MORAL HAZARD EFFECTS OF BAILING OUT UNDER ASYMMETRIC INFORMATION

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Abstract

With a four-stage sequential game model, we study how bailouts ameliorate the effects of liquidation on fundamentals, reduce the likelihood of currency crises and affect the financial sector's (non-observable) effort. In stage 1, exchange rate regime is announced and all agents receive probabilistic information that a shock may occur in stage 4. Here, the government can commit to an optimal bailout or may wait until stage 4 when a bad shock may occur. The private sector in stage 2 forms exchange rate expectations, and decides on investments and effort. In stage 3, the government faces costs due to expectations of devaluation and liquidation, and may decide to pre-emptively abandon its exchange rate policy. We show that commitment decisions have very important implications for the agents' optimal decisions.

JEL Classification: E44, F30, F41.

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1. Introduction

The last events in Argentina have made pundits to question severely the IMF policy regarding bailouts. It is argued that other policy alternatives should be explored both to avoid Argentina's type of currency and financial crises. There is however still the issue of what to do when a country is in the middle of such crises, in the initial stage of a crisis or under imminent future crisis. It is likely that similar or other such a type of crises may occur at another point of time and in the same or another region/country. The reasons for that to occur can be numerous. We economist hopefully at this point know that there are certain criteria to fulfil in order to avoid such crisis. It is though unrealistic to expect that we know all and that governments will behave socially optimal. Therefore, some crisis may still occur and may take us by surprise. Financial crises whatever their causes are, can threaten countries with huge losses. In this paper, we would like to analyse whether bailouts could ameliorate the effects that costly liquidation associated with financial crisis could have on the fundamentals, and avoid the currency crises that usually follow a panic in the financial sector. We view currency crisis as a by-product to financial distress. We will also examine the effect of the optimal bailout policy on the effort the financial/private sector will put in to avoid insolvency. Insolvency, in this paper, will arise not just because of a "bad" shock occurs but also because the representative investor chooses to put little effort. Thus, insolvency may be avoided with a reasonable amount of effort even when a "bad" shock occurs. The government may or may not commit to an optimal bailout only if a bad shock occurs. If it commits, it will commit before the private sector forms expectations and makes decisions on investments and the effort to put in to make or not the project successful. An important feature introduced in the paper is that the representative financial entity has private information on his own effort and it is likely that this effort will be affected by the bailout policy implemented by the government (committed or no-committed). This is a realistic consideration because even though ex-ante conditionality[1] (availability and size of official crisis lending can be made conditional on the financial entity behaviour) is desirable, its implementation is far from obvious when asymmetric information is present. In our case, the private sector will receive a bailout if the economy ends in the bad state. Moreover, any bailout cannot be conditioned on the type of effort because this is the financial sector's private information. This implies that the uncertainty on the state on the economy and the possibility of obtaining a bailout even when high effort is implemented can give the private sector incentives to make their projects successful and avoid insolvency.

It has been argued that a safety net may also increase the moral hazard incentives for excessive risk-taking on the part of banks (Schwartz (1998) and Bordo and Schwartz (2000). A regulatory and supervisory system is therefore also necessary to reduce excessive risk-taking in the financial system (Mishkin (1999)).

Mishkin (1995), Freixas, Parigi and Rochet (1998), Freixas (1999), Aghion, Bolton and Fries (1999) and Cole and Kehoe (2000) find that under certain conditions, there could be cases where bailing out banks may be efficient. Most people would agree that if a lender-of-last-resort guarantees at least some of the outstanding stock of liabilities (i.e. a bailout), such guarantee should be of a short-run type, and for it to be effective, it has to be implemented very quickly. Less intervention may be required subsequently, once market participants realise that some necessary liquidity has been injected into the system, thus decreasing their uncertainty. Mundaca (2002) finds that a government will generally have incentives to pre-commit itself to making such bailouts. Ex-ante commitments to optimal bailouts are “good” in that they facilitate the achievement of a more efficient unique equilibrium (with no devaluation) when the government has a potential problem of credibility regarding its exchange rate policy. These commitments thus serve as a strategic device for the government.

[1] See Jeanne and Zettelmeyer (2001) for such argument.

Similar results are found in Cole and Kehoe (2000) where implementing an optimal bailout could lead the economy to exit the crisis but this becomes more challenging if the credibility of the government is very low.

Allen and Gale (2000) argue that the common cause of both banking and currency crises, is usually a fall in asset values due to a recession or a weak economy. Recent empirical work has also attempted to study empirically the most likely causes of currency crises and their relationship with credit problems. Studies by the IMF (1998) and Kaminsky and Reinhart (1999) linking banking and currency crises, find that most currency crises are preceded by a build-up of private-sector debt, usually after a boom. Glick and Hutchison (1999) study the empirical relationship between currency crises and banking crises over the period 1975-97, and find a substantial correlation that is highest for the East Asian economies. Eichengreen and Rose (1998) and Rossi (1999) reach similar conclusions for subsets of developing countries. The consensus appears to be that, at least in some cases, financial crises may have "caused" exchange rate crises; in many cases, however, the twin phenomena are likely to be symptoms of underlying weaknesses of the economy, which may be manifested in various ways.[2]

The model here shows that exchange rate crises and debt crises may both be belief-driven and fundamentals-based attacks. We derive the optimal bailout policy when the government cannot observe the type of effort the private sector will put in to make their investment successful and avoid insolvency. We believe that ex-ante commitment to bailing out debt can prevent the multiple equilibria that result from changes in market beliefs. It is then possible to obtain a unique equilibrium outcome, with no currency crisis, and where the private sector may choose to put reasonable amount of effort to make their project successful.

[2] See also Miller (1996), who considers the opposite type of causation, from a currency attack to a banking crisis.

The model is presented as a four-stage sequential game in which the players are the government and the private sector. Information about the probabilistic distribution of a forthcoming (good or bad) shock is given in the first stage. This shock will be realised in the fourth stage and will affect private-sector debt and unemployment. In this first stage, the government announces that it will pursue a fixed exchange rate regime and it may or may not already at this stage commit to an optimal bailout only if a bad shock occurs.[3] It will also incur certain (fixed, constant and not further explained) costs when the fixed exchange rate regime is abandoned. In the second stage, private-sector agents form expectations about the exchange rate, and may in addition undertake risky investment activities choosing a specific amount of effort to put into that investment project. Note that for each specific type of effort implies certain technologies and required labour force. As mentioned above, the chosen effort is not only private information to the private sector but it is also determined endogenously and the level of bailout the government decided to give will dynamically affect it. The private sector's debt is denominated in foreign currency and produces a good for export in the international market. Thus, revenues are obtained in foreign currency. In stage 3, the government may react by either retaining or abandoning the peg. It should be noted that defending the exchange rate regime against attack during this stage implies costs in the interim period for the government and the economy in the form of adverse shifts in the economic fundamentals. The latter is a result, not of a shock, but of the government's policy to defend the fixed exchange rate regime against a speculative attack at this stage. In stage 3, the regime may be abandoned after the onset of the speculative attack, before it does further significant damage to the economy. This outcome, where a self-fulfilling speculative attack leads necessarily to devaluation, resembles the Krugman (1979) first-generation model, where a deterioration of the fundamentals (in addition to the market's anticipation of a financial

[3] This policy does not need to be interpreted as strictly as a fixed exchange rate regime, but it can be more realistically thought of as having an exchange rate target.

crisis) plays an important role in triggering crises. In the final stage, 4, the shock is revealed and the government decides on two things: the optimal bailout, if it has not committed already in stage 1; and whether or not to abandon the fixed-rate regime (given that the fixed rate has been retained up to this stage). Decisions at this stage depend on the state of the economy, the level of investment and the effort the private sector chooses.

We show that when no commitment has been made to a specific bailout, the model may yield multiple (2 or 3) equilibria. One of the equilibria involves always retaining the fixed peg, even in the event of a bad shock and cumulative investment losses when there are no speculative attacks. Another equilibrium involves abandoning the peg only in the worst state, and the last one involves always abandoning the peg. The last two equilibria may occur when there are speculative attacks. The last equilibrium is most likely to occur when the prior probability of a bad shock to debt and unemployment is sufficiently high and/or if shocks are quite serious when they do occur. Thus, a speculative attack is always triggered in stage 3.

