WP/15/218

IMF Working Paper

Capital Controls or Macroprudential Regulation?

By Anton Korinek and Damiano Sandri

INTERNATIONAL MONETARY FUND

 WP/15/218

IMF Working Paper

Research Department

Capital Controls or Macroprudential Regulation?

Prepared by Anton Korinek and Damiano Sandri[1]

Authorized for distribution by Giovanni Dell'Ariccia

October 2015

Abstract

International capital flows can create significant financial instability in emerging economies because of pecuniary externalities associated with exchange rate movements. Does this make it optimal to impose capital controls or should policymakers rely on domestic macroprudential regulation? This paper presents a tractable model to show that it is desirable to employ both types of instruments: Macroprudential regulation reduces overborrowing, while capital controls increase the aggregate net worth of the economy as a whole by also stimulating savings. The two policy measures should be set higher the greater an economy's debt burden and the higher domestic inequality. In our baseline calibration based on the East Asian crisis countries, we find optimal capital controls and macroprudential regulation in the magnitude of 2 percent. In advanced countries where the risk of sharp exchange rate depreciations is more limited, the role for capital controls subsides. However, macroprudential regulation remains essential to mitigate booms and busts in asset prices.

JEL Classification Numbers: F34, F41, E44

Keywords: Financial stability, pecuniary externalities, capital controls, macroprudential regulation, inequality.

Authors' E-Mail Address: akorinek@jhu.edu and dsandri@imf.org

[1] We thank Larry Ball, Olivier Blanchard, Suman Basu, Marcos Chamon, Giovanni Dell'Ariccia, Rex Ghosh, Pierre-Olivier Gourinchas, Sebnem Kalemli-Ozcan, Luc Laeven, Alberto Martin, Enrique Mendoza, Jonathan Ostry, Richard Portes, Joseph Stiglitz for helpful comments and suggestions. We also received helpful comments from Itai Agur, Chikako Baba, Varapat Chensavasdijai, Annamaria Kokenyne, Mary Goodman, and Helene Poirson Ward. Korinek acknowledges financial support from the IMF Research Fellowship and from CIGI/INET.

Contents

1 Introduction

Fighting financial instability is one of the big policy challenges of our time. Many recent financial crises have been triggered in part by large reversals in international capital flows, even in countries that followed seemingly sound fiscal and monetary policies (see e.g. Reinhart and Rogoff, 2008). Policymakers have thus struggled with the question of whether to protect their economies using macroprudential regulations on domestic financial transactions or whether to impose more heterodox policy measurses such as capital controls to regulate international capital flows.[1]

The defining feature of capital controls is that they apply exclusively to financial transactions between residents and non-residents, i.e. they discriminate based on the residency of the parties involved in a financial transaction.[2] For example, controls on capital inflows apply to transactions between foreign creditors and domestic debtors. Similarly, controls on capital outflows apply to transactions between domestic savers and international borrowers. Capital controls segment domestic and international financial markets, as illustrated in the left panel of Figure 1. As a result of this segmentation, international lenders and domestic agents face different effective interest rates.

Macroprudential policies, by contrast, restrict borrowing by domestic agents independently of whether credit is provided by domestic or foreign creditors. They impose a segmentation between borrowers and all types of lenders, as illustrated in the right panel of 1. As a result, borrowers and lenders in the economy face different effective interest rates.[3]

Should countries use capital controls or macroprudential regulation when they experience large credit growth, potentially involving considerable international capital flows? Should the two policy instruments be thought of as equivalent or as close substitutes? Or alternatively, does each of the two have its own comparative advantage depending on specific circumstances?

To study these questions, we set up a model of a small open economy with borrowers who are subject to a collateral constraint. Our key departure from the existing literature is that borrowers can access credit either domestically – from domestic savers – or from international lenders. This allows us to explicitly distinguish between capital controls and

[1] See e.g. Ostry et al. (2011) for an overview of the use of capital controls and Galati and Moessner (2013) for a survey on macroprudential regulation. See also Ostry et al. (2014) for a detailed analysis of the policy considerations involved in choosing between capital controls and macroprudential regulation.

[2] More recently, the IMF (2012) has adopted the term capital flow management measures (CFMs) for capital controls, since the latter term has traditionally had a negative connotation. In this paper, we use the term capital controls in accordance with the tradition in the academic literature.

[3] In some instances, it is difficult to distinguish between capital controls and macroprudential regulation because regulators face a limited set of policy instruments and use one instrument as a substitute for the other. In the current paper, we assume that regulators have both an effective macroprudential instrument and effective capital controls at their disposal. For a more detailed analysis of targeting problems under incomplete instruments see e.g. Ostry et al. (2014).

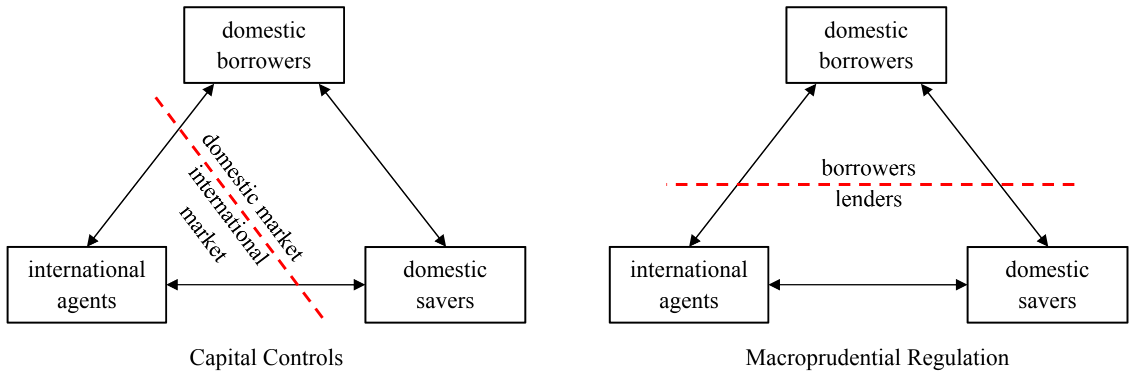

Figure 1: Capital Controls Versus Macroprudential Regulation

macroprudential measures. The key difference between domestic and foreign borrowing materializes when borrowers are forced to delever: repayments to domestic creditors remain in the domestic economy and add to domestic aggregate demand, whereas repayments to international lenders constitute lost purchasing power; they lead to capital outflows and depreciate the country's exchange rate.

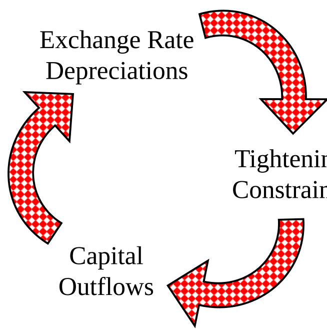

Figure 2: Feedback loop of financial crises with exchange rate depreciations

The level of the exchange rate matters because it determines how much foreign lenders value domestic collateral. When the collateral constraint on borrowers is binding, a depreciation reduces the value of collateral, which triggers a feedback loop of tightening constraints, capital outflows and further exchange rate depreciations, as illustrated in Figure 2. This describes the classic dynamics of sudden stops and financial amplification (see e.g. Korinek and Mendoza, 2014, for a summary and survey). A growing literature has shown that these dynamics give rise to excessive borrowing since private agents do not internalize that their collective actions contribute to the exchange rate declines and resulting sudden stop dynamics. This *pecuniary externality* has been proposed as a rationale for both capital controls and macroprudential regulation.[4,5] However, in the existing literature, there is no difference between the two policy measures – both are simply restrictions on borrowing.

Our paper is the first to differentiate between macroprudential regulation and capital controls by distinguishing between domestic and foreign lending. This allows us to investigate the comparative advantages of the two types of prudential instruments and provide policy lessons for when it is optimal to use how much of which instrument.

Our main result is that it is desirable to use both policy instruments in an emerging economy that is vulnerable to sudden stops. Macroprudential regulation plays the usual role of reducing overborrowing; capital controls create an interest rate differential between the domestic and international credit market, which induces domestic savers to save more. This increases the aggregate wealth of the economy and makes it more resilient to sudden stops, i.e. it implies that the exchange rate will depreciate less for a given level of capital outflows. Put differently, when borrowers are forced to delever, repayments to foreign lenders imply that purchasing power flows out of the economy and depreciates the exchange rate. By contrast, repayments to domestic lenders imply that some of the purchasing power will stay at home, which increases demand for domestic goods and reduces the downward pressure on the exchange rate.

We demonstrate that it is desirable to combine capital controls and macroprudential regulation in a variety of settings. For ease of exposition, we first analyze a framework in which an emerging economy will suffer a financial crisis with perfect foresight. We then show that our result continues to hold if we introduce uncertainty: if domestic agents have access to state-contingent financial instruments, the described externality induces private agents to take on excessive risk and insure too little. An immediate implication is that they take on too much dollar debt – which requires large pay-outs in low states of nature – compared to local currency debt. A planner uses *both* capital controls and macroprudential regulation to remedy this and shift the composition of borrowing towards less risky liabilities. Finally, we consider an economy with uncertainty that only has access to uncontingent bonds, and we find that private agents borrow too much.

The two policy measures should optimally be adjusted to reflect the risks to financial

[4] For a survey of this literature on capital controls see Korinek (2011a). For a survey on macroprudential regulation see Galati and Moessner (2013). A detailed analytic description of the resulting case for capital controls is provided in Korinek (2007, 2010) and Bianchi (2011) in a small open economy with a representative agent. Benigno et al. (2010, 2012, 2013a, 2013b) analyze how the same inefficiencies can be addressed using alternative policy measures. Lorenzoni (2008), Jeanne and Korinek (2010ab), Bianchi and Mendoza (2010) and Korinek (2011b) make the case for macroprudential regulation based on asset price movements that trigger feedback loops. Jeanne (2014) analyzes macroprudential regulation in a framework in which capital controls are by construction a second-best device.

[5] An alternative strand of literature motivates macroprudential regulation and capital controls based on aggregate demand externalities in the presence of nominal frictions. See for example Farhi and Werning (2012, 2013, 2014), Schmitt-Grohe and Uribe (2012), Korinek and Simsek (2014) and Acharya and Bengui (2015).

stability in emerging economies: in an economy in which there is no risk of financial crisis, no intervention is required. Conversely, the larger the risk of sudden stops of capital flows and the resulting current account reversals and exchange rate depreciations, the higher the two measures should be set. It is well known that sudden stop risk increases in the aggregate debt burden of an economy and in the exposure to negative shocks. We also show that it increases in wealth inequality – for a given aggregate debt burden, higher inequality implies that borrowers are more constrained.

