Regulating Capital Flows to Emerging Markets: An Externality View

Anton Korinek*
University of Maryland

October 28, 2008

Abstract

This paper analyzes the external financing decisions of emerging market economies that are prone to collateral-dependent external financing constraints. We show that most forms of capital flows into such economies impose a macroeconomic externality that leads decentralized agents to take on too much systemic risk and makes the recipient country more vulnerable to financial instability and crises.

Every capital inflow entails future outflows in the form of repayments, dividends, or profit distributions. In states of the world when financing constraints in an economy become binding, capital outflows necessitate an increase in the current account and a reduction in aggregate demand. This puts pressure on the exchange rate and triggers a financial accelerator mechanism, i.e. a mutual feedback cycle of depreciating exchange rates, deteriorating balance sheets, tightening financing constraints, and declining aggregate demand.

Decentralized agents take prices as given and do not internalize that the capital outflows associated with their repayments contribute to the financial accelerator. As a result, they do not internalize the full social cost of such payments and take on too much systemic risk in their financing decisions. We illustrate how these externalities can be quantified for different categories of capital flows using historical data from Indonesia, and we describe a pecking order of financial flows that reflects the different magnitudes of the resulting externalities. Furthermore, we define a social pricing kernel that describes the optimal magnitude of policy measures to restore social efficiency.

*The author would like to thank Viral Acharya, Alessandra Bonfiglioli, Phil Brock, Fernando Broner, Tiago Cavalcanti, Eric Fisher, Walt Fisher, Chris Gilbert, Olivier Jeanne, Laura Kodres, Enrique Mendoza, Carmen Reinhart, Joseph Stiglitz, and Carlos Vegh as well as conference participants at the CAF-FIC-SIFR Conference on Emerging Market Finance, the Cambridge Finance Conference on the IMF and Financial Crises, the CREI/Egon Sohmen Symposium, the FDIC/Cleveland Fed Conference on Financial Stability and seminar participants at the IIES Stockholm, the IMF, the University of Washington and the World Bank/IMF Conference on Risk Management for helpful discussions and comments. Address for correspondence: 4118F Tydings Hall, University of Maryland, College Park, MD 20742, USA. Telephone number: +1 (301) 405-4536. Email contact: http://www.korinek.com/

JEL Codes: F41, E44, D62, H23
Keywords: capital market liberalization, international capital flows, externalities, systemic risk, financial crises, pecking order of financial flows

1 Introduction

The emerging market crises that the world witnessed over the past quarter century have led researchers to re-evaluate the benefits and risks of capital market liberalization in developing countries. On the one hand, standard neoclassical models (see e.g. Obstfeld and Rogoff, 1995) suggest that free international capital flows increase the efficiency of the world allocation of capital. In particular, they should allow poor countries to increase their capital stock and insure against idiosynchratic shocks, thereby raising output and welfare (see Henry, 2007, for an excellent survey). During the 1990s, this view was strongly advocated e.g. by a number of researchers in the IMF (see Fischer, 1998) and led dozens of developing country governments to liberalize their capital account.

On the other hand, a number of academics (see e.g. Rodrik, 1998; Stiglitz, 2002) have argued that capital market liberalization strongly increased the risk that an emerging market economy suffers a financial crisis, while the benefits it offered were questionable. They pointed out that the fundamental theorems of welfare economics that lay behind the view that capital market liberalization raised welfare hold only in economies that suffer from no other distortions. The typical emerging market economy is rife of market imperfections; hence restrictions on capital accounts can be an optimal policy in a second-best sense. However, this literature did not provide a detailed economic mechanism that would explain why the decentralized equilibrium in such an economy would be inefficient, and what exact forms of regulations would be warranted.

This paper sets out to provide a theoretical foundation to this question. We show that decentralized agents do not internalize that their financing decisions give rise to financial accelerator effects, which play a key role in emerging market crises. This creates a macroeconomic externality that induces them (i) to undervalue the systemic risks posed by various forms of capital flows and (ii) to contract an excessive level of such flows. As a result, their economies are excessively vulnerable to financial instability and crises. We also show that well-targeted regulations can alleviate this distortion, induce decentralized agents to switch towards safer forms of finance, and offer emerging market economies the opportunity to enjoy the benefits of financial globalization without suffering the social costs imposed by frequent financial crises.

The financial accelerator that we analyze, and by implication the externality, arise from positive feedback effects between collateral-dependent external financing constraints and depreciating exchange rates. Let us define financial crises as situations in which an emerging market economy experiences binding external financing constraints. In such states, repayments on financial obligations require that domestic agents cut back on consumption and investment, which reduces aggregate demand. Declining aggregate demand causes the exchange rate to depreciate, which constitutes a pecuniary externality:[1] Atomistic agents take the exchange rate as given; they do not internalize that it is affected by their financing decisions. However, since depreciations in the exchange rate deteriorate the balance sheet of other agents, this pecuniary externality has real effects in the form of tighter financing constraints for others in the economy. As a result, atomistic agents do not internalize the full social cost of liabilities that mandate repayments in constrained states of nature.

An important condition for this externality to result in welfare losses is that the emerging market economy is in fact subject to aggregate risk. If the emerging market economy was perfectly insured against all aggregate risk (as would be the case if international investors were risk-neutral and financial markets were complete), then financial crises would never occur, and the social optimum could be achieved.[2] However, when international capital markets are averse to some risk factors, atomistic agents in the emerging economy determine the optimal structure of liabilities by weighing off the private risk versus the required return on different forms of finance. Since they undervalue the social costs of payoffs in crisis states, they take on financial flows that entail too much systemic risk and impose an externality on the rest of the economy.

When international capital markets are strongly risk averse to a particular state of the world, emerging market crises can arise from *contagion*, i.e. in the absence of any adverse domestic shock: if international investors receive high repayments in such states (for example, short-term debt confers the implicit option to not roll over the debt in the event of a global liquidity crisis), then the resulting 'sudden stop' in capital flows exerts pressure on the exchange rate and can trigger financial accelerator effects and a financial crisis. Many emerging economies are currently experiencing this as a result of the ongoing global financial crisis.

We construct a *social pricing kernel* that prices emerging market liabilities at their true social cost. (In analogy to traditional pricing kernels, which reflect how much private agents value payoffs across different states of the world, the social pricing kernel

[1] In normal times, emerging economies often peg their exchange rates. However, pegs typically cannot be maintained in case of large systemic shocks that lead to financial crises, as exemplified by Argentina in 2001/02. These are the situations with which our paper is concerned.

[2] In fact, it can be argued that the existence of financial crises is proof that emerging markets do not have access to perfect and risk-neutral financial markets – otherwise they would be fully insured against crisis risk. See Korinek (2008a) for an elaboration of this point.

is a random variable that expresses how much a social planner values payoffs across different states of the world.) The difference between the private and social pricing kernels represents how much decentralized agents undervalue the social costs of state-contingent payoffs. We denote this difference as the *externality kernel.* In unconstrained states of the world, private and social pricing kernels coincide and the externality kernel is zero. In constrained states of the world, the social planner internalizes that payoffs are socially more costly than decentralized agents realize; the externality kernel is positive and grows larger the tighter financing constraints are.

We show that the expected size of the externality imposed by a given liability can be calculated as the product of its stochastic vector of payoffs with the externality kernel. This formula can be used by policymakers to calculate the social costs imposed by capital flows of different forms, such as dollar debt, GDP-linked debt, local currency debt, portfolio investment, or foreign direct investment. For example, foreign currency-denominated debt, which mandates high payoffs in crisis states, is associated with large externalities; by contrast, foreign direct investment, which typically yields no profits during crises, is free of externalities.

Our theoretical results are also consistent with empirical findings regarding the effect of different forms of capital flows on macroeconomic volatility and on the incidence of financial crises in emerging markets. For example, Calvo et al. (2004) and Levy Yeyati (2006) show that flows of foreign currency-denominated debt to emerging markets raise the risk of financial crisis and magnify macroeconomic volatility. Kose et al. (2007) find more generally that "portfolio debt [...] is not conducive to risk sharing." On the other hand, Mauro et al. (2007) show "... that foreign direct investment and other non-debt creating flows are positively associated with long-run growth."

We can therefore provide useful guidance to policymakers on (i) whether measures against a particular form of finance are warranted and (ii) of what magnitude policy measures should be. Selective regulations, for example in the form of taxes or reserve requirements on risky forms of international capital flows, should make it possible for emerging market economies to reap the benefits of global financial integration while avoiding the costs imposed by recurrent financial crises.[3]

We illustrate how the discussed externalities can be quantified for different forms of capital flows using historical data from Indonesia over the past 20 years. We find that during the 1997/98 crisis, the externalities associated with dollar debt, local currency debt and equity portfolio inflows were 30.7%, 8.9% and 6.2% respectively of the value of

[3]In contrast to e.g. Tobin (1978) the policy measures that we propose would apply only to risky forms of finance. In addition, they are motivated from a well-specified externality rather than a general concern about the volatility of international capital flows.

the inflow. Assuming that the incidence of crises over that period was representative, this implies an optimal level of taxes on those inflows of 1.54%, 0.44% and 0.31% respectively.

While the externality that we analyze stems not from the inflows of foreign capital, but from the effects of outflows when financial crises arise, we advocate that policy measures are imposed on inflows rather than outflows. In a rational expectations framework, both measures are equivalent. However, in practice regulations on inflows create a more predictable policy environment and avoid problems of time inconsistency. There is also a role for policy to actively encourage capital inflows in the midst of a financial crisis: decentralized agents will generally undervalue the social benefits of capital inflows in mitigating crises and alleviating economy-wide financing constraints.

Policy measures against the discussed externality are only effective if they affect the price of risky assets. We show that if private agents expect contingent transfer payments in crisis states (e.g. from the emerging market government or, indirectly, from international bodies), they will increase their risk-taking so as to undo the transfer, since the decentralized equilibrium with excessive risk taking constitutes their private optimum. This is a state-contingent version of Ricardian equivalence (see Barro, 1974).

While the model in our paper is set in a rational expectations framework, it is often argued that real-world market participants did not fully expect the severe movements of macroeconomic variables that occurred during financial crises. We can illustrate that errors in expectations regarding the severity of a financial crises entail large social costs, since the financial accelerator magnifies the effects of agents' misallocations. By contrast, errors in expectations in normal times impose only small welfare costs, since the effects of misallocations on consumption can be smoothed over time when borrowing constraints are loose.

In methodology, our work contributes to the literature on the financial accelerator, which has often been invoked as an important mechanism to describe financial crises (see e.g. Fisher, 1933; Kiyotaki and Moore, 1997; Bernanke et al., 1999; Krugman, 1999; Mendoza, 2006). So far little attention has been paid to the constrained welfare implications of such accelerator effects, in particular to the ex ante social efficiency of financing decisions. We show that the financial accelerator generally creates an externality that induces individual firms to take on excessive risk.[4]

[4] In earlier research (Korinek, 2007), we have analyzed the social costs of dollar debt during crises and discussed how to design an unremunerated reserve requirement on dollar debt to restore efficiency. The current paper, by contrast, presents a general theory of the social efficiency of capital flows in a framework with complete ex ante risk markets. This allows us to show for example that any debt flow, even if denominated in local currency debt, imposes a negative externality on the recipient country.

