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HOT MONEY

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ABSTRACT

The conventional wisdom is that capital flows between developing countries and developed countries are more volatile than can be justified by fundamentals. In this paper we construct a simple model in which frictions in international financial markets together with occasional fiscal crises lead to excessive volatility of capital flows. The financial market frictions inhibit the transmission of information across investors and lead to herd-like behavior. The fiscal crises lead to standard debt-default problems. These crises act as tests of fire for borrowing countries. If a country survives this test, its reputation is enhanced and future capital flows become less volatile. Failing this test is associated with a loss of reputation and a decline in the amount of capital flows.

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Capital flows are clearly very volatile in Latin American countries like Argentina and Mexico. Many authors claim these flows are more volatile than can be justified by the fundamentals. For example, writing on Latin American financial crises, Calvo and Mendoza (1996) say that " 'the fall from grace' in world capital markets. . .may be driven by herding behavior not necessarily linked to fundamentals." Similar views are be found in a number of recent papers including Cole and Kehoe (1996) and Sachs, Tornell, and Velasco (1996). The purpose of this paper is to formalize this conventional wisdom in a model in which frictions in the international financial markets generate volatile capital flows.

The basic idea of the paper is that frictions in the transmission of information in international financial markets can cause most of the information in the market to become trapped. Hence, tiny changes in the information that drives the market lead to herd-like behavior by international investors. The implications of the model are, first, there are sustained periods of volatile capital flows, in which tiny bits of new information lead to large swings in the amount of investments. Second, during fiscal crises, governments are tempted to raise funds by expropriating foreign investments. These crises test the government's desire to maintain its reputation for fiscal responsibility. If the government passes the test, its reputation is enhanced and future capital flows become less volatile. If the government fails the test, its reputation is diminished and future foreign investment declines. Finally, our model implies that only governments which have not developed a strong reputation are subject to volatile capital flows.

Our model builds on elements from the debt-default literature and the literature on herd behavior. In the model there is a borrowing country is populated by consumers and a government and a lending country populated by an infinite number of one-period-lived risk neutral lenders. Our modelling of the government captures the standard tension in the debt-default literature, namely, defaulting on outstanding debts has short-term gains but long-term costs. Specifically, in each period the government has access to a country-specific project and has no endowments, so it must borrow funds from lenders to fund the project. There are two types of governments: the competent type and the incompetent type. The competent type is efficient at transforming tax revenues into government spending while the incompetent type is inefficient at this task. (This formulation of the two types builds on

Rogoff and Sibert 1988.) The type of the government is private information. The economy can either be in a normal state or in a crisis state. In a crisis state the government has to raise revenues over and above those raised in the normal state. The state of the economy follows an exogenous stochastic process. In order to finance spending in a crisis the government can either raise additional revenues by levying domestic distorting taxes or it can default on foreign investments.

Our modelling of the lenders captures the idea that there are frictions in the transmission of information in the international financial markets. Specifically, each of the lenders can either invest in his own country or commit to investing some fixed amount in the project in the borrowing country. The project is indivisible and is funded if and only if a fixed number of lenders N commit to funding it. At the beginning of each period, lenders receive private signals about whether the state is normal or a crisis. Lenders are ordered in a sequence, and they sequentially decide to either commit to funding the project or not. If N or more lenders commit to funding the project, the project is funded and the first N of them invests a fixed amount each. If fewer than N lenders in the sequence commit funds the project is not funded, the commitments are nullified, and these lenders are free to invest in the domestic market. In this setup each lender makes his investment decision based on his current prior on the competency of the government, his private signal as to the state of the economy, and his inferences based on the actions of the lenders that precede him in the sequence. (This setup builds Banerjee 1992 and Bikhchandani, Hirshleifer and Welch 1992).