The East Asian crisis of 1997 provides a clear example of sudden stop dynamics.[6] Figure 3 shows that the East Asian crisis countries experienced a sudden reversal of the current account by more than 10 percentage points of GDP within one year. Meanwhile their economies witnessed a sharp correction of the real exchange rate by about 25 percent. This severely impaired the balance sheets of borrowers and constrained their ability to raise new loans. In a numerical illustration of our model that replicates these numbers and assumes a 5 percent crisis probability, we find that it would have been optimal to impose macroprudential taxes and capital controls of about 2 percent each prior to the crisis, implying a combined tax burden on borrowers of 4 percent.

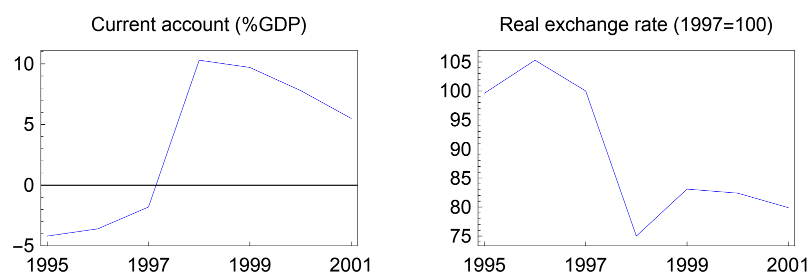

Figure 3: Sudden stop dynamics: the East Asian crisis of 1997.

In an extension, we consider an economy in which collateral constraints depend on asset prices rather than the exchange rate. This framework can better capture the situation of a typical advanced economy where exchange rate fluctuations tend to be less severe and debt is issued in local currency. In this case, borrowers remain vulnerable to a feedback loop of fire sales and asset price declines that is similar to the feedback loop involving exchange rate depreciations in Figure 2: binding constraints reduce borrowers' demand for productive assets, which in turn leads to fire sales, lower prices, and tightening borrowing constraints. In a model of such asset price externalities, macroprudential regulation is sufficient to remedy the overborrowing. There is no role for capital controls to induce greater precautionary savings for domestic lenders since lenders have no comparative advantage to holding productive assets.

[6]The East Asian crisis countries include Indonesia, Malaysia, Philippines, South Korea and Thailand.

This suggests that the optimal mix of capital controls and macroprudential regulation changes as an economy becomes more developed. Concerns about exchange rate volatility are particularly acute in emerging markets, especially those that have significant debts in foreign currency. In advanced economies, by contrast, the exchange rate is less relevant for financial stability, but asset price volatility remains a threat. As an emerging economy becomes more advanced, it is thus optimal to phase out capital controls but keep macroprudential regulation.

2 Model

2.1 Setup

We consider a small open economy with three time periods $t \in \{0, 1, 2\}$. There is a unit mass of domestic borrowers B and a unit mass of domestic savers S in the economy. Furthermore, there is a large set of foreigners F who trade bonds (i.e. lend or borrow) at an exogenous net interest rate of zero. The two types of domestic agents $i \in \{B, S\}$ derive utility from the consumption c_T^i of traded goods and c_N^i of non-traded goods. For simplicity, they consume non-traded goods only in period 1 so that their overall utility is given by,

$$U^i = u(c_{T,0}^i) + u(c_1^i) + u(c_{T,2}^i) \tag{1}$$

where the period utility functions $u(c) = \ln c$ and where $c_1^i = (c_{T,1}^i)^\alpha (c_{N,1}^i)^{1-\alpha}$ is a consumption index of traded and non-traded goods with relative expenditure shares α and $1-\alpha$. For simplicity, the intertemporal discount rate equals zero, the world interest rate.

Domestic agents enter period 0 with a certain stock of bonds b_0^i and receive an endowment of traded goods $y_{T,0}^i$. They then decide how much to consume and how many bonds b_1^i to carry into the next period, where $b < 0$ corresponds to borrowing,

$$c_{T,0}^i + b_1^i = b_0^i + y_{T,0}^i \tag{2}$$

Agents also receive endowments of traded and non-traded goods in period 1 $(y_{T,1}^i, y_{N,1}^i)$, as well as an endowment of traded goods $y_{T,2}^i$ at time 2.

We denote the relative price of non-traded to traded consumption goods by p and observe that p also represents a measure of the country's real exchange rate.[7] The period 1 budget

[7] A country's real exchange rate is commonly defined as the price of a basket of domestic consumption goods in terms of a basket of international consumption goods. In accordance with our small open economy assumption, we take the price of international consumption goods and traded domestic consumption goods as exogenous. Therefore the price of a domestic consumption basket is a strictly increasing function of the relative price of domestic non-traded goods.

constraint of an agent $i \in \{B, L\}$ is

$$c^i_{T,1} + pc^i_{N,1} + b^i_2 = y^i_{T,1} + py^i_{N,1} + b^i_1 \tag{3}$$

where b^i_2 is the amount of bonds carried into the following period.

In period 2, agents finance their consumption using the traded endowment $y^i_{T,2}$ and the bonds carried into the period,

$$c^i_{T,2} = y^i_{T,2} + b^i_2 \tag{4}$$

The initial stock of debt b^i_0 and the income endowments of domestic borrowers and savers are distributed such that in periods 0 and 1 borrowers find it optimal to borrow, $b^B_t < 0$, and savers find it optimal to save, $b^S_t > 0$.

Financial constraint We introduce a financial constraint on borrowers as in Mendoza (2006) that can be motivated by the commitment problem described in Korinek (2010): After borrowers have received their loans in period 1, we assume they have an opportunity to divert their income and renege on their borrowing. However, lenders can take them to court and recover up to a fraction ϕ of their period 1 income. To rule out default, borrowing $-b^B_2$ is limited to

$$-b^B_2 \leq \phi \left(y^B_{T,1} + py^B_{N,1} \right) \tag{5}$$

Broadly speaking, we interpret the coefficient ϕ as a pledgeability parameter.[8]

This type of financial constraint (5) is common in the literature on emerging market crises. The relative price p that appears in the constraint generates both financial amplification effects and pecuniary externalities. The strength of financial amplification depends crucially on the parameter ϕ. For $\phi = 0$, there will be no amplification since the borrowing limit is constant. The higher ϕ, the greater the amplification effects. To ensure that the economy in our model is well-behaved and that financial amplification effects are bounded, we impose

Assumption 1 $\phi < \hat{\phi}$.

where the upper limit $\hat{\phi}$ is characterized in Appendix A.1. This is a common assumption in all models of financial amplification and imposes only mild restrictions (see e.g. the detailed discussion in section 3.2 of Korinek and Mendoza, 2014).

[8] We could refine this constraint by assuming different degrees of pledgeability for traded and non-traded goods but this is not essential to our analysis. We could also impose an equivalent constraint on period 0 borrowing b^i_1 but the model solution would be degenerate if this constraint is binding – all the interesting decisions of borrowers are pre-determined by binding constraints. Without loss of generality, we focus on equilibria in which the period 0 constraint is loose.

2.2 Decentralized Equilibrium

An equilibrium in the described economy consists of a set of allocations and prices in which each type of agent $i \in \{B, S\}$ maximizes her utility (1) subject to the budget constraints (2), (3) and (4) as well as the financial constraint (5) and in which markets for nontraded goods clear

$$\sum_i (C^i_{N,1} - y^i_{N,1}) = 0 \tag{6}$$

In this definition and for the remainder of the paper, we follow the convention of denoting individual variables by lower-case letters and sector-wide or aggregate variables by upper-case letters, e.g. $C^i_{N,1}$ is total nontraded consumption of sector i and so forth. Market clearing for traded goods is ensured by the domestic budget constraints together with the fact that foreign agents can satisfy any amount of borrowing or lending by domestic agents.

Equilibrium in Periods 1 and 2 We solve for the equilibrium via backward induction, starting with periods 1 and 2. It proves useful to express the period 1 welfare of domestic agents $i \in \{B, S\}$ as a function of their period 1 liquid net worth, defined as the period 1 endowment of traded goods plus bond holdings,

$$m^i = y^i_{T,1} + b^i_1$$

The aggregate state of the economy in period 1 is fully described by the sector-wide liquid net worth positions of the two sets of domestic agents (M^B, M^S). In equilibrium, $m^i = M^i$ will hold but private agents do not internalize their impact on aggregate variables when making their optimal choices.

In period 1, an individual agent in sector $i \in \{B, S\}$ takes the state of the economy $\left(M^B, M^S\right)$ as given and solves the utility maximization problem

$$\begin{aligned} V^i\left(m^i; M^B, M^S\right) = \max_{b^i_2, c^i_{T,1}, c^i_{N,1}, c^i_{T,2}} \quad & u\left(c^i_{T,1}, c^i_{N,1}\right) + u(y^i_{T,2} + b^i_2) \\ \text{s.t.} \quad & b^i_2 + \phi\left(y^i_{T,1} + p y^i_{N,1}\right) \geq 0 \\ & m^i + p\left(y^i_{N,1} - c^i_{N,1}\right) \geq c^i_{T,1} + b^i_2 \end{aligned} \tag{7}$$

We assign shadow prices λ^i and μ^i to the borrowing constraint (5) and the period 1 budget constraint (3) and denote by $u^i_{T,1} = \partial u\left(c^i_1\right) / \partial c^i_{T,1}$ the marginal utility of traded consumption in period 1 and similarly for $u^i_{N,1}$, $u^i_{T,2}$ etc. The optimization problem yields the Euler equation

$$u^i_{T,1} = u^i_{T,2} + \lambda^i \tag{8}$$

Domestic savers S are never constrained so $\lambda^S \equiv 0$ always holds.