Our work is also related to the literature on excessive risk-taking in emerging markets. Many authors argue that firms take on excessive risk due to moral hazard, i.e. in order to take advantage of bail-out guarantees (see e.g. Krugman, 1998; Schneider and Tornell, 2004). However, as argued by Eichengreen and Hausmann (1999), risky forms of finance are pervasive even among firms that are unlikely to be bailed out, and in most financial crises government bailouts are not sufficient to cover most of the firms that went bankrupt. Eichengreen and Hausmann (1999) propose instead that emerging market economies simply do not have access to contingent forms of finance, which they term 'original sin.' However, as shown in Reinhart and Rogoff (2008), episodes of 'original sin' are typically temporary in the aftermath of a country experiencing financial distress. Caballero and Krishnamurthy (2003) argue that capital market imperfections can also lead to excessive risk-taking. They show that the interaction between two credit market frictions, in international and domestic financial markets, induces agents in emerging markets to take on too much dollar debt.

Our work is related to this line of research in that the externality that we emphasize also arises from capital market imperfections. However, our work differs in three important dimensions: First, we show that a single market friction – collateral-dependent external borrowing constraints – leads to excessive risk-taking. The resulting procyclical fluctuations in the availability of external finance have long been viewed as the key factor of financial instability in emerging market crises (see e.g. Calvo, 1998; Krugman, 1999; Chang and Velasco, 2001).[5] We can therefore provide a unified theory of the mechanism of financial crises and the reasons for socially excessive exposure to crisis risk.

Second, the paper conceptually introduces the framework of a social pricing kernel and an externality kernel. This enables us to perform a detailed welfare analysis of emerging market capital flows and to provide a clear theoretical foundation for regulations that discriminate among various flows according to the systemic risk that they pose.

Third, both our modeling approach and our results are supported by a wide range of literature. Mendoza (2006) has demonstrated that the financial accelerator framework that generates our externality result is an excellent description of the mechanics

[5] By contrast, Caballero and Krishnamurthy (2003) take the total foreign borrowing capacity of emerging market economies as given and focus on the implications of domestic financial frictions. In their framework, a Pareto improvement can only be achieved by an all-powerful social planner who can engage in transfers from domestic borrowers to domestic lenders. They address this issue by assuming that each agent is *ex ante* equally likely to be a borrower or a lender so that a reduction in dollar borrowing makes all agents better off in expectation. In our paper, by contrast, a constrained social planner can attain a Pareto improvement simply by limiting excessive risk-taking.

of emerging market financial crises. Furthermore, our ranking of the riskiness of various financial flows is in accordance with the conventional wisdom on how dangerous alternative forms of capital flows are (Mauro et al., 2007). We believe that this makes our conceptual framework an excellent theoretical basis for quantitative policy analysis, as we briefly illustrate in section 4 of the paper.

The remainder of the paper is structured as follows. Section 2 introduces a stylized two-period model of a small open emerging market economy in which a financial accelerator is triggered in low output states. We demonstrate that decentralized agents value liquidity in such crisis states less than a social planner. In section 3 we add one time period before the potential crisis and analyze the ex-ante financing decisions of both decentralized agents and the social planner. We show that decentralized agents generally contract a socially excessive level of repayments in crisis states, since they do not internalize that repayments contribute to the strong depreciation in exchange rates in such states. Section 4 analyzes policy measures to correct the distortion, and section 5 concludes.

2 Benchmark Model of Financial Accelerator

This section analyzes a stylized two-period model of a small open emerging market economy that is subject to collateral-dependent financing constraints in the style of e.g. Mendoza (2006). We show that when financing constraints bind, a financial accelerator mechanism is triggered: lower borrowing capacity forces agents to increase repayments, cut back on spending and reduce aggregate demand, which depreciates the country's exchange rate. The decline in the exchange rate in turn lowers the value of domestic collateral, reducing the agent's borrowing capacity even further and leading to a downward spiral of depreciating exchange rates, falling collateral values, tightening financing constraints and contracting demand.

While the equilibrium allocations of decentralized agents and the social planner coincide in this simplified model, we can show that decentralized agents value liquidity in crisis states when the financial accelerator is triggered less than a social planner.

2.1 Analytical Environment

We analyze a small open economy that consists of a continuum of mass 1 of identical representative agents. There are two goods in the economy, a tradable good T which can be traded with large international investors and which is the numeraire good, and a non-tradable good N with a relative price p_N, which is also a measure of the real exchange rate.[6]

The economy spans over two time periods indexed $t = 1$ and 2. At the beginning of time the economy's aggregate state of productivity $\omega \in \Omega$ is realized. This setup allows us to focus on the mechanism of the financial accelerator. In section 3 below we will introduce an additional time period to analyze the ex-ante financing decisions of decentralized agents.

2.2 Domestic Agents

Domestic agents derive utility from the consumption of tradable C_T and non-tradable goods C_N in periods 1 and 2 according to the utility function

$$U = u(C_1) + \beta u(C_2) \quad \text{where} \quad C_t = C_{T,t}^{\frac{1}{1+\sigma}} C_{N,t}^{\frac{\sigma}{1+\sigma}} \tag{1}$$

where u is a standard neoclassical utility function, β is the agent's discount factor, and $\frac{1}{1+\sigma}$ and $\frac{\sigma}{1+\sigma}$ are the shares of tradable and non-tradable goods in the consumption index C_t. This implies that σ is the ratio of the value of non-tradable consumption to tradable consumption, which is constant given the Cobb-Douglas aggregator.

We assume that agents are born with a an initial amount of wealth W_1 (which can be negative because of debts taken on in earlier periods). They need to invest $\bar{I}$ units of tradable goods in period 1. As a result, they receive an endowment of $(Y_{T,t}^{\omega}, \bar{Y}_N)$ in both periods 1 and 2, where $Y_{T,1}^{\omega}$ depends positively on the aggregate state of productivity ω, and for simplicity $Y_{T,2} = \bar{Y}_T$ and $\bar{Y}_N = 1$ are assumed fixed.[7]

Agents can borrow by selling an amount B_1 of bonds to international investors, who buy each unit at price $\frac{\$1}{R}$ in period 1 in exchange for a repayment of \$1 in period 2. We assume without loss of generality that domestic agents' discount factor and international lenders' interest rate are such that $\beta R = 1$. Domestic agents can sell bonds up to a borrowing limit K^{ω}, which depends on the value of their collateral. We follow Mendoza (2006) in assuming that the maximum borrowing capacity K^{ω} is a

[6] We chose to model the economy's exchange rate as a real exchange rate for analytical simplicty. More generally, any model in which the exchange rate depreciates in crises, i.e. in response to strong negative shocks to aggregate demand, will yield our externality result. Note that this property is generally the case in emerging markets, even under pegged exchange rate regimes, which typically collapse in response to strongly negative shocks, as illustrated e.g. by the Argentine crisis in 2001/02.

[7] This assumption reflects that production factors cannot be re-allocated between the two sectors of the economy in the short run. Our insights would be unaffected if we endogenized investment and introduced a lag between investment and production.

fraction κ of the agent's income in period 1:[8]

$$B_1^\omega \leq K^\omega = \kappa\big(Y_{T,1}^\omega + p_{N,1}^\omega \bar{Y}_N\big) \tag{2}$$

This constraint reflects that lower income and net worth reduce the stake that an agent has in his project and therefore amplify the problems of asymmetric information that arise in lending relationships (see e.g. Stiglitz and Weiss, 1981). In other words, lenders reduce the amount of funds they supply to borrowers whose income and net worth decline.[9] We identify periods when the financing constraint on the representative domestic agent is binding as financial crises. In the following subsections it will become clear that this is a good characterization of crises.

The domestic agent's optimization problem can then be denoted as

$$\max_{\{C_{T,t}^\omega, C_{N,t}, B_1^\omega\}} \sum_{t=1}^{2} \beta^t u\left(C_{T,t}^{\frac{1}{1+\sigma}} C_{N,t}^{\frac{\sigma}{1+\sigma}}\right) \tag{3}$$

$$\begin{aligned} \text{s.t.} \quad \bar{I} + C_{T,1}^\omega + p_{N,1}^\omega C_{N,1}^\omega &= Y_{T,1}^\omega + p_{N,1}^\omega \bar{Y}_N + W_1 + B_1^\omega \\ C_{T,2}^\omega + p_{N,2}^\omega C_{N,2}^\omega &= \bar{Y}_T \quad + p_{N,2}^\omega \bar{Y}_N - B_1^\omega R \\ B_1^\omega &\leq \kappa\big(Y_{T,1}^\omega + p_{N,1}^\omega \bar{Y}_N\big) \end{aligned}$$

2.3 Definition of Equilibrium

We can characterize the decentralized equilibrium in the described emerging market economy for a given ω as

- an allocation $(C_{T,t}^\omega, C_{N,t}^\omega, B_1^\omega)$ and
- a price $p_{N,t}^\omega$ for $t = 1, 2$
- which maximize agents' optimization problem (3)
- which clear markets for both time periods:

[8] To ensure that the borrowing constraint is relevant, we make the assumption $\kappa\sigma < 1$. This guarantees that the appreciation of the exchange rate that results from a one dollar capital inflow raises the borrowing capacity of the country by less than one dollar. Otherwise the constraint would never bind.

[9] While the constraint here is not derived from an optimal contract setting, our results continue to hold in any framework where an agent's borrowing capacity depends on the exchange rate. An example of endogenously derived borrowing constraints is given in appendix A.1; our externality results continue to hold in that case. More generally speaking, any model of contractionary depreciations where the level of the exchange rate affects individual constraints exhibits the inefficiency demonstrated in this paper. For a comprehensive overview of alternative channels of contractionary depreciation see e.g. Caves et al. (2007).

– for non-tradable goods: $C^{\omega}_{N,t} = \bar{Y}_N = 1$

– for tradable goods: $C^{\omega}_{T,1} + \bar{I} = Y^{\omega}_{T,1} + B^{\omega}_1$
$C^{\omega}_{T,2} = \bar{Y}_T - B^{\omega}_1 R$

2.4 Equilibrium in the Non-tradable Sector

The first-order condition of the agent's maximization problem with respect to non-tradable consumption in each time period pins down the relative price of non-tradables, i.e. the real exchange rate in the described economy.

$$p^{\omega}_{N,t} = MRS = \sigma \cdot \frac{C^{\omega}_{T,t}}{C^{\omega}_{N,t}} = \sigma C^{\omega}_{T,t} \tag{4}$$

where we used the market-clearing condition for non-tradable goods $C^{\omega}_{N,t} = \bar{Y}_N = 1$ in the last step. For simplicity, endowment and consumption of non-tradable goods are always fixed in the described economy. As a result, fluctuations in aggregate demand take the form of fluctuations in tradable consumption and entail corresponding movements in the relative price of non-tradables. In particular, a decline in aggregate demand, e.g. a fall in the endowment of tradable goods $Y^{\omega}_{T,1}$ or a decline in borrowing B_1 depreciates the exchange rate.

Note that the movement of $p^{\omega}_{N,t}$ in response to endowment shocks is a standard pecuniary externality, i.e. it is the mechanism by which equilibrium in the market for non-tradable goods is restored, and normally this has no adverse welfare implications. However, in the described economy the valuation of agents' collateral depends on the level of the exchange rate. When financing constraints are binding, a depreciation in the exchange rate reduces the value of collateral, which reduces agents' borrowing capacity K and forces them to cut back on borrowing. In other words, when financing constraints are binding, the pecuniary externality turns into a real externality.