We focus on equilibria in which if the economy is in the normal state both types of governments repay, while if it is in the crisis state the incompetent government defaults. Within each period the model works as follows. If the prior that the government is competent is sufficiently high, then regardless of the signals the lenders receive, the project is funded. If this prior is sufficiently low, then regardless of the signals, the project is not funded. If the prior is in an intermediate range, then the possibility of herding behavior exists. For example, if the first lender receives a signal that the state is normal, he invests and all subsequent lenders invest regardless of their signals. However, if the first two lenders receive signals that there is a crisis, they do not invest and no subsequent lenders invest regardless of their signals. Thus in this intermediate range, capital flows are extremely sensitive to tiny bits of information and hence are volatile.

The dynamic model works as follows. Imagine that the economy starts with lenders having intermediate priors about a government, and let the probability of a crisis be small. Then in normal times capital randomly flows into and out of the country based on tiny differences in the realizations of signals to lenders, and thus capital flows are volatile. In crisis times the incompetent government defaults and is not able to borrow again until some event occurs which changes lenders' priors. (This event might correspond to a new government being elected or to a successful policy reform taking place that makes the government more efficient at transforming tax revenues into public services.) More interesting is what happens to the competent government in crisis times. This government repays the debt, even though the short-term gains from defaulting on it are high. By resisting the temptation to default in a crisis, this government proves that it is competent. From then on, until something happens to change lenders' priors, this government is rewarded with a steady stream of capital flows into in its country.

As we have mentioned, our model draws on work in both the debt-default literature and the literature on herding behavior. Our paper is complementary to recent work on financial crises. Especially notable is the recent work of Calvo (1995), Calvo and Mendoza (1996), and Cole and Kehoe (1996). The basic idea in the first two papers is that if individuals are highly diversified, then investment in a country is highly sensitive to news about the country and, moreover, individual investors have little incentive to pay a fixed cost to keep up to date on each of their investments. Thus capital flows may be volatile. The theoretical framework in Calvo and Calvo and Mendoza leads one to expect that all countries will be subject to volatile capital flows. We emphasize that only countries with questionable reputations are subject to volatile capital flows. Moreover, we emphasize that countries can establish a reputation for fiscal responsibility by passing a test of fire. The basic idea of Cole and Kehoe is that liquidity crises can be self-fulfilling. That is, a belief that the government will default on its loans if enough new loans are not made can be self-fulfilling. Cole and Kehoe use this insight to build a model in which financial crises are driven by extraneous sunspots. Our reading of the historical record suggests that financial crises are often an overreaction to small changes in fundamentals. Finally, there is also a literature that views financial crises as driven solely by changes in fundamentals (see, for example, Atkeson and Rios-Rull 1996).

1. Lender behavior

We begin with a description of one period of the dynamic economy and lender behavior. There are two countries. One is populated by an infinite number of one-period-lived risk neutral lenders and the other by a government. The government has access to a country-specific project and has no endowments, so it must borrow funds from lenders to fund the project. The investment occurs at the beginning of the period, and the returns are realized at the end of the period. Each of the lenders can either commit to investing 0 or some fixed amount, say, z in the project, or he can invest in his own country and earn a return R^*. The project is indivisible and is funded if and only if N lenders commit to funding it. The gross return to the project is RN. The government can either default on the debt or not. We let $\tau = 1$ denote default and $\tau = 0$ denote no default. We assume that $R^* < R$, and we let $r = RNz$ so that the government earns total revenues of either r or 0.

There are two types of governments indexed $i = 1, 2$. Government spending, g, is random and in normal times it is 0 while in a crisis it is B. Normal times occur with probability μ_0 while crises occur with probability μ_B. The type of the government is private information. All lenders have prior π_0 that the government is type 1. Initially, the level of government spending is unknown and lenders get signals about its level. Each lender gets a signal $s \in \{0, B\}$ that the economy is in normal times and the spending is thus 0 or the economy is in a crisis and the spending is thus B. The signals are informative and symmetric in the sense that

$$\Pr(s = B \mid g = B) = \Pr(s = 0 \mid g = 0) = q > 1/2. \tag{1}$$

(Note that these signals are about the exogenous random variable g and not about the types.)

