Speculative Attacks and Risk Management*

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Abstract

The paper builds a simple, micro-founded model of exchange rate management, speculative attacks, and exchange rate determination. The country may defend a peg in an attempt to signal a strong currency and thereby boost the government's future re-election prospects or attract foreign capital. The paper relates the size of the speculative attack and government's defense strategy to the market's prior beliefs about the strength of the currency, the ability of foreign speculators to short sell the currency, domestic politics, and initial debt composition. Speculative activities can exhibit strategic complementarity or substitutability. Finally, features of original sin covary with the maintenance of pegs, as letting residents hedge the currency or incentivizing them to lengthen their debt maturity structure is an admission that the currency is overvalued and undoes the signal sent by defending the currency.

Keywords: Speculative attacks, hedging, financial crises.
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"The president who devalues is devalued."
–Mexican President José López Portillo, 1984[1]

1 Introduction

While no two financial crises are identical, most recent ones[2] share (at least) three key features: i) currency peg: The exchange rate is fixed at an ambitious and ultimately unsustainable rate;[3] ii) poor risk management: The corporate sector (banks and firms) is overly exposed to a depreciation of the local currency, and thus suffers from "original sin";[4] (iii) sudden stop: Capital inflows, initially large, rapidly come to a sudden halt.[5]

These familiar observations raise a host of nagging questions, such as: (i) Why do so many countries defend pegs (and floaters manage their exchange rate[6]) if capital mobility makes exchange rate management hazardous? (ii) Why is the corporate sector exposed to exchange rate risk and the concomitant threat of facing liquidity shortages? Or, even more basically, why do domestic residents not enter into insurance contracts with foreigners in which the latter would deliver dollars in bad times and receive dollars in good times? (iii) Why do international financial institutions not take more advantage of the post-crisis depreciated exchange rate to invest in the country?

This paper suggests a common signaling hypothesis as a potential answer to these questions. It builds a simple, micro-founded model of exchange rate and corporate risk management and speculative attacks on the following premises:

a) The domestic government is privately informed about variables, including its own political intentions, that affect the future exchange rate: the level of reserves (broadly defined to account for the State's off-balance sheet liabilities or the quality of reserves tied in contracts or in commodities); the political support necessary to sustain the currency's value; the government's willingness to implement structural reforms, deal with corruption or protect property rights; or the level of fiscal needs.

b) The government has preferences over the market's exchange rate expectations. This paper analyzes the case in which the government benefits from the market's perception of a strong currency, because domestic voters infer that the country is well-managed (which we will use for illustration) or this facilitates its firms' access to the international capital market (see section 7). As we discuss in the conclusion, the government's desire for the perception of

[1] Quoted in Kessler (2000).
[2] E.g., Mexico (1994), Southeast Asia (1997), Russia (1998), Brazil (1999) and Argentina (2001).
[3] See, for example, Fischer (2001) and Summers (2000).
[4] See Eichengreen and Hausmann (1999).
[5] See Calvo and Reinhart (2000).
[6] See Calvo and Reinhart (2002).

a strong currency, which we endogenize, is of course not the only case of interest, but it is certainly the relevant one for countries that underwent financial crises and motivate this paper.

c) Maintaining the peg is costly to a country with an overvalued currency as it must sell the foreign currency at an unfavorable rate, which will later on reduce the country's standard of living. Alternatively, delaying a devaluation will result in even higher bankruptcy costs or more interrupted investment projects in the future.

d) Exchange rate management is only one component of a *cluster of policy signals*. The government's equilibrium policy choices ought to be coherent in that it is irrational for the government to expend resources on policy A in an attempt to signal a strong currency and to simultaneously undo the signal through policy B. In this spirit, we endogenize the domestic residents' ability to hedge foreign exchange risk and, thereby, the source of exchange rate volatility (models of currency risk usually implicitly assume that hedging contracts are for some reason limited). We ask whether the government optimally facilitates or hinders such hedging. Similarly, we ask whether the government would like to use policy to alter the private sector's liability maturity structure.

The paper's main economic insights are:

(1) We identify two wealth effects which are factors of strategic complementarity (SC means that a larger attack by other speculators increases one's incentive to attack the currency) or substitutability (SS). Speculation has an *immiserizing* effect on a country with weak fundamentals and a *windfall gain* effect on a country with strong fundamentals. The former is conducive to SC and the latter to SS.

(2) Hedging is endogenously incomplete. To be credible in its attempt at convincing the market of the currency's strength, the government cannot encourage, and actually must discourage hedging by residents. Letting the residents hedge is a clear admission that the currency is overvalued by the market and makes any complementary attempt at exchange rate management futile.

(3) A peg may make domestic borrowers eager to issue short-term liabilities so as to provide foreign investors with an advantageous exit option. Furthermore, the government does not incentivize firms to lengthen the maturity structure even when it wants to, because doing so would again be an open admission of a future depreciation.

(4) Performing comparative statics with respect to the government's objective function, the model predicts that pegs are more likely to be maintained before an election, and less likely to be maintained, the larger the tradable goods sector.

Our predictions are largely supported by available empirical evidence. While successful attacks often capture the headlines, episodes of speculative pressure can also lead to exchange rate appreciation, consistent with the wealth effects we identify. Indeed, if all attacks were guaranteed to be successful, then a strategy of always attacking a peg would be an arbitrage opportunity. Eichengreen, Rose and Wyplosz (1995) identify episodes of speculative pressure in OECD countries from 1959-1993 as when a weighted index of quarterly macroeconomic indicators deviates significantly from their mean level and find that 21% of their episodes of speculative pressure result in failed attacks. Moreno (1995), using a similar methodology for East Asian countries from 1980-1994, shows that speculative pressure leading to appreciation account for 40% of the episodes in his dataset.[7]

The lack of hedging in recent financial crises has been documented by a number of authors including Eichengreen, Hausmann and Panizza (2002) and Alesina and Wagner (2005). Both papers document that features of original sin are positively correlated with managed floating and fixing. There is also evidence that governments may signal by exposing their countries to devaluation risk. For instance, before the Mexican crisis, a substantial portion of the public debt was restructured from *cetes* (peso-denominated) to *tesobonos* (dollar-denominated). By ensuring that a devaluation would increase the public debt, the creation and rapid growth of this financial instrument signaled to foreign investors that the government was not going to allow the currency to fall. Also, the Bangkok International Banking Facility, initially established to intermediate foreign investment, functioned as a conduit for short-term foreign lending. Thailand also famously offered tax breaks which encouraged offshore borrowing. The model explicitly analyzes the incentives for hedging and suggests why governments under duress, as in these two cases, may not want to encourage it.

The idea that the choice of exchange rate regime and its management arbitrates between (primarily) domestic interest groups has been frequently discussed in case studies and, more recently, in cross-sectional empirical analysis. See Eichengreen (1995) and Frieden (1997) for examples of the former and Alesina and Wagner (2005), Eichengreen, Hausmann, and Panizza (2002), and Levy-Yeyati, Sturzenegger and Reggio (2003) for examples of the latter. Frieden, in his overview of the Mexican crisis in 1997, discusses how depreciation would have affected the purchasing power of swing voters in the urban middle and working classes.

Numerous cross-sectional studies have documented that devaluations are less likely shortly before elections, but often occur right after an election when a new government can blame the previous government for mismanagement. Cooper (1971), for instance, was the first to empirically document the political costs of devaluation. His study, which has been updated and extended by Frankel (2005) for the period 1971-2003, showed that in the aftermath of devaluations, nearly 30 percent of governments collapsed within 12 months, as compared to 14 percent in a control group. These facts suggest that the electorate revises their beliefs about the government in the wake of a devaluation and that governments understand this, viewing exchange rate management as an important signal. Indeed, governments often view the exchange rate as a foundation of macroeconomic policy and their source of economic

[7] Both authors, of course, recognize that they may miss episodes of unsuccessful attacks by using quarterly data when repelled attacks may only last days, and that detecting the magnitude of government intervention in foreign exchange markets is notoriously difficult.

success.[8] In a sample of Latin American countries, Blomberg, Frieden and Stein (2003) find that when an election approaches, pegs are more likely to be maintained. Specifically, when an election is impending, the conditional likelihood of staying on a peg increases by roughly 8 percent. After the election the probability of devaluation increases by 4 percent. Klein and Marion (1997) also show, for a different sample of 17 Latin American countries, that a peg is more likely to be abandoned right after a change in the executive.

Relatedly, Alesina and Wagner (2005) compare characteristics of countries who announce one exchange rate regime and actually have another. They show that countries with stronger fundamentals are likely to manage their exchange rate more than what they have announced and countries with poor political institutions are less able to stick to a pegged exchange rate. Their empirical evidence is consistent with the model here, where countries with strong fundamentals may manage their exchange rate to signal their ability to do so.

2 Roadmap and related literature

2.1 Roadmap

The paper follows the research agenda of second-generation models of rational speculation and exchange rate crises. Like many of these models, it abstracts away from nominal rigidities and focuses exclusively on the real side.[9] The general environment is summarized in Figure 1.

Capturing premise a), the government knows the "fundamentals" σ while other economic agents only have a probability distribution over σ: fundamentals are strong with probability ρ and weak with probability $1 - \rho$. The exchange rate, defined as the number of units of non-tradables needed to purchase one unit of tradables,[10] is pegged (in an extension, we allow the level of the peg to be endogenous).

The speculation game is in the spirit of Morris and Shin (1998). Speculators rationally, but non-cooperatively mount a speculative attack: they demand the conversion of $\mathcal{S}$ pesos into dollars at the pegged exchange rate, where $\mathcal{S}$ is bounded above by their peso assets if short sales are infeasible, and is unbounded otherwise. The government then decides to convert ($y = 1$), i.e. defend the peg, or refuse to convert ($y = 0$), i.e. let the currency float.

[8] For more details and examples, see Roubini and Setser (2004).

[9] Other papers in this tradition include, among others, Caballero and Krishnamurty (2003), Chari and Kehoe (2003) and Morris and Shin (1998). While nominal rigidities are, of course, important, the channels highlighted in the model are present even in their absence.

[10] By abuse of language, we will sometimes identify tradables as "dollars" and non-tradables as "pesos."

Date 1 (present)			**Date 2** (future)
Government has private information about fundamentals σ (strong with probability ρ, weak with probability $1-\rho$).	• Speculators non-cooperatively mount attack of size $\mathcal{S}$. • Government converts $\mathcal{S}$ at rate e ($y = 1$) or lets currency float (refuses to convert, y=0).	• Markets update beliefs: $\rho' = \rho'(y)$. • Third party action depends on ρ'.	Foreign exchange market clears at rate e_2.