The optimality condition that relates period 1 traded and non-traded consumption delivers an expression for the exchange rate

$$p = \frac{u^i_{N,1}}{u^i_{T,1}} = \frac{1-\alpha}{\alpha} \frac{c^i_{T,1}}{c^i_{N,1}}$$

Since this condition has to hold for both domestic agents, we observe that we can add up the traded/non-traded consumption of both agents and combine the result with the market-clearing condition (6) for non-traded goods to obtain

$$p = \frac{1-\alpha}{\alpha} \frac{C^B_{T,1} + C^S_{T,1}}{Y_{N,1}} \tag{9}$$

where $Y_{N,1} = Y^B_{N,1} + Y^S_{N,1}$. In short, the real exchange rate is a strictly increasing function of aggregate tradable spending $\left(C^B_{T,1} + C^S_{T,1}\right)$.

Unconstrained Period 1 Equilibria We first focus on the case when the collateral constraint on borrowers is loose, which is generally the case when the liquid net worth of the two sectors is sufficiently high. Analytically, we collect the set of state variables $\left(M^B, M^S\right)$ for which borrowers are unconstrained in the set $\mathcal{M}^{unc}$, and we denote the set of state variables for which borrowers are constrained by $\mathcal{M}^{con}$. The two sets are the are mutually exclusive and are described in detail in Appendix A.1.

For unconstrained equilibria, i.e. for $\left(M^B, M^S\right) \in \mathcal{M}^{unc}$, all agents smooth consumption according to their Euler equation so that $u^i_{T,1} = u^i_{T,2}$ for $\forall i \in \{B, S\}$. Period 1 traded consumption of agent i is given by

$$c^i_{T,1} = \frac{\alpha}{2} \left(m^i + p y^i_{N,1} + y^i_{T,2}\right) \tag{10}$$

since the agent spends half of her income in period 1 and a fraction α thereof on traded goods. The exchange rate can thus be written as a simple function of $\left(M^B, M^S\right)$

$$p\left(M^B, M^S\right) = \frac{1-\alpha}{1+\alpha} \frac{M^B + M^S + Y^B_{T,2} + Y^S_{T,2}}{Y_{N,1}}$$

This implies that an increase in the liquid net worth M^i of either domestic agent pushes up the real exchange rate by

$$\frac{\partial p}{\partial M^B} = \frac{\partial p}{\partial M^S} = \frac{1-\alpha}{Y_{N,1}(1+\alpha)} > 0$$

Notice that the effects of borrowers and lenders' net worth on the real exchange rate are equal because the marginal propensity to consume out of wealth (MPC) is identical for both agents when they are unconstrained. From equation (10), we can indeed derive

$$MPC^i = \frac{\partial \left[c^i_{T,1} + pc^i_{N,1}\right]}{\partial m^i} = \frac{1}{2}$$

Therefore, an increase in either agent's net worth equally stimulates aggregate domestic demand and appreciates the real exchange rate.

Constrained Period 1 Equilibria For $\left(M^B, M^S\right) \in \mathcal{M}^{con}$, borrowers are constrained and spend their entire liquid net worth in period 1 on consumption. A fraction α thereof is spent on traded consumption,

$$c^B_{T,1} = \alpha\left[m^B + py^B_{N,1} + \phi(y^B_{T,1} + py^B_{N,1})\right] \tag{11}$$

Spending on traded goods by savers is still given by condition (10). We can use the two expressions to express the real exchange rate in (9) as a linear function of $\left(M^B, M^S\right)$ that is given by

$$p\left(M^B, M^S\right) = \frac{1-\alpha}{D}\left(M^B + \phi Y^B_{T,1} + \frac{M^S + Y^S_{T,2}}{2}\right) \tag{12}$$

where $D = Y_{N,1} - (1-\alpha)[Y^B_{N,1}(1+\phi) + Y^S_{N,1}/2] > 0$ is strictly positive under our Assumption 1, $\phi < \hat{\phi}$.

In the constrained region, an increase in either agent's net worth raises the real exchange rate. However, differently from the unconstrained region, an increase in borrowers' net worth has a twice as strong effect as an increase in savers' net worth

$$\frac{\partial p}{\partial M^B} = \frac{1-\alpha}{D} > \frac{\partial p}{\partial M^S} = \frac{1-\alpha}{2D} > 0$$

The reason for the different impact of borrowers' and savers' net worth lies in the different marginal propensity to consume. Facing a binding constraint, borrowers' MPC is now twice as high as under the unconstrained solution. Using equation (11), we indeed observe that

$$MPC^B = 1 > MPC^S = \frac{1}{2}$$

Figure 4 schematically depicts the response of the exchange rate p to varying the level of M^B for two different levels of the net worth of savers M^S. For each level of M^S, there is a threshold value of M^B below which the equilibrium becomes constrained, indicated by the vertical dashed lines. In the constrained region, i.e. to the left, the exchange rate responds strongly to changes in M^B since financial amplification effects are at play: additional net worth allows borrowers to demand more non-traded goods, which pushes up their prices and relaxes the financial constraint, leading to a virtuous cycle of rising prices and loosening of the constraint.

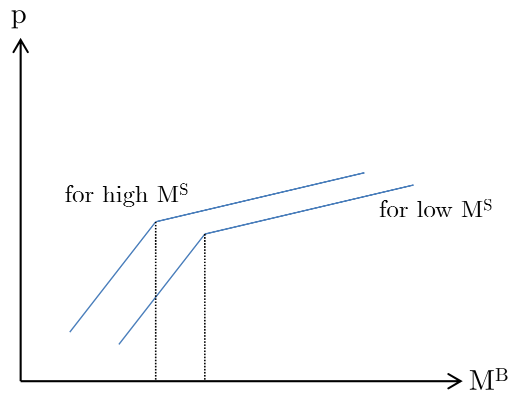

Figure 4: Exchange rate p as a function of M^B

Lemma 1 *(i) The economy's real exchange rate is an increasing function of period* 1 *spending on traded goods, which in turn is an increasing function of both net worth M^B and M^S.*

(ii) If the economy is unconstrained, then $\partial p/\partial M^B = \partial p/\partial M^S > 0$.

(iii) If the economy is constrained, then $\partial p/\partial M^B > \partial p/\partial M^S > 0$

Proof. See discussion above. ■

Comparative Statics of Net Worth M^i. For our subsequent analysis, it proves useful to analyze how the welfare of the two types of domestic agents is affected by changes in aggregate liquid net worth. The derivative of the value function of agent j with respect to the aggregate net worth M^i of agent i is

$$\frac{\partial V^j}{\partial M^i} = u^j_{T,1} \cdot \underbrace{\frac{\partial p}{\partial M^i}(y^j_{N,1} - c^j_{N,1})}_{\text{redistribution between agents } R^j_i} + \lambda^j \cdot \underbrace{\frac{\partial p}{\partial M^i}\phi y^j_{N,1}}_{\text{relaxation of constraint } \Phi^j_i} \tag{13}$$

Changes in aggregate M^i affect the welfare of agent j solely through changes in the price of non-traded goods $\partial p/\partial M^j$, i.e through pecuniary externalities. All other variables are either exogenous or optimally chosen by private agents, which allows us to apply the envelope theorem and omit any associated derivatives in expression (13).

We distinguish the pecuniary externalities that arise from changes in M^i into two parts: The first part corresponds to the first term in equation (13), which we denote by R^j_i, and reflects that price changes create redistributions between agents. Since non-traded goods are only traded among domestic agents, the redistributions between domestic agents always net out, i.e. $R_i^i + R_i^j = 0$. If agent j is a net seller of non-traded goods ($y_{N,1}^j > c_{N,1}^j$) then an increase in the price of the good benefits agent j and vice versa.

The second part corresponds to the second term in equation (13), which we denote with Φ_i^j, and reflects that price changes affect the tightness of collateral constraints in the economy. An increase in the exchange rate relaxes collateral constraints which provides a welfare benefit λ^j.

For our model to be well-behaved, we impose the following assumption on the redistributive terms:

Assumption 2 $1 + R_B^B - R_S^B > 0$.

This rules out "immiserizing" transfers, i.e. it ensures that transferring one dollar from savers to borrowers does not lead to price changes that reduce borrowers' wealth.

Period 0 Equilibrium The period 0 optimization problem of both types of domestic agents is

$$\max_{b_1^i} u\left(b_0^i + y_{T,0}^i - b_1^i\right) + V^i\left(y_{T,1}^i + b_1^i; M^B, M^S\right)$$

and results in the Euler equation

$$u_{T,0}^i = u_{T,1}^i$$

In short, both sets of agents perfectly smooth the utility of traded consumption. Our next question is whether a planner can improve on the resulting decentralized equilibrium allocation.

2.3 Constrained Planning Problem

A social planner in the described economy maximizes the weighted sum of welfare of domestic agents in the economy, subject to the economy's resource constraints. Since international lenders are indifferent between lending or borrowing, their utility is unaffected by the allocations in the domestic economy, and they can be omitted from the planning problem. By implication, any Pareto efficient allocation in the domestic economy is also a Pareto efficient global allocation.

We focus on a constrained planning problem in which the allocations of the planner are subject to the same financial constraint (5) as the allocations of private agents. Following the tradition of Stiglitz (1981) and Geanakoplos and Polemarchakis (1986), we assume that the constrained planner chooses the financial allocations of domestic agents in period 0, but leaves the remaining allocations in periods 1 and 2 to be determined by decentralized agents. This implies that the planner takes it as given that the exchange rate is determined in decentralized markets according to condition (9), capturing the notion that it is commonplace for policymakers to impose financial regulation that restricts borrowing/lending, but that it is difficult for them to directly set the level of exchange rates in financial markets without giving rise to massive arbitrage behavior.[9]

The constrained planner chooses the optimal period 0 allocations while internalizing how the aggregate period 1 state variables, i.e. the aggregate liquid net worth positions (M^B, M^S) of domestic agents, affect the model equilibrium and agents' welfare in periods 1 and 2. Specifically, the social planner maximizes the weighted utilities of domestic borrowers and savers with weights γ^i, subject to the period 0 resource constraint of the economy,

$$\max_{C^i_{T,0}, B^i_1} \sum_{i\in\{B,S\}} \gamma^i \left\{ u\left(C^i_{T,0}\right) + V^i\left(m^i; M^B, M^S\right)\right\} \quad \text{s.t.} \quad \sum_{i\in\{B,S\}} \left(C^i_{T,0} + B^i_1 - B^i_0 - Y^i_{T,0}\right) \leq 0 \tag{14}$$

where she internalizes that $m^i = M^i = Y^i_{T,1} + B^i_1$. By varying the welfare weights, we can trace the entire Pareto frontier of the economy. The continuation utility of private agents of type $i \in \{B, S\}$ from time 1 onwards is given by the value function $V^i\left(m^i; M^B, M^S\right)$ that we characterized in equation (7) in the decentralized equilibrium.