2.5 Equilibrium in the Tradable Sector

Having solved for equilibrium in the non-tradable goods sector, we can simplify our notation of the agent's optimization problem by expressing the utility function in terms of tradable goods $u_T(C_T) = u(C_T^{\frac{1}{1+\sigma}} \bar{Y}_N^{\frac{\sigma}{1+\sigma}}) = u(C_T^{\frac{1}{1+\sigma}})$ where we employed our simplifying assumption that $C^{\omega}_{N,t} = \bar{Y}_N = 1\ \forall \omega$. This results in the following Lagrangian:

$$\underset{C^{\omega}_{T,1}, B^{\omega}_1}{\mathcal{L}^{DE}} = u_T(C^{\omega}_{T,1}) + \beta u_T(Y^{\omega}_{T,2} - B^{\omega}_1 R) - \mu^{\omega}\left[C^{\omega}_{T,1} + \bar{I} - Y^{\omega}_{T,1} - W_1 - B^{\omega}_1 R\right] - \\ - \lambda^{\omega}\left[B^{\omega}_1 - \kappa\left(Y^{\omega}_{T,1} + p^{\omega}_{N,1}\bar{Y}_N\right)\right] \tag{5}$$

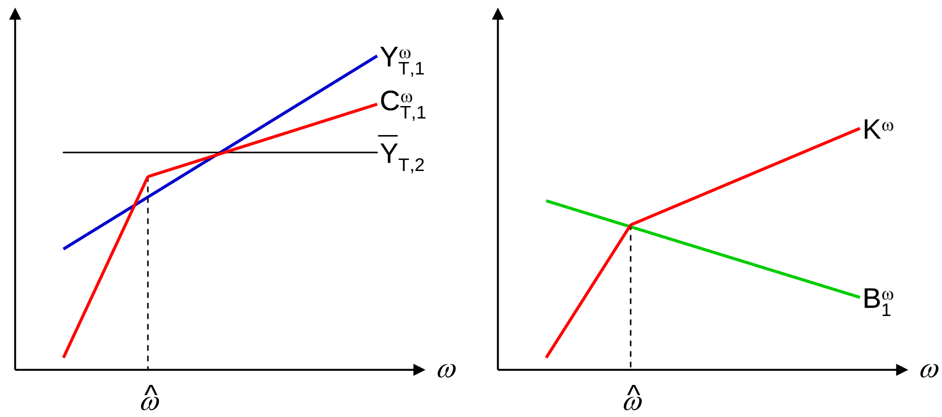

Figure 1: Output and consumption (left panel), and desired borrowing and financing constraint (right panel) as a function of the state of productivity ω

where μ^ω is the shadow value of liquidity (or wealth) in period 1, and λ^ω is the shadow value of relaxing the financing constraint. We can denote the first-order conditions of this problem as follows:

$$\text{FOC}(C^\omega_{T,1}): \quad \mu^\omega = u'_T(C^\omega_{T,1}) \tag{6}$$

$$\text{FOC}(B^\omega_1): \quad \mu^\omega = \beta R u'_T(C^\omega_{T,2}) + \lambda^\omega \tag{7}$$

Loose Financing Constraints

When the agent's collateral is sufficient so that financing constraints are loose, $\lambda^\omega = 0$ and the two first-order conditions reduce to the standard Euler equation $u'_T(C^\omega_{T,1}) = \beta R u'_T(C^\omega_{T,2})$. Agents choose their borrowing such as to perfectly smooth consumption across both time periods.

This is depicted graphically in figure 1. To the right of the threshold $\hat{\omega}$, financing constraints are loose and agents can smooth perfectly. Consumption in both periods 1 and 2 is the average of the levels of output $Y^\omega_{T,1}$ and $\bar{Y}_{T,2}$ in periods 1 and 2 (left panel). As a result, desired borrowing B^ω_1 is a declining function of the state of productivity ω. On the other hand, the maximum amount that an agent can borrow K^ω rises in the state of productivity (right panel). This is because higher tradable income and consumption appreciate the exchange rate, which increases the value of the domestic agent's collateral. The threshold $\hat{\omega}$ is defined as the value of ω where financing constraints are just marginally binding.

Binding Financing Constraints and Financial Accelerator Effect

On the other hand, when financing constraints in the economy are binding, the shadow value on the constraint is positive, $\lambda^\omega > 0$, and agents cannot smooth their income across time, i.e. $u'_T(C^\omega_{T,1}) > \beta R u'_T(C^\omega_{T,2})$. In the described economy, agents borrow the maximum amount possible $B^\omega_1 = \kappa(Y^\omega_{T,1} + p^\omega_{N,1}\bar{Y}_N)$, and this pins down their consumption allocations $C^\omega_{T,1}$ and $C^\omega_{T,2}$. The resulting shadow price on the borrowing constraint is $\lambda^\omega = u'_T(C^\omega_{T,1}) - \beta R u'_T(C^\omega_{T,2})$, which is the wedge in the agent's Euler equation.

Note that any aggregate shock is now amplified by the financial accelerator mechanism. Assume e.g. that we start in an equilibrium with binding financing constraints and analyze the effects of a small reduction in wealth W^ω_1. The first effect is that, for a given borrowing capacity K^ω, the decentralized agent has to contract his spending on consumption $C^\omega_{T,1}$ by an equivalent amount. However, this depreciates the exchange rate (4), and the depreciation in turn reduces the value of the non-tradable collateral of all agents and tightens the financing constraint (2). A tightening in the financing constraint forces the agent to cut back further on his consumption, and the result is a feedback cycle of falling exchange rates, tightening financing constraints, and decline in consumption. Note that all these phenomena, including the rise in the current account that mirrors the decline in borrowing, are typical features of financial crises (Calvo et al., 2004).

In figure 1 aggregate states where financing constraints bind are depicted to the left of the threshold $\hat{\omega}$. The left panel shows that consumption reacts much more strongly to marginal changes in productivity than in unconstrained states, reflecting the amplification effects of the financial accelerator mechanism. The right panel depicts the threshold where financing constraints become binding as the level of productivity where desired borrowing B^ω_1 and the constraint K^ω coincide. The maximum amount of borrowing K^ω declines more sharply when financing constraints bind because the financial accelerator strongly depreciates the exchange rate in such states.

2.6 Social Planner's Equilibrium

The social planner internalizes the effects of her intertemporal consumption allocations on exchange rates. She realizes that higher tradable consumption in period 1 appreciates the exchange rate, which in turn loosens the financing constraint K^ω. Analytically, we can express this by substituting the equilibrium condition for the exchange rate (4) into the decentralized agent's maximization problem (5) to obtain

$$\mathcal{L}^{SP}_{C^{\omega}_{T,1},B^{\omega}_1} = u_T(C^{\omega}_{T,1}) + \beta u_T(Y^{\omega}_{T,2} - B^{\omega}_1 R) - \mu^{\omega}\left[C^{\omega}_{T,1} + \bar{I} - Y^{\omega}_{T,1} - W_1 - B^{\omega}_1\right] - \\ - \lambda^{\omega}\left[B^{\omega}_1 - \kappa\left(Y^{\omega}_{T,1} + \sigma C^{\omega}_{T,1}\right)\right]$$

This results in the following first-order conditions for the social planner, where we index the shadow prices by 'SP' to distinguish them from the values prevailing in the decentralized equilibrium, indexed by 'DE':

$$\text{FOC}(C^{\omega}_{T,1}): \quad \mu^{\omega}_{SP} = u'_T(C^{\omega}_{T,1}) + \kappa\sigma\lambda^{\omega}_{SP}$$
$$\text{FOC}(B^{\omega}_1): \quad \mu^{\omega}_{SP} = \beta R u'_T(C^{\omega}_{T,2}) + \lambda^{\omega}_{SP}$$

Let us compare these two conditions with the decentralized agent's first order conditions (6) and (7). When financing constraints are loose and $\lambda^{\omega}_{SP} = 0$, it is easy to see that both equilibria lead to identical allocations that involve perfect consumption smoothing.

When financing constraints are binding, both the social planner and decentralized agents choose to borrow the maximum amount possible $B^{\omega}_1 = K^{\omega} = \kappa(Y^{\omega}_{T,1} + p^{\omega}_{N,1}\bar{Y}_N)$., and the resulting wedge in the Euler equation is identical in both equilibria. However, as the first-order condition on $C^{\omega}_{T,1}$ illustrates, the social planner's valuation μ^{ω}_{SP} of liquidity in period 1 is higher than that of the decentralized agent in (6). This is because she realizes that increasing period 1 wealth would not only raise consumption, but would also appreciate the exchange rate, increase the value of domestic collateral and relax the financing constraint, thereby leading to a superior intertemporal allocation of consumption.

By the same token, the social planner perceives binding borrowing constraints to be more costly, as captured by her shadow price on the constraint λ^{ω}_{SP}. Combining the two first-order conditions above yields that

$$\lambda^{\omega}_{SP} = \frac{u'_T(C^{\omega}_{T,1}) - \beta R u'_T(C^{\omega}_{T,2})}{1-\kappa\sigma} = \frac{\lambda^{\omega}_{DE}}{1-\kappa\sigma} \tag{8}$$

The social planner's valuation of relaxing collateral constraints is by a factor $\frac{1}{1-\kappa\sigma} > 1$ higher than that of decentralized agents. This is because a one unit exogenous relaxation of the constraints has amplification effects of $\kappa\sigma$ in round two, which in turn yield an amplification of $(\kappa\sigma)^2$ in the next round and so on, and summing up these terms gives $1 + \kappa\sigma + (\kappa\sigma)^2 + \cdots = \frac{1}{1-\kappa\sigma}$.

Proposition 1 (Undervaluation of Liquidity in Crises) *In crisis states (when financing constraints are binding), the social planner values liquidity more highly than decentralized agents $\mu^{\omega}_{SP} > \mu^{\omega}_{DE}$, since she internalizes the financial accelerator effects arising from the constraints.*

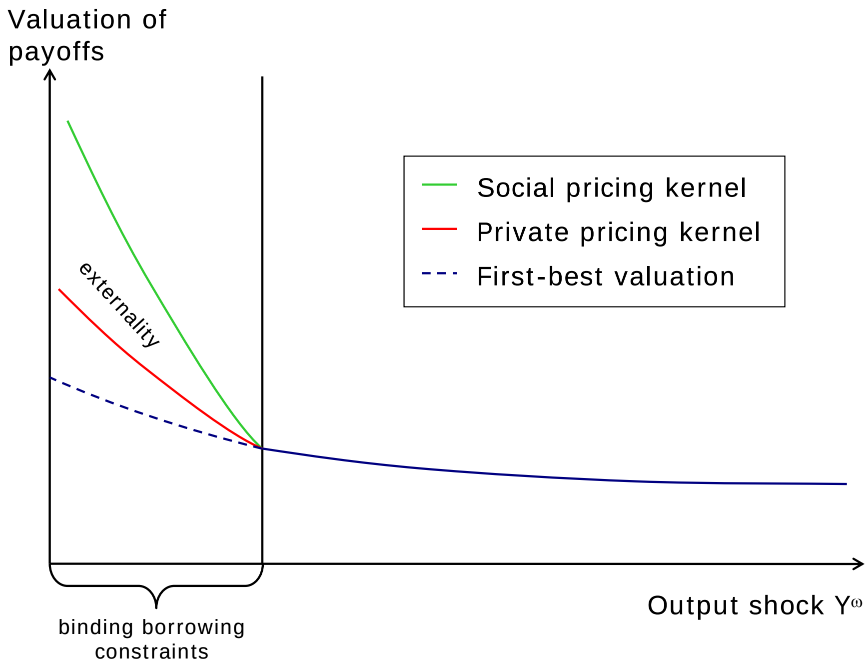

Figure 2: Private and social valuation of liquidity

We depict a simple illustration of this result in figure 2. In a first-best world without constraints productivity shocks have only mild effects on the agent's valuation of liquidity, since he can borrow and lend so as to smooth over shocks. By contrast, when financial constraints are binding, a decentralized agent's valuation of liquidity (or net worth) in response to bad shocks is higher than in the first-best world: the agent would like to borrow so as to smooth consumption, but the constraint prevents him from doing so and the shock has to be fully absorbed through a decline in current consumption. Furthermore, while the decentralized agent takes the tightness of borrowing constraints as given, the social planner internalizes that an increase in liquidity in a constrained state would raise consumption not merely one-for-one, but would also lead to financial accelerator effects, which relax financing constraints and increase consumption further by allowing the agent to smooth out more of the shock through financial markets.