Figure 1.– General Structure.

Observing the government's behavior, economic agents update their probability that fundamentals are strong from ρ to ρ'. The key feature is that posterior beliefs ρ' matter; they influence some "third party decision." This third party decision may refer to any private sector decision that the government cares about. For concreteness, we will give two illustrations of such decisions, but the approach encompasses a variety of environments.

Date 1 is the focus of our analysis. Date 2 stands for the continuation game, and is characterized by a future exchange rate e_2 that determines the price of tradables and thereby affects welfare.

Our model boils down to two equations:

- *Government's objective function*: Labelled W, it takes the form:

$$W = \phi(\rho') + v(e_2),$$

  where ϕ is increasing (the government prefers a strong market perception of the currency) and v is decreasing (a weaker currency in the future reduces the consumers' purchasing power.)

- *Exchange rate determination*: The date-2 exchange rate

$$e_2 = \psi(\sigma, L, \rho')$$

  is decreasing in the fundamental ($\frac{\partial\psi}{\partial\sigma} < 0$), and increasing in the loss (or gain if negative) to speculators:

$$L = y\mathcal{S}\left(\frac{1}{e} - \frac{1}{e_2}\right).$$

  In the second, but not the first application, e_2 also depends on posterior beliefs at date 1.

Behavior follows a perfect Bayesian equilibrium: speculation maximizes the speculators' profit given subsequent equilibrium government behavior; the government optimizes given the size $\mathcal{S}$ of the attack and given the predicted impact of a defense or abandonment of the currency on market beliefs ρ'; and finally, the market updates beliefs about fundamentals according to Bayes rule and equilibrium strategies.

In our first illustration, third parties are domestic voters, who are more likely to re-elect the government if the latter's past management, as measured by the fundamentals, is perceived to have brought wealth (in the form of international collateral) to the country, and therefore future purchasing power to consumers. The government then attaches particular importance to beliefs ρ' ($\frac{d\phi}{d\rho'}$ is high) when re-election concerns are strong (the election is near and disputed).

In the second illustration, third parties are foreign investors, whose investment in domestic firms increases with their perception of strength of the currency. The government then attaches particular importance to these beliefs ρ' when it is closely related to corporate interests and corporate borrowers benefit from an increased access to international capital markets.

Note that in our model there need not be a "fundamental exchange rate" to which the currency returns after the speculative attack; indeed, the post-speculative-attack exchange rate depends on the peg's ambition, the size of the speculative attack, and the government's response to it. An attack on an undervalued (overvalued) currency further appreciates (depreciates) its long-term value. Relatedly, that speculative attacks make the country wealthier when the currency is undervalued implies that we cannot assume that defending the peg is systematically costly. Nor do speculative activities always exhibit strategic complementarity.

2.2 Related theoretical literature

The signaling approach is connected to several other papers that study policy signaling in an open economy (i.e. Drazen and Masson (1994), Bartolini and Drazen (1997), and Drazen (2003), Chari and Kehoe (2003)), but these papers focus on different issues. Drazen and Masson show how the public may learn from policy the strength of the government's aversion to inflation. Bartolini and Drazen argue that capital account liberalization can send a favorable signal to market participants, which in turn leads to capital inflows. Chari and Kehoe's model allows for two types of government, as we do here, but they emphasize the role of non-fundamental factors in financial crises. Our emphasis is on pegs, speculative attacks and risk management and does not encompass these other papers.

Financial crises are ultimately linked to an incompleteness in country hedging. Eichengreen and Hausmann (1999) argue that pegs lead to unhedged foreign-currency borrowing, suggesting that private agents systematically underestimate exchange rate risk. In contrast, both pegs and endogenously incomplete hedging are co-determined in our model and all agents are rational. Jeanne (1999) reasons that dollar-denominated debt can signal strength for borrowers, while Jeanne (2001) argues that dollar-denominated debt may be less risky in an environment where the monetary authority lacks credibility. Chamon and Hausmann (2002) present a model where borrowers expect others to borrow in dollars and optimal monetary policy is forced to fulfill those expectations. Tirole (2003) shows how short-term dollar debt and home bias affect government incentives and may constrain moral hazard. Finally, soft budget constraint problems may lead banks to gamble on a government bailout (see McKinnon and Pill (1997), Burnside, Eichenbaum and Rebelo (2001), Schneider and Tornell (2004)). In particular, Ranciere, Tornell and Westermann (2003) present a model where consumers and firms can hedge all exchange rate risk and there is endogenous financial fragility because of systemic bailout guarantees. The systemic bailout guarantees literature leaves open the question of why there is inadequate prudential regulation in the domestic banking system rather than more efficient transfers to the government's banking friends. This paper makes the government's reluctance to let banks and other residents borrow in domestic currency or enforce prudential regulation an integral part of a signaling strategy and does not rely on government capture.

The literature on exchange rate regimes is immense and will not be surveyed here.[11] Some common arguments in favor of fixed rates are that they reduce transaction costs and discourage noise traders (Jeanne and Rose (2002)), they serve as policy commitments (Giavazzi and Pagano (1988)), and help governments gain monetary credibility (Herrendorf (1999)). However, Tornell and Velasco (2000) argue that fixed exchange rates may delay the impact of fiscal policy and therefore might provide bad incentives for a short-sighted fiscal authority.

Following seminal contributions by Krugman (1979) and Obstfeld (1996) among others, this paper contributes to the currency crises literature since speculation in the model influences the choice of the exchange rate regime. Like Cukierman, Goldstein and Spiegel (2004), we endogenize the level of the peg. Cukierman et. al. study the strategic interaction between the ex ante choice of exchange rate regime and the likelihood of ex post currency attacks in a country that is vulnerable to a speculative attack. Their paper relies on a reduced-

[11] See Ghosh, Guide and Wolf (2003) for a recent survey.

form macroeconomic structure following Morris and Shin (1998)'s classic paper. This paper, on the other hand, provides a micro-founded model of exchange rate management which shows how defending the peg is costly and might actually be profitable and when to expect strategic complementarities and positive externalities in speculation. In this framework, the post-speculation exchange rate is also contingent on a loss of reserves and depends on the speculative attack and exchange rate management. The theoretical finding that speculative attacks are not always strategic complements has counterparts in the literature on banking crises (Goldstein and Pauzner (2005)).[12]

3 Model

The model has two periods: $t = 1, 2$ and three types of agents: domestic consumers, foreign investors/foreign speculators, and the government.

Let "*" denote the tradable good. The utility function of foreign investors or speculators is given by:

$$U^{\text{foreigners}} = c_1^* + c_2^*,$$

while that of domestic residents is

$$U^{\text{domestic}} = c_1 + c_2 + u(c_2^*),$$

where (unless otherwise stated) $u(\cdot)$ is strictly concave and $u(c_2^*) = -\infty$ for $c_2^* \leq 0$. Let e_2 denote the date-2 exchange rate in units of pesos per dollar, so a strong exchange rate corresponds to a low e_2. The domestic residents' date-2 consumption of tradables, $c_2^*(e_2)$, is given by:

$$\arg\max_{c_2^*} \left\{ u(c_2^*) - e_2 c_2^* \right\}.$$

Let $v(e_2) \equiv u(c_2^*(e_2))$ denote the consumer's gross surplus from consuming tradables. v is a decreasing function.

Let us first describe the timing, and then discuss the modelling elements.

Timing:

The game starts with pre-determined peg e and level of foreign-owned liabilities (in pesos D) due at date 1. It then unfolds as described in Figure 2.

[12] Their model allows for one-sided strategic complementarity: an agent's incentive to withdraw from a bank early is not highest when all agents do so, but when the number of agents demanding withdrawal reaches the level at which the bank just goes bankrupt.

Date 1 (present)			Date 2 (future)
(i)	(ii)	(iii)	(iv)
Government privately learns future international collateral $\mathcal{R} = \begin{cases} \mathcal{R}_s & (\rho) \\ \mathcal{R}_w & (1-\rho) \end{cases}$ where $\mathcal{R}_s > \mathcal{R}_w$.	• Speculators non-cooperatively mount speculative attack $\mathcal{S}$. • Government observes $\mathcal{S}$ and maintains peg (converts $\mathcal{S}$ at rate e) or lets currency float (refuses to convert).	• The market updates its beliefs to ρ'. • Election: government's probability of re-election increases with ρ'.	Foreign exchange market clears at exchange rate e_2.

Figure 2.– Timing.

(i) The country is either "strong" (has international collateral $\mathcal{R}_s$) with probability ρ and is "weak" (has international collateral $\mathcal{R}_w$) with probability $1-\rho$, where $\mathcal{R}_s > \mathcal{R}_w$.

(ii) D is repaid to foreign investors.
The foreign speculators take $\mathcal{S}$ out of the country. $\mathcal{S}$ is the size of the attack, which we allow to be either unbounded (unlimited short sales) or bounded by D (no short sales). The government observes $\mathcal{S}$ and maintains the peg (converts $\mathcal{S}$ at rate e) or lets the currency float by refusing to convert.

(iii) The foreign exchange market updates its beliefs to ρ', which depends on whether the government maintained the peg. Voters evaluate the government based on their posterior beliefs and decide whether to re-elect it. The forward exchange rate is denoted f.

Date 2:

(iv) The foreign exchange market clears (the remaining reserves are equal to the net demand for tradables),[13] and consumption takes place.

Discussion:

Our first assumption is that the peg is pre-determined. Section 7.2 extends the model by letting the government choose the peg. The existence of an initial debt D in pesos is not crucial for much of the theory. It establishes a lower bound on the volume of funds that can be mobilized for a speculative attack: when reimbursed at date 1, foreign investors can either roll over or take the money out of the country. D could also denote the amount of money that foreigners could obtain by selling their equity portfolio at date 1 or the peso-denominated collateral (e.g. real estate) seized by holders of dollar debt in defaulting firms.[14] We will focus on two polar cases: in the absence of short sales by foreigners, $0 \leq \mathcal{S} \leq D$. With costless short selling of the currency by foreigners, $0 \leq \mathcal{S} < \infty$.[15] The motivation for introducing initial debt D in the model is two-fold. First, D, as discussed above, serves as an upper bound for speculation when short sales are infeasible. Second, we will later endogenize debt maturity, i.e. whether foreign lenders prefer to be repaid at date 1 or date 2 (Section 6.2).