We assume that the infinite number of lenders are in a sequence ordered 1, 2, 3, and so on. Each lender observes the decisions of those ahead of him in the sequence, and lenders sequentially decide to either commit to funding the project or not. If N or more lenders commit to funding the project, the project is funded and the first N of them invests a fixed amount each. If fewer than N lenders in the sequence commit to funding, the project is not funded, the commitments are nullified, and these lenders are free to invest in the domestic market.

The overall timing of events within the period is as follows. First, lenders receive their signals whether the economy is in normal times or in a crisis and sequentially make their lending decisions. The project is either funded or not funded. Second, the level of government spending is realized and made known to all. Finally, if the project is funded, the government decides to default or not.

In the version of the model with government behavior endogenous we focus on equilibria in which in normal times neither type of government defaults, while in a crisis only the type 2 government defaults. For now we simply assume this pattern of government behavior and work out the behavior of the lenders.

Consider the first lender. The lender is repaid if $\tau = 0$. Thus the lender's probability of being repaid given a signal $s = B$ is

$$\Pr(\tau = 0 \mid s = B) = \frac{\mu_0(1-q) + \mu_B \pi_0 q}{\mu_0(1-q) + \mu_B q} \tag{2}$$

while this lender's probability of being repaid conditional on the signal being low is

$$\Pr(\tau = 0 \mid s = 0) = \frac{\mu_0 q + \mu_B \pi_0 (1-q)}{\mu_0 q + \mu_B(1-q)}. \tag{3}$$

To understand (2) note that repayment occurs either if $g = 0$ and the government is of either type or $g = B$ and the government is type 1. Since the prior that the government is type 1 is π_0, $\Pr(\tau = 0) = \mu_0 + \mu_B \pi_0$. The signal is B if either the state is 0 and the wrong signal is received or the state is B and the right signal is received. Thus $\Pr(s = B) = \mu_0(1-q) + \mu_B q$. For $\tau = 0$ and $s = B$ to jointly occur, the government can be either type when $g = 0$, but it must be type 1 when $g = B$, so $\Pr(\tau = 0 \text{ and } s = B) = \mu_0(1-q) + \mu_B \pi_0 q$. The derivation of (3) is similar.

The expected return from investing given a signal $s = B$ is $\Pr(\tau = 0 \mid s = B)R$ and the expected return given a signal $s = 0$ is $\Pr(\tau = 0 \mid s = 0)R$. We assume that

$$\Pr(\tau = 0 \mid s = 0)R > R^* > \Pr(\tau = 0 \mid s = B)R \tag{4}$$

so that the first lender commits to investing only if the signal is 0. We rewrite this assumption as

$$\Pr(\tau = 0 \mid s = 0) > P^* > \Pr(\tau = 0 \mid s = B) \tag{5}$$

where $P^* = R^*/R$ is the probability of being repaid, which makes a lender indifferent between lending abroad and investing domestically.

Consider the second lender. There are several possibilities. Suppose that the first lender invested. The second lender knows the first lender received $s = 0$. If the second lender receives $s = 0$, then clearly the conditional probability of being repaid is higher than that of the first lender and the second lender invests. If the second lender receives $s = B$, then the first two signals cancel out and the second lender's probability of being repaid is simply the unconditional probability $\mu_0 + \mu_B \pi_0$. We assume that

$$\mu_0 + \mu_B \pi_0 > P^* \tag{6}$$

so that even if there is no signal, lenders find it profitable to invest. Notice that if the first lender invests then the second lender lends regardless of his signal. This situation is the beginning of what we will refer to as an *information cascade with investment.*

Now suppose that the first lender did not invest. The second lender then knows the first lender received $s = B$. If the second lender receives $s = B$, then clearly the probability of being repaid is lower than that for the first lender and the second lender doesn't invest. If the second lender receives $s = 0$, then the first two signals cancel out and the probability of being repaid is the unconditional probability (6), so the lender invests.