3 Optimal Financing Decisions

In the simple model that we have analyzed so far, the private and social valuations of liquidity differed, yet given the constraints, this did not introduce any social inefficiency into the real allocation of resources. The reason was that when financing constraints were binding, decentralized agents simply borrowed the maximum amount available and did not effectively have any optimization problem to solve.

This section analyzes the implications of the mis-valuation of liquidity for the *ex ante* financing decisions of decentralized agents. For this purpose, we extend the model of the previous section by adding another time period $t = 0$, in which decentralized agents need to invest $\bar{I}$ while facing uncertainty about what aggregate state of productivity $Y_{T,1}^{\omega}$ will be realized in the next period. Agents can finance themselves in period 0 using a complete set of Arrow-Debreu securities. We show that in general, their under-valuation of liquidity leads agents to insure insufficiently against crisis states in which financing constraints are binding. In other words, they take on too many dangerous forms of finance and expose their economy to excessive risk from a social point of view.

Analytically, this section assumes that domestic agents are born in period 0 with wealth W_0. They need to raise $\bar{I}$ units of tradable goods for investment so as to produce output in period 1. They can finance this by using their initial wealth and by selling the amounts B_0^{ω} of Arrow-Debreu securities that each pay off one unit in state ω of period 1. International investors buy these securities at a price of M_0^{ω} each in period 0. In other words, their period 0 value of a one unit payoff in state ω of period 1 is M_0^{ω}. By implication the random variable M_0^{ω} represents the pricing kernel of international investors. The total amount of finance that domestic agents raise by selling a state-contingent bundle B_0^{ω} of Arrow-Debreu assets is $E[B_0^{\omega} M_0^{\omega}]$. For example, if domestic agents promised a non-contingent payoff of one unit, we would set $B_0^{\omega} \equiv 1$ and find that the risk-free interest rate satisfies $RE[M_0^{\omega}] = 1$. More generally, the budget constraints for periods 0 and 1 are

$$\bar{I} = E[B_0^{\omega} M_0^{\omega}] + W_0 \tag{9}$$

$$C_{T,1}^{\omega} + B_0^{\omega} + \bar{I} = Y_{T,1}^{\omega} + B_1^{\omega} \tag{10}$$

3.1 Decentralized Period 0 Financing Problem

We can then extend the formulation (5) of the optimization problem of decentralized agents with the terms describing the problem of period 0 financing as

$$\begin{aligned}\underset{B_0^{\omega}, C_{T,1}^{\omega}, B_1^{\omega}}{\mathcal{L}^{DE}} = E \Big\{ & u_T(C_{T,1}^{\omega}) + \beta u_T(Y_{T,2}^{\omega} - B_1^{\omega} R) - \nu \left[\bar{I} - W_0 - M_0^{\omega} B_0^{\omega}\right] \\ & - \mu^{\omega} \left[C_{T,1}^{\omega} + B_0^{\omega} + \bar{I} - Y_{T,1}^{\omega} - B_1^{\omega}\right] - \lambda^{\omega} \left[B_1^{\omega} - \kappa \left(Y_{T,1}^{\omega} + p_{N,1}^{\omega} \bar{Y}_N\right)\right] \Big\}\end{aligned}$$

where ν is the shadow price of period 0 liquidity. While the first-order conditions on $C_{T,1}^{\omega}$ and B_1^{ω} remain unchanged from (6) and (7) in the previous section, the additional first-order condition on B_0^{ω} is

$$\text{FOC}(B_0^{\omega}): \ \mu_{DE}^{\omega} = M_0^{\omega} \cdot \nu_{DE} = M_0^{\omega} \cdot RE[\mu_{DE}^{\omega}] \tag{11}$$

In the second step we used the expression $\nu_{DE} = RE[\mu^{\omega}_{DE}]$, which follows from the same first-order condition by taking expectations. It states that the shadow price of period 0 liquidity is simply the discounted expected shadow price of liquidity in period 1. Let us define the pricing kernel of domestic agents as

$$D^{\omega}_{0} = \frac{\beta \mu^{\omega}_{DE}}{E[\mu^{\omega}_{DE}]} = \frac{\beta u'(C^{\omega}_{T,1})}{E[u'(C^{\omega}_{T,1})]} \tag{12}$$

where the subscript DE emphasizes that the shadow prices μ^{ω}_{DE} in the expression are evaluated in the decentralized equilibrium.

The first-order condition (11) entails that decentralized agents issue Arrow-Debreu securities up to the point where their relative marginal valuation of liquidity in period 1 coincides with the relative marginal valuation of payoffs of international investors, or where the pricing kernels of domestic agents and international investors coincide:

$$\frac{\mu^{\omega}_{DE}}{E[\mu^{\omega}_{DE}]} = \frac{M^{\omega}_{0}}{E[M^{\omega}_{0}]} \quad \text{or} \quad D^{\omega}_{0} = M^{\omega}_{0} \tag{13}$$

3.2 Social Planner's Period 0 Financing Problem

By the same token, we can express the social planner's optimization problem using the following Lagrangian:

$$\begin{aligned} \mathcal{L}^{SP}_{B^{\omega}_0, C^{\omega}_{T,1}, B^{\omega}_1} = E \Big\{ & u_T(C^{\omega}_{T,1}) + \beta u_T(Y^{\omega}_{T,2} - B^{\omega}_1 R) - \nu \left[\bar{I} - W_0 - M^{\omega}_0 B^{\omega}_0 \right] \\ & - \mu^{\omega} \left[C^{\omega}_{T,1} + B^{\omega}_0 + \bar{I} - Y^{\omega}_{T,1} - B^{\omega}_1 \right] - \lambda^{\omega} \left[B^{\omega}_1 - \kappa \left(Y^{\omega}_{T,1} + \sigma \cdot C^{\omega}_{T,1} \right) \right] \Big\} \end{aligned}$$

As in the previous section, the only difference between the two problems is that the social planner recognizes that the exchange rate is endogenous, i.e. that $p^{\omega}_{N,1} \bar{Y}_N = \sigma \cdot C^{\omega}_{T,1}$ in her formulation of the borrowing constraint. Hence she internalizes feedback effects from aggregate consumption to the exchange rate and the valuation of collateral. The first order conditions to this problem on $C^{\omega}_{T,1}$ and B^{ω}_1 are unchanged from the ones in section 2.6, and the one on B^{ω}_0 is identical to decentralized agents' first order condition in (11).

In analogy to the pricing kernel of decentralized agents above, we denote the social planner's shadow prices by the subscript SP and we define the *social pricing kernel* S^{ω}_0 as

$$S^{\omega}_{0} = \frac{\beta \mu^{\omega}_{SP}}{E[\mu^{\omega}_{SP}]} = \frac{\beta \left[u'_T(C^{\omega}_{T,1}) + \lambda^{\omega}_{SP} \right]}{E[u'_T(C^{\omega}_{T,1}) + \lambda^{\omega}_{SP}]} \tag{14}$$

The social pricing kernel therefore represents the period 0 social cost of a repayment of one unit of tradable goods to foreign investors at time 1 in state ω.

3.3 Equilibrium Period 0 Financing Decisions

Risk-Neutral International Capital Markets

If international capital markets are risk-neutral, their pricing kernel is a constant, i.e. $M_0^\omega = 1/R \ \forall\omega$. Given that risk markets are complete, international investors would then be willing to provide actuarially fair insurance against domestic shocks. Since the utility function of domestic agents is concave, both decentralized agents and the social planner would take advantage of this opportunity by fully insuring against the shock $Y_{T,1}^\omega$.

Proposition 2 (Full Insurance) *If international capital markets are risk-neutral, the ex ante financing decision of decentralized agents in economies that are prone to financial crises entail full insurance against aggregate shocks, and they are socially efficient.*

Even though decentralized agents and the social planner put a different value on liquidity in period 1 when financing constraints are binding, they both agree that the optimum in the described economy entails full insurance. Their equilibrium allocations are therefore identical. In fact, when all shocks are insured away, it is likely that financing constraints will be loose in all states of nature, implying that the decentralized and the social valuation of liquidity would actually coincide in all states of nature.

Risk-Averse International Capital Markets

On the other hand, if international capital markets are risk-averse so that M_0^ω is a non-degenerate random variable, then the choice of B_0^ω for the different states of the nature ω involves a risk-return trade-off.

While our analytical results hold for any general specification of M_0^ω, we will focus on the more relevant case that international capital markets are on average averse to emerging market risk. In that case, M_0^ω and $Y_{T,1}^\omega$ are negatively correlated, i.e. the value M_0^ω that capital markets put on payoffs is relatively high when the productivity shock $Y_{T,1}^\omega$ is low and vice versa. We assumed that the economy we examined is small compared to international capital markets, but we believe it is reasonable to characterize international investors as risk averse towards the emerging market economy: First, many of the shocks to the tradable sector in emerging market economies are correlated with global factors. One example that is particularly important are fluctuations in commodity prices, which are driven by the global business cycle. Another example are exchange rate depreciations in competing emerging markets, which often play a role in the propagation of financial crises ('contagion') across countries. Secondly, as we observed above, if international capital markets were neutral towards emerging market risk, then decentralized agents could insure their economies costlessly against all aggregate shocks. This is clearly counter-factual.[10]

Let us compare the insurance decision B_0^ω for state ω of a decentralized agent (subscript DE) and of the social planner (subscript SP). If risk aversion among international investors is sufficiently small that decentralized agents decide to insure to the point that they will never face binding financing constraints, or equivalently if financing constraints are sufficiently loose that they never bind in the decentralized equilibrium, then $\lambda^\omega = 0 \; \forall \omega$. As a result, the decentralized equilibrium is socially efficient and coincides with the social planner's optimum.

Proposition 3 (Loose Financing Constraints) *If financing constraints in the decentralized equilibrium are always loose, then the decentralized equilibrium is socially efficient.*

Analytically, we can see that $\mu_{DE}^\omega = \mu_{SP}^\omega$ for all ω since $\lambda^\omega = 0$. Since financing constraints are always loose, there are no financial accelerator effects in such an economy, and no externalities arise.

On the other hand, in an emerging economy where insurance is too expensive to avert binding financing constraints in some states of the world, this result no longer holds. It is easy to see that $E[\mu_{DE}^\omega] < E[\mu_{SP}^\omega]$ as long as there are some states of the world in which financial crises occur, since the social planner accounts for the role of higher period 1 consumption in alleviating financing constraints in her valuation of period 1 liquidity μ_{SP}^ω in constrained states ω.

In unconstrained states, $\mu_{DE}^\omega = u_T'(C_{T,1}^\omega)$ and $\mu_{SP}^\omega = u_T'(C_{T,1}^\omega)$, but the denominator on the left-hand side of (13) is higher for the social planner. For condition (13) to hold, the social planner has to contract higher repayments in state ω than the decentralized agent, implying a higher marginal product of consumption $u_T'(C_{T,1}^\omega)$. This captures that the social planner repays more in unconstrained states of nature so as to save liquidity for crisis states.

