition 3. We can then ask whether the same economy also admits a safe equilibrium. The next proposition shows that the answer is yes.

PROPOSITION 5: *Take an economy with a fragile equilibrium constructed as in Proposition 3. The economy also has a safe equilibrium. Comparing the safe and the fragile equilibria,* c_0 *and* p_0 *are higher and the trade balance is lower in the safe equilibrium.*

The idea behind this proposition is to take the good continuation equilibrium that is part of the fragile equilibrium under consideration and rearrange the debt composition of the bankers in favor of nontradable debt in order to reduce their exposure to an exchange rate depreciation. The logic of Figure 3 suggests that this eventually eliminates the multiplicity while leaving total repayments in the good equilibrium unchanged. Because of market clearing, $b_1^N = a_1^N$, this requires an increase in the consumers' positions in nontradable denominated bonds. But if the bad continuation equilibrium is eliminated, this can always be done because consumers face no more risk and they are thus indifferent between denominating their savings in tradables or nontradables.

The proposition states that the safe equilibrium has higher consumption and a more appreciated real exchange rate than the fragile equilibrium. This happens because consumers at $t = 0$ are no longer concerned about the bad equilibrium outcome, and this reduces their incentives to save. As they choose higher consumption at $t = 0$, their demand for nontradables increase, and this pushes up the real exchange rate. The prediction on the current account follows from the fact that output and the choice of capital at date 0 are the same in the two equilibria.

D. *A Numerical Example*

We now present a numerical example of a fragile equilibrium, and compare its predictions to the corresponding safe equilibrium. For this illustration we set $e^N = 1$ and $e_{b,1}^N = e^N$. We further set $\beta = 0.985$, to obtain an annual risk-free rate of 1.5 percent, and $\omega = 0.35$, to match the share of tradable goods in the total consumption basket for a typical emerging market economy, see Kehoe and Ruhl (2009) for example.

As discussed in this section, the risk-sharing conditions (14) are necessary for the existence of a fragile equilibrium. In our numerical example, the bankers are unconstrained in the good continuation equilibrium, so these conditions can be written as

$$\left(\frac{c_1^{T,B}}{c_1^{T,G}}\right)^{\omega(1-\gamma)-1} = \frac{r_2^B - \theta_2}{1 - \beta\theta_2}. \tag{16}$$

If we interpret the bad continuation equilibrium as a financial crisis, we can choose $[\alpha, \theta_2, \phi]$ to produce an empirically plausible risk-sharing problem between consumers and bankers.

Specifically, we choose these parameters to match an 8 percent fall in the consumption of tradables, $c_1^{T,B}/c_1^{T,G} = 0.92$, a leverage ratio for the bankers of 3, $1/(1 - \beta\theta_2) = 3$, and annualized excess returns in the bad continuation equilibrium of 4 percent, $r_2^B - 1/\beta = 0.04$.[20] These targets are matched by setting $\alpha = 0.28, \theta_2 = 0.68, \phi = 1.05$. Finally, and following the logic of Proposition 3, we set the consumers' coefficient of relative risk aversion so that (16) holds. This is achieved by setting γ to 2.45.[21]

Table 1 reports prices and quantities across the two equilibria. To interpret the forces at work in the two equilibria, it is useful to introduce a standard asset pricing condition (that comes from equations (13)) that relates the interest rates on tradable and nontradable denominated bonds $1 + i_0^T = 1/q_0^T$ and $1 + i_0^N = 1/q_0^N$:

$$1 + i_0^T - (1 + i_0^N)E\left[\frac{p_1}{p_0}\right] = \text{cov}\left((1 + i_0^N)\frac{p_1}{p_0}, \frac{\lambda_{c,1}}{E[\lambda_{c,1}]}\right), \tag{17}$$

where $\lambda_{c,1}$ is the consumers' marginal utility of wealth. The left-hand side of equation (17) can be interpreted as a standard uncovered interest rate parity (UIP) relation, which compares the returns of bonds denominated in different units.

In the safe equilibrium, consumers hold financial assets denominated in nontradable goods. Banks absorb these savings and issue bonds denominated in tradable goods to finance any shortfall between desired investment and their initial net worth. Because most of the banks' liabilities are denominated in nontradables, banks are not exposed to exchange rate fluctuations. Indeed, in our example there is no mismatch at all $(b_1^N = e_{b,1}^N)$, and the economy has only a unique stable continuation equilibrium at date $t = 1$. An implication of this is that consumers' lifetime

[20] Mendoza (2010) reports that emerging markets suffer a loss of 8 percent in private consumption expenditures during financial crises. Banks in our model consolidate financial and nonfinancial firms, and a leverage ratio of 3 is in line with values used in the literature, see Gertler and Karadi (2011). The excess returns $r_2^B - 1/\beta$ represent pure deviations from arbitrage, and we are not aware of previous studies that have quantified these deviations during financial crises in emerging markets. Gârleanu and Pedersen (2011), Bocola (2016), and Gilchrist and Zakrajšek (2012) have measured these deviations to be between 1–4 percent during the recent financial crises in the United States and Italy. We choose the upper bound in this range.