At stage (i), the government acquires private information about the country's future international collateral. The simplest interpretation of $\mathcal{R}$, and that which will be pursued in the paper, is the level of date-2 reserves held by the government and redistributed to the residents, as date 2 is the last period. More generally, $\mathcal{R}$ should refer to any government held private information about a variable that will affect the date-2 exchange rate: international collateral of public enterprises, willingness to implement structural reforms, off-balance sheet liabilities, forthcoming export promoting policies, fiscal needs (leading to a taxation of private international collateral), etc.

At stage (ii), speculators are competitive: they individually do not affect the volume of speculative movements, and therefore the government's decision of whether to defend the currency. We do not set an arbitrary upper bound on the size of the speculative attack that the government can resist. In other words, we assume for simplicity that the government can (possibly secretly) borrow in the market to resist the attack. This assumption is particularly relevant in the case of costless short sales.

At stage (iii), the market puts posterior probability ρ' on fundamentals being strong. Since the world interest rate and domestic interest rates are zero in this model, under unlimited short sales, or when short sales constraints do not bind, the forward rate f is

[13] There is no loss of generality in imposing floating at date 2. Since this is the last period and so the reputation concerns are gone, the government has no incentive to maintain a peg.

[14] Dollar debt that is repaid to investors can be directly counted in $\mathcal{R}$ and so we do not need to consider it.

[15] More generally, we could consider convex costs of short selling as in Drazen (2000).

given by

$$\frac{1}{f} = E_{\rho'}\left[\frac{1}{e_2}\right]. \tag{1}$$

This condition is equivalent in our risk-neutral world to the uncovered interest rate parity condition common in international finance.

Last, at date 2, the government's foreign reserves or whatever will remain of them after the speculative attack will be sold in the market at date 2 in the exchange of non-tradables, and the proceeds distributed equally among domestic residents.[16] Pesos that are not used to attack the peg ($D - \mathcal{S}y_i$) remain in the country between period 1 and period 2, and are repatriated by foreigners in period 2, at rate e_2.[17]

More generally, "date 2" should be viewed as a reduced form for the "future." While reserve losses here directly translate into reduced consumption of tradables at date 2, the only effect of a loss of reserves we utilize is that such a loss may jeopardize the country's future welfare. So, losses of reserves may compromise the country's ability to resist future speculative attacks, trigger future reductions in corporate investment or bankruptcies and so on. Similarly, it is by no means important that the country returns immediately to floating.

The market-clearing equation for type $i \in \{w, s\}$ at date 2 is:

$$\mathcal{R}_i - \frac{\mathcal{S}y_i}{e} - \frac{D - \mathcal{S}y_i}{e_i} = c_2^*(e_i), \tag{2}$$

where $y_i = 1$ if type i defends the peg and $y_i = 0$ if it lets the currency float.

Finally, the government's objective function reflects both the desire to be re-elected (ϕ) and, perhaps due to own consumption or a legacy concern, consumer welfare (which is measured by v since the consumption of non-tradables is exogenous in this model):

$$W = \phi(\rho', \alpha) + v(e_2), \tag{3}$$

where ϕ is increasing in ρ', so the government unambiguously values appearing as a strong type. The parameter α will be used as an index of re-election concerns: $\frac{\partial\phi}{\partial\alpha} > 0$ and $\frac{\partial^2\phi}{\partial\rho'\partial\alpha} > 0$.

Equations (1), (2), and (3) together with rational speculation (see below), summarize the description of the model.

Benchmark: Symmetric information

Suppose that $\mathcal{R}$ is common knowledge. Then, rational expectations imply that the date-2 exchange rate is perfectly foreseen by the market at date 1. Let e_s^{FI} and e_w^{FI} stand for the exchange rate of the strong and weak type under full information.

[16] The assumption that the proceeds are distributed equally among domestic residents is not essential and while the government's objective function would take a slightly different form with unequal distributions, the qualitative results would remain the same.

[17] To avoid cluttering the notation, we will define $e_i \equiv e_{2i}$ for $i \in \{s, w\}$ for the rest of the paper.

Under common knowledge about the future exchange rate, defending an ambitious exchange rate (i.e., an exchange rate e below the full information, floating level) reduces consumer welfare without altering market beliefs ($\rho' = 1$ or 0). Conversely, speculators do not want to attack a currency that they know is undervalued. Furthermore, under floating, speculative trades are irrelevant; and so, clearing in the foreign exchange market is equivalent to:

$$\mathcal{R}_i - \frac{D}{e_i^{FI}} = c_2^*(e_i^{FI}).$$

Since $\mathcal{R}_s > \mathcal{R}_w$,

$$e_w^{FI} > e_s^{FI}.$$

The government's utility under full information is:

$$W_i^{FI} = \phi(\rho_i, \alpha) + v(e_i^{FI}),$$

where $\rho_i = 1$ if $i = s$ and $\rho_i = 0$ if $i = w$.

4 Speculative attacks: strategic complementarity or substitutability?

Turning to incomplete information, we look for perfect Bayesian equilibria of the game between the speculators and the government. The speculators' strategy is a function $\mathcal{S} = \mathcal{S}(e)$ mapping the exchange rate peg e into $[0, D]$ or $[0, \infty)$, depending on whether we allow short selling of the currency by foreigners.

The type i government's strategy is a function $y_i = y_i(\mathcal{S}, e)$ mapping volume of speculation $\mathcal{S}$ and arbitrary peg e into $[0, 1]$. When $\mathcal{S} = 0$, defending or abandoning the peg is "cheap talk." We nevertheless need to define the government's strategy $y_i(0, e)$ at this level of speculation since in the absence of speculation, atomistic speculators must still know whether the government would convert at the pegged exchange rate if they did speculate individually. Alternatively (and equivalently), we can define $y_i(0, e)$ as the limit of $y_i(\mathcal{S}, e)$ as $\mathcal{S}$ converges to 0. Let $x_i(e) \equiv y_i(\mathcal{S}(e), e)$.

The first proposition checks that, when the peg undervalues the currency in view of strong fundamentals, the exchange rate appreciates relative to the full information case because the government makes a windfall profit when defending the peg ($e > e_s$); and conversely, when the peg overvalues the currency because fundamentals are weak.

Proposition 1 (windfall gain and immiserization)[18]: *If $e_s^{FI} < e < e_w^{FI}$, then for all $\mathcal{S} > 0$, $e_s < e_s^{FI}$ and $e_w > e_w^{FI}$, where e_s and e_w are the date-2 exchange rates of the strong*

[18] All proofs are gathered in the appendix.

and weak types when the government has defended the peg.

Next, note that the concavity of u generates a sorting condition: fixing a peg e and an (undominated) speculation level $\mathcal{S}$, the strong type is relatively more eager to defend the peg. Because the government can obtain e_i^{FI} by floating, sorting requires

$$v(e_w^{FI}) - v(e_w) \geq v(e_s^{FI}) - v(e_s),$$

or

$$u\left(\mathcal{R}_w - \frac{D}{e_w^{FI}}\right) - u\left(\mathcal{R}_w - \frac{\mathcal{S}}{e} - \frac{D-\mathcal{S}}{e_w}\right) \geq u\left(\mathcal{R}_s - \frac{D}{e_s^{FI}}\right) - u\left(\mathcal{R}_s - \frac{\mathcal{S}}{e} - \frac{D-\mathcal{S}}{e_s}\right).$$

For $e_s^{FI} \leq e \leq e_w^{FI}$, the LHS is positive while the RHS is negative since from Proposition 1, $e_s \leq e_s^{FI} < e_w^{FI} \leq e_w$. For $e \geq e_w^{FI}$, then $\mathcal{S} = 0$, and the inequality is satisfied (as an equality). Last, for $e < e_s^{FI}$, $\mathcal{S} = \infty$ if short sales are feasible, and the question is moot. Or $\mathcal{S} = D$ if short sales are infeasible, but then

$$u\left(\mathcal{R}_w - \frac{D}{e_w^{FI}}\right) - u\left(\mathcal{R}_w - \frac{D}{e}\right) \geq u\left(\mathcal{R}_s - \frac{D}{e_s^{FI}}\right) - u\left(\mathcal{R}_s - \frac{D}{e}\right)$$

as this inequality holds for $e = e_s^{FI}$, and

$$\frac{\partial}{\partial e}\left[u\left(\mathcal{R}_s - \frac{D}{e}\right) - u\left(\mathcal{R}_w - \frac{D}{e}\right)\right] < 0,$$

and so it a fortiori holds for $e < e_s^{FI}$.

The focus therefore will be on the weak type's probability of maintaining the peg; in order to simplify notation, we let

$$x(e) \equiv x_w(e).$$

When the weak type government defends the currency with probability x and therefore the strong type defends the currency with probability 1, we let

$$\rho'(x) \equiv \frac{\rho}{\rho + (1-\rho)x},$$

denote the posterior beliefs that a government that defends the currency is strong.

Many models of currency crises (e.g. Obstfeld (1986, 1996)) emphasize that speculative attacks may be self-fulfilling because of strategic complementarities in the speculators' behavior. In our model, whether speculative activities are strategic complements or strategic substitutes depends on the strength of the prior beliefs. Speculative activities exhibit strategic complementarity (substitutability) if a higher volume of speculation makes a speculator more (less) willing to convert pesos into dollars. Because considering "a higher volume of speculation" is relevant only when short sales constraints are not binding and the parity condition (1) holds, strategic complementarity (SC) is equivalent to the forward rate increasing with $\mathcal{S}$. Strategic substitutability (SS) is equivalent to the forward rate decreasing with $\mathcal{S}$.

Even so, it is possible to define strategic complementarity /strategic substitutability in two ways. The definition that we will focus on treats the government's currency defense strategy x, and therefore beliefs ρ' as given. The alternate definition embodies the government's reaction to the attack: Because the weak type is less willing to defend a larger speculative attack, a larger attack gives rise to a *speculator's curse*, an effect that is conducive to SS.

Definition.[19] *For a given peg e and arbitrary ρ' (not necessarily the prior), let $f_{\rho'}(\mathcal{S})$ be defined by:*

$$\frac{1}{f_{\rho'}(\mathcal{S})} \equiv \frac{\rho'}{e_s} + \frac{1-\rho'}{e_w},$$

and

$$\mathcal{R}_i - \frac{\mathcal{S}}{e} - \frac{D-\mathcal{S}}{e_i} = c_2^*(e_i), \quad \textit{for } i \in \{w,s\}. \tag{4}$$

Speculative activities exhibit strategic complementarity (strategic substitutability, strategic neutrality) when $f_{\rho'}(\mathcal{S})$ is increasing (decreasing, constant) in $\mathcal{S}$, i.e. conditional on the peg being defended, when a large speculative attack triggers an immediate depreciation (appreciation, no effect on) of the currency, keeping the government's strategy fixed.