On the other hand, in crisis states when financing constraints are binding, $\mu_{SP}^\omega = u_T'(C_{T,1}^\omega) + \lambda^\omega \kappa \sigma$. For condition (13) to hold, the social planner has to contract fewer repayments in such constrained states[11], which raises consumption $C_{T,1}^\omega$, thereby lowering both the marginal product $u_T'(C_{T,1}^\omega)$ and the tightness of financing constraints λ^ω.

[10] For a more extensive discussion of this observation see Korinek (2008a).

[11] More precisely, because of the change in the denominator on the left-hand side of condition (13), the social planner would also increase his repayments when λ^ω is positive but very close to zero, so as to save funds for other states of nature where financing constraints are more costly.

Proposition 4 (Binding Financing Constraints) *If domestic agents do not fully insure against binding financing constraints, their ex ante financing decisions involve socially excessive exposure to crisis risk. This makes financial crisis in the economy more severe and increases macroeconomic volatility.*

3.4 Contagion

As the result above illustrates, financial crises in our framework do not originate exclusively from domestic shocks. Instead the degree of risk aversion in international markets plays a key role in triggering binding constraints in an emerging market economy. In fact, we can show that financial crises can arise in the absence of any domestic shocks, i.e. purely as a result of international risk aversion. This can be interpreted as contagion through contingent liquidity flows.

Assume that output in an emerging market economy is always constant, but that there is a state of nature ω to which international lenders are strongly averse, i.e. M_0^ω is extremely high in that state. Following equilibrium condition (13), decentralized agents in the emerging market economy will sell a large amount of securities contingent on that state, entailing a large capital outflow, low domestic consumption $C_{T,1}^\omega$, and a depreciated real exchange rate $p_{N,1}^\omega$. If the resulting capital outflow and decline in the exchange rate are of sufficient magnitude, domestic agents will commit to repayments that make the financing constraint on the emerging market economy binding, triggering the financial accelerator and creating an externality.

Proposition 5 (Contagion) *Assume there are states of nature in which international lenders obtain large net payments from the emerging market economy, which cause financing constraints to bind. Decentralized agents will under-insure against such states and will experience socially excessive volatility.*

In practice, we can think of two examples of such contingent liquidity outflows from emerging market economies. One results from excessive exposure to risky modern financial instruments such as credit default swaps, toxic mortgage assets etc. However, the risk sharing instrument that has historically proven to be of much greater importance is short-term debt.[12] If international capital markets experience a crisis and require liquidity (high M_0^ω), they will simply not roll over short term debts to emerging markets. Whenever the resulting capital outflows are sufficiently large (and these days it is

[12]While we have not explicitly modeled debts of different maturity structure in our benchmark model, short-term debt can be viewed as a contract that pays out very little (interest only) in normal times when such debt is typically rolled over, and that pays out a lot whenever lenders' liquidity needs suddenly increase and they call the debt, e.g. in case of global financial turmoil.

easy to think of examples), a financial accelerator is triggered that leads to a downward spiral in the exchange rate and in borrowing capacity, and ultimately to a financial crisis in the affected emerging market economy, even though that economy itself had not experienced any domestic shock.

The basic problem in this model of contagion is that emerging market agents (knowingly or unknowingly) provide too much insurance to international investors, given the underdeveloped nature of their financial system. In an integrated global financial system it is in pricinple desirable that global risks are shared among all agents in all countries. However, while emerging market economies *seem* to be integrated into global markets in normal times, their access to international financial markets is state-contingent: it is lost whenever financing constraints on the economy become binding. Decentralized agents find it privately optimal to participate in global risk-sharing by taking on risky forms of finance, but they fail to internalize that the level of financial integration of their economy during financial crises is endogenous: their private risk-taking decisions affect the tightness of constraints in states of global crisis.

Put differently, decentralized agents in the described economy take on risk according to their privately optimal tradeoff between risk and return; a social planner takes on risk according to the tradeoff between risk, return, and the endogenous level of financial integration, as captured by the tightness of borrowing constraints.

3.5 Importance of Rational Expectations

While the model presented in this paper is set in a rational expectations framework, it is often argued that in the real world, market participants are surprised by "unexpectedly" large movements in exchange rates and real variables during financial crises, i.e. that they did not have rational expectations. Our model allows us to shed some light on why a failure of rational expectations is particularly costly in the context of financial crises.

Assume as a starting point that the economy is in period 0 of the decentralized equilibrium, and that agents have rational expectations regarding all prices and quantities. Suppose there is a constrained state ω in which individuals' expectations of the real exchange rate is suddenly perturbed by a noise dp, i.e. they are over-optimistic and predict the exchange rate to be $\hat{p}^{\omega}_{N,1} = p^{\omega}_{N,1} + dp$ in that state. They believe that this relaxes the borrowing constraint in state ω by $dK^{\omega} = dp \cdot \kappa \bar{Y}_N$. Since the constraint was binding before the perturbation, they could now increase consumption by an identical amount. However, this would not be optimal: before the perturbation, decentralized agents had chosen to take on the risk of facing binding constraints in state ω, given the cost of insurance. The same considerations would make them undo the expected extra income from the perturbation, and they would issue an additional amount $dB_0^\omega = dK^\omega$ of Arrow-Debreu bonds in period 0 so as to restore the initial equilibrium. (Note that this additional bond issuance would not have a discernable effect on period 0 wealth, since we assumed the probability for each state to be infinitesimal.)

When the crisis state $\hat{\omega}$ is realized and agents realize the error in their expectations, consumption not only falls by the amount dB_0^ω, which would constitute the repayment on the new bond issues that were designed to undo the perturbation. Instead, the higher repayments are amplified by the financial accelerator effect, i.e. they lead to a decline in the exchange rate below the earlier equilibrium level $p_{N,1}^\omega$, which depreciates borrowers' collateral further, forces them to cut back even more on consumption and so forth. To find the total effect we substitute the borrowing constraint (2) and the equilibrium exchange rate (4) into the agent's budget constraint (10) and obtain

$$C_{T,1}^\omega = Y_{T,1}^\omega - \bar{I} - B_0^\omega + \kappa\sigma C_{T,1}^\omega \quad \text{and} \quad \frac{dC_{T,1}^\omega}{dB_0^\omega} = \frac{1}{1-\kappa\sigma} > 1$$

The total effect of the bond sale dB_0^ω is multiplied by this factor. In short, when borrowing constraints are binding, any small misallocation that arises from erroneous expectations or other biases is strongly amplified and has large welfare and efficiency effects. By contrast, when borrowing constraints are loose, then unexpected income shocks can be smoothed over time, implying that $\frac{dC_{T,1}^\omega}{dB_0^\omega} = \frac{1}{1+\beta} \ll 1$ and reducing the impact of biases in expectations on welfare.

Proposition 6 (Welfare Costs of Expectational Errors) *In constrained states, financial accelerator effects magnify the impact of misallocations resulting from expectational errors on consumption. As a result, the welfare costs of such errors are by an order of magnitude larger than in unconstrained states, when shocks to consumption can be smoothed over time.*

4 Policy Implications

4.1 First-best Policy Measures

The externality in this paper arises as a result of a financial accelerator, i.e. because of the positive feedback effects in low states of the nature between capital outflows, falling exchange rates, and tightening financing constraints. Hence first-best policy measures would attempt to break this feedback mechanism.

One way of doing so would be to correct the capital market imperfections that underlie the financing constraints. While welfare will unambiguously improve if borrowing constraints are completely abolished, it is difficult to predict a priori how a mere relaxation of the constraint as captured by an increase in κ would affect welfare, since the relationship between the tightness of constraints and welfare can be non-monotonic (Matsuyama, 2008). On the other hand, a policy measure that has consistently led to a reduction in the volatility of international capital flows is improvements in the quality of domestic financial institutions (IMF, 2007).

Another measure that can break the accelerator mechanism that unfolds during financial crisis would be to peg the country's exchange rate. In the given model setup, one way of keeping the real exchange rate constant would be to maintain a buffer of foreign reserves that is used to stabilize the domestic consumption of tradable goods. While emerging market economies have long engaged in the practice of pegging exchange rates (Calvo and Reinhart, 2002), their ability to maintain pegs in response to strong adverse shocks has traditionally been limited. Defending a peg during economically challenging times often requires a large amount of foreign reserves. In fact, many researchers (see e.g. Aizenman and Marion, 2003; Durdu et al., 2007) argue that an important factor behind the unprecedented accumulation of foreign reserves in Asia in recent years is the attempt to insure against future financial crises and the associated exchange rate depreciations.

Government Transfers and Ricardian Equivalence

It is often argued that the most effective policy response during crises characterized by financial accelerator effects is to make transfers to the constrained agents so as to alleviate the constraints. While this might be an effective policy measure ex post, we can show that transfer payments to constrained agents during crises will be completely ineffective if they are anticipated ex ante.

Assume that government commits to making a state-contingent transfer T^ω to decentralized agents. In constrained states, we assume that the transfer $T^\omega > 0$; furthermore the government imposes lump-sum taxes, i.e. a negative $T^\omega < 0$, in those states of nature where constraints are loose so as to make the policy in expectation revenue-neutral, i.e. $E[M_0^\omega T^\omega] = 0$. We can then show the following result:

Proposition 7 (Ineffectiveness of Anticipated Government Transfers) *Decentralized agents will undo any anticipated state-contingent government transfer T^ω with $E[M_0^\omega T^\omega] = 0$.*

The solution to the decentralized agent's problem (5) is an optimal risk-return tradeoff. If the government provides an anticipated transfer T^ω in state ω, the agent will sell a state-contingent bond in the same amount to undo the effects of the transfer, since the decentralized equilibrium with excessive risk-taking constitutes his private optimum. By our assumption $E[M_0^\omega T^\omega] = 0$, the government transfer will not affect the agent's wealth. Therefore his equilibrium consumption allocations are identical to the allocations that we derived for the decentralized equilibrium above.

An example of this seems to be the current situation of Russia, where the government accumulated large amounts of foreign currency reserves, while the private sector accumulated equally large amounts of foreign currency debts in recent years, making the country acutely exposed to the currently unfolding financial crisis.

Note that our proposition 7 is closely related to the equivalence result in Barro (1974): According to the traditional version of Ricardian equivalence, private agents will undo any reallocations of a given tax burden across time, given that they have access to perfect intertemporal capital markets. In our state-contingent version of Ricardian equivalence, private agents undo a government's reallocations of liquidity across different states of nature, given that they have access to perfect state-contingent risk markets. In both cases, rational agents recognize that the government's budget constraint is ultimately part of their own budget constraint.[13]

Naturally, our equivalence proposition is subject to similar limitations as the traditional version of Ricardian equivalence. In particular, the result depends on the assumption that those agents who receive transfers have access to a complete set of Arrow-Debreu markets in order to undo the transfers. If there are some agents in the economy who do not have access to such markets (e.g. financially-constrained workers), then an anticipated government transfer to this group does have real effects and can mitigate the financial accelerator that is triggered during crises by expanding aggregate demand and mitigating the fall in the exchange rate. This has important implications for the design of automatic stabilizers that are effective against financial crises.

Naturally, proposition 7 applies only to *anticipated* transfers. If a government transfer was unanticipated, it would have the desired positive effects. By the same token, if a transfer has been anticipated in the event of a crisis, then an unexpected decision to withhold the transfer can be extremely costly: in anticipation of the transfer private agents have taken on additional risk, making the crisis more severe.