Consider the third lender. Let h_2 denote the possible histories of investing behavior the third lender might confront. If $h_2 = (1, 1)$, signifying the first two lenders have invested then the third lender invests regardless of the current signal. The history $h_2 = (1, 0)$ is not possible given our assumed behavior and we ignore it. If $h_2 = (0, 1)$, then the third lender deduces that the first two lenders received the signals 0 and B, respectively. These signals cancel out and the third lender invests if $s = 0$ and does not if $s = B$. If $h_2 = (0, 0)$, then the third lender deduces that the first two lenders both received signals of 0 and does not invest regardless of his signal. This situation is the beginning of what we will refer to as an *information cascade with no investment.*

Continuing with this same logic, we find that under assumptions (5) and (6), N lenders fund the project after the following types of histories: $(1), (0,1,1), (0,1,0,1,1), ...,$ up to a sequence $(0,1,0,1,...,0,1,1)$, which has $N-2$ zeros and $N-1$ ones, together with the history that starts with 0, alternates between 0 and 1 and has N ones. The probability that the project is funded conditional on $g = 0$ is denoted p_0 and is given by

$$\begin{aligned} & q + (1-q)q^2 + (1-q)^2q^3 + (1-q)^3q^4 + ... + (1-q)^{N-2}q^{N-1} + (1-q)^Nq^N \\ = \; & q + (1-q)q^2[1 + (1-q)q + (1-q)^2q^2 + (1-q^3)q^3 + ... + (1-q)^{N-3}q^{N-3}] + (1-q)^Nq^N. \end{aligned}$$

Simple algebra gives

$$p_0 = \frac{q - (1-q)^{N-1}q^N}{1-(1-q)q} + (1-q)^Nq^N. \tag{7}$$

Likewise, the probability of the project being funded conditional on the event $g = B$ is

$$p_B = \frac{1 - q - q^{N-1}(1-q)^N}{1-(1-q)q} + (1-q)^Nq^N. \tag{8}$$

In the model with endogenous government behavior, the behavior of the lenders for an initial prior π_0 satisfying (5) and (6) is summarized by (7) and (8).

2. Endogenous Government Behavior

We describe the dynamic economy and our model of endogenous government behavior. So far we have worked out the behavior of the lenders assuming a particular default rule of the governments. Here we work out the optimal behavior of an infinitely lived government. We find conditions under which governments optimally choose to follow the default rule of Section 1.

The dynamic economy is as follows. There are an infinite number of periods indexed $t = 0, 1, ...$ The timing and information structure within each period is the same as before. The lenders are one-period-lived and hence face exactly the same problem as before. The interesting agents are the governments.

The state of the economy follows an exogenously given i.i.d. process over a normal state with probability μ_0 and a crisis state with probability μ_B. We normalize the level of spending in normal times to zero. The level of spending in the crisis state is B. The government must finance this spending with a combination of taxes on foreign investment and distorting domestic taxes. The tax rates on foreign investment $\tau_t \in \{0, 1\}$ are the same as before. Tax revenues consist of domestic tax revenues, T, plus the revenues from taxes on foreign investment, τx, where $x \in \{0, r\}$.

We follow Rogoff and Sibert (1988) in assuming that the two types of government differ in how competent they are in the sense of how efficiently they can transform tax revenues, $T + \tau x$, into government services in crises. Both types of governments require the same level of revenues to provide the normal level of government services. Crises require additional levels of government spending, and the two types of government differ in their ability to provide government services above normal levels. These ideas allow us to normalize the level of spending in normal times to 0. We assume that a government of type i needs θ^i units of revenues for each 1 unit of services it provides, so that in the crisis state $g = B$, we have