Example: Let $u(c_2^*) = w(c_2^*)$ for $c_2^* \leq c^*$ and $u(c_2^*) = w(c^*) + s(c_2^* - c^*)$ for $c_2^* \geq c^*$ (with $s(0) \equiv 0$), and suppose that $\mathcal{R}_s$ is large enough ($\mathcal{R}_w$ is low enough) that c_2^* in the relevant range exceeds (is lower than) c^* for the strong (weak) type.

(a) If w is linear, $w(c^*) = e_w c^*$, and s is concave, then the weak type's exchange rate is fixed at e_w while that of the strong type appreciates under speculation. Speculative activities exhibit strategic *substitutability* (SS).

[19]**Alternative definition.** *For a given peg e, let $f(\mathcal{S})$ be defined by:*

$$\frac{1}{f(\mathcal{S})} \equiv \frac{\rho'(\mathcal{S})}{e_s} + \frac{1-\rho'(\mathcal{S})}{e_w},$$

where $\rho'(\mathcal{S}) = \frac{\rho}{\rho+(1-\rho)y_w(e,\mathcal{S})}$, $y_w(e,\mathcal{S})$ is the weak type's equilibrium probability of maintaining peg e when facing attack $\mathcal{S}$, and

$$\mathcal{R}_i - \frac{S}{e} - \frac{D-\mathcal{S}}{e_i} = c_2^*(e_i) \quad \textit{for } i \in \{w,s\}.$$

Speculative activities exhibit strategic complementarity (substitutability) when $f(\mathcal{S})$ is increasing (decreasing) in $\mathcal{S}$.

(b) If w is concave, and s linear, $s(c_2^* - c^*) = e_s(c_2^* - c^*)$, then the strong type's exchange rate is fixed at e_s and speculative activities exhibit strategic *complementarity* (SC).

(c) If both are linear (with $e_s < e_w$, so that u is concave), an assumption made in much of the literature on speculative attacks which presumes that there exists a fundamental exchange rate that is invariant to the extent of speculation, then speculative activities exhibit strategic *neutrality* (SN).

The next proposition shows that whether speculative activities exhibit SC or SS depends on the government's initial reputation:

Proposition 2: *For* $e_s^{FI} < e < e_w^{FI}$*, there exists* $\bar{\mathcal{S}} > D, \rho_1,$ *and* ρ_2 *such that* $0 < \rho_1 < \rho_2 < 1$*, such that speculative attacks exhibit, on* $[0, \bar{\mathcal{S}}]$*, SC if* $\rho \in [0, \rho_1]$ *and SS if* $\rho \in [\rho_2, 1]$*.*

The intuition behind Proposition 2 is straightforward.[20] As we have already observed, an increase in the size of the speculative attack generates wealth effects: an immiserizing one for the weak type, whose currency is overvalued, and a windfall gain for the strong type, whose currency is undervalued. The impact on the forward rate depends on which of these effects dominates, and therefore on the beliefs. The bound $\bar{\mathcal{S}}$ on the speculative activities is just meant to guarantee that the weak (strong) type's exchange rate does not go to infinity (zero), and so exchange rates remain bounded; this bound can therefore be taken quite large.

5 Exchange rate defense

5.1 Unlimited short sales

With unlimited short sales, the forward rate when the peg is defended must be equal to the peg ($f = e$). Suppose it were higher ($f > e$); because speculators' profit is determined by what happens when the peg is defended (from an individual standpoint, a speculative trade that is not converted is equivalent to no speculative trade), the expectation of an average devaluation conditional on the peg being defended would trigger $\mathcal{S} = \infty$. Conversely, if $f < e$, foreign investors would sell tradables for non-tradables.[21]

It is convenient to decompose the range of pegs into three regions, defined by the strong type's full-information exchange rate e_s^{FI} and the prior exchange rate, defined by the harmonic mean e^{hm}, in the absence of speculation defined as follows:

[20]Note that the example just discussed does not contradict Proposition 2, which relies on the strict concavity of $u(\cdot)$.

[21]Provided that there is a store of value at zero rate of interest in the country, which is compatible with the presumed preferences $c_1 + c_2 + u(c_2^*)$.

$$\frac{1}{e^{hm}} \equiv \frac{\rho}{e_s^{FI}} + \frac{1-\rho}{e_w^{FI}}.$$

a) Unambitious peg: $e \geq e^{hm}$

For $e \geq e^{hm}$, it is an equilibrium for the government to maintain the peg and for speculators not to attack. If, in the absence of speculation, the government defends the currency regardless of its type ($x(e) = 1$), then speculators are better off not converting pesos into dollars at the weak pegged exchange rate. Conversely, facing no or small speculation, the government prefers to defend the currency, keep market beliefs at the prior level ρ rather than abandoning the peg and being perceived as the weak type, since the government's welfare is increasing in ρ'.

The equilibrium is unique under SS or SN;[22] intuitively, if there were a speculative attack ($\mathcal{S} > 0$), market participants would expect a weak appreciation (on average) and so would be even more reluctant to convert their dollars at the unfavorable rate e. By contrast, the equilibria are not unique under SC for e a bit above e^{hm}. Indeed, for "weak SC" (the slope of $f_{\rho'}(\mathcal{S})$ is positive, but small) there are two stable equilibria for e close to e^{hm} (see Figure 4a below): the no-speculation one and the one with positive speculation.[23]

b) Ambitious peg: $e_s^{FI} \leq e < e^{hm}$

With a more ambitious peg, a small amount of speculation is strictly profitable whenever the government defends the currency for sure. In this region, $\mathcal{S} > 0$.

Define $e_w(\mathcal{S})$ and $e_s(\mathcal{S})$ from the two FX clearing equations:

$$\mathcal{R}_w - \frac{\mathcal{S}}{e} - \frac{D - \mathcal{S}}{e_w(\mathcal{S})} = c_2^*(e_w(\mathcal{S})), \tag{5}$$

$$\mathcal{R}_s - \frac{\mathcal{S}}{e} - \frac{D - \mathcal{S}}{e_s(\mathcal{S})} = c_2^*(e_s(\mathcal{S})). \tag{6}$$

Because speculative flows are positive, the forward rate f must be equal to the pegged exchange rate e. In a mixed-strategy continuation equilibrium, the mimicking condition is:

$$W_w^{FI} = \phi(\rho', \alpha) + v(e_w(\mathcal{S})). \tag{M}$$

Equation (5) implies that e_w must increase with the amount of speculation, while equation (6) implies the opposite for e_s. Taken together, they allow us to write the parity condition as:

$$\frac{1}{e} = \frac{\rho'}{e_s(\mathcal{S})} + \frac{1-\rho'}{e_w(\mathcal{S})}. \tag{P}$$

[22] If $\mathcal{S} = 0$, it must be that $\frac{1}{e} < \frac{\rho}{e_s(0)} + \frac{1-\rho}{e_w(0)}$. SS or SN implies that $\frac{1}{e} < \frac{\rho'}{e_s(\mathcal{S})} + \frac{1-\rho'}{e_w(\mathcal{S})} \quad \forall \rho' \geq \rho, \quad \mathcal{S} \geq 0$.

[23] This can easily be seen by using Figure 3 adapted to $e > e^{hm}$ so that curve P lies below curve M for $\mathcal{S}$ small.

Equation (P) determines a relationship between $\mathcal{S}$ and ρ'. Equation (M) defines an increasing mapping between e_w and ρ'. Together with (5) in the relevant range, we obtain an increasing relationship between $\mathcal{S}$ and ρ'. The above system of equations determine the strong and weak types' exchange rates, the level of speculation, and posterior beliefs $\rho' = \rho'(x)$.

Figure 3 shows how equilibrium is determined in the $(\rho', \mathcal{S})$ space.[24]

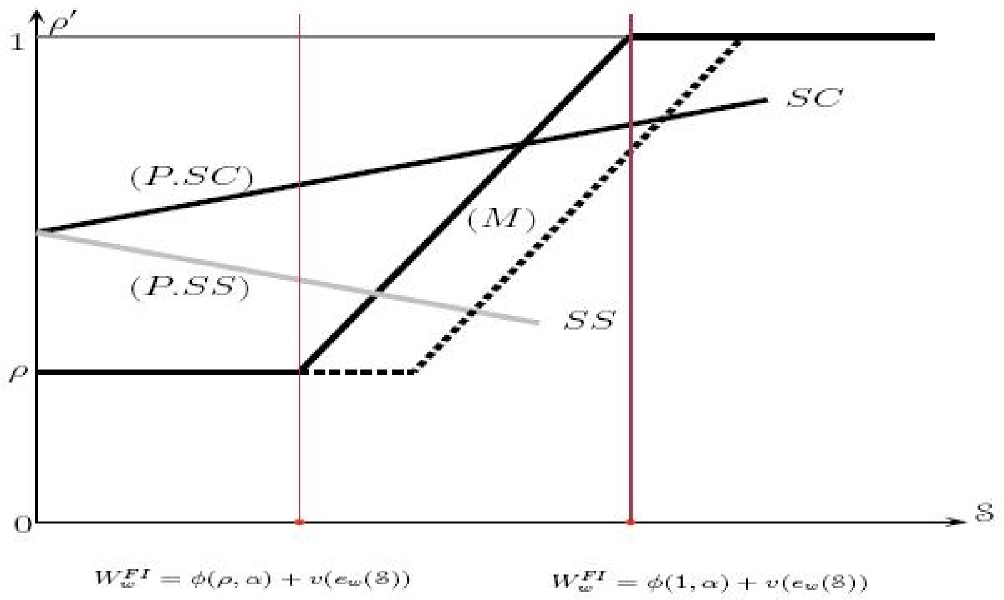

Figure 3.– Equilibrium Determination for $e_s^{FI} < e < e^{hm}$.

As e approaches e_s^{FI}, $x(e)$ approaches 0 and e_s approaches e_s^{FI}. This demonstrates that, unlike in most signaling models, separation need not be costly (given costless short sales).