[21] These parameters can be chosen independently from π, the probability that the sunspot selects the bad continuation equilibrium: as shown in the proof of Proposition 3, the asset positions chosen at date 0 and the equilibrium values of capital and the exchange rate in the continuation equilibria depend only on preference and technological parameters. The parameter π, however, affects date 0 consumption choices, interest rates, and the initial conditions that are consistent with the fragile equilibrium. Because the focus in this section is mostly on the former set of variables, we do not choose π with any specific target in mind, and set it to 0.20.

TABLE 1—SAFE AND FRAGILE EQUILIBRIA: A NUMERICAL EXAMPLE

	Safe	Fragile
a_1^N, b_1^N	1.000	0.000
b_1^T	0.115	0.167
$\text{std}_0(\tilde{w}_1 + \beta \tilde{w}_2)$	0.000	0.006
$\text{std}_0(\tilde{p}_1)$	0.000	0.034
$\text{corr}_0(\tilde{w}_1 + \beta \tilde{w}_2, \tilde{p}_1)$	0.000	1.000
$E_0\left[(1 + i_0^N)(p_1/p_0)\right]$	1.015	1.043
$(1 + i_0^T)$	1.015	1.015

Notes: In the table, $\text{std}_0(\cdot)$ denotes the standard deviation of a variable conditional on time 0 information set. The terms corr_0 and E_0 denote, respectively, the correlation coefficient and the expected value. The tilde accent denotes the logarithm of a variable. The parameters used in the example are $\alpha = 0.280$, $\beta = 0.985$, $\omega = 0.350$, $e^N = 1.000$, $e_{b,t}^N = 1.000$, $\theta_2 = 0.680$, $\phi = 1.055$, $\gamma = 2.445$, $\pi = 0.200$. The initial conditions are $K_0 = 0.167$, $a_0^T = -1.206$, $b_0^T = 0.220$, $a_0^N = b_0^N = 0.000$.

labor income and the real exchange rate are not stochastic from date 0 perspective, so their standard deviations equal 0.

Why are these $t = 0$ asset choices optimal from the perspective of consumers and banks? The absence of the bad equilibrium at date $t = 1$ means that agents in the economy do not face any risk. Thus, the two bonds are perfect substitutes and their interest rate is equalized in equilibrium, see equation (17). At those prices, both consumers and banks are indifferent about the denomination of assets and liabilities, and so their financial positions are optimal.

In the fragile equilibrium, consumers do not hold assets denominated in non tradable goods, $a_1^N = 0$. Because of market clearing, banks need to finance their date $t = 0$ operations by issuing debt denominated in tradable goods. These choices generate a mismatch in the balance sheet of the banks $\left(e_{b,1}^N > b_1^N\right)$, and it exposes the economy to equilibrium multiplicity at date $t = 1$. Given the selection rule, agents at $t = 0$ assign probability π to being in the bad continuation equilibrium at $t = 1$, and probability $1 - \pi$ to be in the good one.

The possibility of a bad equilibrium at date $t = 1$ is what justifies the portfolio choices of agents at date $t = 0$. From Table 1, we can verify that consumers' lifetime income is exposed to the realization of the sunspot at date $t = 1$. Importantly, the real exchange rate depreciates when a crisis occurs, and this generates a positive comovement between consumers' lifetime income and the real exchange rate. This property of the exchange rate makes bonds denominated in nontradable goods risky from the perspective of consumers, and this justifies their decision to set $a_1^N = 0$. The precautionary motive of the households is met, in equilibrium, by a riskier balance sheet of the banks, which is ultimately what exposes the economy to financial instability.

Why are banks happy to borrow in tradables and be exposed to exchange rate risk? The answer is that borrowing in tradables is cheaper in expected value for banks. This can be seen by comparing the interest rates of the two bonds. From Table 1, in the fragile equilibrium, the rate of return on bonds denominated in tradables is lower than the one on nontradables. This deviation from the UIP condition is effectively a result of the consumers' unwillingness to save in nontradables, which in equilibrium bids up the interest rate on these bonds. Paradoxically, this behavior generates in equilibrium the very risk that consumers are trying to insure.

E. *Discussion*

Before continuing, let us discuss some of the key assumptions that lead to the possibility of fragile equilibria.

Fragile equilibria are sustained by the precautionary motive of domestic consumers, who have weaker incentives to hold domestic currency assets when they expect a crisis in the future. As just explained, this force leads to an increase in the interest rates for borrowing in domestic currency, which induces banks to issue foreign currency debt. An important assumption that makes this mechanism work is that foreigners do not participate to the market for local currency assets. To understand why, consider the fragile equilibrium in Table 1 and suppose that we allow foreign investors to purchase claims denominated in nontradable goods. Risk-neutral foreign investors would have an incentive at date $t = 0$ to purchase those claims, until there are no further deviations from UIP. Once the return on tradable and nontradable bonds is equalized, the incentive of banks to borrow in tradables goes away and the fragile equilibrium disappears.