$$B = \theta^i(T + \tau x). \tag{9}$$

In the normal state $g = 0$, tax revenues are distributed in a lump-sum fashion to consumers. We capture the distortions associated with distorting domestic taxes by letting output be a decreasing function of domestic tax revenues T denoted $y(T)$ as long as T is positive and $y(T) = y(0)$ if T is negative. If a project is funded, it yields wr units of the consumption good to domestic consumers. Consumption of domestic consumers is given by

$$c = y(T) + wx - T. \tag{10}$$

The period utility of the government depends on consumption of the domestic consumers. For simplicity, we let this utility function be linear. From (9) and (10) it follows that the period utility of government i is given by

$$U^i(g, x, \tau) = y(g/\theta^i - \tau x) - g + wx.$$

The lenders' decisions are summarized by the probability of investing conditional on their prior π on the realization of g. We let $p_0(\pi)$ and $p_B(\pi)$ denote these probabilities conditional on the realizations of government spending 0 and B, respectively. We focus on Markov equilibrium in which government strategies and lenders updating rules depend only on the state variables (π, g, x). The government chooses the default decision τ to solve

$$W^i(\pi, g, x) = \max_{\tau} \left\{ U^i(g, x, \tau) + \beta \sum_{j=0,B} \mu_j [p_j(\pi') W^i(\pi', j, 1) + (1 - p_j(\pi')) W^i(\pi', j, 0)] \right\} \tag{11}$$

where $\pi' = \Pi(\pi, g, x, \tau)$ is the updating rule for the prior and $W^i(\pi, g, x)$ is the value function for government i . Here it is understood that if $x = 0$, so that the amount owed to lenders is 0, then the default decision is irrelevant to payoffs. This dynamic programming problem gives us decision rules of the form $\tau^i(\pi, g, x)$.

The timing of events within a period is as follows: the lenders receive signals and make commitments to invest, the government invests, it is publicly revealed whether there is a crisis or times are normal, the government makes its taxation and default decisions, and finally private agents consume. We assume that the government's default decision is publicly revealed but that lenders do not observe domestic tax revenues. (As will become clear, none of the results is affected by this last assumption.)

An *equilibrium* consists of default rules $\tau^1(\cdot)$ and $\tau^2(\cdot)$, an updating rule $\Pi(\cdot)$, and probability-of-lending rules $p_0(\cdot)$ and $p_B(\cdot)$ such that (*i)* given the lending and updating rules, the default rule τ solves the dynamic programming problem (11), (ii*)* the probability of lending rules $p_j(\pi)$, $j \in \{0, B\}$, are consistent with optimality of lenders' decisions given their beliefs, and (iii*)* the updating rule $\Pi(\cdot)$ satisfies Bayes' rule whenever possible.

We focus on an equilibrium in which the governments pool in normal times and separate in crises . More precisely, we focus on equilibria in which in normal times neither type defaults if $\pi = \pi_0$ or 1 and both types default if $\pi = 0$, while in crises only the second type defaults if $\pi = \pi_0$ or 1 and both default if $\pi = 0$. In our construction of an equilibrium, we only define strategies and updating rules at the initial prior π_0, together with priors of 0 and 1. While it is straightforward to define strategies and updating rules for all priors, none of these other priors can be reached regardless of the behavior of the lenders or the government.

Formally, these strategies are

$$\tau^1(\pi, g, 1) = \left\{ \begin{array}{ll} 0 & \text{if } \pi \in \{\pi_0, 1\},\ g \in \{0, B\} \\ 1 & \text{if } \pi = 0 \end{array} \right\} \tag{12}$$

$$\tau^2(\pi, g, 1) = \left\{ \begin{array}{ll} 0 & \text{if } \pi \in \{\pi_0, 1\},\ g = 0 \\ 1 & \text{otherwise} \end{array} \right\}. \tag{13}$$