Characterizing the Planning Solution

Using the envelope condition $\partial V^i/\partial m^i = u^i_{T,1}$, the planner's optimality conditions are

$$\gamma^i u^i_{T,0} = \gamma^j u^j_{T,0} \tag{15}$$

$$\gamma^i u^i_{T,0} = \underbrace{\gamma^i u^i_{T,1}}_{\text{private benefit}} + \underbrace{\gamma^i \frac{\partial V^i}{\partial M^i} + \gamma^j \frac{\partial V^j}{\partial M^i}}_{\text{social benefit of agent } i \text{ liquidity}} \tag{16}$$

for $j \neq i$. The intra-temporal condition (15) equates the weighted marginal utility of consumption across agents at time 0. In the Euler equation (16), the usual consumption smoothing motive – captured by the marginal utilities $u^i_{T,t}$ – is complemented by two additional terms that reflect the pecuniary externalities of agent i carrying wealth into period 1 on himself and the other agent.

Using equation (13), the market clearing condition (6), and $\lambda^S = 0$ since savers are by

[9]The assumption that policymakers cannot directly set exchange rates can be relaxed as long as there is a cost associated with doing so. See, for example, Benigno et al. (2013) for exchange rate intervention. Our basic results continue to hold in these cases. Our assumption is also supported by the experience of many emerging economies that were either forced to abandon nominal pegs or experienced strong real depreciations under fixed nominal exchange rates during crises.

construction not borrowing-constrained, we rewrite the planner's Euler equation (16) as

$$\underbrace{\gamma^i u^i_{T,0} = \gamma^i u^i_{T,1}}_{\text{smoothing consumption}} + \frac{\partial p}{\partial M^i}\left[\underbrace{\left(\gamma^i u^i_{T,1} - \gamma^j u^j_{T,1}\right)(y^i_{N,1} - c^i_{N,1})}_{\text{redistributing between agents}} + \underbrace{\gamma^B \lambda^B \phi y^B_{N,1}}_{\text{relaxing constraint}}\right] \tag{17}$$

The first curly brackets capture the usual consumption smoothing considerations and coincide with the Euler equation of private agents. In addition to this, the planner recognizes that her allocation of liquid wealth M^i affects the real exchange rate and leads to two further effects: a higher exchange rate redistributes from net buyers to net sellers of non-traded goods, as captured by the second curly bracket; furthermore, a higher real exchange rate relaxes the collateral constraint of borrowers, captured by the last term.

Using the terms R^j_i and Φ^j_i for the redistributions and collateral effects of changes in net worth, we can rewrite the equation more compactly as

$$\gamma^i u^i_{T,0} = \gamma^i u^i_{T,1} + \left(\gamma^i u^i_{T,1} - \gamma^j u^j_{T,1}\right) R^i_i + \gamma^B \lambda^B \Phi^B_i$$

We characterize the solution to the constrained planning problem in the economy as follows:

Proposition 2 *(i) Any constrained efficient allocation in the domestic economy satisfies*

$$\frac{u^B_{T,1}}{u^B_{T,0}} = 1 - \frac{\lambda^B}{u^B_{T,0}} \frac{\Phi^B_B}{1 + R^B_B - R^B_S} \tag{18}$$

$$\frac{u^S_{T,1}}{u^S_{T,0}} = 1 - \frac{\lambda^B}{u^B_{T,0}} \frac{\Phi^B_S}{1 + R^B_B - R^B_S} \tag{19}$$

(ii) In allocations in which the financial constraint is loose, $\lambda^B = 0$, the planner's optimality conditions coincide with those of decentralized agents.

(iii) In allocations in which the financial constraint is binding, $\lambda^B > 0$, the planner introduces a wedge in the marginal rate of substitution and acts in a more precautionary manner than private agents in period 0, i.e. $u^i_{T,0} > u^i_{T,1}$. Furthermore, the wedge is larger for borrowers than for savers.

Proof. For (i), we derive equations (18) and (19) by combining the planner's Euler equation (17) for both agents to obtain

$$\gamma^B u^B_{T,1} - \gamma^S u^S_{T,1} = -\frac{\gamma^B \lambda^B \left(\Phi^B_B - \Phi^B_S\right)}{1 + R^B_B - R^B_S}$$

The difference between the weighted marginal utilities of borrowers and savers reflect the difference in how much borrower and saver net worth relax the constraint $\Phi_B^B - \Phi_S^B$ normalized by the redistributions created by moving one dollar from savers to borrowers. Substituting this expression back into the Euler equation delivers the result.

For (ii), we observe that the terms on the right-hand side of equations (18) and (19) drops out.

For (iii), notice that all parts of the wedge terms are positive. For λ^B and $u_{T,0}^B$ this holds by definition; $\Phi_B^B > \Phi_S^B > 0$ holds because $\partial p / \partial M^B > \partial p / \partial M^S > 0$. Finally, $1 + R_B^B - R_S^B > 0$ by Assumption 2 ■

Intuitively, when the collateral constraint on borrowers is loose, the only pecuniary externalities that appear are the redistributions between borrowers and lenders R_i^j and the associated allocation is Pareto efficient. This result reflects the standard finding that pecuniary externalities cancel out when financial markets are complete, as implied by the first welfare theorem – the gain of one type of agent is the loss of another.

By contrast, when borrowers are constrained, the planner can relax the constraint by shoring up the net worth of both borrowers and savers since both of them consume nontraded goods. Higher net worth during crisis times means that they have more to spend on nontraded goods, which pushes up the real exchange rate and mitigates the contractionary depreciations. The planner introduces a larger wedge in the optimality condition of borrowers since they have a higher marginal propensity to spend.

2.4 Implementation

Policymakers can replicate any constrained optimal allocation through a combination of taxes and subsidies on borrowers and savers combined with a lump sum transfer. Specifically, assume that policymakers have the ability to impose a tax/subsidy τ^i on the bond purchases and can implement lump-sum transfers T^i in period 0 for $i \in \{B, S\}$. The budget constraint of individual agents in period 0 becomes

$$c_{T,0}^i + \left(1 - \tau^i\right) b_1^i + T^i = b_0^i + y_{T,0}^i$$

Specifically, when $b_1^i > 0$ so agent i is a saver, then $\tau^i > 0$ represents a subsidy to saving. When $b_1^i < 0$ so agent i is a borrower, then $\tau^i > 0$ constitutes a tax on borrowing. In either case, a positive value for the policy instrument τ^i induces agent i to carry more liquid net worth into the following period. This modifies the private optimization problem of decentralized agents so their Euler equation becomes

$$\left(1 - \tau^i\right) u_{T,0}^i = u_{T,1}^i$$

A policymaker can use these instruments to implement the constrained efficient allocations characterized in Proposition 2 as follows:

Corollary 3 *(i) Any constrained efficient equilibrium can be implemented by a pair of taxes* $\left(\tau^B, \tau^S\right)$ *with* $\tau^B > \tau^S$ *together with lump-sum transfers that satisfy the government budget constraint* $T^B + T^S = \tau^B b_1^B + \tau^S b_1^S$.

(ii) The relative size of taxes is pinned down by agents' marginal propensity to consume

$$\frac{\tau^B}{\tau^S} = \frac{MPC^B}{MPC^S}$$

(iii) A policymaker can achieve a Pareto improvement on any decentralized equilibrium with binding constraints in which savers achieve utility $U^{S,DE}$ *by solving the planning problem*

$$\max_{C_0^i, B_1^i} u\left(C_{T,0}^B\right) + V^B\left(M^B; M^B, M^S\right) \quad s.t. \qquad \sum_{i\in\{B,S\}} \left(C_{T,0}^i + B_1^i - B_0^i - Y_{T,0}^i\right) \leq 0$$
$$u\left(C_{T,0}^S\right) + V^S\left(M^S; M^B, M^S\right) \geq U^{S,DE}$$

and implementing it using a pair of taxes and lump-sum transfers as described in (i).

Proof. For (i) we observe that the planner can implement a given constrained efficient equilibrium by setting T^i such that $c_{T,0}^i + M^i + T^i = b_0^i + y_{T,0}^i + y_{T,1}^i \forall i$ and setting the pair of taxes equal to

$$\tau^B = \frac{\lambda^B}{u_{T,0}^B} \cdot \frac{\Phi_B^B}{1 + R_B^B - R_S^B} \qquad \tau^S = \frac{\lambda^B}{u_{T,0}^B} \cdot \frac{\Phi_S^B}{1 + R_B^B - R_S^B} \tag{20}$$

Given these tax rates, the optimality conditions of private agents coincide with the planner's intertemporal optimality conditions (18) and (19).

For (ii), by substituting out the definition of Φ_i^B from equation (13) in the expressions for the optimal taxes in equation (20), we see that $\tau^B/\tau^S = \frac{\partial p}{\partial M^B} / \frac{\partial p}{\partial M^S}$. In turn, the relative impact of agents' net worth on the price level depends on their marginal propensity to consume, thus delivering the result.

For (iii), note that if we assign γ^S as the shadow price on the constraint $U^S \geq U^{S,DE}$ and set $\gamma^B = 1$, then the described optimization problem coincides with the planner's optimization problem (14). In equilibrium, the constraint $U^S \geq U^{S,DE}$ will hold with equality and will guarantee that savers are equally well off. Since the initial allocation is feasible for the planner but the planner does not choose it, borrower welfare is strictly higher and the planner's allocation constitutes a Pareto improvement. It can be implemented as described in (i). ■

How can the tax instruments $\left(\tau^B, \tau^S\right)$ be mapped into macroprudential regulation and capital controls? As illustrated in Figure 1, capital controls impose a wedge between all domestic agents and foreigners so as to segment domestic and international financial markets. This implies that capital controls increase both τ^B and τ^S. By contrast, macroprudential measures increase the rate at which domestic agents borrow but do not affect the rate at which savers lend. Therefore they increase τ^B but do not affect τ^S. These considerations imply the following mapping between $\left(\tau^B, \tau^S\right)$ and $\left(\tau^{CC}, \tau^{MP}\right)$:

$$\begin{aligned} 1-\tau^S &= \left(1-\tau^{CC}\right) \\ 1-\tau^B &= \left(1-\tau^{CC}\right)\left(1-\tau^{MP}\right) \end{aligned}$$

Corollary 4 *The regulated equilibrium described in Corollary 3 can also be implemented by setting the economy's level of capital controls to $\tau^{CC}=\tau^S$ and setting the level of macroprudential regulation to fill the gap between τ^S and τ^B so that $1-\tau^{MP}=\left(1-\tau^B\right)/\left(1-\tau^S\right)$.*

Proof. See discussion above. ■

2.5 Uncertainty

This section extends our earlier analysis to explicitly account for uncertainty. Our baseline setup described the simplest framework possible to zero in on the imperfections created by exchange rate depreciations by assuming perfect foresight. However, it goes without saying that the occurrence of financial crises in practice involves a considerable amount of uncertainty. In this section, we explicitly account for this.