The argument above works because foreign investors are risk neutral and have deep pockets, so that there is an infinitely elastic foreign demand for nontradable denominated assets, which eliminates all UIP deviations. In practice, we do observe positive and large UIP violations when comparing the returns of assets issued by emerging economies in domestic and foreign currency. Moreover, a large fraction of international capital flows to emerging economies is denominated in foreign currency.[22] This suggests that a realistic model must feature some limit to international arbitrage of UIP violations, by assuming either limited participation (as we do) or some other assumptions that make the foreign demand for nontradable denominated bonds not infinitely elastic.

In online Appendix Section D we modify the baseline model to introduce a nonzero, but finitely elastic foreign demand for nontradable bonds. We assume international investors are risk-averse "specialists" endowed with limited wealth who can invest in both tradable and nontradable bonds. Our main result is that it is possible to construct fragile equilibria following a similar logic of Proposition 3. The wealth of specialists that hold bonds denominated in nontradables falls in the bad continuation equilibrium because of the decline in the real exchange rate. Therefore specialists are willing to hold these assets only at a premium, which in equilibrium incentivizes the banks to borrow in tradable goods.[23]

A second important assumption that makes fragile equilibria possible is that consumers and bankers are distinct agents. This assumption is shared by recent papers such as Brunnermeier and Sannikov (2014) and He and Krishnamurthy (2013), and allows us to consider parametrizations of the model in which the consumers

[22] For example, Du and Schreger (2017) and Maggiori, Nieman, and Schreger (forthcoming) document the dominance of dollar denomination of international portfolios.

[23] A model with specialists is not the only way to make the foreign demand for nontradable bonds finitely elastic. The crucial thing is that the foreign investors' stochastic discount factor is higher in the event of a crisis. For example, foreigners may discount payoffs more heavily in the bad than in the good continuation equilibrium if there is correlation between shocks affecting world consumption and the sunspot that select across the two equilibria in the small open economy.

are relatively more risk averse than the bankers.[24] More primitive frictions limiting the participation of consumers to asset markets would offer a justification for our assumption.

IV. Lending of Last Resort

In this section, we introduce a government that intervenes in financial markets at $t = 1$, study continuation equilibria, and find under what conditions government intervention can eliminate the bad continuation equilibrium. In the next section, we move back to $t = 0$ to analyze the portfolio choice of the government and how it interacts with the private sector's portfolio choice.

A. *Equilibrium with Government Interventions*

We introduce in the model a benevolent government that can make a transfer T_b to the banks at date 1. This transfer is financed by raising linear labor income taxes on consumers and by borrowing against labor income taxes at $t = 2$. The timing of events in period 1 is as follows.

First, consumers submit a demand schedule for nontradable goods $C^N(p_1)$ and the nontradable goods market clears at the price p_1. This price determines the banks' net worth

$$n_1 = \alpha K_1^{\alpha} - b_1^T + p_1\left(e_{b,1}^N - b_1^N\right). \tag{18}$$

Next, the government raises funds by issuing government bonds $b_{g,2}^T$ subject to the constraint

$$b_{g,2}^T \leq B.$$

The value of the government debt limit B is endogenous, and we explain how it is determined below. The government uses the funds from bonds' issuance and revenue from a linear labor income tax τ_1 to finance a transfer to the banks T_b. Thus, the government budget constraint at $t = 1$ is

$$T_b \leq \tau_1 w_1 + \beta b_{g,2}^T,$$

where β is the price of the bond denominated in traded goods.

The banks use their net worth, the transfer from the government, and resources borrowed from consumers and foreign investors to invest in capital. Consumers

[24]The fragile equilibrium would disappear if bankers were discounting future payoffs using the stochastic discount factor of the consumers. In this case, the bankers' stochastic discount factor would be the product of the consumers' marginal utility and $(r_2 - \theta_2)/(1 - \beta\theta_2)$. Because the latter is always greater than or equal to 1, the bankers' would always act as more "risk averse" than the consumers. Thus, by equation (14), the financial constraint will never bind and the economy would feature only the good unconstrained equilibrium at date 1.

choose their consumption of tradable goods and their savings subject to the budget constraint

$$c_1^T + \beta a_2^T \leq a_1^T + p_1 a_1^N + (1 - \tau_1) w_1 + p_1 e_{c,1}^N - p_1 C^N(p_1). \tag{19}$$

In period 2, the government raises labor income taxes at the rate τ_2 and makes a transfer to consumers T_2, subject to the budget constraint

$$T_2 = \tau_2 w_2 - b_{g,2}^T.$$

All other variables in period 2 are determined as in the model with no government intervention. To capture limited fiscal capacity, we introduce an upper bound on the labor tax rate[25]

$$\tau_t \leq \xi. \tag{20}$$

Limited fiscal capacity implies that the government can only promise to repay up to its maximum tax revenue at $t = 2$. This means that consumers and investors set the debt limit as follows:

$$B = \xi w_2^e, \tag{21}$$

where w_2^e denotes the private sector's wage expectations.

The government is benevolent and maximizes the social welfare function

$$U(c_1^T, c_1^N) + \beta U(c_2^T, c_2^N) + \Phi c_b^T, \tag{22}$$

where c_b^T denotes the consumption of the banker at $t = 2$.