The updating rule for beliefs is

$$\Pi(\pi, g, 1, \tau) = \left\{ \begin{array}{ll} 0 & \text{if } \tau = 1 \\ 1 & \text{if } \tau = 0 \text{ and } g = B \\ \pi & \text{if } \tau = 0 \text{ and } g = 0 \end{array} \right\} \tag{14}$$

and trivially, $\Pi(\pi, g, 0, \tau) = \pi$, for all g and τ. The lending probabilities for $j = 0, B$ are

$$p_j(\pi) = \left\{ \begin{array}{ll} 0 & \pi = 0 \\ p_j & \pi = \pi_0 \\ 1 & \pi = 1 \end{array} \right\}. \tag{15}$$

Along the equilibrium path, the behavior is as follows. Starting from the initial prior, both governments repay in normal times and the prior is unaffected. At the first realization of a crisis, government 1 repays and government 2 defaults. The new priors move to 1 and 0, respectively. After this separation of the types, lenders invest with probability 1 with government 1 in all future periods and this government never defaults. Lenders never again invest with government 2.

For these conjectured strategies and beliefs to constitute an equilibrium, we need certain inequalities to hold. We begin by developing those for the type 1 government. In order to keep the expressions manageable, we simplify the notation. For $j = 0, B$,we let $u_{rj} = U^1(j, r, 0)$, $\hat{u}_{rj} = U^1(j, r, 1)$, and $u_{0j} = U^1(j, 0, 0) = U^1(j, 0, 1)$. Note that the first subscript is r if lenders have invested and 0 if they have not and the second subscript is 0 if the state is normal and B if the state is a crisis.

Consider the crisis state and a prior of π_0 or 1. For government 1 to repay and separate itself starting from either a prior of π_0 or 1, it must be that

$$u_{rB} + \beta G(1) \geq \hat{u}_{rB} + \beta G(0) \tag{16}$$

where $G(1)$ and $G(0)$ are continuation payoffs associated with priors of 1 and 0, respectively. These continuation payoffs are the present value of expected discounted utilities from the next period onward under the equilibrium strategies. With a prior of 1, funds always flows in and government 1 never defaults, so its continuation payoff is given by

$$G(1) = \frac{1}{1-\beta} \sum_{j=0,B} \mu_j u_{rj}. \tag{17}$$

With a prior of 0, funds never flow in and the continuation payoff is given by

$$G(0) = \frac{1}{1-\beta} \sum_{j=0,B} \mu_j u_{0j}. \tag{18}$$

Consider next the normal state and a prior of π_0 or 1. For government 1 to repay at π_0 and continue with this same prior, it must be that

$$u_{r0} + \beta G(\pi_0) \geq \hat{u}_{r0} + \beta G(0) \tag{19}$$

where the continuation $G(\pi_0)$ is implicitly defined by

$$\begin{aligned} G(\pi_0) \;=\; & \mu_B p_B (u_{rB} + \beta G(1)) + \mu_B (1 - p_B)(u_{0B} + \beta G(\pi_0)) \\ & + \mu_0 p_0 (u_{r0} + \beta G(\pi_0)) + \mu_0 (1 - p_0)(u_{00} + \beta G(\pi_0)). \end{aligned} \tag{20}$$

To understand this expression for the continuation payoff, recall the possible events and associated payoffs under the optimal strategy for government 1 following each such event. With probability $\mu_B p_B$, a crisis occurs and the government receives funds. In this event the type 1 government separates itself by repaying and gets a current payoff u_{rB} and a continuation payoff $G(1)$. In the other three events, no information is revealed. The government receives the current payoff under the equilibrium strategy for that event and a continuation payoff