We assume there is a stochastic shock $\omega \in \Omega$ that is realized at the beginning of period 1 and that affects either the period 1 traded income of domestic agents $y^i_{T,1}(\omega)$ or the tightness of the financial constraint $\phi(\omega)$. We assume that the lowest realization of the two shocks is sufficiently low to make the financial constraint on borrowers binding.

In the following, we focus first on the case of complete markets in period 0 in which private agents can make their privately optimal insurance decisions against the stochastic shock ω. Next we will assume that the period 0 financial market is incomplete and domestic agents can only borrow or save in uncontingent bonds.

2.5.1 Complete Markets

We assume that private agents can borrow or save with foreigners in a complete market of Arrow securities in period 0. We denote the contracted payoff that agent i receives in state of nature ω by $b^i_1(\omega)$ and observe that foreigners are willing to sell this payoff at a price of $E\left[b_1^i(\omega)\right]$ in period 0. We use our earlier definition of the reduced-form utility $V^i(\cdot)$ to express the optimization problem of private agents as

$$\max_{b_1^i(\omega)} u\left(b_0^i + y_{T,0}^i - E\left[b_1^i(\omega)\right]\right) + E\left[V^i\left(m^i(\omega); M^B(\omega), M^S(\omega), \phi(\omega)\right)\right] \tag{21}$$

where $m^i(\omega) = y_{T,1}^i(\omega) + b_1^i(\omega)$ and $\left(M^B(\omega), M^S(\omega)\right)$ are now stochastic and private agents take the latter as given. Given $m^i(\omega)$ and $\left(M^B(\omega), M^S(\omega), \phi(\omega)\right)$, the utility of domestic agents and the associated allocations in periods 1 and 2 are fully characterized by the optimization problem $V\left(m^i; M^B, M^S\right)$ with $\phi(\omega)$ that we defined in section 2.2.

Private agents choose their Arrow security holdings $b_1^i(\omega)$ according to the standard Euler equation

$$u_{T,0}^i = u_{T,1}^i(\omega) \tag{22}$$

They find it optimal to perfectly smooth consumption between periods 0 and 1 and across all states of nature in period 1, given the risk-neutrality of foreigners and the availability of actuarially fair insurance. However, in states of nature in which the financial constraint is binding, optimal consumption smoothing between periods 1 and 2 is inhibited.

Let us contrast the decentralized equilibrium with the solution chosen by a constrained planner under uncertainty. As before, a constrained social planner maximizes the weighted sum of domestic welfare

$$\max_{C_{T,0}^i, B_1^i(\omega)} \sum_{i\in\{B,S\}} \gamma^i \left\{u\left(C_{T,0}^i\right) + E\left[V^i\left(m^i(\omega); M^B(\omega), M^S(\omega), \phi(\omega)\right)\right]\right\} \tag{23}$$

$$\text{s.t.} \sum_{i\in\{B,L\}} \left(C_{T,0}^i + E\left[B_1^i(\omega)\right] - B_0^i - Y_{T,0}^i\right) \leq 0\ ,\ m^i(\omega) = M^i(\omega) = Y_{T,1}^i(\omega) + B_1^i(\omega)$$

The planner's intra- and inter-temporal optimality conditions can be written as a state-contingent version of equations (15) and (16) or (17). The resulting allocations mirror our findings in Proposition 2:

Proposition 5 (Underinsurance) *Any constrained efficient allocation in the domestic economy satisfies*

$$\frac{u_{T,1}^i(\omega)}{u_{T,0}^i} = 1 - \frac{\lambda^B(\omega)}{u_{T,0}^B} \frac{\Phi_i^B(\omega)}{1 + R_B^B(\omega) - R_S^B(\omega)} \quad \textit{for } i \in \{B,S\} \tag{24}$$

Proof. The proof follows along the same lines as the Proof of Proposition 2. ■

Equation (24) reflects that the planner does not deviate from the optimal smoothing condition (22) of private agents as long as the financial constraint of borrowers is loose so

$\lambda^B = 0$ and the last term in the equation drops out. However, in states of nature in which the financial constraint is binding, $\lambda^B > 0$, the planner acts in a more precautionary manner and introduces a wedge in the marginal rate of substitution of both sets of private agents in period 0, i.e. $u^i_{T,0} > u^i_{T,1}(\omega)$. As before, the wedge is larger for borrowers than for savers.

Intuitively, the planner insures more against states of nature with binding constraints than private agents. She carries greater net worth for both agents into constrained states of nature in period 1 in order to push up the exchange rate and relax the financial constraint. This creates a deviation from optimal smoothing between periods 0 and 1 in those states but enables better smoothing between periods 1 and 2.

Our result on underinsurance in the decentralized equilibrium underline that capital controls and macroprudential policy measures need to be sensitive to the riskiness of financial transactions. In a stochastic world, the pecuniary externality induces borrowers to take on excessively risky liabilities, e.g. dollar debt instead of local currency debt and equity; it induces savers to hold insufficient insurance, e.g. insufficient dollar reserves compared to risky local currency assets. Uncontingent dollar debt contracts that require repayments even in bad states of nature therefore impose larger externalities and call for higher levels of regulation, whereas contingent financial instruments that provide insurance (e.g. equity) create much smaller externalities. This mirrors the findings of Korinek (2010, 2011) on the desirability of risk-sensitive capital controls and macroprudential regulations.

2.5.2 Incomplete Markets

In practice, emerging economies frequently have limited access to insurance instruments against aggregate risk. We capture this in the current subsection by assuming that domestic agents can only borrow or save in uncontingent bonds, even though their traded income $y^i_{T,1}(\omega)$ in period 1 and the tightness of the borrowing constraint $\phi(\omega)$ are stochastic.

The optimization problem of domestic agents is identical to problem (21) except that the choice variable is now the uncontingent bond holdings b^i_1 instead of $b^i_1(\omega)$ so that $m^i(\omega) = y^i_{T,1}(\omega) + b^i_1$ and similarly for $M^i(\omega)$. Private agents choose their bond position b^i_1 so as to smooth the expected marginal utility of traded consumption, according to the standard Euler equation

$$u^i_{T,0} = E\left[u^i_{T,1}(\omega)\right]$$

The problem of a planner can also be expressed analogously to problem (23) with the uncontingent bond holdings b^i_1 replacing $b^i_1(\omega)$. The inter-temporal optimality condition of the planner is

$$\gamma^i u^i_{T,0} = \gamma^i E\left[u^i_{T,1}\right] + E\left[\left(\gamma^i u^i_{T,1} - \gamma^j u^j_{T,1}\right) R^i_i\right] + \gamma^B E\left[\lambda^B \Phi^B_i\right]$$
$$= \gamma^i E\left[u^i_{T,1}\right] + E\left(\gamma^i u^i_{T,1} - \gamma^j u^j_{T,1}\right) E\left[R^i_i\right] + Cov\left(\gamma^i u^i_{T,1} - \gamma^j u^j_{T,1}, R^i_i\right) + \gamma^B E\left[\lambda^B \Phi^B_i\right] \tag{25}$$

As in our earlier analysis, saving one additional unit of net worth in period 0 in the uncontingent bond has three effects in period 1: it reduces the expected marginal utility of traded consumption; it leads to a change in the exchange rate and an expected redistribution between the two agents; and it leads to an expected relaxation in the collateral constraint. Notice that we can express the redistributive effect as the sum of the expected redistribution plus a covariance term. To sign the latter, recall that $R^B_i = \partial p/\partial M^i \cdot (y^B_{N,1} - c^B_{N,1})$ where $\partial p/\partial M^B > 0$ is constant. Therefore

$$Cov\left(\gamma^B u^B_{T,1} - \gamma^S u^S_{T,1}, R^B_B\right) = \partial p/\partial M^i \cdot Cov\left(\gamma^B u^B_{T,1} - \gamma^S u^S_{T,1}, y^B_{N,1} - c^B_{N,1}\right)$$

Notice that when borrowers are constrained, both the gap between marginal utilities $\gamma^B u^B_{T,1} - \gamma^S u^S_{T,1}$ and the amount of their fire sales $y^B_{N,1} - c^B_{N,1}$ are above average and vice versa. Therefore the covariance term is generally positive.

The following proposition characterizes how the planner will optimally intervene in an economy with incomplete markets:

Proposition 6 (Excessive Leverage, Incomplete Markets) *Any constrained efficient allocation in the domestic economy with uncertainty and bond markets only satisfies*

$$\frac{E\left[u^i_{T,1}(\omega)\right]}{u^i_{T,0}} = 1 - \frac{E\left[\lambda^B(\omega)\Phi^B_i(\omega)\right] + Cov\left(\gamma^B u^B_{T,1}(\omega) - \gamma^S u^S_{T,1}(\omega), R^B_i(\omega)\right)/\gamma^B}{u^B_{T,0} \cdot \left(1 + E\left[R^B_B(\omega) - R^B_S(\omega)\right]\right)}$$

Proof. We combine the inter-temporal optimality conditions (25) for the two agents to find

$$E\left[\gamma^B u^B_{T,1} - \gamma^S u^S_{T,1}\right] = -\frac{E\left[\gamma^B \lambda^B \left(\Phi^B_B - \Phi^B_S\right)\right] + Cov\left(\gamma^B u^B_{T,1} - \gamma^S u^S_{T,1}, R^B_B - R^B_S\right)}{1 + E\left[R^B_B - R^B_S\right]}$$

Plugging this expression back into (25) and simplifying terms by using $R^B_S = R^B_B/2$ and $\Phi^B_S = \Phi^B_B/2$ delivers the planner's optimal wedges. ■

Since the covariance term is positive, the wedge imposed by the planner is greater under incomplete markets than what is suggested by the expected tightness of constraints

$E\left[\lambda^B \Phi_B^B\right]$. Intuitively, the covariance term captures that shoring up the net worth of domestic agents has the greatest redistributive effects when borrowers are most constrained since they cannot insure. This increases the incentive of the planner to shore up the net worth of both agents.