DEFINITION 2: *A continuation equilibrium with government intervention is given by a demand schedule $C^N(\cdot)$, a price p_1, a debt limit B, a government strategy $(\tau_1, b_{g,2}^T, T_b) = \sigma(p_1, B)$, a mapping from $(\tau_1, b_{g,2}^T, T_b)$ to the equilibrium allocation*

$$(c_1^T, c_2^T, c_b^T, k_2, K_2) = \sigma_P(\tau_1, b_{g,2}^T, T_b),$$

and private sector expectations $w_2^e, \tau_1^e, \tau_2^e, T_2^e$, such that

(*i*) *Consumers choose $C^N(\cdot)$ optimally, based on their expectations of wages at $t = 2$, w_2^e, and of tax rates and transfers, $\tau_1^e, \tau_2^e, T_2^e$.*

(*ii*) *The government chooses its strategy optimally given σ_P.*

[25] In the online Appendix, we provide a microfoundation for this assumption by introducing an informal sector, shielded from taxation, that employs labor and capital and in which labor is less efficient by a factor $1 - \xi$. We then show that constraint (20) needs to be satisfied to prevent labor and capital from switching to the informal sector.

(*iii*) *σ_P is consistent with optimization by consumers and bankers and market clearing.*

(*iv*) *Expectations are rational: $w_2^e = w_2, \tau_1^e = \tau_1, \tau_2^e = \tau_2, T_2^e = T_2$.*

(*v*) *The government debt limit B satisfies* (21).

Let us emphasize an important feature of our model of government intervention. The banks' net worth n_1, which depends on p_1, and the government debt limit B are determined before the government chooses T_b. When the government intervenes it takes p_1 and B as given, even though its actions will eventually affect these variables through K_2 and future wages. This timing allows us to introduce a notion of credibility in government interventions. To rule out the bad equilibrium it is not enough that the government prefers the good equilibrium allocation to the bad one. To rule out the bad equilibrium it must be *feasible* and *optimal* for the government to intervene even if the private sector holds pessimistic expectations. This is the reason why fiscal capacity matters for the government's ability to fight a financial crisis.

B. *Equilibrium Characterization*

To make the analysis interesting, assume that at date 0, absent government intervention, the economy is in a fragile equilibrium in which crises occur with positive probability. We also assume, for simplicity, that the capital stock is at its first-best level K^* in the good continuation equilibrium. We set the banks' Pareto weight to $\Phi = \beta U_{c^T}\left(c_1^{T,Good}, e^N\right)$ so that the government does not want to redistribute resources between bankers and consumers in the good continuation equilibrium.[26]

To characterize continuation equilibria, we analyze a fixed point problem in (p_1, B). Namely, we define a mapping $f: \mathbb{R}^2 \to \mathbb{R}^2$, and show that all continuation equilibria correspond to pairs (p_1, B) that satisfy $(p_1, B) = f(p_1, B)$. The formal construction of the mapping f is presented in the online Appendix. Here we provide a sketch of the construction and a graphical representation.

The construction of the mapping f is in two steps. First, given a candidate equilibrium pair (p_1, B), we characterize the equilibrium allocation of the subgame that begins with the government's choice of the vector $\left(\tau_1, b_{g,2}^T, T_b\right)$. This allocation can be found by solving an optimization problem in which the government chooses the size of the transfer to the banks. Next, we compute a new pair (p_1', B') that is consistent with rational expectations. In particular, the equilibrium allocation from the first step gives us K_2 and thus the wages $w_2 = (1-\alpha)K_2^\alpha$. Assuming consumers expect future wages to be w_2, we derive the demand schedule $C^N(\cdot)$ and find the price p_1' that clears the nontradable goods market. Assuming that international investors also expect future wages to be w_2, the government debt limit is set to $B' = \xi w_2$. We define $f(p_1, B)$ to be the pair (p_1', B') derived in the manner described. It is not hard to see from the construction, that a fixed point that satisfies $(p_1, B) = f(p_1, B)$ satisfies the equilibrium conditions in Definition 2 and that the converse is also true.

[26] The labels *Good* and *Bad* denote prices and quantities at the good and bad continuation equilibria in the economy with no government intervention.