It turns out, however, that a commitment to a bailout (only if a bad shock occurs) in stage 1, expressly announced before the market forms expectations, has very important implications for the outcome of this sequential game.

The paper is organised as follows: The next section presents an overview of the stages of the sequential game; section 3 presents the representative investor's problem, while section 4 presents the government's problem. Section 5 aims to show the optimal solutions in stage 4, both with and without speculative attacks and for both favourable and unfavourable state of the economy. Section 6 shows the possible optimal decisions that can be taken in stage 3, while section 7 is planned to present the government's problem when it decides to commit to a bailout at stage 1. Finally, section 8 presents a conclusion.

2. Stages of the sequential-game theoretical model

The model deals with a sequential game that consists of four stages and is represented by figure 1.

Stage 1

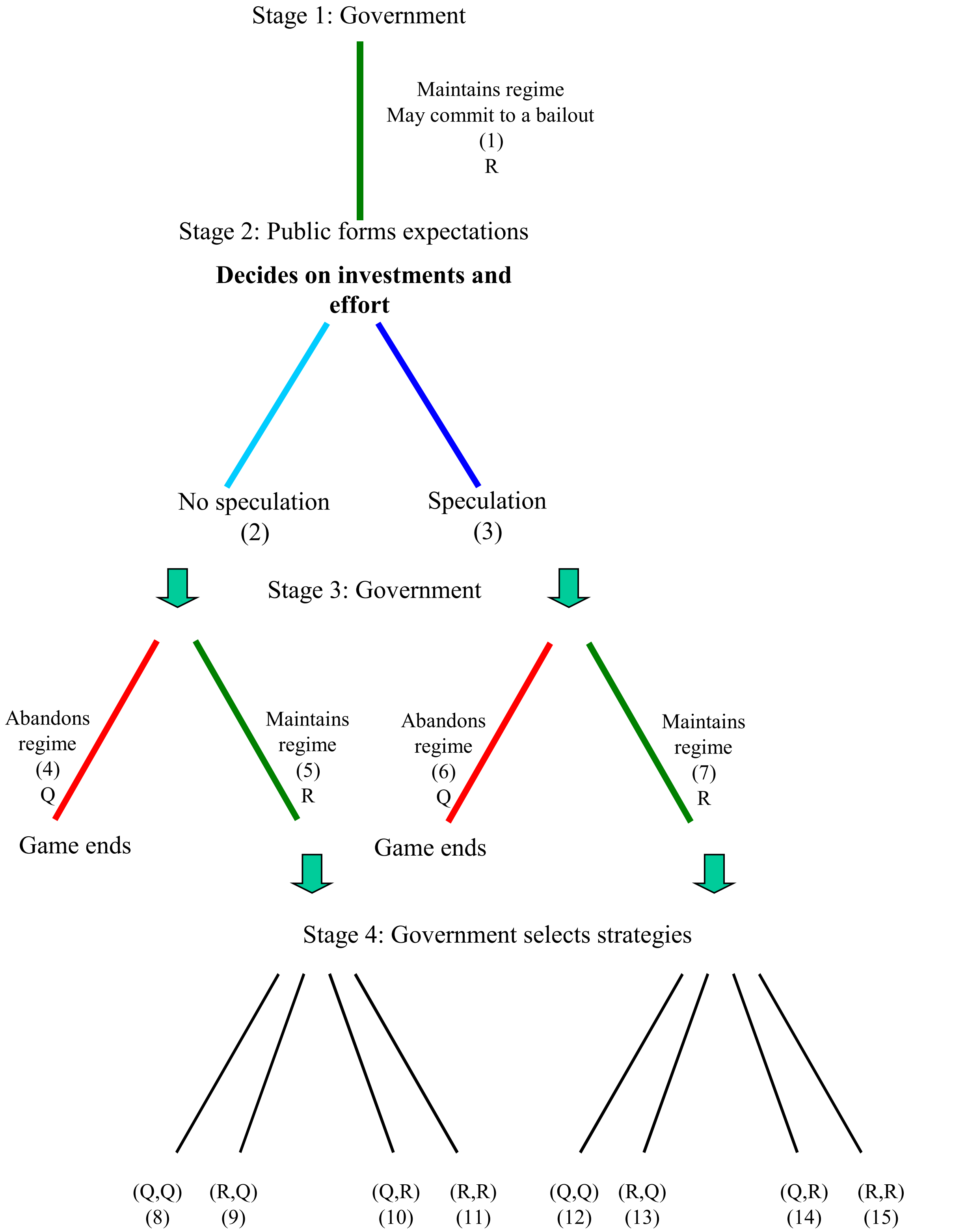
All the agents in the economy receive probabilistic information about a future shock that will occur in the last stage, affecting unemployment and the net returns on investments made by the private sector. There will be a bad shock, s_1, or a good shock, s_2, which will occur with probability π and $(1-\pi)$, respectively. We assume that s_2 takes the value of zero. That is, if s_2 occurs, this shock will have no effect on the economic fundamentals. At this stage, the government announces that it will be pursuing a fixed exchange rate regime and may or may not commit to bailing out part of the outstanding debt of the private sector.

Stage 2

If it is assumed that the regime is maintained until stage 4:

- The private sector forms expectations about the exchange rate that will be determined in stage 4 after the shock has occurred.
- The private sector makes (risky) investments to produce a good for export in the international market and incurs in costs of investment that result from borrowing in foreign currency. At the same time, agents decide on the amount of effort they will put into their investment project. The final net return to investment will depend on the shock, the exchange rate and the effort. The private sector uses these final net returns to consume in the national market. The lower net returns are, the lower the consumption.

Figure 1: Game tree describing possible strategies in the sequential game



Q represents a decision to abandon the regime; R represents a decision to maintain the regime. (m,n), m=R or Q if shock of type one, s_1, occurs; and n=R or Q if shock of type two, s_2, occurs.

Stage 3

Only the government moves. It defends the fixed exchange regime against any speculative attack, or it may give up this regime already at this stage. We find that when there is no speculative attack, the equilibrium strategy of the government involves retaining the fixed exchange rate regime. However, as soon as speculative attacks start, the government incurs certain costs that may lead it to abandon the regime already at this stage. These costs take the form of first, expected adverse shifts in unemployment because of changes in the interest rate. The government uses interest rates to defend the exchange rate regime when there are speculative attacks. The other additional costs are the expected loss of credibility (given that devaluation may occur), and the expected net loss of investment, which could always worsen in the event of devaluation and an adverse shock. The government will still face these costs until it decides to abandon the regime during this stage.

Stage 4

A stochastic shock, either s_1 or s_2, occurs and affects employment and the net returns on investment. Also at this stage, the government decides on the value of the exchange rate and the proportion of the private liabilities of outstanding stock that will be bailed out if s_1 occurs when no ex-ante commitment to bailing out has been made in stage 1. At this point it will take into consideration the realisation of investment and effort.[4]

Figure 1 is again the graphic representation of this sequential game and illustrates the basic decision structure with respect to the exchange rate. However, as noted, there are other decisions about investments, effort and possible bailouts. In the case of government commitment to bailouts, such commitment enters the picture in stage 1. Private-sector

[4] See Freixas (2000) for a description of the different ways of providing liquidity guarantees and managing crises.

investment decisions enter the picture in stage 2. Non-committed government debt bailouts enter the picture in stage 4.

A few additional introductory remarks are in order. First, we assume that whenever the government abandons the fixed exchange rate, we say that the game ”ends”; this applies to the game of setting the exchange rate, which is left, entirely to competitive market forces from then on. Even in such cases, however, the government may still need to make decisions about bailouts in stage 4. We will come back to this below. Secondly, in stage 4 there are 8 possible end nodes for the game (provided that the game progresses to that stage). As we show, few of these can be reached. We note that a rational expectations equilibrium can be compatible only with end nodes (11) (corresponding to maintaining the fixed rate in both states) and (14) (giving up the fixed rate in state 1, but not in state 2). Thirdly, the structure of payoffs in the game is such that end node (12) can also be counted out. The reason is that if the strategy combination (Q,Q) were relevant in stage 4, the government would always anticipate this and quit preemptively already in stage 3, thus avoiding the costs of a speculative attack in stage 4 (i.e., one actually ends up in node 6). We will in the following disregard possible cases with the strategy combination (Q,Q) and assume that the fixed rate will never be abandoned in stage 4 when a ”good” shock occurs in that stage.