2.6 Numerical illustration

In this section, we calibrate the model with uncertainty of Section 2.5.2 to replicate the dynamics of the countries affected by the East Asian crisis of 1997 that we depicted in Figure 3.[10] We use this to solve for the optimal capital control and macroprudential taxes and investigate several comparative statics.

We set the endowment income of all agents so that the economy is in a steady state with constant gross borrowing and saving positions if it does not experience binding financial constraints. In particular, we assume that both agents receive endowments of equal value every time period, $Y^i_{T,0} = 1$, $Y^i_{T,1} = \alpha$, $Y^i_{N,1} = 1 - \alpha$, and $Y_{T,2} = 1$, where we use $\alpha = 0.3$ for the weight of traded goods in period 1 consumption. Moreover, we assume that agents exit period 2 with the same amount of debt $B^i_3 = B^i_0$ that they enter with in period 0.[11] This ensures that gross debt and savings remain constant over time so that $B^i_0 = B^i_1 = B^i_2 = B^i_3$ for $i = B, S$ if financial constraints are non-binding, and that the real exchange rate in period 1 is $p = 1$ and GDP in every period is 2.

We calibrate the initial debt of borrowers and the initial savings of savers to replicate the average net foreign asset (NFA) position of East Asian crisis countries over the five years prior to the crisis of -40 percent of GDP. Initially, we take the most conservative approach and assume that borrowers carry all this debt (so $B^B_0 = -0.8$) and savers have no asset holdings (so $B^S_0 = 0$). Then we illustrate that increases in wealth heterogeneity, i.e. assuming that borrowers have greater debt and savers correspondingly greater asset holdings so that the net foreign asset position remains constant, implies that the model predicts higher optimal capital controls and macroprudential taxes.

We assume that there are two states of nature in period 1 where the financial constraint ϕ can take a high or low (sudden stop) value. We set the probability of the sudden stop state equal to $\pi = 5 percent$, consistent with a long-run crisis probability of 5 percent per year as found by Reinhart and Rogoff (2008). In our baseline, we calibrate $\phi(L) = 0.65$ so the model matches the current account surplus of 10 percent and the exchange rate depreciation of 25

[10]As shown by Korinek (2010) and Korinek and Mendoza (2014) and as illustrated by the optimal tax formulas (20), what matters for the magnitude of optimal policy interventions in this class of models is the tightness of borrowing constraints and the response of the borrowing capacity to greater net worth. This is true both in infinite horizon versions and in three period versions of the model like ours. Our calibration is therefore a useful guide for policymakers in countries that find themselves at risk for comparable financial instability to the East Asian crisis countries prior to the 1997 crisis.

[11]In the model setup described above, this is equivalent to setting $Y^i_{T,2} = 1 - B^i_0$.

percent during the East Asian crisis, as illustrated in Figure 3. In the "high" state of nature we assume that $\phi(H) = \infty$ so that the borrowing constraint is always loose, representing good times when world capital markets are flush with liquidity. The parameter values are summarized in Table 1.

α	$Y^i_{T,0}$	$Y^i_{T,1}$	$Y^i_{N,1}$	$Y^i_{T,2}$	B^B_0	B^S_0	π	$\phi(L)$	$\phi(H)$
0.3	1	α	$1-\alpha$	1	-0.8	0	0.05	0.65	∞

Table 1: Baseline Calibration

Under this parameterization, our model predicts optimal taxes on borrowers $\tau^B = 4$ percent and on savers $\tau^S = 2$ percent. This translates into capital control and macroprudential taxes of 2 percent each. Implementing these policy measures reduces the current account reversal during the crisis by about 2 percent and keeps the real exchange rate by about 4 percent more appreciated. These effects may seem relatively small when compared with the overall adjustment of the current account and exchange rate. However, it is important to keep in mind that the purpose of prudential policy intervention is not to completely avoid macroeconomic adjustment, but to smooth excess volatility by internalizing the externalities associated with it.

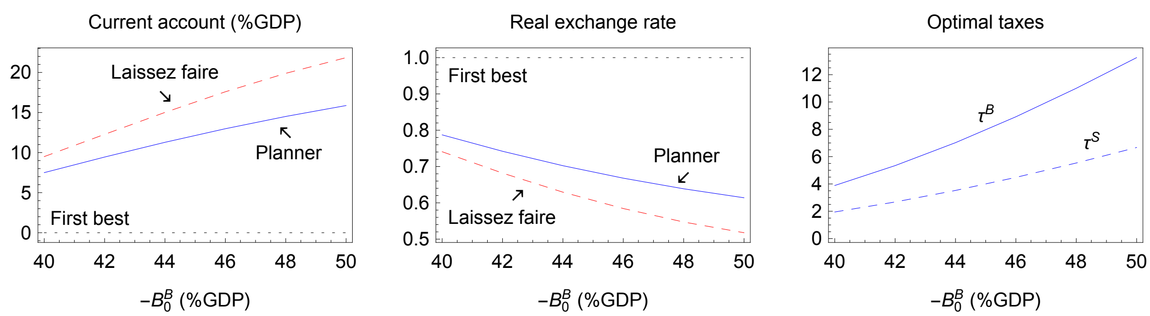

Figure 5: Effects of Increasing Wealth Inequality

Figure 5 shows the implications of increases in wealth heterogeneity $|B^S_0 - B^B_0|$ while holding all other parameters constant. In particular, we increase both the initial debt stock of borrowers from 40 to 50 percent of GDP and the initial savings of savers from 0 to 10 percent of GDP. The left two panels of the figure show the current account and the real exchange rate in the low state of period 1 as a function of wealth heterogeneity. The dashed (red) lines depict the decentralized equilibrium allocation, whereas the solid (blue) lines depict the planner's optimal allocation. For comparison, the dotted (black) lines indicate what the first-best equilibrium in the absence of financial constraints would look like. The third panel indicates the optimal taxes on borrowers (solid lines) and savers (dashed lines) that implement the planner's allocation. The vertical axis ($B^B_0/GDP = -40$

percent) corresponds to our baseline calibration. As we increase wealth heterogeneity from there, borrowers become more and more constrained, leading to deeper crises, i.e. greater current account reversals and real exchange rate depreciations. This in turn calls for higher optimal macroprudential taxes and capital controls. Increasing wealth heterogeneity by just 10 percent of GDP (i.e. setting $B_0^B = -1$ and $B_0^S = 0.2$) more than doubles the current account reversal and real depreciation, and increases optimal taxes by more than threefold.[12]

We also performed a comparative static exercise with respect to the parameter $\phi(L)$. A graph of the exercise is presented in Figure 6. The borrowing constraint is loose for $\phi(L) \geq 0.8$, allowing the economy to replicate the first-best allocation so no policy intervention is required. For lower values of $\phi(L)$, the economy experiences a current account surplus and real depreciation as borrowers are forced to deleverage, with the magnitude of the effect increasing with the tightness of the borrowing limit, i.e. the lower $\phi(L)$.

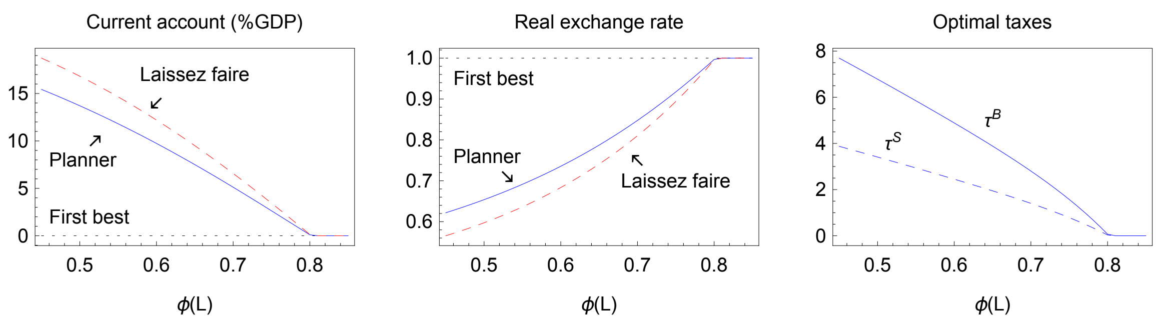

Figure 6: Effects of Increasing Borrowing Limit

3 Asset Price Externalities

Borrowing constraints that are linked to asset prices can give rise to vicious cycles and pecuniary externalities similar to those that arise from exchange rate depreciations. We have shown so far that externalities linked to contractionary exchange rate depreciations call for both macroprudential regulation and capital controls. Although such contractionary depreciations are relevant in emerging markets economies (especially those with significant foreign currency debts), they play less of a role in advanced economies where exchange rates tend to be more stable and debt is issued in domestic currency. However, advanced economies are nonetheless vulnerable to feedback loops triggered by falling asset prices,

[12] If the increase in wealth heterogeneity is accompanied by a simultaneous increase in borrowing capacity in the low state to $\phi(L) = 0.9$ in order to match the current account and real depreciation from the 1997 crisis, the optimal capital controls and macroprudential taxes would increase only to 3.1 percent. The intuition is that borrowers are less constrained, the crisis is less severe, and so the required policy intervention is less.

tightening collateral constraints, and fire sales, as illustrated in Figure 7. These can also give rise to pecuniary externalities.

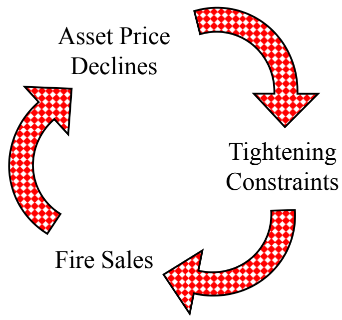

Figure 7: Feedback loop of financial crises with deflation of capital prices

This section shows that macroprudential regulation alone is sufficient to address pecuniary externalities linked to fire sales in asset prices. This contrasts with our baseline model in which pecuniary externalities are driven by exchange rate depreciations. The key insight of the section is that fire sales and asset prices are determined solely by the net worth of borrowers; therefore there is no economic rationale for shoring up the net worth of savers, and capital controls are superfluous.