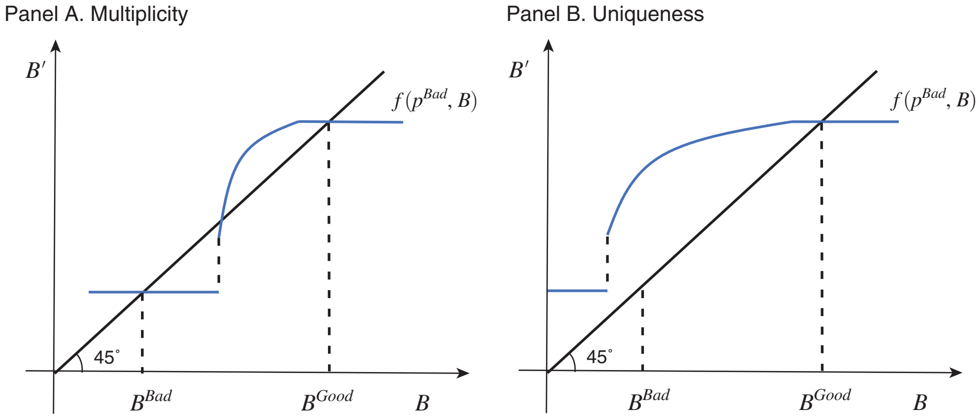

FIGURE 4. EQUILIBRIA WITH GOVERNMENT INTERVENTION

Given this construct, we can see first show that the good continuation equilibrium in the model without government interventions is also an equilibrium in the model with government interventions. When $p_1 = p_1^{Good}$, the banks achieve the first-best capital investment K^* even in absence of a government transfer. The government can thus set $T_b = 0$ and implement the good equilibrium allocation, which is the government's global optimum. Therefore, $\left(p_1^{Good}, B^{Good}\right) = f\left(p_1^{Good}, B\right)$ for any $B \geq 0$, where $B^{Good} = \xi w_2^{Good}$.

So the interesting case is when pessimistic expectations prevail on the nontradable good market and $p_1 = p_1^{Bad}$. We now provide a graphical representation of the mapping f in two cases, one in which government intervention eliminates multiple equilibria and one in which it does not.

Let f^B be the second element of the mapping f. In Figure 4, we plot $B' = f^B\left(p_1^{Bad}, B\right)$. This function has two noticeable properties, both proved in the online Appendix. First, it is nondecreasing in B: a higher debt limit B allows the government to make (weakly) larger transfers to the bankers, reaching (weakly) higher levels of K_2. This in turn leads to higher expected wages and tax revenues in period 2, and thus to a higher B'. Second, the function has a flat region for low levels of B, with $f^B\left(p_1^{Bad}, B\right) = B^{Bad} = \xi w^{Bad}$. This flat region is due to a nonconvexity in the government's problem, which leads the government to optimally set $T_b = 0$ if fiscal resources are below a certain cutoff.[27]

Given the properties of f^B just described, two cases are possible.

In the first case, depicted in panel A, we have $f^B\left(p_1^{Bad}, B^{Bad}\right) = B^{Bad}$. In this case, the bad equilibrium survives under government intervention because, under pessimistic expectations about future wages, the government has insufficient fiscal resources to intervene. These expectations are validated because banks will invest little when the government does not intervene, leading to low future wages for consumers.

[27] The logic is the following. The government needs a large enough transfer to move K_2 above $\underline{K}$. If K_2 remains under $\underline{K}$ all the efficiency gains from an intervention go to the banks, as wages are unaffected. Given the banks' Pareto weight, this transfer does not increase social welfare. An intervention can increase social welfare only when the government can produce a large enough increase in K_2 (and w_2).

In the second case, depicted in panel B, we have $f^B\left(p_1^{Bad}, B^{Bad}\right) > B^{Bad}$. In this case, the bad equilibrium of the economy with no intervention is ruled out because, if we start there, the government has sufficient resources to move the economy to an allocation with higher investment and higher future wages. In fact, this condition is sufficient to rule out any equilibrium that does not correspond to $\left(p_1^{Good}, B^{Good}\right)$, not just an equilibrium at $\left(p_1^{Bad}, B^{Bad}\right)$. The full argument is given in the proof of the following proposition, which gives a necessary and sufficient condition for multiplicity.

PROPOSITION 6: *There is a cutoff $\hat{N}$ such that the economy with government intervention has a unique continuation equilibrium if and only if*

$$N^{Bad} \equiv n_1^{Bad} + \xi w_1 + \beta B^{Bad} > \hat{N}. \tag{23}$$

If (23) *holds, the unique equilibrium allocation corresponds to the good continuation equilibrium with no government intervention. If* (23) *is violated, there are at least two stable continuation equilibria: one with $K_2 = \underline{K}$ and one with $K_2 = K^*$.*

V. The Role of Reserves

We now consider the role of foreign currency reserves. To do so, we allow the government to take positions in tradable and nontradable bonds at date 0, so the government enters period 1 with an initial portfolio of net financial positions $\left(a_{g,1}^T, a_{g,1}^N\right)$, denominated in tradable and nontradable goods. The analysis of the previous section can easily be extended to this case. However, in order to proceed, we need to make assumptions on how the economy responds at date 0 to the portfolio choices of the government. Here we consider two experiments.

First, we consider the case of unexpected interventions. That is, we assume the government buys the portfolio $\left(a_{g,1}^T, a_{g,1}^N\right)$ at date 0, but the private sector does not expect the government to use these resources to intervene in financial markets at $t = 1$. Second, we consider the case of fully anticipated interventions. That is, we assume that the private sector takes into account that the government will use its resources to intervene optimally at date 1. Both exercises are useful in understanding how reserve accumulation affects the economy.

A. *Unexpected Interventions*

In our first experiment, we assume that the private sector expects the government to simply transfer $a_{g,1}^T + p_1 a_{g,1}^N$ back to the consumers at date 1. This experiment shows how holding of reserves by the government affects its ability to credibly act as a lender of last resort.