3. The investors' problem

3.1 Optimal decisions

The decisions of investors play a most important role in the model when the government decides to make an ex-ante commitment to bailout at stage one, that is, before the market forms expectations.

The private-sector finances its investment by borrowing abroad K units of foreign currency. $R_i(K,e)$ is the net gross return on K when putting effort e. This return realises in the final stage 4, after the shock s_i has occurred. i denotes the state of the economy (i=1,2). The government will *only* bail out a fraction of the net losses that is denoted by ϕ ($\phi \in [0,1]]$, and *solely* in state 1. It will turn out that the investors' optimal decisions on e and K will depend in a certain way on ϕ.

Here, investments are to produce a good for export in the international market. $R_1(K,e)$ can become negative due to a bad shock. A bad shock may be due to for example difficulties in selling abroad (i.e. the rest of the world is in recession). It could though become positive in spite of the "bad" shock if enough effort is put in.

It is important to keep in mind that when the private sector form expectations about the exchange rate in stage 2, it also decides on the level of investment it will engage in and the effort she/he will put into her project. The government may find it worthwhile to make commitments on bailouts if it can influence the private sector in a desirable way. Therefore, influencing these expectations also implies influencing the level of investment and effort that the private sector will choose, specially because this private sector pays back its in foreign currency.

A competitive investor with rational expectations would maximise expected net return with respect to the amount invested and effort, taking into consideration the government's decisions to be taken at stage 4 on the bailout ϕ it may receive in state 1, and the exchange rate. The expected net return function, NR, is as follows:

$$E[NR] = \pi\,(1-\phi)(x(s_1)/\bar{x}\,)\,R_1(K,e) + (1-\pi)(x(s_2)/\bar{x}\,)R_2\,(K,e) - \psi(e), \qquad (1)$$

where:

- x is the (log) exchange rate (number of domestic currency units per unit of foreign currency).
- $\bar{x}$ can be interpreted either as the (log) fixed exchange rate level or the long-run equilibrium level.
- $\psi(e)$ are the costs of putting effort e.

The following assumptions about the net gross return functions are made:

When s_1 *occurs*:

- $R_1(K,e) \gtrless 0$ depending on the level of effort.

When s_2 *occurs*:

- $R_2(K,e)>0$ always.

$R_{(i)KK}(K,e)<0$ and $R_{(i)ee}(K,e)<0$; $i = 1, 2$.

R_1 may be positive or negative which implies that investors will receive respectively either a *compensation or a bailout* $\phi(x(s_1)/\bar{x})R_1(K,\hat{e})$. $(1-\phi)(x(s_1)/\bar{x})R_1(K,e)$ will be the net loss for the investors when R_1 is negative.

Maximising (1) with respect to K yields the following first-order condition:

$$\frac{R_{(1)K}(K,e)}{R_{(2)K}(K,e)} = -\frac{(1-\pi)x(s_2)}{\pi(1-\phi)x(s_1)} \tag{2}$$

In (2), the left-hand side is the ratio between the marginal net return on investment in the bad state and the good state. For (2) to hold true, the marginal net return on a given investment cannot be positive in both states. K will depend on the exchange rate and the bailout. We derive the following partial derivatives:

$$\frac{\partial K}{\partial \phi} = \frac{\pi R_{(1)K}(K,e)x(s_1)}{(1-\pi)R_{(2)KK}(K,e)x(s_2) + \pi(1-\phi)R_{(1)KK}(K,e)x(s_1)} > 0 \tag{3}$$

$$\frac{\partial K}{\partial x(s_1)} = \frac{-\pi R_{(1)K}(K,e)(1-\phi)}{(1-\pi)R_{(2)KK}(K,e)x(s_2) + \pi(1-\phi)R_{(1)KK}(K,e)x(s_1)} < 0 \tag{4}$$

(3) and (4) will be fulfilled if $R_{(1)K}(K,e) < 0$.[5]

[5] If this condition is fulfilled, (2) will be satisfied if $R_{(2)K}(K,e) > 0$.

From (3), the anticipation of a greater fraction of bailouts, ϕ, in the "bad" future state (1), all else being equal, leads to higher risky investments. From (4), an increase in $x(s_1)$, i.e. a stage 4 devaluation which is rationally anticipated by investors in stage 2, makes investors incur less risky investment. (3) then indicates that the private sector would have a greater incentive to prefer high levels of risky investments, such as K. Thus, the possibility of a safety net evidently causes a moral hazard problem. However, since the government will only provide a bailout in the case that a "bad" shock occurs, this may cause investors to choose a lower K than they would otherwise would because of the uncertainty as to what stage of the economy will prevail in stage 4. Note that we are not modelling how different types of investment may be chosen, e.g. in terms of their riskiness, in response, for example, to ϕ. This will be the topic of future research.

Maximising (1) with respect to e yields the following first-order condition:

$$\pi(1-\phi)x(s_1)R_{e(1)}(K,e) = \psi'(e) - (1-\pi)x(s_2)R_{e(2)}(K,e) \tag{5}$$

e will depend on K, the exchange rates and the bailout.

We will also get that:

$$\frac{\partial e}{\partial \phi} = \frac{\pi x(s_1)R_{(1)e}(K,e)}{(1-\pi)R_{(2)ee}(K,e)x(s_2) + \pi(1-\phi)R_{(1)ee}(K,e)x(s_1) - \psi''(e)} < 0\,; \tag{6}$$

if $R_{(1)e}(K,e)$ is positive.

$$\frac{\partial e}{\partial x(s_1)} = \frac{\pi R_{(1)e}(K,e)(1-\phi)}{(1-\pi)R_{(2)ee}(K,e)x(s_2) + \pi(1-\phi)R_{(1)ee}(K,e)x(s_1) - \psi''(e)} < 0\,; \tag{7}$$

if $R_{(1)e}(K,e)$ is positive.

(6) indicates that if the marginal net return at the optimal solution for the representative investor is positive, the anticipation of a greater fraction of bailouts, ϕ, in the "bad" future state (1), all else being equal, could lead investors to put less effort. From (7), an increase in

$x(s_1)$, i.e. a stage 4 devaluation which is rationally anticipated by investors in stage 2, may also make investors put less effort.

The investor's decisions are indeed most relevant when the government wishes to commit to a bailout in stage 1 before the investor forms expectations, and decides on K (level of investment) and e (level of effort). In contrast to the case when there is no commitment, the government will minimise its costs considering simultaneously individuals responses to any commitment to bailing out. Note that with no commitment before stage 4, the government makes decisions on bailouts and exchange rate after observing the decisions investors have already made regarding K and e.

We finally assume that not all investors are equal. Some of them will decide to put a lower effort than the optimal one according to (5). This will lead to what we could call endogenous risk. It differs from Freixas (2000) basically because the government's bailout policy (when it commits in stage 1) may influence both the decisions of all type of investors and the proportion of the investors that will decide to put a different effort than the one in (5).

3.2 Endogenous risk

The risk becomes endogenous since the degree of riskiness depends on the investors' own strategy even though the government can also influence such decisions. All investors choose *K optimally*, according to (2), say $\hat{K}$. They will be however some of them who may choose to put lower effort, say e^L, which will differ from the *optimal e* determined in (5)*, say* $\hat{e}$. The optimal effort $\hat{e}$ is a function of K, the exchange rate, and the fraction of debt that will be bailed out.

We assume that the investors who will choose e^L will follow a Ss scheme for changing her effort.[6] That is, whenever an agent adjusts her effort, she does such as the difference between the optimal effort ($\hat{e}$) and her actual effort (e^L), $\hat{e}$ - e^L equals some target level, S. From (5), we know that bailouts, among other things, have effects on $\hat{e}$. Investors will maintain effort e^L until a change in the bailout makes $\hat{e}$-e^L to decrease to some trigger value, s. She then resets e^L so that $\hat{e}$-e^L again becomes equal S, and the process begins anew.