We drop non-traded goods from our baseline model and assume instead that agents obtain an endowment k_1^i of capital goods that are traded domestically in period 1 and produce output according to a production function $F^i\left(k_2^i\right)$ in period 2. In order to generate the potential for fire sales, we assume that the production function of savers is inferior to that of borrowers. Specifically, we assume $F^B\left(k_2^B\right) = Ak_2^B$ and $F^{S\prime}(0) = A$ but $F^{S\prime\prime}\left(k_2^S\right) < 0$, where we use one and two prime symbols to denote the first and second derivative. In other words, borrowers have a linear production and savers are equally productive in employing the first marginal unit of asset but experience decreasing returns thereafter.

The utility function and the budget constraints of domestic agents $i \in \{B, S\}$ define the following optimization problem:

$$\begin{aligned} \max U^i \quad \text{s.t.} \quad c_{T,0}^i + b_1^i &= b_0^i + y_{T,0}^i \\ c_{T,1}^i + b_2^i &= b_1^i + y_{T,1}^i + q(k_1^i - k_2^i) \\ c_{T,2}^i &= b_2^i + y_{T,2}^i + F^i(k_2^i) \end{aligned}$$

where q is the price at which capital goods trade in period 1 so that $q(k_1^i - k_2^i)$ constitutes the revenue derived from fire sales.

We follow Jeanne and Korinek (2010ab) in assuming that borrowers can borrow up to a fraction ϕ of the period 1 value of their capital asset holdings,

$$-b_2^B \leq \phi q k_2^B$$

The first order conditions of private agents include the standard Euler conditions

$$\begin{aligned} u_{T,0}^i &= u_{T,1}^i \\ u_{T,1}^i &= u_{T,2}^i + \lambda^i \end{aligned}$$

and the optimality condition for capital asset purchases, which pins down the price of capital

$$q = \frac{u_{T,2}^i F^{i\prime}(k_2^i)}{(1-\phi)u_{T,1}^i + \phi u_{T,2}^i} = \frac{F^{i\prime}(k_2^i)}{\phi + (1-\phi)u_{T,1}^i / u_{T,2}^i} \tag{26}$$

The price q equals the marginal product of capital discounted by the marginal rate of substitution, where only a fraction $(1-\phi)$ of the asset needs to be financed with period 1 funds and a fraction ϕ can be financed by borrowing from period 2. The asset price is therefore inversely related to consumption growth between period 1 and 2, which reflects the tightness of the borrowing constraint.

Characterizing the Decentralized Equilibrium

Since savers are unconstrained, it follows that $\lambda^S = 0$ and $u_{T,1}^S = u_{T,2}^S$. This also implies that savers simply set the marginal product of capital equal to the market price

$$q = F^{S\prime}(k_2^S)$$

This is an implication of the Fisherian separation between consumption and investment that applies to unconstrained agents. Therefore, changes in the net worth of savers M^S have no impact on asset prices

$$\frac{\partial q}{\partial M^S} = 0$$

Similarly, changes in net worth of borrowers M^B have no effect on asset prices if the financial constraint is loose. In this case, borrowers purchase the whole stock of capital since they have a better production technology, and the unconstrained asset price is given by $q = A$.

If instead borrowers are constrained, they face a trade-off between consuming and purchasing capital. Savers still set their marginal product of capital equal to q, but borrowers reduce capital in proportion to the tightness of the constraint as in equation (26). This generates a reallocation of capital from borrowers to savers which lowers asset prices below their unconstrained level A.

As shown in Appendix A.2, an increase in the net worth M^B of constrained borrowers leads under mild regularity conditions to higher capital prices,

$$\frac{\partial q}{\partial M^B} > 0$$

Higher net worth raises borrowers' demand for capital that increases asset prices and in turn relaxes borrowing constraints. We summarize the above considerations in the following lemma:

Lemma 7 *(i) The asset price q is independent of the liquid net worth M^S of savers, i.e. $\partial q/\partial M^S = 0$.*

(ii) As long as borrowers are unconstrained, the asset price equals $q = A$ and is independent of the net worth of borrowers. If borrowers are constrained, the asset price is an increasing function of the liquid net worth of borrowers,

$$\frac{\partial q}{\partial M^B} > 0 \tag{27}$$

Proof. See discussion above. ■

When borrowers are constrained, an increase in M^B, by rising asset prices, triggers redistributive effects and relaxes the borrowing constraint. The redistributive effect on borrowers is captured by:

$$R_B^B = \frac{\partial q}{\partial M^B}\left(k_1^B - k_2^B\right)$$

which is positive if borrowers are net sellers of capital and negative otherwise. Similarly to the model with exchange rate externalities, we assume

Assumption 3 $1 + R_B^B > 0$

This ensures that providing one extra dollar to borrowers does not immiserize them by reducing their wealth through large negative redistributive effects. The impact of higher M^B on the borrowing constraint is captured by

$$\Phi_B^B = \frac{\partial q}{\partial M^B}\phi k_2^B > 0$$

Characterizing the Planner Solution

The setup of the planner's problem is analogous to the one described in section 2.3. In choosing the Pareto efficient allocation, the planner takes into account that changes in M^S have no effect on asset prices, and thus do not trigger redistributive effects, $R_S^B = 0$, and do not affect borrowing constraints, $\Phi_S^B = 0$. The planner has therefore no reason to distort savers' intertemporal decisions and the planner's Euler equation for savers is identical to the laissez-faire optimality condition:

$$u^S_{T,0} = u^S_{T,1}$$

However, the planner still intervenes in the financial decisions of borrowers when the constraint is binding. Greater liquidity M^B increases borrowers' demand for capital and raises asset prices. The planner's Euler equation for borrowers (18) is:

$$u^B_{T,0} = u^B_{T,1} + \lambda^B \frac{\Phi^B_B}{1 + R^B_B}$$

Given Assumption 3 and $\lambda^B \Phi^B_B > 0$, the planner's wedge raises $u^B_{T,0}/u^B_{T,1}$ which limits borrowing at time 0.

The social planner thus shores up the liquid net worth of borrowers so as to reduce asset fire sales without distorting the inter-temporal decisions of lenders. Intuitively, this is because an increase in the net worth of borrowers supports asset prices and relaxes borrowing constraints, whereas the net worth of savers is inconsequential for asset prices. The willingness of savers to purchase assets in period 1 depends on their production function and on the interest rate at which they are able to fund asset purchases, which is determined on world markets and does not depend on their net worth since savers are unconstrained. Therefore there is no reason for the planner to distort their intertemporal allocation in period 0.

Corollary 8 (Asset Price Externalities) *In a model in which financial constraints are linked to asset prices, a planner imposes macroprudential restrictions on borrowers,*

$$\tau^{MP} = \tau^B = \frac{\lambda^B}{u^B_{T,0}} \cdot \frac{\Phi^B_B}{1 + R^B_B} > 0,$$

but does not impose capital controls so $\tau^{CC} = \tau^S = 0$.

Proof. See discussion above and Corollary 4. ■

4 Conclusions

This paper has analyzed the desirability of capital controls versus macroprudential regulation in mitigating financial instability. Our main finding is that it is necessary to use both instruments in emerging economies that are at risk of contractionary exchange rate depreciations. To limit such depreciations, a planner finds it optimal to impose both capital controls and macroprudential regulation. Imposing capital controls raises the net worth of both domestic borrowers and savers. Macroprudential regulation raises the net worth of borrowers even further, which is desirable because constrained borrowers have a higher marginal propensity to consume than unconstrained savers. Capital control and macroprudential taxes should be optimally varied over time depending on the risk of financial instability. In our model, this risk is primarily affected by the level of debt, the degree of wealth inequality, and the incidence of adverse shocks.

We have also considered the case of pecuniary externalities linked to asset prices. In advanced economies, where fluctuations in real exchange rates are less destabilizing, there is still a role for policy intervention in order to avoid boom and bust cycles in asset prices. To address these externalities, a planner finds it optimal to increase the net worth of domestic borrowers, but has no reason to intervene on domestic savers because the net worth of domestic savers has no influence on their demand for capital and thus on asset prices because of the Fisherian separation between consumption and investment decisions. Macroprudential regulation is thus sufficient to deal with externalities linked to asset prices.

There are a number of issues that are beyond the scope of the current paper. First, our paper distinguishes between capital controls and macroprudential regulation based on one specific dimension along which borrowing from foreign and domestic lenders differs – the exchange rate effects that they generate. Although contractionary movements in exchange rates are of utmost importance during financial crises, there is a range of additional dimension that are relevant. For example, borrowing from domestic and foreign lenders likely leads to different bailout and risk-shifting probabilities and generates different incentive effects. They also lead to different aggregate demand effects. Furthermore, when interacting with international lenders, considerations about market power that are absent in domestic lending relationships may come into play. It may also be desirable to regulate borrowing from domestic or foreign lenders differently when the residency of the lender correlates with features that cannot be directly observed, such as the flightiness of funds, or that cannot be targeted directly because restrictions on regulatory instruments. Finally, differences in the ability to circumvent taxation, reputational considerations, or the structure of financial intermediation may also affect the balance between capital controls and macroprudential regulation.

Secondly, there are additional policy measures that have sometimes been used in a prudential manner. For example, reserve accumulation may be helpful to stem real appreciation if international capital markets are sufficiently segmented to prevent arbitrage; contractionary monetary policy may be able to prick bubbles; fiscal consolidation may prevent an economy from overheating. Ostry et al. (2010) and Blanchard et al. (2014) discuss several of these options. It would be interesting to analyze in future research the interaction of these policies with capital controls and macroprudential regulation. For example, Korinek and Simsek (2014) show that when monetary policy is constrained by the zero lower bound, it is crucial to adopt macroprudential measures to stem against excessive leverage.

Thirdly, our paper focuses on prudential interventions to mitigate crisis risk, i.e. policy measures that are taken in good times in order to reduce the risk and magnitude of crises in response to bad shocks in the future. There is a complementary literature that focuses on ex-post policy measures (see e.g. Benigno et al., 2010, 2012, 2013ab; Jeanne and Korinek, 2013) that are taken if a country experiences a financial crisis. This is particularly relevant for the analysis of capital controls since many countries (including e.g. Iceland and Cyprus) have used controls on outflows as a crisis management tool.