[13]Note that commentators often describe it as "moral hazard" when decentralized agents take on more risk in response to anticipated government transfers. However, oftentimes the increased risk exposure is publicly observable and does not constitute a "hidden action." In that case the term "moral hazard" is a misnomer – decentralized agents just rationally increase their exposure to crisis risk in response to badly designed government incentives.

4.2 Second-best Policy Measures: Ex-Ante Taxation

In practice it has proven impossible for emerging market governments to enact reforms that fully alleviate all capital market imperfections and allow the economy to reach the first-best equilibrium in which financial crises no longer occur. (The same can be said for industrialized nations as well.) As a result it is desirable to investigate what forms of second-best policy measures are desirable. In this and the following subsection we will discuss two forms of such measures, (i) taxes that aim to discourage the use of socially risk forms of finance ex ante and (ii) quantity restrictions that limit capital outflows ex post in the event of financial crises.[14]

Every asset in the real world can be thought of as a bundle of Arrow-Debreu securities with appropriate weights. We define the vector of Arrow-Debreu securities that represents a given real-world security X as follows:

Definition 1 *A security X is a contract that obliges the issuer to make state-contingent payments X^ω to the buyer.*

Naturally, the greater the payoffs of a given security in crisis states, the larger the externality that the security imposes on the economy. For example, foreign currency denominated debts mandate a fixed payoff in terms of tradable goods across all states of nature, including those states in which financing constraints are binding. This implies a relatively large weight on states in which private agents undervalue the social costs of repayments. By implication foreign currency denominated debts create large externalities. By contrast, flows that take the form of foreign direct investment are unlikely to reap profits in low output states and are therefore unlikely to entail repatriations of profits, i.e. capital outflows, in crisis states. This implies that they create no or only very small externalities.

In period 0, international investors supply finance to domestic agents at a price determined by their pricing kernel M_0^ω. In the unregulated decentralized equilibrium, domestic agents adjust their portfolio so that their private pricing kernel $D_0^\omega = \frac{\beta u_T'(C_{T,1}^\omega)}{E[u_T'(C_{T,1}^\omega)]}$ equals the exogenous pricing kernel M_0^ω of investors. In the given complete markets framework, the period 0 valuation P_X of any asset X with payoffs X^ω in period 1 is therefore identical for decentralized domestic agents and international lenders; we

[14]Theoretically, a wide range of Ramsey equivalent policy measures could be designed to induce decentralized agents to internalize the full social value of liquidity in constrained states. We focus on the two cited instruments since they correspond most closely to measures taken by emerging market economies in practice, as we discuss below. Alternative measures that seem equivalent in the framework that we presented (e.g. imposing taxes on risky forms of finance *ex post* in the midst of crises) are likely to face significantly more stringent political economy constraints.

denote this price as P_X:

$$E[M_0^\omega X^\omega] = P_X = E[D_0^\omega X^\omega]$$

However, this condition does not account for the social costs that repayments in constrained states and the resulting exchange rate depreciations impose on the owners of domestic collateral. The social valuation P_X^* of a liability X with payoffs X^ω is instead

$$P_X^* = E[S_0^\omega X^\omega] \tag{15}$$

Accounting for the fact that capital outflows create negative externalities in constrained states, this social valuation is higher than the decentralized price P_X demanded by international investors.

Externality Kernel

Let us assume the economy is in the social planner's equilibrium and denote the difference between the social and the private valuation of liquidity in period 1 of that equilibrium, normalized by the expected private valuation, as the *externality kernel* τ^ω:

$$\tau^\omega = \frac{\mu_{SP}^\omega - \mu_{DE}^\omega}{E[\mu_{DE}^\omega]} = \kappa\sigma \cdot \frac{\lambda_{SP}^\omega}{=} \frac{\kappa\sigma}{1-\kappa\sigma} \cdot \frac{u_T'(C_{T,1}^\omega) - \beta R u_T'(C_{T,2}^\omega)}{E[\mu_{DE}^\omega]} \tag{16}$$

where we employed equation (8) in the last step. The intuition of this expression is straightforward: the uninternalized social benefit of a one unit payoff in state ω is a relaxation of the borrowing constraint by $\kappa\sigma$, which yields an increase in utility of $\left[u_T'(C_{T,1}^\omega) - \beta R u_T'(C_{T,2}^\omega)\right]$ that is in turn magnified by the factor $\frac{1}{1-\kappa\sigma}$ by the financial accelerator.

A social planner could make agents internalize the externality associated with capital inflows by imposing a tax that raises the cost of capital on each asset to its socially efficient level. The optimal tax on a unit payoff in state ω equals the externality kernel τ^ω created by that payoff. By implication, the optimal tax t_X^* on a given security X with contingent payoffs X^ω is the expected product of the externality kernel with the vector of payoffs:

$$t_X^* = E\left[\tau^\omega X^\omega\right]$$

Figure 3 schematically shows both the private and social valuation of payoffs as a function of the state of the economy ω. Repayments in states when financing constraints are binding entail an externality of size τ^ω, which is represented as the wedge between private and social valuation in the figure. In the lower panel we have schematically depicted the repayments on various forms of capital flows as a function of the state of the economy, from uncontingent dollar debt to foreign direct investment.

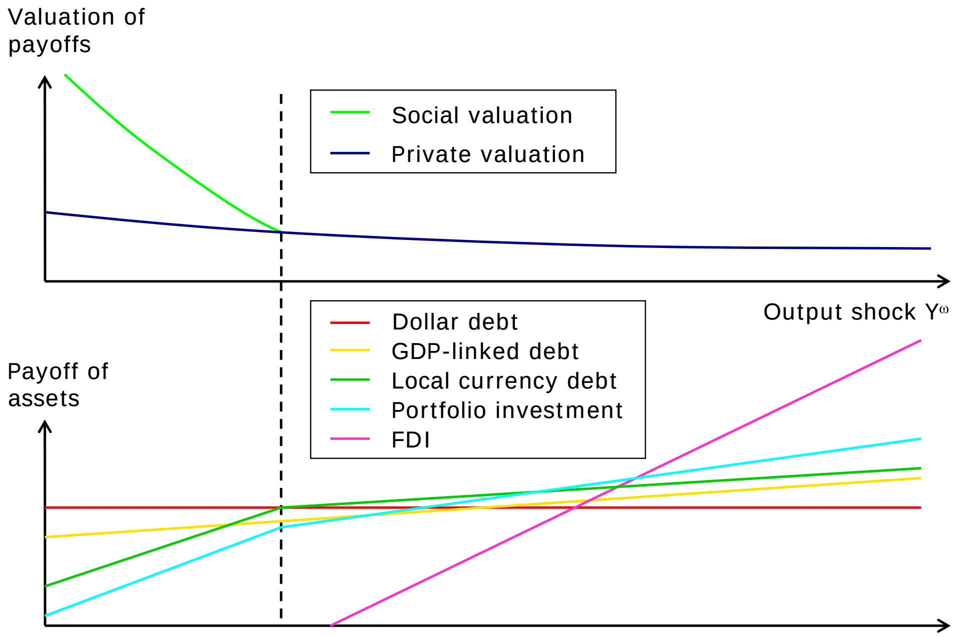

Figure 3: Different forms of financing entail different repayments in different states of the world. Repayments in constrained states create an externality. The optimal tax on any particular flow can be calculated as the expected product of a given asset's payoff vector with the externality kernel.

4.3 A Sample Calibration to the Case of Indonesia

Let us now perform a simple exemplary calibration of the externality kernel in Indonesia and derive the optimal tax on a number of different forms of capital flows to the country. We base our calibration on yearly historical data from the past two decades (i.e. 1988 – 2007).[15] While we obtained our analytical results in a simple three period model, our calibration method uses only few structural assumptions and is therefore robust to a large number of different specifications of the financial accelerator mechanism that drives variations in external borrowing capacity (see e.g. Krugman, 1999; Schneider and Tornell, 2004; Mendoza, 2005; Mendoza and Smith, 2006).

Before we proceed let us note three caveats. Firstly, since our calibration is based on historical data, it does not account for permanent changes in the structure of the economy. Second, if the vulnerability of an economy to financial crisis fluctuates over time, the externality kernel itself should be regarded as a time-varying random variable. We do not account for this an describe instead a permanent externality kernel.[16] Third, we implicitly assume a yearly maturity for the assets we investigate. Debt flows that

[15]Data from International Financial Statistics, IMF, 2008.

[16]This would be desirable for example as guidance for policymakers who want to impose constant tax rates on international capital inflows.

are of shorter (longer) maturity than one year would naturally impose larger (smaller) externalities. While these three concerns are certainly important for the practical implementation of capital flow regulations, it should be clear that the framework that we outline below can easily be adjusted to take these factors into account. Our main goal in this section is to conceptually illustrate how existing data can be used to quantify the externality kernel that we described.

Our proposed calibration method proceeds in five steps:

Step 1: *Describe the set Ω of potential outcomes and identify constrained states:* In our simple example, we define $\Omega = \{1988, \ldots, 2007\}$ as the state space, which we assume representative for the Indonesian economy, i.e. we assign to each of these states a probability $\pi_\omega = 5\%$. During the described time span, the Asian financial crises of 1997/98 is the only incident in which a currency crises as defined by Frankel and Rose (1996) and a sudden stop as defined by Calvo (1998) took place. The crisis hit Indonesia in the second half of 1997, culminated in 1998 and a modest recovery started before the end of that year (Radelet and Sachs, 1998). For simplicity, we attribute the entire crisis to the calendar year of 1998.

Step 2: *Quantify the tightness $\frac{\lambda^\omega_{DE}}{E[\mu^\omega_{DE}]}$ of constraints:* As described above, the tightness of constraints (as perceived by decentralized agents) is given by the wedge in the agent's Euler equation, which we normalize by the decentralized agent's expected marginal utility. Since real consumption data during the crisis episode is rather unreliable, we approximate the wedge by using the economy's percentage decline in real GDP $\Delta y^{1998} = 13.1\%$ as a rough guide for the decline in consumption and the difference in relative marginal utilities that was experienced. Assuming agents have a CRRA utility function with a coefficient of relative risk aversion $\gamma = 2$ we can use a Taylor-approximation to calculate this wedge as

$$\frac{\lambda^{1998}_{DE}}{E[\mu^\omega_{DE}]} \approx \gamma \cdot \Delta y^{1998} = 26.2\%$$

We assumed that no financial accelerator effects were at work in other years, i.e. $\lambda^\omega_{DE} = 0$ for all other states of the world $\omega \neq 1998$.