The initial distribution of $\hat{e}$-e^L, across those investors who deviate from $\hat{e}$, is uniform between s and S. How would the bailout policy affect investors' decisions on effort? Consider that the government decides to commit in stage 1 to bailout a proportion ϕ of the outstanding debt such as $\Delta\phi$<S-s. We can then analyse how a change in the bailout policy from no-commitment to commitment affects the initial equilibrium level of effort $\hat{e}$. If for example, the committed bailout is higher than the no-committed one, it will decrease $\hat{e}$ as (6) may seem to indicate. If this causes $\hat{e}$-e^L to become equal or lower than s, investors will reduce their initial level of e^L, in order to reset $\hat{e}$-e^L=S. This together with the occurrence of a bad shock may increase the likelihood of obtaining negative returns. Thus, a significant increase in the level of bailout or simply a higher bailout may bring the economy into a financial crisis with inefficient low effort. Note however that such argument is an incomplete story. There are other mechanisms that are in place in the model, specially the effect on the investors' expectations regarding the exchange rate and the level of borrowing. We will then be able to study the relationship between currency crisis and financial distress and the consequences of these on the rest of the economy.

It is of the government interest not to create moral hazard effects both on the investors' decisions on effort and investment when deciding on the optimal bailout when it commits

[6] The modelling of out endogenous effort is an application of the model of Caplin-Spulber (1987) for menu costs.

before stage 4. *If the government decides to commit to a specific bailout,* it has then to take into consideration how many investors will decrease their initial level of effort as a result of committing to bailing out. The fraction of investors that will put lower effort than the initial $\hat{e}$ when ϕ is different than the level when there is no-commitment, will be denoted by p^L. This probability can be also interpreted as the probability that $\hat{e}$-e^L will become smaller than s when there are changes in ϕ. This is:

$$p^L = \frac{d\hat{e}}{S-s} = \frac{\frac{\partial \hat{e}}{\partial \phi} d\phi + \frac{\partial \hat{e}}{\partial x(s_1)} \frac{\partial x(s_1)}{\partial \phi} d\phi}{S-s} \tag{8}$$

d$\hat{e}$ should be interpreted as the change in the optimal equilibrium of effort as derived from (5) as a result of changing ϕ. dϕ will be again in our specific set up the difference between the committed and the no-committed bailout, this will play a very important role in all the investors decisions. We will study how effort, both the optimal one, $\hat{e}$, and the one enhanced by the investors that shirk e^L, will be affected by the decision of the government to commit to an optimal bailout in stage 1 in relation to the optimal bailout that would be given in stage 4. Having stated the representative investor optimisation problem, and the investors' strategies regarding effort, the government will take them into account when deciding its bailout policy.

4. The government's problem

We assume that the government does not like unemployment, high bailouts and any outstanding debt. These variables will enter the government's loss function.

We first assume that the unemployment rate in state i in stage 4 is determined as follows:

$$u_4(s_i) = -\alpha_1[x(s_i) - \bar{x}] + u_n + \alpha_2 r + s_i - \alpha_3[(1-\phi(s_1))(x(s_1)/\bar{x})R_i(K,e)]; \tag{9}$$

- u_n is its natural rate level; and
- $\phi(s_2) = 0$.

In (9), the first term implies that currency devaluation ex-post in stage 4 reduces unemployment. Private-sector debt problems however have negative consequences for employment in state 1 because debts lead to insolvency and maybe bankruptcies that usually lead to job losses. Any unemployment gap can however be influenced by the bailout from the government or lender of last resort. Moreover, the government may use high interest rates to stave off a speculative attack or eliminate devaluation expectations, but increases in interest rates may slow down economic activity and therefore yield higher unemployment rates.

The following relationship is also assumed:

$$r = g(Ex - \bar{x}); \qquad (10)$$

where g is a positive constant. Ex-$\bar{x}$ represents the magnitude of the speculative attack (or the devaluation expectations) that the government may try to fight against in stages 3 and 4 by increasing interest rates. g will only take values greater than zero if Ex $>\bar{x}$. Otherwise it equals zero.

The government expected loss function when the fixed exchange rate is retained until stage 3 is the following:

$$V_3(s_i, Ex, x(s_i), \phi, e, K) = a_1(u_3 - u_n)^2 + a_2 E_{s,e}(u_4 - u_n)^2 - E_{s,e}\phi(s_i)(x(s_i)/\bar{x})R_i(K,e) + EC; \qquad (11)$$

where:

$$E_{s,e}[u_4(s_1) - u_n]^2 = \pi[\alpha_1[x(s_1) - \bar{x}] + \alpha_2 r + s_1 -$$

$$\alpha_3\{(1-p^L)(1-\phi(s_1))(x(s_1)/\bar{x})R_1(K,\hat{e}) + p^L(1-\phi(s_1))(x(s_1)/\bar{x})R_1(K,e^L)\}]^2;$$

and:

$$E_{s,e}\phi(s_1)(x(s_1)/\bar{x})R_1(K,e) = \pi\{(1-p^L)\phi(s_1)(x(s_1)/\bar{x})R_1(K,\hat{e}) + p^L\phi(s_1)(x(s_1)/\bar{x})R_1(K,e^L)\}$$

Note then that insolvency will arise not just because of a "bad" shock occurs but also if many investors choose to put little effort (e^L). Insolvency will always have negative effects on the fundamentals.

The loss function in stage 4 is:

$$V_4(s_i, Ex, x(s_i), \phi, e, K) = a_2(u_4 - u_n)^2 - \phi(s_1)(x(s_1)/\bar{x})R_1(K,e) + \lambda C \qquad (12)$$

- Note that at stage 4, the type of investor and the level of the risky investment, K, become public information. The government decides the level of the exchange rate and bailout in basis on that and the realised shock.
- All parameters are greater than zero.
- E represents the conditional expectations operator.
- C represents the costs of abandoning the fixed exchange regime, for example through loss of credibility. On the other hand, λ is a dummy variable that takes the value of one when the fixed-rate policy is abandoned, and zero otherwise.
- u_j is the actual rate of unemployment in stage j (j=3 or 4).

Finally, note that the government loss function in the third stage (10) includes the costs of excess unemployment originated by the speculative attacks at that stage plus the expected ones in stage 4. (10) also includes the expected costs of any outstanding debt and of bailing out.

5. Stage 4 when there are no commitments to bailing out

When the government has made no commitments to any bailout before stage 4, the optimal level of exchange rate and bailout will depend on the realised e, K and of course the final shock to the economy (and the parameters of the model). Thus, the government faces no uncertainty regarding the actual level of effort since this becomes known at this stage. In such case, the solution for the optimal exchange and bailout in stage 4 will be similar to the ones found in Mundaca (2002) where effort is not considered, but the relationship between exchange rate and financial crises and optimal bailout policy are analysed.

Mundaca (2002) shows that when the representative investor has no devaluation expectations (Ex=$\bar{x}$), she chooses a specific level of risky investment, $\tilde{K}$ and $\tilde{e}$ leading us to the following propositions:

Proposition 1: *A rational expectations equilibrium can only be compatible with the end node (11), in figure 1. This node corresponds to the decision of maintaining the fixed exchange rate when either shock takes place. Node (11) implies that:*

$$x(s_1) = \bar{x};$$
$$x(s_2) = \bar{x}$$

The proof is shown in Mundaca (2002).

Mundaca (2002) also shows that when there are devaluation expectations (Ex>$\bar{x}$) conditioning the level of risky investment, $\hat{K}$, and effort $\hat{e}$ chosen by the private sector, we will have the following proposition:

Proposition 2: *When there are speculative attacks, a rational expectations equilibrium is compatible only with end node (14), in figure 1, which corresponds to abandoning the fixed rate if a "bad" shock takes place but maintaining it if a "good" shock occurs. Node (14) implies that:*

$$x(s_1) > \bar{x};$$
$$x(s_2) = \bar{x}$$

The proof is also presented in Mundaca (2002).