References

Alfaro, Laura, Anusha Chari and Fabio Kanczuk, 2014, "The Real Effects of Capital Controls: Liquidity Constraints and Firm Investment," *manuscript, Harvard.*

Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric R. Young, 2010, "Revisiting Overborrowing and Its Policy Implications", in Central Bank of Chile: *Analysis and Economic Policies Series*, Vol. 14.

Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric R. Young, 2012, "Optimal Policy for Macro-Financial Stability," *manuscript, LSE.*

Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric R. Young, 2013a, "Capital Controls or Real Exchange Rate Policy? A Pecuniary Externality Perspective," *manuscript, LSE.*

Benigno, Gianluca, Huigang Chen, Christopher Otrok, Alessandro Rebucci, and Eric R. Young, 2013b, "Central Bank of Chile"Financial Crises and Macro-Prudential Policies", *Journal of International Economics* 89(2), pp. 453-470.

Bianchi, Javier, 2011, "Overborrowing and Systemic Externalities in the Business Cycle," *American Economic Review* 101(7), pp. 3400-3426.

Bianchi, Javier, and Enrique Mendoza, 2010, "Overborrowing, Financial Crises and 'Macro-prudential' Taxes," *NBER Working Paper w16091.*

Blanchard, Olivier J., Jonathan D. Ostry, Atish R. Ghosh, and Marcos Chamon, 2014, "Capital Flow Management," *manuscript.*

Caballero, Ricardo J., and Arvind Krishnamurthy, 2003, "Excessive Dollar Borrowing: Financial Development and Underinsurance," *Journal of Finance* 58(2), pp. 867-894.

Claessens, Stijn, Swatish R. Ghosh, Roxana Mihet, 2013, "Macro-Prudential Policies to Mitigate Financial System Vulnerabilities," *Journal of International Money and Finance* 39, pp. 153–185.

Farhi, Emmanuel and Iván Werning, 2012, "Dealing with the Trilemma: Optimal Capital Controls with Fixed Exchange Rates," *NBER Working Paper* w18199.

Farhi, Emmanuel and Iván Werning, 2013, "A Theory of Macroprudential Policies in the Presence of Nominal Rigidities," *NBER Working Paper* w19313.

Farhi, Emmanuel and Iván Werning, 2014, "Dilemma not Trilemma? Capital Controls and Exchange Rates with Volatile Capital Flows," *manuscript, Harvard.*

Federico, Pablo M., Carlos A. Végh and Guillermo Vuletin, 2013, "Effects and Role of Macroprudential Policy: Evidence from Reserve Requirements Based on a Narrative Approach," *manuscript, Johns Hopkins University.*

Forbes, Kristin, Marcel Fratzscher and Roland Straub, 2013, "Capital Controls and Macro-prudential Measures: What Are They Good For?" *DIW Discussion Paper* 1343.

Galati, Gabriele, and Richhild Moessner, 2013, "Macroprudential policy – a literature review, "*Journal of Economic Surveys* 27(5), pp. 846-878.

IMF, 2012, The Liberalization and Management of Capital Flows: An Institutional View, Washington, DC.

Jeanne, Olivier, 2014, "Macroprudential Policies in a Global Perspective," *NBER Working Paper* w19967.

Jeanne, Olivier, and Anton Korinek, 2010a, "Excessive Volatility in Capital Flows: A Pigouvian Taxation Approach," *American Economic Review P&P*, pp. 403-407.

Jeanne, Olivier, and Anton Korinek, 2010b, "Managing Credit Booms and Busts: A Pigouvian Taxation Approach,"*NBER Working Paper* w16377.

Jeanne, Olivier, and Anton Korinek, 2013b, "Macroprudential Regulation versus Mopping Up After the Crash,"*NBER Working Paper* w18675.

Keynes, John M., 1929, "The German Transfer Problem," *Economic Journal* 39(1929), pp. 1-7.

Korinek, Anton, 2007, "Excessive Dollar Borrowing in Emerging Markets,"*manuscript, University of Maryland.*

Korinek, Anton, 2010, "Regulating Capital Flows to Emerging Markets: An Externality View," *manuscript, University of Maryland.*

Korinek, Anton, 2011a, "The New Economics of Prudential Capital Controls," IMF Economic Review 59(3), pp. 523-561.

Korinek, Anton, 2011b, "Systemic Risk-Taking: Amplification Effects, Externalities, and Regulatory Responses,"*ECB Working Paper* 1345.

Korinek, Anton and Alp Simsek, 2014, "Liquidity Trap and Excessive Leverage,"*NBER Working Paper w*19970.

Lorenzoni, Guido, 2008, "Inefficient Credit Booms," *Review of Economic Studies* 75(3), pp. 809-833.

Magud, Nicolas E., Carmen M. Reinhart, and Kenneth S. Rogoff, 2011, "Capital Controls: Myth and Reality - A Portfolio Balance Approach," *NBER Working Paper* w16805.

Mendoza, Enrique G., 2002, "Credit, Prices and Crashes: Business Cycles with a Sudden Stop," in S. Edwards and J. Frankel (editors), *Preventing Currency Crises in Emerging Markets,* pp. 335-392, NBER, University of Chicago Press.

Ohlin, Bertil, 1929, "The German Transfer Problem: A Discussion," *Economic Journal* 39(1929), pp. 172-182.

Ostry, Jonathan D., Atish R. Ghosh, Karl Habermeier, Marcos Chamon, Mahvash S. Qureshi and Dennis B.S. Reinhardt, 2010, "Capital Inflows: The Role of Controls," *IMF Staff Position Note* 10/04.

Ostry, Jonathan D., Atish R. Ghosh, Karl Habermeier, Luc Laeven, Marcos Chamon, Mahvash S. Qureshi and Annamaria Kokenyne (2011), "Managing Capital Inflows: What Tools to Use?" *IMF Staff Discussion Note* 11/06.

Schmitt-Grohe, Stephanie and Martin Uribe, 2012, "Prudential Policy for Peggers," *NBER Working Paper* w18031.

A Mathematical Appendix

A.1 Model with Non-Traded Goods

The technical condition that characterizes the upper limit $\hat{\phi}$ on the pledgeability parameter in the model with non-traded goods is

$$Y_{N,1} - (1-\alpha)\left[Y_{N,1}^{B}(1+\hat{\phi}) + Y_{N,1}^{S}/2\right] = 0$$

Given this definition, the assumption $\phi < \hat{\phi}$ implies that the denominator D in expression (12) is strictly positive so as to avoid degenerate equilibria.

The unconstrained region, i.e. the set of $\left(M^B, M^S\right) \in \mathcal{M}^{unc}$, is determined by the fact that the borrowing level that ensures perfect consumption smoothing is no greater than the constrained limit:

$$\frac{1}{2}\left(M^B + pY_{N,1}^B - Y_{T,2}^B\right) \geq -\phi\left(Y_{T,1}^B + pY_{N,1}^B\right)$$

By substituting out the definition of the price level in the unconstrained region:

$$p = \frac{1-\alpha}{1+\alpha}\left(M^B + M^S + Y_{T,2}\right)$$

where $Y_{T,2} = Y_{T,2}^B + Y_{T,2}^S$, we can derive the following inequality that pins down the set $\left(M^B, M^S\right) \in \mathcal{M}^{unc}$

$$M^B\left(\frac{1}{2} + Y_{N,1}^B\frac{1-\alpha}{1+\alpha}\left(\frac{1}{2}+\phi\right)\right) + M^S Y_{N,1}^B\frac{1-\alpha}{1+\alpha}\left(\frac{1}{2}+\phi\right) \geq \frac{Y_{T,2}^B}{2} - \phi Y_{T,1}^B - Y_{T,2}Y_{N,1}^B\frac{1-\alpha}{1+\alpha}\left(\frac{1}{2}+\phi\right)$$

A.2 Model with Capital Goods

To understand how M^B affects the price of capital goods when borrowers are constrained, note that savers set their marginal product of capital equal to the price q. Using the market clearing condition $K_2^S = K - K_2^B$, where K is the total stock of capital, we infer that

$$\frac{\partial q}{\partial M^B} = -F^{S\prime\prime}\frac{\partial K_2^B}{\partial M^B}$$

Since $F^{S\prime\prime} < 0$, we see that $\partial q/\partial M^B > 0$ if and only if $\partial K_2^B/\partial M^B > 0$. This latter derivative can be analyzed by considering that the optimality condition (26) implies

$$F^{S\prime} = \frac{F^{B\prime}}{\phi + (1-\phi)u_{T,1}^B/u_{T,2}^B}$$

where the consumption levels of constrained borrowers are given by:

$$
\begin{aligned}
C_{T,1}^{B} &= M^{B} + q(K_{1}^{B} - K_{2}^{B}) + \phi\left(Y_{T,1}^{B} + qK_{2}^{B}\right) \\
C_{T,2}^{B} &= F^{B} + Y_{T,2}^{B} - \phi\left(Y_{T,1}^{B} + qK_{2}^{B}\right)
\end{aligned}
$$

By using the implicit function theorem, we can show that

$$\frac{\partial K_{2}^{B}}{\partial M^{B}} > 0$$

if the following (sufficient but not necessary) conditions are satisfied:

$$
\begin{aligned}
\frac{\partial C_{T,1}^{B}}{\partial K_{2}^{B}} &= -F^{S\prime\prime}\left(K_{1}^{B} - K_{2}^{B} + \phi K_{2}^{B}\right) - F^{S\prime}(1-\phi) < 0 \\
\frac{\partial C_{T,2}^{B}}{\partial K_{2}^{B}} &= A - \phi\left(-F^{S\prime\prime}K_{2}^{B} + F^{S\prime}\right) > 0
\end{aligned}
$$

The first condition implies that an increase in K_{2}^{B} should come at the cost of a reduction in $C_{T,1}^{B}$. This requires placing an upper bound on the collateral parameter ϕ and ensuring that the second derivative of the savers' production function is not too high in order to limit the responsiveness of prices to the demand for capital. The second condition requires that a marginal increase in K_{2}^{B} should lead to greater net worth at time 2 and thus higher $C_{T,2}^{B}$. This condition also places an upper bound on ϕ.