Step 3: *Estimate the strength of accelerator effects in constrained states:* The factor $\frac{\kappa\sigma}{1-\kappa\sigma}$ in equation (16) captures how strongly a given change in aggregate demand affects the tightness of borrowing constraints in our model at the margin, i.e. $\frac{\kappa\sigma}{1-\kappa\sigma} = \frac{dK^\omega}{dY^\omega}$. For data availability reasons, we approximate this marginal effect using the average change in borrowing capacity as captured by the magnitude of the observed current account reversal (expressed as the change in the ratio of the

Asset category	**Real gross return**	**Externality in 1998**	**Optimal tax**
Dollar debt	218%	30.7%	1.54%
GDP-indexed dollar debt	190%	26.8%	1.34%
CPI-indexed rupiah debt	100%	14.1%	0.71%
Rupiah debt	63%	8.9%	0.44%
Stock market index	44%	6.2%	0.31%

Table 1: Realized real gross return and externality of different asset categories in Indonesia, 1998.

current account to GDP CA/Y) resulting from a change in aggregate demand by the economy's growth rate Δy in constrained states. This implies that

$$\frac{dK^{1998}}{dY^{1998}} \approx \frac{\Delta(CA/Y)^{1998}}{\Delta y^{1998}} = \frac{-7.1\%}{-13.1\%} = .54$$

In our analytical model, the factor $\frac{\kappa\sigma}{1-\kappa\sigma}$ was constant across all states with financial accelerator effects, and in the given example, the state $\omega = 1998$ is the only one in which binding constraints occurred. More generally, exchange rates can be non-linear functions of aggregate demand and constraints can be non-linear in exchange rates. This can be captured by calibrating the magnitude of $(\frac{\kappa\sigma}{1-\kappa\sigma})^{\omega}$ separately for each state ω based on the observed accelerator effects.

We can then express the externality kernel

$$\tau^{1998} = \frac{dK^{1998}}{dY^{1998}} \cdot \lambda_{DE}^{1998} = .54 \cdot 26.2\% = 14.1\%$$

In other words, we estimate the externalities (i.e. uninternalized welfare costs) caused by any capital outflow from Indonesia in 1998 to be equivalent to 14.1% of the amount of the outflow.

Step 4: *Describe the payoff structure X^{ω} of different assets in constrained states:* In order to obtain the externalities caused by different forms of capital flows, we need to characterize the state-contingent payoffs of different asset classes in constrained states, i.e. in 1998 in our simple example. We have compiled a list of the realized gross returns of different asset categories measured in real domestic consumption units (i.e. local currency units deflated by consumer prices) in the first column of table 1.

Step 5: *Calculate the expected magnitude of the externality as $E[\tau^{\omega}X^{\omega}]$:* The externality created by each payoff in a given state ω can simply be obtained as the realized real gross return X^ω multiplied by the externality kernel τ^ω. We have calculated this for Indonesia in 1998 in the second column of table 1.

Finally, since we assumed that the set Ω is representative of the long-run incidence of adverse shocks and binding constraints, we can express the expected magnitude of the externality by multiplying this number with the probability of the state $\pi^{1998} = 5\%$. The results are given in the final column of the table.

Our results are the following:

- **Dollar debt** is characterized by large repayments in constrained states of the world and is therefore one of the most dangerous forms of finance, imposing a large externality on the economy. Calibrated to the case of Indonesia, we found the size of this externality to be roughly 1.54% in the decentralized equilibrium.

- **GDP-linked debt** is typically still denominated in foreign currency. Repayments are indexed to the state of the economy, which is supposed to mitigate fluctuations in aggregate demand. In our calibration we assumed the dollar interest rate on GDP-linked debt to equal the growth rate of the economy, i.e. -13%. While GDP-linked debt is a superior insurance instrument to uncontingent dollar debt, declines in exchange rates are typically much larger than declines in GDP during a financial crises, implying that local currency debt offers a far superior risk profile.

- **CPI-indexed local currency debt** offers an acyclical repayment of 100% that is always constant in terms of domestic real consumption units. During emerging market crises exchange rates typically decline more strongly than inflation rises, implying that CPI-indexed debt protects borrowers from the pro-cyclicality of dollar denominated debts.

- **Local currency debt** is inflated when a country's price level rises, which is typically the case during emerging market crisis. This implies that the real value of local currency debts falls when the economy experiences a crisis – non-indexed local currency debt is an excellent insurance instrument.

- **Portfolio investment** in equity markets enhances risk-sharing opportunities significantly. When capital flows reverse, investors in emerging market equity markets see both the domestic currency value of their shares and the dollar value of the domestic currency drop sharply. This implies that portfolio investment entails only small repayments in constrained states and a very small negative externality.

- **Foreign direct investment** (omitted in the table) is unlikely to entail profit repatriations in low states of nature, when profits are generally low or non-existant. From this point of view, foreign direct investment is the one form of finance that does not create an externality. In fact, if a parent company injects additional liquidity into its emerging market subsidiary, then the resulting capital inflow entails a positive externality that would call for a subsidy, since capital inflows raise aggregate demand and mitigate the financial accelerator effect.

Taxing risky assets makes decentralized agents internalize the externalities that their contracted repayments impose on the rest of the economy. Instead of direct taxes on capital inflows, equivalent policy measures such as unremunerated reserve requirements (URRs) or banking regulations can be employed in order to reduce the relative attractiveness of risky forms of finance and raise the relative demand for safer assets. As a result, the incidence and severity of borrowing constraints in the economy is reduced, macroeconomic volatility is lower, and social welfare is increased. The social planner's interventions therefore constitute a Pareto improvement.

In this context, it should be noted that most tax systems around the world enable entrepreneurs to deduct interest payments on debt from corporate (or individual) taxes. By contrast, dividend payments are subject to taxation. This introduces an important bias into the capital structure of firms that leads to excessive debt financing and therefore magnifies the externality that we discussed. The fact that agency problems are more severe for assets with highly state-contingent payoffs reinforces this problem.

It is often argued (see e.g. Forbes, 2005) that capital account regulations are undesirable because they increase the cost of finance for private firms and they give rise to evasion. However, raising the private cost of capital inflows to the social cost is precisely the point of such regulations (just as environmental regulations raise the cost of pollution in order to discourage it). All regulation that imposes costly constraints gives rise to attempts to circumvent it (this includes e.g. banking regulation in developed countries). However, attempts to circumvent regulation are not a good reason to abolish it; rather it should encourage regulators to come up with better ways of enforecement.[17]

Encouraging Capital Inflows

There is a role for policy to actively encourage capital inflows during financial crises, i.e. when financing constraints are binding: decentralized agents will generally undervalue

[17]One proposal to enforce regulations on capital inflows is for example to make claims by foreign creditors that have evaded capital controls unenforcable in court.

the social benefits of capital inflows in mitigating crises and alleviating economy-wide financing constraints. For example, individuals might be reluctant to sell equity at fire-sale prices, even though it would be optimal from a social point of view, since the associated capital inflow would support the exchange rate and mitigate the financial accelerator. In such a situation, government incentives to attract foreign capital would be socially beneficial.[18]

4.4 Second-best Policy Measures During Crises

Capital Flight and Suspension of Convertibility

In severe crises, when a country experiences strong capital outflows (i.e. states in which $B_0^\omega > \frac{B_1^\omega}{R}$) and a financial accelerator is triggered and magnifies the resulting contraction, a policy measure of last resort might be to temporarily suspend international capital flows (see e.g. Krugman, 1999). Naturally, such a strong measure raises a number of difficult questions regarding adverse signaling and confidence effects. Ideally, the temporary suspension of capital account convertibility should take place in an international framework that (i) defines clearly under what circumstances the policy can be applied, i.e. in crises when strong financial accelerator mechanisms are at work, such as the East Asian crisis and that (ii) is supervised by an international organization. The goal of these conditions is to legitimize suspension of convertbility as a policy measure of last resort in extreme circumstances.[19]

However, our focus here is to discuss the merits of such a measure in alleviating the negative externality associated with capital outflows when financing constraints are binding and financial accelerator effects are at work. For this purpose, let us return to the model emerging market economy outlined in the previous section and assume that policymakers there have credibly committed to temporarily suspending capital account convertibility when a financial crisis beyond a defined magnitude occurs. The threshold for such action could be described e.g. as a quota on capital outflows.

In a rational expectations framework international investors would anticipate this policy action when allocating their funds, i.e. they realize that any repayments from the emerging market economy can be subject to delay if they come due in the event of a financial crisis, and they adjust their required return accordingly. Since they are

[18]However, if foreign owners are less efficient at managing domestic companies than domestic owners, fire-sales to foreigners can introduce inefficiencies of a different nature (see Acharya et al., 2008).

[19]As described e.g. in Radelet and Sachs (1998), the downward spiral and the financial meltdown in the countries that experienced the East Asian crisis came to an end only when a temporary suspension of debt payments to international creditors was announced. In the case of Korea, this suspension and forced roll-over of debts was part of an agreement brokered by the US government.

compensated for this risk, international investors would be indifferent to the policy measure. However, if no capital outflows from the economy are permitted in crisis times, no financial accelerator is triggered, and no externality arises. These benefits would have to be weighed carefully against the cost of completely preventing any risk-sharing between domestic agents and international lenders.[20]

Quota on Capital Outflows

One way of operationalizing such a policy measure would be a pre-defined quota on capital outflows. The externality kernel defined in (16) is linear in the shadow cost of borrowing constraints λ^ω, which is approximately proportional to the outflow of capital from the economy, once the threshold where constraints become binding has been reached. This motivates a quota that allows capital to flow out of the country freely up to the point where borrowing constraints become binding, and that requires investors to either delay outflows or face a haircut once this threshold has been reached.

5 Conclusions

This paper showed that the financial accelerator effects that arise during emerging market financial crises create an externality that induces decentralized agents to take on excessively risky forms of finance and expose the economy to too much systemic risk. The resulting macroeconomic equilibrium exhibits socially excessive volatility, which takes the form of current account reversals coupled with sharp declines in consumption and the exchange rate when economy-wide financing constraints bind and accelerator effects are triggered.

We described the basic building blocks of an optimal regulatory system for international capital flows in emerging market economies that makes decentralized agents internalize the systemic externalities they impose on the rest of the economy and that mitigates the risks of financial globalization. This should allow emerging market economies to enjoy the benefits of financial globalization while avoiding most of the associated downsides, thereby increasing social welfare.

While this paper has analyzed the externality in one particular (and, admittedly, highly simplified) model, a similar mechanism arises more generally whenever an economy is subject to financial accelerator effects whereby a decline in some macroeconomic price (such as the exchange rate, asset prices etc.) and a fall in output (e.g. because of balance sheet effects) mutually reinforce each other. The essential feature is that

[20] Optimal risk-sharing entails that domestic agents also carry *some* risk, though less than what they would take on in the unregulated market equilibrium.

atomistic agents take macroeconomic prices as given, even if price declines have adverse effects on the constraints that they are subject to. For a related analysis in a closed-economy model where financial crises entail feedback effects between declining asset prices and tightening borrowing constraints see Korinek (2008b).

Aside from distorting financing decisions in an emerging market economy, the same externality also creates two distortions in their investment decisions: First, the undervaluation of liquidity in period 1 implies that agents do not internalize the full social cost of capital in period 0 when promising repayments in constrained states of period 1, for example whenever they issue debt. As a result, they generally invest too much. Secondly, when they evaluate the state-contingent payoffs of different investment projects, they do not internalize the full social value of payoffs in constrained states of period 1. Therefore their investment will be biased towards excessively pro-cyclical projects. For example, an entrepreneur in a commodity-dependent economy who evaluates two investment projects, of which one is to invest more in the commodity-producing sector and the other to invest in a counter-cylical project, will not internalize the social benefits of risk diversification and might pick the pro-cyclical commodity project even if the social value of the other project is higher. These questions are the subject of our ongoing research.

References

Acharya, V. V., Shin, H. S., and Yorulmazer, T. (2008). Fire sales, foreign entry and bank liquidity. *London Business School, mimeo.*

Aizenman, J. and Marion, N. (2003). The high demand for international reserves in the far east: What's going on? *Journal of the Japanese and International Economies*, 17(Sept.):370–400.

Barro, R. J. (1974). Are government bonds net wealth? *Journal of Political Economy*, 82(6):1095–1117.