Notice that expectations in the foreign exchange market are also (as in (ii) above) taken into account by considering that:

$$Ex = \pi x_1 + (1-\pi)x_2 \tag{13a}$$

From propositions 1 and 2 we know that the government sets $x_2=\bar{x}$ it so that:

$$Ex-\bar{x}=\pi(x_1-\bar{x}) \tag{13b}$$

The main difference from the case of no devaluation expectations is that equations (9) and (10) now comes into play. They together represent the adverse effect on fundamentals caused by the speculative attack. Recall that the government raises domestic interest rates to stave off speculation but this policy shifts unemployment up. Unemployment may of course decrease in proportion to the bailout that will be given. Assuming $\bar{x}=1$, the optimal bailout can be obtained by maximising the following loss function:

$$\begin{aligned} V_4(s_1,Ex>\bar{x},x(s_1)>\bar{x},\hat{\phi},\hat{K},C,\hat{e}) &= a_2[-\alpha_1(\hat{x}(s_1)-\bar{x})+\alpha_2 g\pi(\hat{x}(s_1)-\bar{x})+s_1 \\ &-\alpha_3(1-\hat{\phi}s(_1))(\hat{x}(s_1)/\bar{x})R_1(\hat{K},\hat{e})]^2-\hat{\phi}(s_1)(\hat{x}(s_1)/\bar{x})R_1(\hat{K},\hat{e})+C \end{aligned} \tag{14}$$

Thus, the optimal bailout when the government devalues in state 1 is:

$$\hat{\phi}=1-\frac{2a_2\alpha_3 s_1-1+2a_2\alpha_3(\hat{x}(s_1)-1)(\alpha_2 g\pi-\alpha_1)}{2a_2\alpha_3^2\hat{x}(s_1)R_1(\hat{K},\hat{e})} \tag{15}$$

There will not be any bailout if:

a) $\dfrac{2a_2\alpha_3 s_1-1+2a_2\alpha_3(\hat{x}(s_1)-1)(\alpha_2 g\pi-\alpha_1)}{2a_2\alpha_3^2\hat{x}(s_1)R_1(\hat{K},\hat{e})}\rangle 0$, and

b) $\dfrac{2a_2\alpha_3 s_1-1+2a_2\alpha_3(\hat{x}(s_1)-1)(\alpha_2 g\pi-\alpha_1)}{2a_2\alpha_3^2\hat{x}(s_1)R_1(\hat{K},\hat{e})}\rangle 1$

The optimal $\hat{x}(s_1)$ will be then:

$$\begin{aligned} \hat{x}(s_1) &= \frac{\hat{\phi}R_1(\hat{K},\hat{e})+2a_2\{\alpha_2 g\pi-\alpha_1-\alpha_3(1-\hat{\phi})R_1(\hat{K},\hat{e})\}(\alpha_2 g\pi-\alpha_1)}{2a_2[\alpha_2 g\pi-\alpha_1-\alpha_3(1-\hat{\phi})R_1(\hat{K},\hat{e})]^2}+ \\ &\frac{2a_2 s_1\{\alpha_2 g\pi-\alpha_1-\alpha_3(1-\hat{\phi})R_1(\hat{K},\hat{e})\}}{2a_2[\alpha_2 g\pi-\alpha_1-\alpha_3(1-\hat{\phi})R_1(\hat{K},\hat{e})]^2} \end{aligned} \tag{16}$$

We would like to present the above results in a less abstract manner, we have assumed a specific functional form for the investment return $R_i(K,e)$, i=1,2:

When i=1: $$R_1(K,e)=\gamma_1 K-\frac{1}{2}\delta_1\frac{K^2}{e}$$

When i=2: $$R_1(K,e)=\gamma_2 K-\frac{1}{2}\delta_2\frac{K^2}{e^2}$$

While the the cost function of effort is assumed to take the following form:

$$\psi(e)=\beta e^2$$

All the parameters in the return functions and the cost function are positive.

The net return to investment will always be positive in (the good) state 2 while in (the bad) state 1, it can be both negative or positive depending on the level of K and e.

We also assumed the following reasonable parameter values: $\bar{x}=1$, $a_1=a_2=0.6$, $\alpha_1=2.2$, $\alpha_2=4$, $\alpha_3=0.45$, $g=0.71$, $p=0.5$, $s=0.25$, $\gamma_1=0.2$, $\delta_1=0.8$, $\gamma_2=2$, $\delta_2=0.08$.

Figure 2a. Optimal bailout for given exchange rate and investment

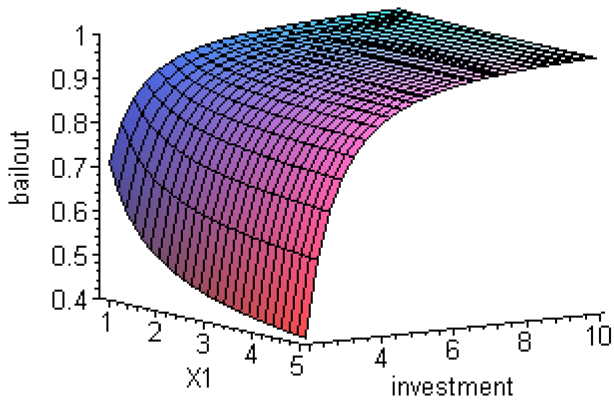


Figure 2a shows optimal bailout, $\hat{\phi}$ (equation (15)), for different values of the exchange level, $x(s_1)$ and investment K, holding effort constant. Thus, K and $x(s_1)$ are taken as given. Figure 2b (also equation (15)) shows optimal bailout, $\hat{\phi}$ for different values of the exchange level, $x(s_1)$ and effort e, but now investment K is held constant.

When the government makes no commitment, it decides on the optimal level of bailout and the exchange rate in stage 4, taking as given the investors' decisions on investment and effort.

Effort has already mentioned, becomes known and therefore the number of investors who do and do not shirk becomes common knowledge. This is what figures 2a and 2b represent.

Figure 2b. Optimal bailout for given exchange rate and effort

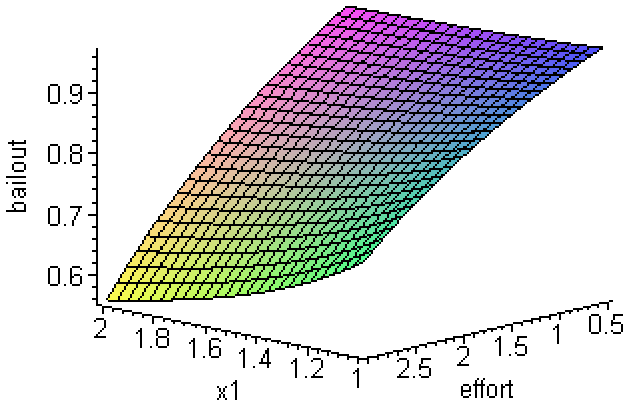


Figure 2a indicates that with non-commitment, the larger the devaluation, the smaller the bailout the government will give to the private sector. It is also the case that for given exchange rate level, the larger K the larger ϕ will be. Recall that devaluation will be optimal when it is desirable to avoid the negative effects of a bad shock and outstanding debt on unemployment. If the government finds it optimal to make a large devaluation in order to leave the economic fundamentals minimally affected, a smaller bailout will be needed. Figure 2b indicates that for a fixed level of investment, bailouts will decrease as effort increases. This is so because a higher effort may lead to obtain positive returns on investment in spite of the occurrence of a bad shock become instead positive. Also here, the larger the devaluation, the smaller the bailout should be.

Simulations were done to check the robustness of the solutions. The following was found:

- A higher bailout will be offered for a given depreciation of the exchange rate when:

  i) The probability that the economy will be in the bad state becomes larger.

  ii) The effect of the debt problems on unemployment increases.

iii) The size of the "bad" shock is larger.

iv) Depreciation has not significant effect on unemployment.