[24]Expressing e_w as an increasing function of $\mathcal{S}$, curve M can be drawn by noting the following: when $\mathcal{S} = 0$, $W_w^{FI} = \phi(0, \alpha) + v(e_w(0)) < \phi(\rho, \alpha) + v(e_w(0))$ implies that $\rho' = \rho$; as $\mathcal{S}$ increases, beliefs stay constant until $W_w^{FI} = \phi(\rho, \alpha) + v(e_w(\mathcal{S}))$; after this point, when $\mathcal{S}$ increases ρ' must increase to keep the weak type indifferent; and finally, this increasing mapping becomes flat when $\rho' = 1$ and $W_w^{FI} = \phi(1, \alpha) + v(e_w(\mathcal{S}))$. The intersecting line (curve P.SC or P.SS) depends on whether speculation has the SC (dark) or SS (light) property. The SS property, for example, implies that $\frac{\rho'}{e_s(\mathcal{S})} + \frac{1-\rho'}{e_w(\mathcal{S})}$ increases with $\mathcal{S}$, which in turn implies that ρ' must decrease and explains why curve P.SS is downward sloping. For the case of strategic complements, curve P.SC is upward sloping for the opposite reason and must intersect the upward sloping portion of curve M since if it did not ($x = 0$), there would be infinite speculation due to the speculator's curse.

As seen in Figure 3, the equilibrium is unique under SS or SN. It is also unique for weak SC. When strategic complementarity is strong, though, multiple equilibria may exist.

c) Unsustainable peg: $e \leq e_s^{FI}$

The speculative attack is infinite and both types abandon the peg.

While the equilibrium is unique under SS and SN, there may be multiple equilibria for $e < e^{hm}$ under strong SC ($f_\rho(\mathcal{S})$ rapidly increasing in $\mathcal{S}$). We have nothing new to add to what the literature has said about self-fulfilling attacks, so we will posit SS, SN, or weak SC.[25] Weak SC creates a multiplicity in the neighborhood to the right of e^{hm}. We select arbitrarily the no-speculation outcome in that case[26]; this selection actually has no consequence for the rest of the paper: it just enables us to talk about "the equilibrium."

Figure 4a depicts the equilibrium behavior for the SC case, while Figure 4b depicts the SS case:

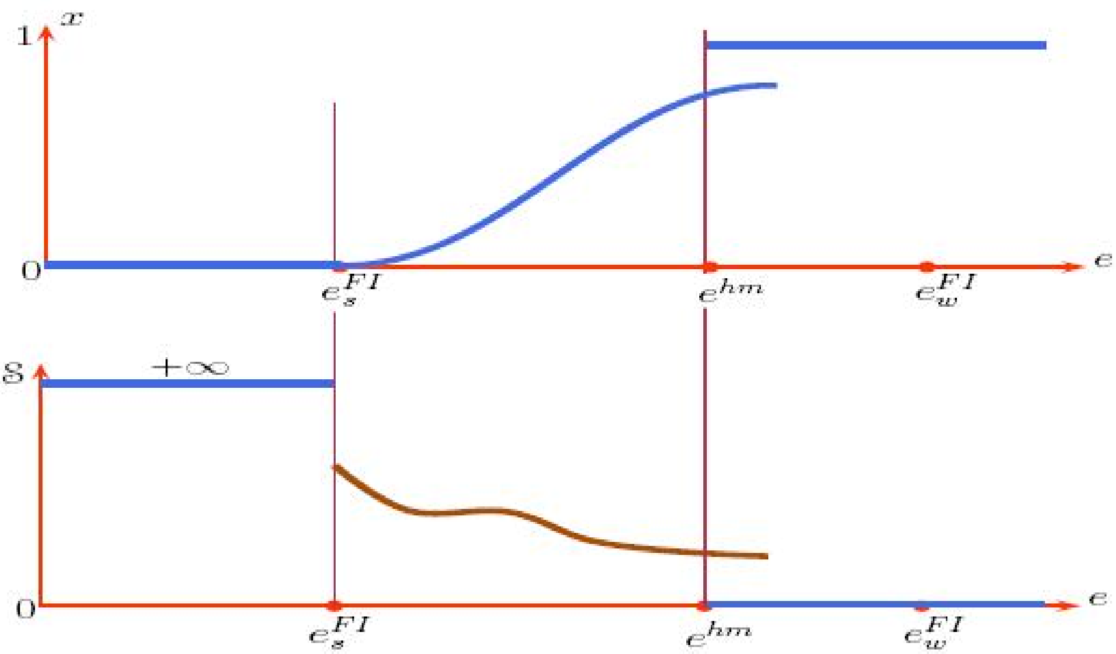

Figure 4a.– Equilibrium with Unlimited Short Sales (SC)

[25] Chang and Velasco (2001) show that the exchange rate regime dictates the set of feasible equilibria in a model building on Diamond and Dyvbig (1983).

[26] The Pareto-dominance criterion does not help us select among equilibria: The weak type prefers the absence of speculation, and the strong type benefits from more speculation.

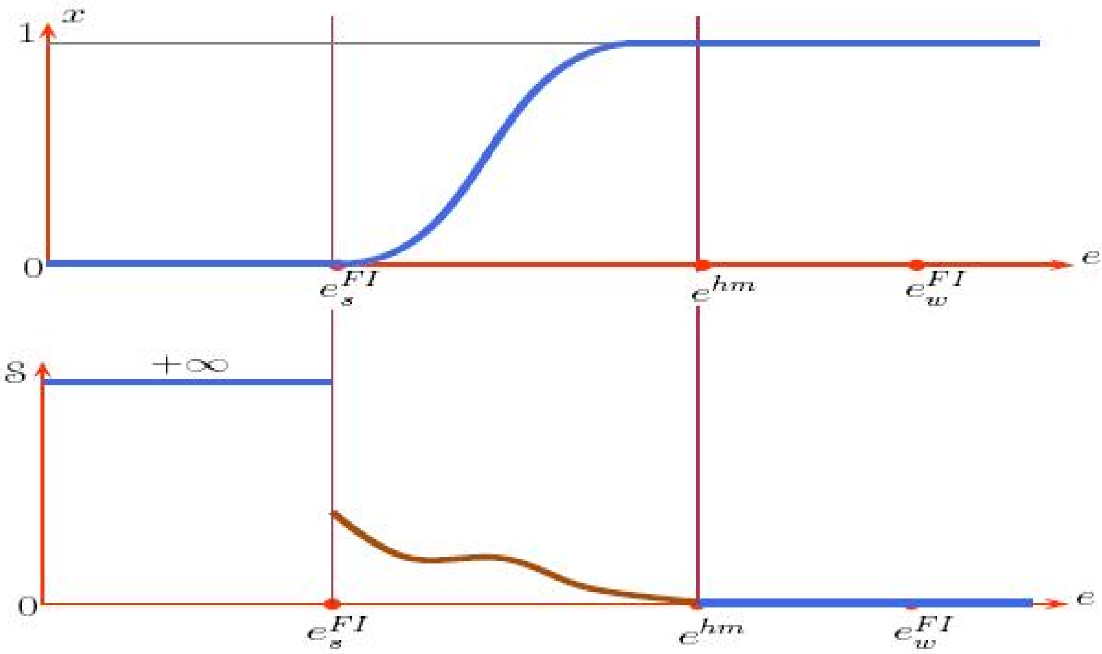

Figure 4b.– Equilibrium with Unlimited Short Sales (SS)

We now examine some comparative statics, focusing on the relevant range for analysis $e \in [e_s^{FI}, e^{hm}]$.[27]

Proposition 3: *For a given peg e, an increase in the government's re-election concerns (an increase in α) leads to*

(i) an increase in speculative activity,

(ii) a depreciation of the currency of the weak type if it defends the peg,

(iii) an appreciation of the currency of the strong type,

(iv) if speculative activities are SS (SC), an increase (decrease) in the probability of maintaining the peg.

Intuitively, as the government is more concerned about its electoral concerns, it becomes more willing to sacrifice purchasing power of consumers. At a given peg, this occurs through an increase in speculative activities, and, under SS, a higher probability of maintaining the

[27]For $e > e^{hm}$, the outcome is the same as for $e = e^{hm}$ (under our equilibrium selection rule when the SC property holds).

peg. Implication (iv) may seem counterintuitive at first sight. Regardless of SC/SS, an increase in re-election concerns makes the weak type more eager to mimic the strong type and so speculation must increase in order to preserve the mimicking constraint. This increase in speculative activity makes investors more eager to attack the currency and so, under SC, the speculator's curse must worsen (ρ' must increase).

5.2 No short sales

Suppose now that speculation is bounded above by the short-term debt D in pesos. The equilibrium identified above is still an equilibrium as long as

$$\mathcal{S} \leq D.$$

In particular, when $e \geq e^{hm}$, the previous equilibrium had no speculative attack and therefore is not altered by the no-short-sales constraint. When $e < e_s^{FI}$, then $\mathcal{S} = D$: speculation is repressed by the constraint on short sales.

Focusing, last, on the interesting region, $e_s^{FI} \leq e < e^{hm}$, suppose that in the equilibrium analyzed in Section 5.1, speculation involves short sales. Then $\mathcal{S} = D$, and we have

$$\frac{1}{e} \geq \frac{\rho'}{e_s} + \frac{1-\rho'}{e_w},$$

and

$$W_w^{FI} \leq \phi(\rho, \alpha) + v(e_w).$$

We can derive the following proposition:

Proposition 4: *(When they are binding), short sales constraints:*

(i) appreciate the weak type's date-2 exchange rate when the peg is maintained,

(ii) depreciate the strong type's date-2 exchange rate when the peg is maintained and $e > e_s^{FI}$*,*

(iii) raise the probability that the weak type defends the peg.

Figure 5 describes equilibrium with no short sales, in the SC case. The dotted line in the first panel shows how the weak type's probability of defending the peg is strictly higher, while the dotted line in the second panel shows that the level of speculation is bounded relative to the no short sales case (repressed speculation). Together the panels show that the weak type is protected from the speculators when short sales constraints are binding.