Bernanke, B., Gertler, M., and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. In Taylor, J. B. and Woodford, M., editors, *Handbook of Macroeconomics*, volume 1C, pages 1341–1393. Elsevier.

Caballero, R. J. and Krishnamurthy, A. (2003). Excessive dollar debt: Financial development and underinsurance. *Journal of Finance*, 58(2):867–894.

Calvo, G. A. (1998). Capital flows and capital-market crises: The simple economics of sudden stops. *Journal of Applied Economics*, 1(1):35–54.

Calvo, G. A., Izquierdo, A., and Mejía, L.-F. (2004). On the empirics of sudden stops - the relevance of balance-sheet effects. *NBER Working Paper*, w10520.

Calvo, G. A. and Reinhart, C. M. (2002). Fear of floating. *Quarterly Journal of Economics*, 107(2):379–408.

Caves, R. E., Frankel, J. A., and Jones, R. W. (2007). *World Trade and Payments: An Introduction*. Addison Wesley, 10th edition.

Chang, R. and Velasco, A. (2001). A model of financial crises in emerging markets. *Quarterly Journal of Economics*, 116:489–517.

Durdu, B. C., Mendoza, E. G., and Terrones, M. E. (2007). Precautionary demand for foreign assets in sudden stop economies: An assessment of the new merchantilism. *NBER Working Paper*, 13123.

Eichengreen, B. and Hausmann, R. (1999). Exchange rates and financial fragility. In *New Challenges for Monetary Policy*, pages 329–368. Federal Reserve Bank of Kansas City, Kansas City, Missouri.

Fischer, S. (1998). Capital account liberalization and the role of the imf. In Fischer, S., editor, *Should the IMF Pursue Capital-Account Convertibility*. International Finance Section, Department of Economics, Princeton University, Princeton.

Fisher, I. (1933). The debt-deflation theory of great depressions. *Econometrica*, 1(4):337–357.

Forbes, K. J. (2005). The microeconomic evidence on capital controls: No free lunch. *NBER Working Paper 11372*.

Frankel, J. A. and Rose, A. K. (1996). Currency crashes in emerging markets: An empirical treatment. *Journal of International Economics*, 41(3):351 – 366.

Henry, P. B. (2007). Capital account liberalization: Theory, evidence and speculation. *Journal of Economic Literature*, 45(4):887–935.

IMF (2007). The quality of domestic financial markets and capital inflows. *Global Financial Stability Report*, Fall 2007:77–109.

Kiyotaki, N. and Moore, J. (1997). Credit cycles. *Journal of Political Economy*, 105(2):211–248.

Korinek, A. (2007). *Dollar Borrowing in Emerging Markets*. Dissertation. Columbia University, New York.

Korinek, A. (2008a). Dollar borrowing in emerging markets: An underinsurance puzzle. *University of Maryland, mimeo.*

Korinek, A. (2008b). Systemic risk-taking: Amplification effects, externalities, and regulatory responses. *University of Maryland, mimeo.*

Kose, A., Prasad, E. S., and Terrones, M. E. (2007). How does financial globalization affect risk sharing? patterns and channels. *IMF Working Paper*, 07/238.

Krugman, P. R. (1998). Analytical afterthoughts on the asian crisis.

Krugman, P. R. (1999). Balance sheets, the transfer problem, and financial crises. In Isard, P., Razin, A., and Rose, A. K., editors, *International Finance and Financial Crises: Essays in Honor of Robert P. Flood Jr.*, pages 31–44. International Monetary Fund, Washington, DC.

Levy Yeyati, E. (2006). Financial dollarization: evaluating the consequences. *Economic Policy*, 21(45):61–118.

Matsuyama, K. (2008). Aggregate implications of credit market imperfections. In Acemoglu, D., Rogoff, K. S., and Woodford, M., editors, *NBER Macroeconomics Annual 2007*, pages 1–60. Chicago University Press.

Mauro, P., Ostry, J. D., Dell'Ariccia, G., di Giovanni, J., Faria, A., Kose, A., Schindler, M., and Terrones, M. E. (2007). Reaping the benefits of financial globalization. *IMF Discussion Paper.*

Mendoza, E. G. (2005). Real exchange rate volatility and the price of nontradables in sudden-stop-prone economies. *Economia*, 6(1):103–148.

Mendoza, E. G. (2006). Lessons from the debt deflation theory of sudden stops. *American Economic Review, Papers and Proceedings*, 96(2):411–416.

Mendoza, E. G. and Smith, K. A. (2006). Quantitative implications of a debt-deflation theory of sudden stops and asset prices. *Journal of International Economics*, 70(1):82–114.

Obstfeld, M. and Rogoff, K. (1995). *Foundations of International Macroeconomics.* MIT Press.

Radelet, S. and Sachs, J. D. (1998). The east asian financial crisis: Diagnosis, remedies, prospects. *The East Asian Financial Crisis; Diagnosis, Remedies, Prospects, Brookings Papers on Economic Activity*, 1998(1):1–90.

Reinhart, C. M. and Rogoff, K. S. (2008). Domestic debt: The forgotten history. *NBER Working Paper*, 13946.

Rodrik, D. (1998). Who needs capital-account convertibility? In Fischer, S., editor, *Should the IMF Pursue Capital-Account Convertibility*. International Finance Section, Department of Economics, Princeton University, Princeton.

Schneider, M. and Tornell, A. (2004). Balance sheet effects, bailout guarantees and financial crises. *Review of Economic Studies*, 71(3):883–913.

Stiglitz, J. E. (2002). *Globalization and its Discontents*. W.W. Norton, New York and London.

Stiglitz, J. E. and Weiss, A. (1981). Credit rationing in markets with imperfect information. *American Economic Review*, 71(3):393–410.

Tobin, J. (1978). A proposal for international monetary reform. *Eastern Economic Journal*, 4(3-4):153–159.

A Appendix

A.1 Endogenous Specification of Borrowing Constraints

The benchmark model presented in section 2 of this paper was set in an endowment economy where we imposed a collateral constraint that limited borrowing to a certain fraction of the dollar value of the representative agent's income (see Mendoza, 2005). Binding constraints prevented the agent from smoothing consumption over time and resulted in financial accelerator effects and the discussed externality. This appendix presents a production economy that is subject to borrowing constraints derived from micro foundations and shows that both financial accelerator effects and our externality are still present in this framework.

We assume that the representative agent can choose an amount of investment I_1^ω in period 1, which yields tradable production of $F(I_1^\omega)$ in period 2. For simplicity we continue to assume that non-tradable production is constant at $\bar{Y}_N$. The borrowing constraints arise because agents can only pledge a fraction κ of their period 2 income. This can be motivated e.g. by assuming that a fraction $1-\kappa$ is lost if creditors attempt to enforce repayment, or that agents withdraw their effort if their share in the project falls below $1-\kappa$.

$$B_1^\omega R \leq \kappa \left[F(I_1^\omega) + p_{N,2}^\omega \bar{Y}_N \right] \tag{A.1}$$

The main distinction between this version of the constraint and specification (2) is that the agent's borrowing capacity is now proportional to his future income, which depends on the future realization of the exchange rate. However, the financial accelerator that we discussed in section 2 is still present: a decline in period 1 borrowing capacity reduces period 1 investment and period 2 tradable output, which depreciates the period 2 exchange rate, leads to a further decline in period 1 borrowing capacity and so forth.

In this version of the problem, the analogon to the Lagrangian (5) of the decentralized agent can be formulated as

$$\mathcal{L}^{DE}_{C^\omega_{T,1},B^\omega_1,I^\omega_1} = u_T(C^\omega_{T,1}) + \beta u_T(F(I^\omega_T) - B^\omega_1 R) - \mu^\omega\left[C^\omega_{T,1} + I^\omega_T - Y^\omega_{T,1} - W_1 - B^\omega_1 R\right] - \\ - \lambda^\omega\left[B^\omega_1 - \frac{\kappa}{R}\left(F(I^\omega_T) + p^\omega_{N,1}\bar{Y}_N\right)\right]$$

The two first-order conditions (6) and (7) on $C^\omega_{T,1}$ and B^ω_1 are unaffected; the agent's privately optimal choice of investment I^ω_1 is described by the first-order condition

$$\left[\beta u'_T(C^\omega_{T,2}) + \kappa\lambda^\omega/R\right] F'(I^\omega_1) = \mu^\omega \tag{A.2}$$

By contrast, the social planner internalizes that the period 2 real exchange rate in general equilibrium is $p^\omega_{N,2} = \sigma C^\omega_{T,2} = \sigma\left[F(I^\omega_T) - B_1 R\right]$, allowing him to formulate the borrowing constraint (A.1) as

$$B^\omega_1 R\,(1+\kappa\sigma) \le \kappa(1+\sigma)F(I^\omega_T)$$
$$\text{or}\quad B^\omega_1 R \le \kappa\xi^{SP}F(I^\omega_T)\quad\text{where}\quad \xi^{SP} = \frac{1+\sigma}{1+\kappa\sigma R} > 1$$

We can then describe the social planner's Lagrangian as

$$\mathcal{L}^{SP} = u_T(C^\omega_{T,1}) + \beta u_T(F(I^\omega_T) - B^\omega_1 R) - \mu^\omega\left[C^\omega_{T,1} + I^\omega_T - Y^\omega_{T,1} - W_1 - B^\omega_1 R\right] - \\ - \lambda^\omega\left[B^\omega_1 - \frac{\kappa\xi^{SP}}{R}F(I^\omega_T)\right]$$

The social planner's first-order conditions on consumption and borrowing coincide again with (6) and (7) in the decentralized agent's problem. The first-order condition on investment is

$$\left[\beta u'_T(C^\omega_{T,2}) + \kappa\xi^{SP}\lambda^\omega/R\right] F'(I^\omega_1) = \mu^\omega \tag{A.3}$$

Note that the only difference between conditions (A.2) and (A.3) is the term ξ^{SP} – the social planner internalizes that raising investment relaxes the borrowing constraint not only because it increases future tradable output, but also because it appreciates the exchange rate. If we define $\xi^{DE} = 1$, we can characterize both the private and social optimum by substituting the appropriate ξ^i with $i \in \{DE, SP\}$ in expression (A.3).

When the borrowing constraint is slack, observe that the two conditions coincide since $\lambda^\omega = 0$. The optimal amount of investment is then determined by the standard neoclassical requirement that $F'(I_T^\omega) = R$. On the other hand, when the constraint is binding, the social planner's higher valuation of investment induces him to allocate more funds to investment than in the decentralized equilibrium so as to appreciate the exchange rate in period 2. This reduces the amount of funds available for consumption in period 1 and increases the marginal product μ^ω.

To demonstrate this analytically we substitute for λ^ω and μ^ω from the other first-order conditions (6) and (7). The optimal trade-off between consumption and investment is then characterized by

$$u'(C_{T,1}^\omega)\left[1 - \kappa\xi^i F'(I_T^\omega)/R\right] = \beta u_T'(C_{T,2}^\omega) F'(I_T^\omega)\left[1 - \kappa\xi^i R\right]$$

Implicitly differentiating this condition reveals that $dI_T^\omega/d\xi > 0$. We can therefore repeat the result from proposition 1 in the text above:

Proposition 1' (Undervaluation of Liquidity in Crises) *In crisis states, the social planner values liquidity more highly than decentralized agents, i.e.* $\mu_{SP}^\omega > \mu_{DE}^\omega$, *since she internalizes the financial accelerator effects arising from the constraints.*

This can be directly applied to re-derive our earlier results on excessive ex-ante risk-taking.