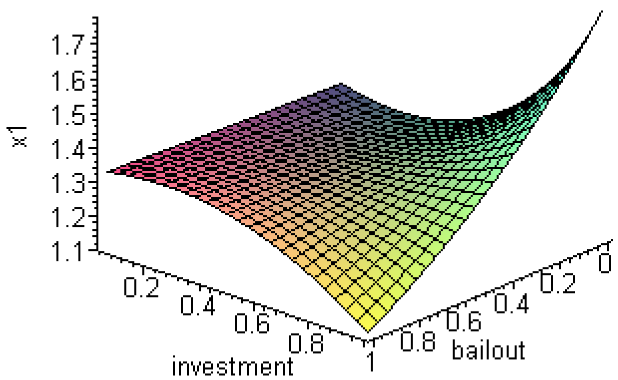
- The relationship between $\hat{\phi}$ and x1 will be positive when:

i) The effect of devaluation expectations on unemployment and the government's desutility becomes larger.

ii) The desutility to the government from higher unemployment is larger.

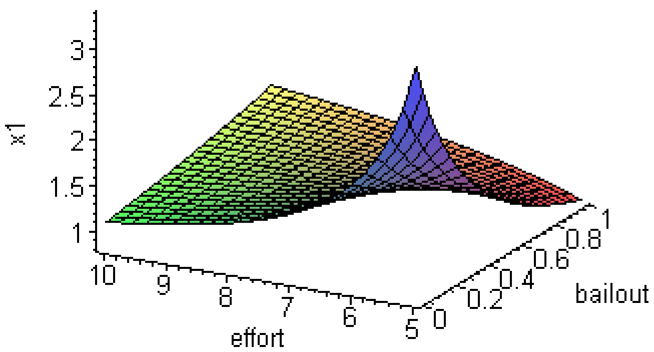
Figure 3a shows the relation between the optimal exchange rate (equation (16)) and different values of bailout and investment, while keeping effort constant. A bailout smaller than 30% together with a high level of risky investment will require a relatively high devaluation.

Figure 3a. Optimal exchange rate for given bailout and investment



Otherwise, if the proportion of outstanding debt that will be bailout is sufficiently large, the devaluation needs not to be that large when the level of investment is large. This must imply that as the government obtains less utility from investment losses in the bad state due to the high levels of risky investment, only a sufficiently large bailout could avoid a large devaluation to compensate for the negative effects on the fundamentals (and the government's welfare). This seems to reflect Argentina's case, both before it abandons the dollar peg and thereafter its current situation. Huge amount of financial rescue seemed to be needed in this country to avoid further devaluation and further collapse of the economy.

Figure 3b. Optimal exchange rate for given bailout and effort



While figure 3b shows the relation between the optimal bailout and different values of the exchange rates and effort, while keeping investment constant. We find that sufficiently small effort could lead to very large devaluation, especially if bailouts are minimal.

We have finally calibrated the model to obtain the equilibrium values of the exchange rate ($\hat{x}$), bailout ($\hat{\phi}$), effort ($\hat{e}$), and investment (borrowing abroad) ($\hat{K}$) in stage 4 for different values of β, the parameter in the effort cost function. $\hat{x}$ and $\hat{\phi}$ are obtained by solving simultaneously equations (15) and (16) taking as given (2) and (5):

Table 1

β	$\hat{x}$	$\hat{\phi}$	$\hat{e}$	$\hat{K}$
0.1	3.61	0.13	3.46	3.60
0.5	2.16	0.23	1.02	1.68
1	1.72	0.29	0.63	1.285
2	1.36	0.36	0.41	0.99

We summarise our calibration results with the following proposition.

Proposition 3 *Higher (lower) costs in putting effort reduces (increases) the amount of borrowing abroad and effort, and the equilibrium levels of exchange rate and bailout that minimises the government cost function are higher (lower).*

These results will be taken into consideration when we compare the results of the commitment case.

6. Stage 3 when there are no commitments to bailing out

It is important to notice that when there are no speculative attacks, it will never be optimal to abandon the regime in stage 3 because there are no costs for staving off speculative attacks. The government might as well wait until stage 4 to make decisions about the exchange rate and bailouts. If the fixed exchange regime is abandoned, the government will incur a cost C, the loss of credibility. Interesting things happen, though, when there are speculative attacks in the exchange rate market, Ex> $\bar{x}$.

We will still consider here the case where the government has made no commitment to a specific bailout before stage 4. At this third stage, by rational expectations, agents in the economy know that if in stage 4 a "bad" shock occurs, there will be given a bailout $\hat{\phi}$ (equation (14)), as well as an amount of risky investments equal to $\hat{K}$ and effort level equal $\hat{e}$.

Now, when speculative attacks have been initiated, the government can make either of the following decisions:

i) To abandon the fixed exchange regime right after the private sector's expectations have formed, that is at the very beginning of stage 3.

ii) To maintain the exchange rate regime, bearing all the costs of defending it, and wait until stage 4 to make a decision on the exchange rate. Such a decision implies that the government may consider it worthwhile to wait until the shock to the economy occurs and to abandon the regime only in the bad state, i.e. $x(s_1)>\bar{x}$ and $x(s_2)=\bar{x}$.

iii) To stave off speculative attacks during stage 3 and face the costs of defending the exchange rate regime. If in the interim, the government anticipates that the costs of continuing to defend the regime during stage 3, will be unaffordable, it is possible that the exchange rate regime may be abandoned regardless of whether a "bad" or "good" shock is expected to occur in stage 4, i.e. $x(s_1)>\bar{x}$ and $x(s_2)>\bar{x}$. The government will need to evaluate whether or not to abandon the regime already during this stage with the possibility of maintaining the regime until stage 4.

In order to make the optimal decision, it is necessary to evaluate the loss functions resulting from each of the above alternatives and compare them.

If the government chooses (i), it will incur a cost equal to C. On the other side if the government decides to defend the exchange rate regime in stage 3 against speculative attacks and maintain it until stage 4 only in the good state (i.e. $x(s_1)>\bar{x}$ and $x(s_2)=\bar{x}$), the loss function (11) after using (13), and simplifying (9) by making the following assumption, $u_3-\bar{u}=\alpha_2 g(Ex-\bar{x})$:

$$\begin{aligned}
V_3(Ex>\bar{x},\hat{x}(s_1)>\bar{x},x(s_2)=\bar{x},\hat{\phi},\hat{K},\hat{e}) &= a_2\pi[(-\alpha_1(\hat{x}(s_1)-\bar{x})+\alpha_2 g\pi(\hat{x}(s_1)-\bar{x})+s_1- \\
&\alpha_3\{(1-p^L)(1-\hat{\phi})(\hat{x}(s_1)/\bar{x})R_1(K,\hat{e})+p^L(1-\hat{\phi})(\hat{x}(s_1)/\bar{x})R_1(K,\hat{e}^L)\}]^2 \\
&+[a_1(\alpha_2 g)^2+a_2(1-\pi)g^2\alpha_2^2]\pi^2(\hat{x}(s_1)-\bar{x})^2 \\
&-\pi\{(1-p^L)\hat{\phi}(\hat{x}(s_1)/\bar{x})R_1(K,\hat{e})+p^L\hat{\phi}(\hat{x}(s_1)/\bar{x})R_1(K,e^L)\}+\pi C
\end{aligned} \quad (17)$$

Note that one of the differences between (14) and (17) (the government's loss function in the fourth stage) is that (17) now includes both the shifts, during stage 3 and the expected shifts in stage 4, in the fundamentals (unemployment) due to devaluation expectations. The other difference is that now we have the *expected* costs resulting from net loss of investment and abandonment of the regime in stage 4 (i.e. another argument in (17) is π, the probability that a bad shock will occur). p^L is also another difference.