We proceed in two steps. First, we characterize the equilibrium in which the government buys a portfolio $\left(a_{g,1}^T, a_{g,1}^N\right)$ at date 0 but does *not* intervene in financial markets at date 1. This step gives us agents' portfolios at date 0. Then, given the portfolio choices of the private sector, we will study "off-equilibrium" optimal interventions of the government at date 1 following the analysis of Section IV.

Suppose we start at the fragile equilibrium of an economy with no government intervention and a zero government portfolio. If the government buys $\left(a_{g,1}^T, a_{g,1}^N\right)$ at date 0 and transfers the net return back to the consumers at date 1, it is easy to see that there is still a fragile equilibrium, with values of $\left(a_1^T + a_{g,1}^T, b^T, a_1^N + a_{g,1}^N, b^N\right)$ identical to those of the original equilibrium, and all remaining quantities and prices are unchanged. This is a standard Ricardian equivalence result. The only thing we need to check, given that taxes are bounded by (20), is that if there are states of the world in which $a_{g,1}^T + p_1 a_{g,1}^N$ is negative, i.e., the government is a net debtor, the government has sufficient fiscal capacity to repay its debt.

Consider now what happens if the government decides, unexpectedly, to intervene at date 1. The following result shows that an appropriate choice of $\left(a_{g,1}^T, a_{g,1}^N\right)$ allows the government to uniquely implement the good continuation equilibrium.

PROPOSITION 7: *Take an economy with a fragile equilibrium. Let $\hat{N}$ and N^{Bad} be defined as in Proposition 6. Suppose the government portfolio $\left(a_{g,1}^T, a_{g,1}^N\right)$ satisfies the inequalities*

$$(24) \qquad a_{g,1}^T + p_1^{Bad} a_{g,1}^N \ \geq \ \hat{N} - N^{Bad},$$

$$(25) \qquad a_{g,1}^T + p_1^{Good} a_{g,1}^N \ \geq \ -\xi(1-\alpha)\left[K_1^\alpha + \beta(K^*)^\alpha\right],$$

$$(26) \qquad q_0^T a_{g,1}^T + q_0^N p_0 a_{g,1}^N \leq \beta E_0\left[a_{g,1}^T + p_1 a_{g,1}^N\right] + \xi(1-\alpha)E_0\left[K_0^\alpha + \beta K_1^\alpha + \beta^2 K_2^\alpha\right].$$

Then, the government can purchase $\left(a_{g,1}^T, a_{g,1}^N\right)$ at date 0 and uniquely reach the good equilibrium at $t = 1$.

To provide an interpretation of this result, consider the interesting case in which $N^{Bad} < \hat{N}$, so optimal government intervention with a zero portfolio is not sufficient to eliminate the bad equilibrium, as shown in Proposition 6.

Now suppose the government borrows in nontradables to finance the accumulation of reserves denominated in tradables, taking positions $a_{g,1}^T > 0 > a_{g,1}^N$, and assume that these positions yield a zero average payoff $E_0\left[a_{g,1}^T + p_1 a_{g,1}^N\right] = 0$. Given that $p_1^{Good} > p_1^{Bad}$, the government makes a net gain in the bad state and a net loss in the good state. Moreover, given that tradable bonds pay a lower expected return than nontradable bonds in a fragile equilibrium, the portfolio will cost $q_0^T a_{g,1}^T + q_0^N p_0 a_{g,1}^N > 0$ at date 0.

Condition (24) ensures that the net portfolio gain in the bad state is large enough to cover the difference $\hat{N} - N^{Bad}$. This shifts up the resources available to the government in the bad equilibrium, moving the economy from the situation depicted in panel A of Figure 4 to the situation depicted in panel B, and thus eliminating the bad equilibrium. This is our main result on the ex post effects of reserve accumulation: reserves allow the government to hedge against the bad equilibrium state and, by boosting the government's resources in that state, end up eliminating that equilibrium.[28]

[28] Conditions (25) and (26) are needed to make sure that the portfolio $\left(a_1^T, a_1^N\right)$ is feasible. In particular, condition (25) ensures that the government has sufficient fiscal capacity to cover the portfolio losses in the good state. Condition (26) ensures that it has sufficient fiscal capacity to cover the ex ante cost of reserve accumulation.

The results above provide a rationale for some recent empirical findings. Obstfeld, Shambaugh, and Taylor (2010) shows that the size of the banking sector liabilities is an important predictor in explaining the accumulation of foreign currency reserves by emerging markets. In our model, we can compare two economies that have multiple equilibria at $\underline{K}$ and K^*, have the same foreign net position $a_1^T - b_1^T$, and are identical in all other respects except for the balance sheet of the financial sector at date 1, that is, for the debt levels b_1^N and b_1^T. The conditions in Proposition 7 imply the following.[29]

Remark 1 (Reserves and Banks' Balance Sheets)**:** Between the two economies described above, the one with more bank debt requires a higher value of $a_{g,1}^T$ to rule out the bad equilibrium.

Leverage in the banking sector reduces banks' net worth in a crisis, thus requiring a larger government buffer to eliminate the bad equilibrium.

A second remark comes out of our analysis.

Remark 2 (Unused Reserves)**:** Reserves can play a useful role in credibly ruling out financial panics and yet never be used in equilibrium.