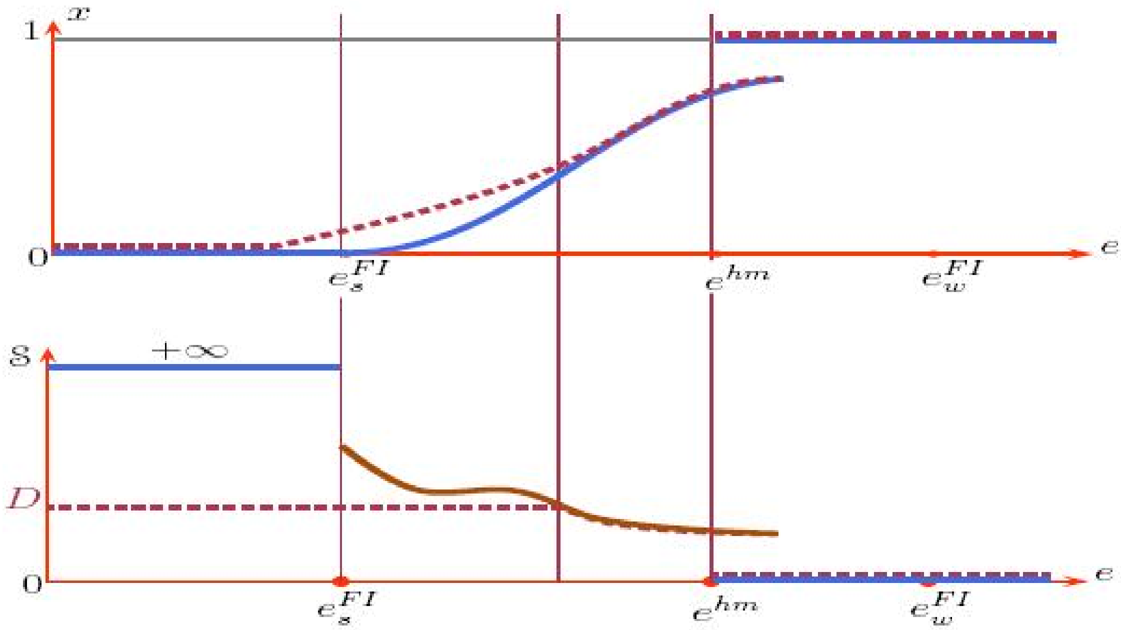

Figure 5.– Equilibrium with No Short Sales (SC).

6 Risk management

6.1 Hedging

Foreign exchange rate uncertainty creates potential gains from trade. Domestic residents can contract with foreigners and promise to deliver dollars when the currency appreciates at date 2 and receive dollars when it depreciates. Here the exchange rate will appreciate to e_s with probability ρ' and depreciate to e_w with probability $1 - \rho'$. Domestic residents or domestic financial intermediaries can obtain a basic insurance contract with international lenders who will pay them $\frac{1}{1-\rho'}$ units of tradables in case of depreciation and will receive $\frac{1}{\rho'}$ units of tradables if the currency appreciates. Foreigners break even on such basic insurance contracts, and residents receive a gain in expected utility equal to

$$\rho' \left(-\frac{1}{\rho'} \right) e_s + (1 - \rho') \left(\frac{1}{1 - \rho'} \right) e_w = e_w - e_s > 0.$$

Furthermore, trades in such contracts eliminate exchange rate uncertainty.

Entering FX insurance contracts is usually prohibitively costly for individuals; larger entities, e.g. corporations and financial institutions, can hedge FX risk, though. In practice, a government can limit hedging in many ways. For example, it could not enforce risk management policies of banks supervised by the banking commission; this policy encourages FX risk exposure if banks face a soft budget constraint and expect to be bailed out in times of crises. Another simple policy to limit hedging is to subsidize offshore borrowing. We capture this policy dimension in a stylized way by allowing the government to cap the number of basic insurance contracts.

Hedging by domestic residents increases the weak type's incentive to maintain the peg and makes it more costly for the strong type to separate. We consider the following extension to our game, in which the government can also either allow or limit hedging. Namely, enrich the timing in the following way:

- At stage (ii), the speculators take $\mathcal{S}$ out of the country. The government observes $\mathcal{S}$ and simultaneously chooses (a) whether to defend the peg or let the currency float and (b) a maximum volume V of the basic insurance contracts described above that domestic residents can enter into.
- At stage (iii), domestic residents evaluate the performance of the government. Domestic residents enter into $v \in [0, V]$ basic insurance contracts with foreigners.[28]

The rest of the timing is unchanged.

The exchange rate determination is as earlier, except that reserves $\mathcal{R}_i$ must be replaced by $\hat{\mathcal{R}}_i$ where

$$\hat{\mathcal{R}}_s \equiv \mathcal{R}_s - \frac{v}{\rho'}$$

and

$$\hat{\mathcal{R}}_w \equiv \mathcal{R}_w + \frac{v}{1-\rho'},$$

where, as earlier, ρ' denotes the posterior belief at stage (iii). For example, when maintaining the peg, e_i is given by:

$$\hat{\mathcal{R}}_i - \frac{\mathcal{S}}{e} - \frac{D-\mathcal{S}}{e_i} = c_2^*(e_i).$$

With this extension to our framework, the strong type wants to prohibit hedging by residents for two reasons:

1) Under (full or partial) pooling, the currency is undervalued, so hedging is disadvantageous.

[28]For example, the government can impose tax rate τ on receipts from such contracts. Then the actual volume is controlled by the tax rate:

$$\begin{aligned} &\text{either } e_s = e_w(1-\tau) \text{ and } v \geq 0 \\ &\text{or } e_s > e_w(1-\tau) \text{ and } v = 0. \end{aligned}$$

2) The strong type (who loses when residents hedge) wants to separate from the weak type (who gains when residents hedge).

When the strong type prohibits hedging, the weak type is forced to also prohibit if it wants to mimic the strong type and with this extension we return to the equilibrium described above.

We can summarize this discussion in the following proposition.

Proposition 5: *In the extended game in which the government chooses the extent to which the domestic residents can hedge, the equilibrium obtained when residents cannot hedge is still an equilibrium. Indeed:*

(i) either the government maintains the peg and then fully prohibits hedging: $V = 0$ *(this happens with probability* $\rho + (1-\rho)x(e)$ *if the peg is* e*),*

(ii) or the government abandons the peg in which case there is no hedging either.

The proof of Proposition 5 is straightforward. For $e \geq e_s^{FI}$, let the market believe that the government has a weak type ($\rho' = 0$), if it either abandons the peg or allows any hedging ($V > 0$). For $e < e_s^{FI}$, the market believes that the government has the weak type if it allows any hedging. Then, no hedging takes place regardless of the government's behavior at stage (ii). So the outcome and payoffs are the same as in Section 5.1 (with unlimited short sales) or Section 5.2 (no short sales).

Needless to say, the conclusion that there is never any hedging, while striking, is extreme. For example, introducing external shocks would make it costly for domestic firms with ongoing projects not to hedge FX risk.[29] In those more general environments, the government would allow some hedging, but the general conclusion would remain: Policies encouraging hedging do signal weak fundamentals.

6.2 Short-term liabilities as an escape option

Our model assumed that the peso liabilities (debt, equity portfolio, etc.) were short-term in that the foreign investors could avail themselves of the money at date 1. More generally, we could decompose peso liabilities into short-term (due at date 1) and long-term (due at date 2) liabilities:

$$D = D^{ST} + D^{LT}.$$

It is often argued that foreign investors demand short-term debt (when in local currency) so as to be able to "escape on time." While intuitive, this argument requires some deepening: After all, foreigners would derive no benefit from a short maturity if the exchange rate

[29] As in Holmström and Tirole (2000) for example.

followed a martingale. This is indeed what happens in the case of short sales, for which

$$\frac{1}{e} = \frac{1}{f} = E\left[\frac{1}{e_2}\right].$$

The maturity choice is then neutral: all equilibrium variables, including exchange rates, are given by:

$$\mathcal{R}_i - \frac{\mathcal{S}}{e} - \frac{D^{ST} + D^{LT} - \mathcal{S}}{e_i} = c_2^*(e_i),$$

are invariant to a chance in the maturity structure, keeping D constant.

By contrast, the absence of short sales or more generally costly short sales, when they are binding, cause the martingale property to break down:

$$\frac{1}{e} > E\left[\frac{1}{e_2}\right],$$

as was shown in section 5.2. To the extent that $\mathcal{S} \leq D^{ST}$, domestic borrowers have an incentive to tilt the maturity structure of their liabilities toward the short end:

$$D^{ST} = D.$$

Another interesting point is that the government has no incentive to oppose this short-term bias, for a now-familiar reason: The weak type would rather have these liabilities converted at the unfavorable rate e_w at date 2 than at the better rate e at date 1; but forcing the domestic borrowers to borrow long is an open admission of a future depreciation.

This discussion can be summarized in the following proposition.

Proposition 6: *The maturity structure of liabilities*

(i) is neutral under costless short sales;

(ii) is not neutral in the absence of short sales. Domestic borrowers prefer to offer short term liabilities as the exchange rate does not follow a martingale; the government cannot tilt the maturity structure of these liabilities without confessing a future depreciation.

7 Extensions and welfare analysis

7.1 Attracting foreign investment

Consider the second illustration alluded to in the introduction where the defense of a peg attracts foreign capital. An addendum to the paper[30], Pathak and Tirole (2006), presents

[30] Available from the authors' webpages or upon request.

all details of the illustration and shows that many of the key results of the first illustration carry over to the second illustration.[31] The third parties in the second illustration are risk-neutral foreign lenders. Credit-constrained domestic entrepreneurs borrow $I(f)$ at stage (iii) in tradables (with $I' < 0$) and produce non-tradables at date 2, of which $rI(f)$ will be returned to foreign investors.[32]

Domestic entrepreneurs must convert their nontradable output into dollars at date 2, implying the following market-clearing foreign exchange rate equation for type $i \in \{w, s\}$:

$$\mathcal{R}_i - \frac{\mathcal{S}y_i}{e} - \frac{D - \mathcal{S}y_i}{e_i} = c_2^*(e_i) + \frac{r}{e_i}I(f).$$

The addendum presents a microfoundation for a government objective function of the form:

$$W = \pi(I, \alpha) + v(e_2),$$

where α is a parameter indexing the weight attached to domestic entrepreneurs, and

$$\frac{\partial \pi}{\partial I} > 0 \quad \text{and} \quad \frac{\partial^2 \pi}{\partial \alpha \partial I} > 0.$$

The government's welfare improves when there is greater investment and the size of the improvement is increasing in the weight the government places on domestic entrepreneurs.

Under two mild assumptions ensuring that there is a demand for capital inflows and a sorting condition, we are able to obtain similar results as the main text. In particular, when there is an increase in the demand for foreign borrowing, there will be an increase in speculative activity, and if speculative activities are SS, an increase in the probability of maintaining the peg (Proposition A3). Furthermore, with binding short sales constraints, if we further assume that the government is able to verify that capital inflows are invested in physical capital, and not used for relaxing the short sales constraint, the weak type receives partial impunity from speculative attacks as before; therefore it has more incentives to defend the peg (Proposition A4). Finally, the government's policies serve as a cluster of signals: when the government can influence the extent of hedging in the economy, it will discourage hedging in equilibrium (Proposition A9); and it does not encourage firms to lengthen the maturity structure of their liabilities because doing so would confess future depreciation (Proposition A10).