$G(\pi_0)$. Similarly, for the government to repay in the normal state with a prior $\pi = 1$, it must be that

$$u_{r0} + \beta G(1) \geq \hat{u}_{r0} + \beta G(0). \tag{21}$$

Consider next a prior of 0. Since in both states the prior is unaffected by the action of the government, the continuation payoffs are $G(0)$ and the government will default if

$$\hat{u}_{rj} \geq u_{rj}, \quad j = 0, B. \tag{22}$$

For the type 2 government, we simplify notation as follows. For $j = 0, B$, we let $v_{rj} = U^2(j, r, 0)$, $\hat{v}_{rj} = U^2(j, r, 1)$, and $v_{0j} = U^2(j, 0, 0) = U^2(j, 0, 1)$. Consider the crisis state and priors of π_0 and 1. For a prior of π_0 or 1, government 2 will default if

$$\hat{v}_{rB} + \beta H(0) \geq v_{rB} + \beta H(1) \tag{23}$$

where $H(0)$ and $H(1)$ are the continuation payoffs associated with priors of 0 and 1. Clearly, if the prior is 0, lenders never invest and the continuation payoff is

$$H(0) = \frac{1}{1-\beta} \sum_j \mu_j v_{0j}. \tag{24}$$

If the prior is 1, the continuation payoff is implicitly defined by

$$\begin{aligned} H(1) \quad = \quad & \mu_B p_B(\hat{v}_{rB} + \beta H(0)) + \mu_B(1 - p_B)(v_{0B} + \beta H(1)) \\ & + \mu_0 p_0(v_{r0} + \beta H(1)) + \mu_0(1 - p_0)(v_{00} + \beta H(1)). \end{aligned} \tag{25}$$

To understand this payoff note that with probability $\mu_B p_B$, a crisis occurs and the government receives funds. In this event the government defaults and receives a current payoff of $\hat{v}_{rB}$ and a continuation payoff of $H(0)$. In all other states, no information is revealed, the government receives its current equilibrium payoff, and its continuation payoff is $H(1)$.

Consider the normal state and priors of π_0 and 1. For the government to repay at π_0, it must be that

$$v_{r0} + \beta H(\pi_0) \geq \hat{v}_{r0} + \beta H(0) \tag{26}$$

where the continuation payoff $H(\pi_0)$ is implicitly defined by

$$\begin{aligned} H(\pi_0) &= \mu_B p_B(\hat{v}_{rB} + \beta H(0)) + \mu_B(1-p_B)(v_{0B} + \beta H(\pi_0)) \\ &\quad + \mu_0 p_0(v_{r0} + \beta H(\pi_0)) + \mu_0(1-p_0)(v_{00} + \beta H(\pi_0)). \end{aligned} \tag{27}$$

This continuation payoff is the same as in (25) except that here, when no information is revealed, the new prior is π_0 and the continuation payoff is $H(\pi_0)$. Note that with probability $\mu_B p_B$, a crisis occurs and the government receives funds. In this event the government defaults. For the government to repay starting from a prior $\pi = 1$, it must be that

$$v_{r0} + \beta H(1) \geq \hat{v}_{r0} + \beta H(0). \tag{28}$$

Finally, starting from the prior $\pi = 0$ in either state, the continuation payoff is $H(0)$ regardless of the action taken. Thus the government will default if

$$\hat{v}_{rj} \geq v_{rj}, \; j = 0, B. \tag{29}$$

We can reduce the set of necessary conditions as follows. Conditions (22) and (29) trivially hold by our assumptions on the utility functions. Condition (21) follows from condition (19), because $G(1) \geq G(\pi_0)$ as long as $u_{rB} > u_{0B}$ and $u_{r0} \geq u_{00}$ which hold by assumption. Likewise, condition (28) follows from condition (26). This leaves us with four inequalities: (16), (19), (23), and (26).

Consider the following assumptions. Define the constants M and N by

$$M = y(B-r) - y(B) + r, \; N = y(B/\theta - r) - y(B/\theta) + r.$$

We assume that

$$M \leq \frac{\beta wr}{1-\beta} \leq N \tag{30}$$

and

$$\frac{\beta}{1-\beta}\left[\mu_B p_B + \mu_0 p_0\right] wr \geq r. \tag{31}$$

Notice that $N \geq M$ if the function $y(\cdot)$ is concave. This function is concave if the marginal cost of raising taxes is increasing in tax revenues. Assumption (30) is more likely to be satisfied the more concave is the function $y(\cdot)$ and the smaller is the competency parameter θ. Assumption (31) is more likely to be satisfied the larger is β. We then havethe following.