When the conditions in Proposition 7 are satisfied, the government doesn't intervene in equilibrium and rebates the reserves back to the households. However, the presence of reserves is important to rule out the bad equilibrium.

B. *Anticipated Interventions*

We now consider the case of a fully expected intervention, that is, we assume that agents correctly anticipate that the government will use reserves optimally at $t = 1$ to eliminate the bad equilibrium.

Suppose that we start at a fragile equilibrium and the government takes positions that satisfy the conditions in Proposition 7. If all agents correctly anticipate that the government will intervene and eliminate the bad equilibrium, the positions they take at date 0 will adjust. In particular, it is possible to show that there is an equilibrium in which the values of $b_1^T - a_{g,1}^T$ and $b_1^N - a_{g,1}^N$ are equal to the values of b_1^T and b_1^N in the safe equilibrium constructed in Proposition 5 and the conditions of Proposition 7 are satisfied, so there is a unique (good) continuation equilibrium. This means that the consolidated tradable denominated debt of the banks and the government is lower, and their consolidated nontradable denominated debt is larger relative to the original fragile equilibrium. In other words, increased holdings of tradable positions by the government are not undone by increased borrowing in tradables by the banks. We summarize this finding in the next remark.

[29] Notice that the value of $\hat{N}$ depends on the net foreign position of the country, but not on individual balance sheets.

Remark 3 (Catalytic Reserves)**:** When reserves are large enough to eliminate the bad equilibrium, their presence can lead to a higher net consolidated tradable denominated position of banks and the government.

Here the interesting observation is that banks do not have incentives to undo the positive foreign currency position of the government by borrowing more in foreign currency. In other words, the presence of credible intervention at date $t = 1$ does not induce more risk taking by banks at $t = 0$ as the usual moral hazard logic would suggest, and anticipated government rescues do not lead to more risk taking.

To understand the logic behind this result, it is useful to identify two opposing channels through which government intervention affects banks' behavior ex ante.

First, if we fix the interest rates in tradables and nontradables at date 0, there is a direct effect of intervention that leads banks to issue more tradable denominated debt. The argument is as follows. As argued in Section III, the presence of the bad equilibrium gives banks an incentive to borrow less in tradables, because the marginal value of net worth is higher and tradable denominated debt increases in value in the bad equilibrium. Therefore, when the bad equilibrium is removed, the incentive to borrow in tradables goes up. This is the traditional moral hazard mechanism, where reducing the risk to which banks are exposed, by eliminating the bad equilibrium, would lead to increased risk taking.

Second, there is a general equilibrium effect that works in the opposite direction. When government interventions remove the bad equilibrium, domestic savers are no longer concerned about a large depreciation correlated to a contraction in consumption. Hence, savers will demand more nontradable denominated assets. This force pushes down the interest rate differential between tradable and nontradable denominated debt and induces banks to borrow more in nontradables. Our argument above shows that the general equilibrium effect dominates in our economy.

Remark 3 provides a testable prediction for our theory: all else equal, we should expect countries with higher official holdings of foreign currency reserves to feature a lower degree of foreign currency borrowing. The main challenge for testing this prediction is that reserve accumulation is itself endogenous, and it could be correlated to factors that affect foreign currency borrowing and that we cannot control for. While resolving this endogeneity problem is outside the scope of the current paper, we can use the same data underlying the construction of Figure 1 to verify whether, in a cross section of countries, we observe evidence consistent with the predictions of Remark 3.

Specifically, we estimate by OLS the following linear relation:

$$\Delta fc_{it} = \alpha + \beta \Delta\, reserves_{it} + \varepsilon_{it}, \tag{27}$$

where Δfc_{it} is the first difference in the fraction of banks' deposits denominated in a foreign currency for country i obtained from Levy Yeyati (2006) and it spans the period 1990–2009, while $\Delta\, reserves_{it}$ is the first difference of official holdings of reserves scaled by gross domestic product over the same horizon.[30] These series

[30] We estimate equation (27) in first differences to correct for two potential issues. The first is the presence of country-specific effects that could affect, at the same time, the *level* of foreign currency borrowing and reserves. The

TABLE 2—OLS ESTIMATES OF EQUATION (27)

	Restricted sample	Full sample	Full sample, floaters
α	−0.00	0.00	−0.00
	(−0.13)	(0.65)	(−0.04)
β	−0.83	−0.34	−0.41
	(−1.97)	(−3.74)	(−2.46)
Observations	122	405	192
R^2	0.09	0.05	0.05

Note: Robust *t*-statistic in parentheses.

are obtained from the *World Development Indicators* of the World Bank (see World Bank 2020).[31]

The first column of Table 2 reports the estimate of equation (27) when considering only the seven countries reported in Figure 1, while the second column reports the results when using the full set of countries in the Levy Yeyati (2006) dataset. The estimated β is negative in both specifications, and significantly different from zero at 5 percent. Of course, there are other mechanisms that could generate this negative association between foreign reserves and our indicator of financial dollarization. Countries may hold foreign reserves to implement a peg or, more generally, to reduce the volatility of their exchange rate. To the extent that a lower volatility of the exchange rate reduces the incentives to hold foreign currency assets, we might estimate a negative β in equation (27). Column 3 of Table 2 restricts the sample further to countries/year that, according to the classification of Klein and Shambaugh (2008), are not pegging their exchange rate. Although less precisely estimated, β is still negative and significantly different from zero at 5 percent. That is, after controlling for a country's exchange rate regime, we observe a negative association between official holdings of foreign reserves and the degree of financial dollarization of a country, consistent with the predictions of Remark 3.