Adding a concern for the firms' access to the international capital market generates two new insights: (1) a negative reaction of capital inflows to a depreciation and (2) a higher

[31] The point of departure is the added complexity of the welfare analysis, which we have not pursued. The reason for this is that consumers compete with domestic borrowers for international collateral, which complicates the analysis of a welfare impact of an increased access of firms to the international capital market.

[32] With slight abuse of notation, we write investment as a function of the forward rate f, which is the case when short sales are unlimited or short sales constraints are not binding. When short sales constraints bind, investment is a function of the market's posterior belief ρ'.

likelihood to let the currency float in the wake of a speculative attack when the export sector is stronger.

The cross-sectional implication on investment when a peg is abandoned (insight (1)) corresponds to empirical evidence on sudden stops, where a "sudden stop" is here proxied by a low level of investment I. As for insight (2), Blomberg et al. (2003) demonstrate that the larger the tradables sector exposed to international competition, the less likely is the maintenance of a fixed exchange rate regime. One of their main findings is that that controlling for economic factors, a one percentage point increase in the size of the manufacturing sector is associated with a reduction in sixth months in the longevity of a country's currency peg.

7.2 Choice of peg

In this section, the peg is not set exogenously (by legacy or an agreement), but is chosen by the government at stage (i) (knowing its private information). For simplicity, the choice of exchange rate is per se costless, as setting a peg and letting the currency float at stage (ii) is, for given beliefs, equivalent to not setting the peg. Accordingly, we will look for an equilibrium where there is full pooling. It is straightforward to extend the theory to allow for a cost of "sheer embarrassment" associated with announcing a peg and letting the currency float. Then with positive probability the government could let the currency float; if it does not, then as here, it may still let it float under a speculative attack at stage (ii).[33]

We assume that the peg is dictated by the strong type's preferences (the weak type being forced to mimic the strong type). Let $\hat{e}_s(e)$ be the exchange rate of the strong type when the choice of the peg is e. Abusing notation and writing the posterior belief as a function of the peg e, the welfare of the strong type as a function of e is:

$$W_s = \phi(\rho'(e), \alpha) + v(\hat{e}_s(e)).$$

We do not have a general characterization of the equilibrium choice of peg, but the simple case of a fundamental exchange rate provides many insights.[34]

Proposition 7: *In the fundamental exchange rate model, where $u(c_2^*) = e_w c_2^*$ for $c_2^* \leq c^*$*

[33]Introduce embarrassment cost c for pegging then letting the currency float in response to the speculative attack. The following example of introducing government uncertainty about its re-election concerns is simple to solve: The government's parameter for re-election concerns (α) is drawn from a distribution at stage (ii) (and publicly observed). Prior to this, the government has a signal about this distribution. If the signal indicates that re-election concerns are likely to be small, then the government chooses to float. Otherwise it pegs the currency and the equilibrium is as described in the paper for each realization of α at stage (ii).

[34]Another example we have considered is the case of log utility: $u(c_2^*) = \log(c_2^*)$ when short sales are allowed. As α increases, the weak type's equilibrium probability of defending the exchange rate $x(e)$ is non-decreasing in the announced exchange rate e and the equilibrium peg e^* (weakly) decreases, so the peg becomes more ambitious. The details of the argument are in the addendum.

and $u(c_2^*) = e_w c^* + e_s(c_2^* - c^*)$ for $c_2^* > c^*$:

(i) As α increases, the equilibrium peg e^* (weakly) decreases (the peg becomes more ambitious).

(ii) Suppose that ϕ is weakly convex in ρ' up to some $\bar{\rho} \leq 1$ and that $\phi(\rho', \alpha) = \phi(\bar{\rho}, \alpha)$ for $\rho' \geq \bar{\rho}$. Then, under unlimited short sales, speculation $\mathcal{S}$ and the strong type's welfare W_s are weakly decreasing in e over the semi-separating region;

- *if $\bar{\rho} = 1$, there is full separation and the optimal peg is $e^* = e_s^{FI}$,*
- *if $\bar{\rho} < 1$, the optimal peg is such that $\rho'(x) = \bar{\rho}$. Hence there is pooling and financial crises on the equilibrium path.*

(iii) Under the same assumptions as in (ii), suppose that $D < \bar{D}$ where $\bar{D}$ denotes the equilibrium level of speculation in (ii). The equilibrium peg is more ambitious in the absence of short sales than under unlimited short sales. When short sales are prohibited, there is no change in the weak type's welfare and a reduction in the strong type's welfare.

The government chooses a more ambitious exchange rate peg when its re-election concerns increase. With weakly increasing returns to reputation, a more ambitious peg results in more speculation and the strong type's welfare weakly increases provided that there is some pooling. When the returns to reputation are not bounded, the strong type separates by choosing an exchange rate peg equal to the full information level. If there is a bound, however, there are crises in equilibrium. Finally, when the short sales constraint binds, the equilibrium peg is more ambitious. The last part of the proposition formalizes the idea that capital controls, by treating the symptom, may aggravate the disease. With capital account liberalization (interpreted here as relaxing the constraint on short sales), the welfare of the weak type is unchanged, but the strong type is better off, so overall welfare increases.[35]

Needless to say, there are several rationales for having a peg, including the signaling motive. For example, a classic argument is that a peg serves as a nominal anchor. However, the positive and normative implications of signaling concerns are still relevant even if the peg is entered into for another reason.

7.3 Further welfare analysis

The micro-foundations of our model allow for welfare calculations. Assume the welfare function is calculated behind the veil of ignorance. Proposition 7 showed that capital account liberalization can unambiguously improve welfare by forcing the country to choose more realistic pegs. We now take capital account liberalization as a given and we consider a policy prohibiting pegs and managed floats. Such a policy could be externally imposed (say,

[35] Both the government and consumers are better off (note that the consumers' posterior beliefs are $\bar{\rho}$ regardless of the existence of short sales).

by the IMF actively discouraging pegs and managed floats). Alternatively, the policy could be internal as in the case of a constitutional amendment banning pegs and exchange rate intervention. With a ban on pegs, the resulting allocation has no speculation and no private information is revealed. As a result, $f = e^{hm}$ and $\rho' = \rho$.

We will focus on how this policy will affect the welfare of consumers, assuming that the screening benefit from learning the politician's ability from their exchange rate defense strategy is small. This is reasonable as voters have many signals of a politician's competency and the exchange rate defense strategy is only one of many tasks. Note, however, that this assumption is not incongruent with the assumption that politicians value being perceived as strong: As long as re-election concerns loom large relative to the welfare of consumers in the government's objective function, the government will pay a lot of attention to the signal provided by financial crises even if this signal is only one of several used by voters to determine whether they will re-elect the government.[36]

Assume that $D = 0$, so we can ignore externalities on the owners of debt.[37] In this case, the no short-sales case is uninteresting so we focus on the costless short sales, where with a peg, c_2^* incurs a mean-preserving spread. The weak type consumes even less, the strong type consumes even more, and speculators break even. Therefore, when pegs are feasible, the ex-ante welfare of consumers decreases.

Proposition 8: *When $D = 0$ and short sales are allowed, the ex-ante welfare of consumers is weakly lower when pegs are allowed.*

It is easy to see that the same proposition holds for the government, which behind the veil of ignorance (i.e. before learning $\mathcal{R}_s$) would like to commit not to peg provided that ϕ is concave or linear in ρ'.[38] Yet, while a ban on the peg dominates behind the veil of ignorance, the government cannot refrain from attempting to signal when it acquires private information.

8 Directions for future work

This paper has developed a simple micro-founded model of speculative attacks and currency crises, in which a country may defend a peg in order to influence the market's perception of

[36]The government's objective function can then be approximated as $W_s \approx \alpha[\epsilon\rho'] + v(c_2^*)$, with α large and ϵ small, and is therefore linear in ρ'. When learning effects are substantial, one must trade off the welfare gains attached to learning about the politician's type (if the equilibrium separates types enough) and the welfare loss resulting from a mean-preserving spread in consumption (see below).

[37]Prior owners of peso claims on the country may well be hurt on average by the introduction of a peg. When $D > 0$, the welfare analysis requires inquiring into the price at which this debt was issued, which in turn depends on whether a peg is banned or feasible.

[38]Then $E[\phi(\rho', \alpha)] \leq \phi(\rho, \alpha)$.

the currency's strength and thereby either increase the government's chances of re-election or facilitate the corporate sector's access to international borrowing. Policy decisions were shown to come as a package: Signaling strong fundamentals requires not only defending the peg, but also discouraging (or at least not encouraging) country hedging, allowing for short maturity structures, and so forth. The model and its implications match well the empirical evidence that governments view exchange rate management as an important policy signal to domestic voters and foreign investors.

The introduction already summarized the main insights. Let us rather discuss some of the (many) areas for future research. It will be clear to the reader that our model is overly simplistic and should be enriched in several directions:

(1) *Comparison of alternative FX support strategies*: We have assumed that the country defends the currency by relinquishing international collateral. Alternatively, it could raise interest rates.[39] As Drazen (2003) and Drazen and Hubrich (2003) point out, however, an interest rate defense is costly to both the government and the corporate sector, and may actually signal weak fundamentals.

(2) *Dynamics*: Our model lacks dynamics in several respects. First, the speculative attack and the decision of defending the peg are one-shot. Our model can be extended to depict the game between speculators and the government as a war of attrition. Second, the dynamics of investment would be better described in an infinite-horizon model. The sharp decline in investment when the peg is abandoned in Section 7.1 has a cross-sectional nature. Its time-series counterpart in an emerging economy would be similar, but better correspond to the evidence on sudden stops.

(3) *Demand for a weak currency:* While our model has emphasized the demand for a strong market perception of the currency, a country may want a weak currency to be competitive in export markets. The model developed in this paper could be employed to study the behavior of a government eager to favor exporters through an undervalued currency. Because this policy succeeds in depreciating the local currency only if markets cannot tell weak and strong fundamentals apart, we conjecture that competitive depreciations should be accompanied by the government's *encouraging* hedging, even though a high level of hedging is not in the country's direct interest when fundamentals are strong.

(4) *Propagation of speculative attacks:* Competitive devaluations (as opposed to competitive depreciations) occur when countries have a demand for a strong currency. Recent crises have shown that one of the mechanisms of international propagation of currency crises is through trade effects. In a two-country model, where speculators sequentially

[39] To accommodate this possibility within the context of our model, one could assume that at stage (ii) the government further sets a peso interest rate $\nu > 0$. This policy engenders a windfall gain for foreign investors, whose peso asset value jumps from D to $(1+\nu)D$. It further reduces the peso NPV of production by entrepreneurs.

mount their attacks, a depreciation in one country may trigger a stronger speculative attack and a depreciation in the other country through a competitive devaluation effect. Analyzing the equilibrium consequences of such linkages remains for future work.