Finally, if the government believes that the regime will be abandoned in stage 4 in both states (i.e. $x(s_1) > \bar{x}$ and $x(s_2) > \bar{x}$), (16) will be written as:[7]

$$\begin{aligned} V_3(Ex > \bar{x}, \hat{x}(s_1) > \bar{x}, x(s_2) > \bar{x}, \hat{\phi}, \hat{K}, \hat{e}) = a_2\{\pi[-\alpha_1(\hat{x}(s_1) - \bar{x}) + \alpha_2 g\pi(\hat{x}(s_1) - \bar{x}) + s_1 - \\ \alpha_3((1-p^L)(1-\hat{\phi})(\hat{x}(s_1)/\bar{x})R_1(K,\hat{e}) + p^L(1-\hat{\phi})(\hat{x}(s_1)/\bar{x})R_1(K,\hat{e}^L))]^2 + \\ (1-\pi)[-\alpha_1(\hat{x}(s_2) - \bar{x}) + \alpha_2 g(Ex - \bar{x})]^2\} + a_1(\alpha_2 g)^2(Ex - \bar{x})^2 - \\ \pi\{(1-p^L)\hat{\phi}(\hat{x}(s_1)/\bar{x})R_1(K,\hat{e}) + p^L\hat{\phi}(\hat{x}(s_1)/\bar{x})R_1(K,e^L)\} + \pi C \end{aligned} \quad (18)$$

Proposition 4: *Assume that the government has the alternative of maintaining the exchange rate regime until stage 4 when it will devalue only if a "bad" shock occurs; it has made either no commitment to a specific bailout before stage 4; and there are devaluation expectations. It will never be optimal to abandon the exchange rate regime at the very start of stage 3 if the probability that a bad shock will occur, π, is very small.*

Proof: If the government abandons the regime just after the end of stage 2, it will incur in a cost equal to C, the loss of credibility. Waiting until stage 4 and devaluing only in the bad state implies that the government will incur in costs equal πC and other costs that are also multiplied by π. Thus, even if the costs of maintaining the regime until stage 4 are significant, it will not be optimal to abandon the exchange rate regime if the probability that the economy will end up in the bad state, π, is very small and the credibility loss is very large.

[7] Note that we now do not use (16) but rather $Ex = \pi x(s_1) + (1-\pi)x(s_2)$ since it is expected rationally that $x(s_2) > \bar{x}$.

Proposition 5: *Assume that the government has the alternative of maintaining the exchange rate regime until stage 4 but it will abandon it if a "bad" shock occurs; it has made no commitment to a specific bailout before stage 4; and there are devaluation expectations. The government will then stave off the speculative attacks during stage 3 and wait until stage 4 to make decisions on the exchange rate and bailout if the following condition is fulfilled:*

$$a_1(\alpha_2 g)^2\pi^2(\hat{x}(s_1)-\bar{x})^2 > (1-\pi)\{V_4[s_1, Ex>\bar{x}, x(s_1)>\bar{x}, x(s_2)=\bar{x}, \hat{\phi}, \hat{K}, E\hat{e}, C]+ a_2 g^2\alpha_2^2\pi^2(\hat{x}(s_1)-\bar{x})^2\} \tag{19}$$

Note that the expression on the left-hand side represents the costs of staving off speculative attacks in terms of higher unemployment during stage 3. The expression in the right-hand side is the probability that a "good shock" will occur times the total cost of maintaining the exchange rate regime until stage 4 when speculative attacks have started in stage 2 taking into account that either a "bad" or "good" shock may occur. [8]

Proof. (19) is obtained by comparing (14) and (17).

Proposition 6: *Assume that the government has the alternative of abandoning the exchange rate regime in stage 4 either when a "bad" shock or a "good" occurs; it has made no commitment to a specific bailout before stage 4; and there devaluation expectations. The government will then abandon the exchange rate regime already in stage 3 if the following condition is fulfilled:*

$$a_1(\alpha_2 g)^2\pi^2(\hat{x}(s_1)-\bar{x})^2 < (1-\pi)\{V_4[s_1, Ex>\bar{x}, \hat{x}(s_1)>\bar{x}, x(s_2)=\bar{x}, \hat{\phi}, \hat{K}, Ee, C]+ a_2[-\alpha_1(x(s_2)-\bar{x})+\alpha_2 g(Ex-\bar{x})]^2\} \tag{20}$$

[8] Notice that:

- $a_1(\alpha_2 g)^2\pi^2(\hat{x}(s_1)-\bar{x})^2 = a_1\{\alpha_2 g(Ex-\bar{x})\}^2 = a_1(u_3-u_n)^2$; and
- $(1-\pi)a_2 g^2\alpha_2^2\pi^2(\hat{x}(s_1)-\bar{x})^2\} = (1-\pi)a_2\{\alpha_2 g(Ex-\bar{x})\}^2 = (1-\pi)a_2\{u_4(s_2)-\bar{u}\}^2$

In contrast to (18), the right-hand side now also includes the costs, in terms of higher unemployment, for planing to devalue also in the good state.[9]

Proof.

(20) is obtained by comparing (14) and (18).

7. Bailout commitments

When expectations for devaluation are born, non-commitment to any optimal bailout before stage 4 has been made and if it is too costly to devalue already in stage 3, it will be optimal to devalue in stage 4 only in the bad state (proposition 3). In this section we analyse a situation in which the government can commit to a certain bailout before the market forms expectations, that is at stage 1. There are the following questions that we would like to answer: What would then be the optimal bailout that the government can commit to before the private sector forms expectations, in order to avoid devaluation at stage 4? What will be the size of the bailout that the government could optimally commit to at stage 1 by comparison with the bailout given at stage 4, which is only contingent on the state of the economy? How will a commitment to bail out will affect the level of risky investment and the amount of effort in relation to the case when no commitments to bailing out are made? One should take into account that since effort and investment (borrowing) are endogenous and affected among other things by changes in the proportion of liabilities that will be bailed out. Moreover, the probability p^L will not only be affected by the effort the representative investor chooses to put in, but also by the difference between the proportion of debt that the government would commit (before stage 4) to bail out and the no-committed one, as indicated by (8).

The government may have an incentive to commit to a bailout such as ϕ^{COMM} if devaluation can be avoided, effort does not decrease to undesirable and inefficient levels, and

[9] Notice that: $(1-\pi)a_2\{\alpha_1(x(s_2)-\bar{x})+\alpha_2 g(Ex-\bar{x})\}^2 = (1-\pi)a_2\{u_4(s_2)-\bar{u}\}^2$, since $\hat{x}(s_2)>\bar{x}$.

borrowing in foreign currency does increase excessively. If a commitment to an optimal bailout were to be made, it should be to avoid deterioration of the economic fundamentals that could arise as a consequence of a financial crisis. Better perspectives on the economic fundamentals will make the public not to expect devaluation and devaluation itself will then become unnecessary. In this case one could reach at best node (11) (see proposition 1), instead of node (14) in figure 1. The government could then in principle evaluate the possibility of committing to an optimal bailout in stage 1 if expectations of devaluation were imminent and consequently devaluation were likely to occur in the bad state (at stage 4). This implies avoiding not the costs for staving off the speculative attacks during stages 3 and 4, but also those associated with abandoning the fixed exchange rate regime at stage 4 in the bad state by committing to a certain bailout. The government will find the optimal bailout at stage 1 by minimising a loss function. This function shall include all the costs of maintaining the exchange rate regime during stage 3, and the expected costs of keeping the regime during stage 4, given that devaluation expectations exist. Having this established, the government loss will be:

$$V_1 = V_1(Ex > \bar{x}, \hat{x}(s_1) > \bar{x}, x(s_2) = \bar{x}, \phi, K) \tag{21}$$

Note now that the functional form of (21) needs to be like (17). The government will however minimise V_1 to find the optimal bailout (say ϕ^{COMM}) that it can commit in stage 1. ϕ^{COMM} can then be obtained from the following expression after assuming that $\bar{x} = 1$:

$$\frac{dV_1}{d\phi} = \frac{dV_3}{d\phi} + \frac{dV_3}{dK}\left[\frac{\partial K}{\partial \phi} + \frac{\partial K}{\partial \hat{x}(s_1)} * \frac{d\hat{x}(s_1)}{d\phi}\right] + \frac{dV_3}{de}\left[\frac{\partial \hat{e}}{\partial \phi} + \frac{\partial \hat{e}}{\partial \hat{x}(s_1)} * \frac{d\hat{x}(s_1)}{d\phi}\right] + \frac{dV_3}{dp^L}\left[\frac{\partial p^L}{\partial \phi}\right] = 0, \tag{22}$$

where

$$\frac{dV_3}{d\phi} = \frac{\partial V_3(Ex > \bar{x}, \hat{x}(s_1) > \bar{x}, x(s_2) = \bar{x}, \phi, K, E(e))}{\partial \hat{x}_1(Ex > \bar{x})} * \frac{d\hat{x}(s_1)}{d\phi}$$

$$+ \frac{\partial V_3(Ex > \bar{x}, \hat{x}(s_1) > \bar{x}, x(s_2) = \bar{x}, \phi, K, E(e))}{\partial \phi};$$