C. *Alternative Policies*

In the last two sections, we focused on government ex post interventions and how reserve accumulation can support these interventions. There are other policies that could limit the country exposure to financial fragility. In particular, various of forms of financial regulation are commonly used to discourage borrowing or saving in foreign currency. We now briefly discuss these policies.

In the context of our simple model, policies that discourage dollar borrowing ex ante can be sufficient to eliminate the fragile equilibrium of Section III. In the

second is the presence of country-specific time trends in these two variables, which would lead us to overstate the statistical significance of our results if we were to estimate the relation in levels. We obtain similar results to the ones reported in Table 2 when adding country and time fixed effects to equation (27) or when estimating a version of equation (27) in levels with country and time fixed effects.

[31] The indicator code for total reserves at current US dollars is FI.RES.TOTL.CD. The indicator code for GDP at current US dollars is NY.GDP.MKTP.CD. The series can be downloaded at https://datacatalog.worldbank.org/dataset/world-development-indicators.

numerical example of Table 1, a regulation that puts an upper bound on dollar debt b_1^T at its safe equilibrium level, can uniquely implement the safe equilibrium. In richer models, however, these forms of prudential regulation may encounter trade-offs. In particular, we have in mind models with heterogeneity in the financial and nonfinancial sector that makes some agents better equipped to deal with shocks leading to a depreciation. In such models, a uniform regulation may hinder some trades that are Pareto improving ex ante. Of course, in practice also reserve accumulation involves trade-offs, as foreign reserves pay low rates of return.[32] A full-blown analysis of the optimal ex ante and ex post intervention is beyond the scope of this paper. The objective of this section was just to study the role of reserves in supporting financial stability and to understand their effect on the incentives of the private sector to borrow in foreign currency.

Let us add an additional remark on regulation. Ex ante regulation in our model may be desirable even if it does not eliminate the fragile equilibrium. Suppose we are in a fragile equilibrium and consider a tax at date 0 that induces banks to borrow less in tradables and more in nontradables. If the sunspot at date 1 selects the bad equilibrium, the shift in banks' debt denomination reduces the state-contingent transfer from banks to consumers. Individual banks internalize this effect as they know their individual balance sheet is less exposed to a depreciation. However, they do not internalize two general equilibrium effects: the fact that higher investment will lead to higher wages w_2 and the fact that higher future wages for consumers at date 1 increase the demand for nontraded goods and hence the price p_1. As argued at the end of Section IIC, these pecuniary externalities improve the efficiency of the allocation and can produce a Pareto improvement. Therefore, the same externalities that make ex post interventions Pareto improving can also make ex ante regulation desirable.

VI. Conclusion

Our model provides a novel perspective on financial dollarization in emerging markets, pointing out the interaction between financial instability and the insurance motive of domestic savers. We have used our model to study the ex post and ex ante effects of lending of last resort, introducing a notion of fiscally credible interventions. Our analysis provides a rationale for the view that official foreign currency reserves support financial stability, as they improve the credibility of domestic authorities to intervene in financial panics.

Our model is stylized and abstracts from a number of important policy issues.

First, we leave aside the role of monetary policy. Our model can be interpreted as making the implicit assumption that the domestic monetary authority is committed to keep the price of nontradables stable. It would be interesting to model explicitly monetary policy in an environment with nominal rigidities, to capture important dilemmas faced by monetary policy both ex post and ex ante. Ex post, the monetary authority faces the problem that a monetary expansion causes a nominal devaluation,

[32] In our model, reserve accumulation entails no costs for the government because, by ruling out the bad continuation equilibrium, it equalizes the interest rate on peso and dollar debt at date 0. It would be interesting to extend the model to allow for a country or a currency premium that cannot be completely eliminated by ex ante policy.

which increases the burden of dollar debt. Ex ante, the monetary authority faces the problem that agents taking domestic currency positions are afraid of future inflation in financial crises. Adding these considerations to our framework is an interesting avenue for future research.

Second, in our paper, the role of foreign currency reserves is to boost the fiscal position of the domestic government in the event of a crisis. There are additional reasons why dollar reserves can help support a financial system in distress. In particular, currency market interventions can be used to dampen movements in the exchange rate, reducing the burden of foreign currency debt.[33] Capturing this role would require introducing additional frictions in currency markets, which is outside the scope of the present paper.

The central mechanism of our paper is that private savers do not internalize the effect of their portfolio choices on the financial fragility of the economy. The logic of this mechanism can be extended beyond the specific environment considered here, where savers only choose the currency composition of their portfolio. In Bocola and Lorenzoni (2020), we explore this mechanism in a more general dynamic macro-financial model in which borrowers and lenders trade state-contingent claims, and study its implications for aggregate volatility.

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