(5) *Nominal exchange rate*: Because micro-founded models of the nominal exchange rate are notoriously hard to develop, we have focused on real exchange rates for simplicity. It goes without saying that the analysis of nominal exchange rates stands high on the research agenda.

We leave these, and other important extensions for future research.

Appendix

Proof of Proposition 1. The market clearing equations for $i \in \{w, s\}$

$$\mathcal{R}_i - \frac{\mathcal{S}}{e} - \frac{D - \mathcal{S}}{e_i} = c_2^*(e_i)$$

imply that $e_s < e_w$. When $\mathcal{S} \leq D$, this is obvious. When $\mathcal{S} > D$, consider the smallest $\mathcal{S}$ such that $e_w = e_s$: the two market clearing equations are inconsistent, so there exists no such $\mathcal{S}$. Next, let

$$\frac{1}{f} = \frac{\rho'}{e_s} + \frac{1 - \rho'}{e_w}$$

and assume that $e_w \leq e_w^{FI}$. Then $f < e_w^{FI}$; for if $f = e_w^{FI}$, then $\rho' = 0$ and $e_w = e_w^{FI}$, which implies that $\mathcal{S} = 0$. But $\mathcal{S} = 0$ is not optimal for speculators as $e < f$.

Since $e_w \leq e_w^{FI}$, the RHS of the exchange rate clearing equation for the weak type strictly exceeds the full information level. As a result,

$$\frac{\mathcal{S}}{e} + \frac{D - \mathcal{S}}{e_w} < \frac{D}{e_w^{FI}}$$

which requires $\mathcal{S} > 0$ and $e_w < e$. This implies that $f < e$ and so $\mathcal{S} = 0$, a contradiction. The proof that $e_s < e_s^{FI}$ is identical, by symmetry. $\diamond$

Proof of Proposition 2. Let us demonstrate the proposition for ρ small. Differentiating (4) yields:

$$\frac{de_w}{d\mathcal{S}} \left[c_2^{*'} - \frac{D - \mathcal{S}}{e_w^2} \right] = \frac{1}{e_w} - \frac{1}{e}.$$

From Proposition 1, the RHS is negative and bounded away from 0. For $\mathcal{S} \leq D$, the coefficient of $\frac{de_w}{d\mathcal{S}}$ is negative. Hence,

$$\frac{de_w}{d\mathcal{S}} \geq k > 0, \quad \text{for some } k.$$

When ρ is small, the forward rate increases with $\mathcal{S}$. The proof of SS for ρ large follows a similar reasoning. $\diamond$

Proof of Proposition 3. When the peg is defended $f = e$. Either $W_w^{FI} < \phi(\rho', \alpha) + v(e_w)$ and nothing changes ($x = 1$) or $W_w^{FI} = \phi(\rho', \alpha) + v(e_w)$. When α increases, the only change is that curve M (defined through weak type indifference) shifts outward (the dotted line in Figure 3). We see that speculation increases, and from equations (5) and (6), e_w depreciates, while e_s appreciates. Finally, if speculation is SS (SC), ρ' decreases (increases), so x increases (decreases). $\diamond$

Proof of Proposition 4. If the constraint on speculation $\mathcal{S} \leq D$ does not bind, then the equilibrium when short sales are feasible still holds. When $e < e_s^{FI}$, then $\mathcal{S} = D$ and speculation is repressed by no short sales.

When $e_s^{FI} \leq e < e^{hm}$, suppose that the equilibrium when short sales are allowed involves short sales. When short sales are not allowed, this creates a partial impunity for the weak type. For an equilibrium, we require

$$\mathcal{S} \leq D.$$

Since $\mathcal{S} = 0$ and/or $x = 0$ cannot be part of an equilibrium,

$$\frac{1}{e} \geq \frac{\rho'}{e_s} + \frac{1-\rho'}{e_w},$$

and

$$W_w^{FI} \leq \phi(\rho', \alpha) + v(e_w).$$

Furthermore,

$$\mathcal{R}_i - \frac{\mathcal{S}}{e} - \frac{D-\mathcal{S}}{e_i} = c_2^*(e_i) \quad i \in \{w, s\}.$$

Consider, first, the possibility of non-repressed speculation ($f = e$). Then $\mathcal{S} \leq D$ would be an equilibrium of the short-sales situation with $x \leq 1$ and $W_w^{FI} = \phi(\rho', \alpha) + v(e_w)$ or $x = 1$ and $W_w^{FI} < \phi(\rho', \alpha) + v(e_w)$, a contradiction. As a result, the equilibrium without short sales involves *repressed speculation*:

$$f > e,$$

and so $\mathcal{S} = D$.

The forward rate f, date-2 exchange rates e_s and e_w, and the pooling probability are given by:

$$\mathcal{R}_w - \frac{D}{e} = c_2^*(e_w),$$

$$\mathcal{R}_s - \frac{D}{e} = c_2^*(e_s)$$

$$W_w^{FI} \geq \phi(\rho', \alpha) + v(e_w), \quad \text{with equality if } x < 1,$$

and

$$\frac{1}{f} = \frac{\rho'(x)}{e_s} + \frac{1-\rho'(x)}{e_w}.$$

The two FX clearing equations completely determine e_w and e_s. Since $\mathcal{S}$ is smaller than under short sales (short sales constraints cut the weak type's losses), e_w appreciates relative to the short sales case and e_s depreciates relative to the short sales case. Since e_w appreciates, when the weak type mixes with positive probability, ρ' must fall, which happens when we increase the probability that the weak type defends the peg. $\diamond$

Proof of Proposition 5. (i) In the fundamental exchange rate model, e_w and e_s are fixed. The parity condition: $\frac{1}{e} = \frac{\rho'}{e_s} + \frac{1-\rho'}{e_w}$ implies that ρ' is a weakly decreasing function of e, so that x is a weakly increasing function of e. Result (i) follows from a simple revealed preference argument: let e_A be an optimal peg for α_A and e_B an optimal peg for α_B, with $\alpha_B > \alpha_A$ and let $\mathcal{C}_2^*(e) \equiv \mathcal{R}_s - \mathcal{S}\left(\frac{1}{e} - \frac{1}{e_s}\right) - \frac{D}{e_s}$. Then

$$\phi(\rho'(e_A), \alpha_A) + e_s\mathcal{C}_2^*(e_A) \geq \phi(\rho'(e_B), \alpha_A) + e_s\mathcal{C}_2^*(e_B),$$
$$\phi(\rho'(e_B), \alpha_B) + e_s\mathcal{C}_2^*(e_B) \geq \phi(\rho'(e_A), \alpha_B) + e_s\mathcal{C}_2^*(e_A).$$

These two equations imply that

$$\phi(\rho'(e_A), \alpha_A) - \phi(\rho'(e_A), \alpha_B) \geq \phi(\rho'(e_B), \alpha_A) - \phi(\rho'(e_B), \alpha_B).$$

Since $\phi_\alpha(\rho', \alpha)$ is weakly increasing in ρ', and ρ' is weakly decreasing in e, we find that the optimal e is weakly decreasing in α.
(ii) The welfare of the strong type is:

$$W_s = \phi(\rho', \alpha) + e_s\mathcal{R}_s - D - e_s\mathcal{S}\left(\frac{1}{e} - \frac{1}{e_s}\right) + (e_w - e_s)c^*.$$

Likewise for the weak type to be willing to randomize: $W_w^{FI} = \phi(\rho', \alpha) - e_w\mathcal{S}\left(\frac{1}{e} - \frac{1}{e_w}\right) + e_w\mathcal{R}_w - D$. Substituting for $\phi(\rho', \alpha)$, the strong type's welfare is $W_s = \frac{\mathcal{S}}{e}(e_w - e_s) + k$, where k is a constant. The weak-type mimicking condition implies that $\phi(0, \alpha) + e_w\mathcal{R}_w - D = \phi(\rho', \alpha) - e_w\mathcal{S}\left(\frac{1}{e} - \frac{1}{e_w}\right) + e_w\mathcal{R}_w - D$, allowing us to write the strong type's welfare as a constant plus $(e_w - e_s)\left[\frac{\phi(\rho'(e),\alpha)-\phi(0,\alpha)}{e_w-e}\right]$. Using the parity condition, $\rho'(e) = \frac{\frac{1}{e}-\frac{1}{e_w}}{\frac{1}{e_s}-\frac{1}{e_w}}$, we find that W_s is an increasing and affine function of $\frac{\phi(\rho'(e),\alpha)-\phi(0,\alpha)}{e_w-e}$. It is easy to check that this function is decreasing in e if $\frac{\partial^2\phi}{\partial\rho'^2} \geq 0$. Similarly, one can show that $\mathcal{S}$ is weakly decreasing in e.

Let $\bar{e}$ denote the equilibrium exchange rate: $\frac{1}{\bar{e}} = \frac{\bar{\rho}}{e_s} + \frac{1-\bar{\rho}}{e_w}$ and $\bar{\mathcal{S}}$ denote the corresponding speculation.

(iii) Suppose that $D < \bar{D} \equiv \bar{\mathcal{S}}$. Because $\mathcal{S}$ is weakly decreasing in e (see (ii)), and W_s is monotonic for $\rho \leq \bar{\rho}$, the optimal exchange rate must lie in the region in which speculation is constrained by the short-sales constraint.

When the short sales constraint binds $\mathcal{S} = D$, the weak type indifference condition is $W_w^{FI} = \phi(\rho', \alpha) - e_wD\left(\frac{1}{e} - \frac{1}{e_w}\right) + e_w\mathcal{R}_w - D$. This implies that $W_s = D\left(\frac{e_w-e_s}{e}\right) + k'$, where k' is a constant, and thus the strong type will want to set e as small as possible. Hence $\rho'(e) = \bar{\rho}$. Let $\hat{e}$ and $\hat{S}$ denote the equilibrium exchange rate and speculation under unlimited short sales and $\tilde{e}$ and $\tilde{\mathbb{S}} = D$ their counterparts under no short sales. The strong type is worse off in the absence of short sales if and only if $\frac{\tilde{\mathbb{S}}}{\tilde{e}} < \frac{\hat{S}}{\hat{e}}$, which results from the weak type's indifference equations and the property that $\tilde{e} < \hat{e}$. $\diamond$

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