Note that δK/δϕ and δe/δϕ (the moral hazard effect of bailing out) can be then obtained from (3) and (6), respectively; δK/δ$\hat{x}(s_1)$ and δ$\hat{e}$/δ$\hat{x}(s_1)$ can be obtained from (4) and (6) while d$\hat{x}(s_1)$/dϕ in turn will be calculated from (16).[10] It is not possible to get an explicit solution for ϕ^{COMM} from (22). This is found by solving (22) numerically employing the parameter values assumed above when solving for the no-committed bailout (15), and same functional forms for the net return to investment and the effort cost function. We also assumed values for the support values, S and s, of the uniform distribution of $\hat{e} - e^L$ across investors. Notice that the larger S-s is the smaller the fraction of investors that will change their effort when for example there are changes in the proportion of debt that the government will bailed out (see (8)).

Simulations of (22) using the same parameter values used in the non-commitment case are carried out. We use *β=1* while S=0.2 and s=0.05. The equilibrium values for the exchange rate, bailout, effort and investment (borrowing) are shown in the first row of table 2.

The second row in this table shows the equilibrium values for the exchange rate, bailout and effort under the assumption that for the government to commit to bailing out, the private sector needs to commit to borrow *less* than the amount it would borrow when there is no-commitment to bail out. That is, we have assumed that the private sector is not allowed to borrow more than K=0.8. (Note that K in the no-commitment case was 1.28, when β=1, as

[10] When it is expected devaluation only in the bad state, the equilibrium exchange rate in the bad state is $\hat{x}(s_1)$ (equation (16)). In the good state there will not be any devaluation so $\hat{x}(s_2) = \bar{x}$. Such a solution is one in which the government devalues optimally in the most adverse state and when the private sector expects devaluation. Note that the optimal exchange rate (16) and the optimal bailout (15) determine the equilibrium

shown in the fourth row in table 1). In this case, the government finds the optimal bailout from (22) with the consideration that $(dV_3/dK)=0$. [11]

Table 2

β=1:

ϕ^{COMM}**=0.01**	x_1^{COMM}**=1.06**	e^{COMM}**=0.28**	K^{COMM}**=0.10**
ϕ^{COMM}**=0.60**	x_1^{COMM}**=1.13**	e^{COMM}**=0.01**	$\overline{K}$ **= 0.8**

We now compare the above results with the ones obtained when the government does not commit to any bailout before stage 4, as shown in table 1. To recall, with no ex-ante commitments, for β=1, we obtained the following equilibrium values:

β	$\hat{x}$	$\hat{\phi}$	$\hat{e}$	$\hat{K}$
1	**1.72**	**0.29**	**0.63**	**1.285**

We could summarise the results with the following propositions:

Proposition 7: *A commitment to (even small) bailing out causes moral hazard on effort. Given that the final effort is too low, investors will have difficulties to find financing. The level of borrowing will be much smaller in comparison to the case when there is no-commitment to bailing out.*

levels for the exchange rate and bailout at the fourth stage, when the government has not made any commitment to do it before stage 4.

[11] It also implies that $(\delta K/\delta\phi)$ and $(\delta K/\delta x_1)$ are both equal to zero.

Proposition 8: *When there are speculative attacks in the foreign exchange market and the fixed exchange rate regime is expected to be abandoned in state 1 but not in state 2, the optimal bailout under commitment is smaller than the optimal bailout with non-commitment*

Proof. Given that commitment led to low level effort (e) and low level of borrowing (K) (from Proposition 7), the government will find that it will need to bail out less.

It is important to notice that the government also optimises with respect to the number of investors who will decide to shirk. It can be observed from (22) and (8), that the government minimises its costs by minimising among other things the probability p^L.

Proposition 9: *When the government commits to a specific optimal bailout at stage 1, it will need to devalue less often or simply not to devalue.*

Proof. Low levels of borrowing will not lead to significant private sector net losses and consequently there will be a smaller deterioration of the fundamentals. It becomes less necessary to devalue. The private sector takes this into account when forming expectations about the exchange rate: devaluation is less likely to occur. By the time the private sector form expectations, they realise that with commitments, it will never be optimal for the government to devalue and therefore that it will be not rational to start a speculative attack. In this case, the node in the game tree (figure 1) that will be reached may be at best (11).

The most important results of this section are *first*, if the government commits, it can persuade the private sector not to speculate in the foreign exchange market. *Second*, ex-ante commitment to bailing out will decrease the level of effort making very difficult for the private sector to obtain financiation of its projects. The final equilibrium level of investment, K, will be very low. This result is obtained is spite of the government including in its optimisation problem the moral hazard effects of bailing out on effort and investment/borrowing.

Proposition 10: *If the government commits to bailout under the condition that the private sector borrows less in the foreign exchange market, the final equilibrium level of effort that the private sector will choose will be significantly smaller than when that condition is not imposed and lower than the level when the government does not commit to any bailout before stage 4. Also, both the proportion of outstanding debt that will bailed out will be larger and there will be larger depreciation.*

8. Conclusions

We present a model for analysing the interrelationships between exchange rate crises and debt crises. It is shown that crises can be characterised by both belief-driven and fundamentals-driven attacks. The model is presented as a four-stage sequential game where the players are the government and the financial sector. Information about the probabilistic distribution of a forthcoming (good or bad) shock is given in the first stage. This shock will be realised in the fourth stage and will affect private-sector debt and unemployment. The government may or may not wish to commit to a bailout for a specific amount of private debt before the market forms expectations, in stage 1. In stage 2, the private sector forms expectations and makes decisions about investment and effort. In stage 3, the government may react by either retaining or leaving the peg, depending on the costs that staving off speculative attacks at this stage and the expected costs that the government will incur in stage 4 if the peg is maintained. The regime may then be abandoned after the onset of the speculative attack, before it does further significant damage to the economy. This outcome, where self-fulfilling expectations of a speculative attack lead necessarily to devaluation, resembles the Krugman (1979) first-generation model of currency crisis, where a deterioration of the fundamentals (in addition to the market's anticipation of a financial crisis) plays such an important role in triggering a crisis. In the final stage, 4, the shock occurs and the government decides on the optimal bailout, if it has not committed already in stage 1, and whether or not to abandon the fixed-rate regime (given that the fixed rate has been retained up to this stage). Decisions are here contingent on the prevailing state of the economy. It turns out that when there is no commitment at the early stage of the game, the model yields multiple equilibria.

When there is commitment to bail out before the market forms expectations about the exchange rate and make decisions about effort and investment, we find the following results: *First*, the private sector will enforce lower effort than in the case when there are no commitments on bailing out. The critical consequence of this is that they will likely find difficulties to finance their projects. We find indeed that the final equilibrium level of investment is much lower than in the case of non-commitment. *Second*, if the government commits to bail out before stage 4, it can persuade the private sector not to speculate in the foreign exchange market and in general there will be less depreciation. Since, an ex-ante commitment to bail out decreases the level of investment, one may not need to expect investment losses and therefore not large deterioration on the fundamentals of the economy, and this make devaluation less likely. *Third*, given the low levels of investment and consequently the low likelihood of large investment losses, the government will not need to to commit to a large bail out. These results should reflect the fact that the government includes in its optimisation problem the moral hazard effects of bailing out on effort and investment. The multiple equilibria dilemma is indeed solved by committing ex-ante to bailing out and in such case the optimal solution is one in which there may not be financial and currency crisis. There would be however, very low levels of investment due to the difficulties the private sector may have in finding financing. The latter is a consequence that they find optimal to put too little effort when there are commitments to bailing out.

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