Proposition. Under assumptions (30) and (31), the strategies and beliefs in (12)–(15) constitute an equilibrium.

Proof. It suffices to show that the inequalities in (16), (19), (23) and (26) hold. We first show that (16) holds. Since $\hat{u}_{rB} - u_{rB} = M$ and $u_{rj} - u_{0j} = wr$, (16) can be written as

$$M \leq \frac{\beta wr}{1-\beta}$$

which is the first part of assumption (30). Likewise, since $\hat{v}_{rB} - v_{rB} = N$ and $v_{rj} - v_{0j} = wr$, (23) can be written as

$$\frac{\beta wr}{1-\beta} \leq N \tag{32}$$

which is the second part of assumption (30). To establish (19) note that since $G(\pi_0) < G(1)$, (20) implies that

$$G(\pi_0) \leq \frac{\mu_B \left[p_B u_{rB} + (1-p_B)u_{0B}\right] + \mu_0 \left[p_0 u_{r0} + (1-p_0)u_{00}\right]}{1-\beta}. \tag{33}$$

(Note that the right-hand side of (33) is the payoff that would occur if the prior stayed at π_0 when the government repaid.) Subtracting (18) from (33) gives

$$G(\pi_0) - G(0) \leq \frac{\mu_B \left[p_B(u_{rB} - u_{0B})\right] + \mu_0 \left[p_0(u_{r0} - u_{00})\right]}{1-\beta}. \tag{34}$$

Since $u_{rB} - u_{0B} = u_{r0} - u_{00} = wr$, we can use (34) to write (19) as

$$\frac{\beta}{1-\beta}\left[\mu_B p_B + \mu_0 p_0\right] wr \geq r \tag{35}$$

which is simply (31). To establish (26) we note that since $H(\pi_0) > H(0)$, (27) implies that

$$H(\pi_0) \geq \frac{\mu_B\left[p_B v_{rB} + (1-p_B)v_{0B}\right] + \mu_0\left[p_0 v_{r0} + (1-p_0)v_{00}\right]}{1-\beta}. \tag{36}$$

Subtracting $H(\pi_0)$ from both sides of (36) gives

$$H(\pi_0) - H(\pi_0) \geq \frac{\mu_B p_B(v_{rB} - v_{0B}) + \mu_0(1-p_B)(v_{r0} - v_{00})}{1-\beta}. \tag{37}$$

Since $v_{rB} - v_{0B} = v_{r0} - v_{00} = wr$, we can use (37) to rewrite (26) as (31). Q.E.D.

3. Conclusion

In this paper we have constructed a simple model of how frictions in international financial markets in combination with standard debt-default problems can lead to volatile capital flows. These flows act as tests of fire for borrowing countries. If a country survives this test, its reputation is enhanced and future capital flows become less volatile. Failing this test is associated with a loss of reputation and a decline in the amount of capital flows.

The purpose of this paper is to formalize the conventional wisdom that financial crises may be driven by herding behavior rather than changes in fundamentals. In formalizing this wisdom we have modelled international financial market frictions in the simplest way needed to generate herding behavior. We modelled these frictions as arising from impediments in information sharing and in coordinating decision making across investors. The next step is to develop deeper models of private incentives to share information and coordinate decision making. It is easy to imagine a variety of factors which would prevent private agents from truthfully sharing their information and coordinating decisions. In this context, it is worth pointing out that herding behavior cannot occur in our model if investors made investment decisions simultaneously. In Cole and Kehoe (1996), in sharp contrast, financial crises occur precisely because all investors make simultaneous decisions. These contrasting results suggest that questions regarding the optimal organization of financial markets do not have easy answers. They also suggest that research in this area is of fundamental importance in understanding the volatility of international capital flows.

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