International capital flows and transmission of financial crises

Preliminary Version

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Abstract

This paper proposes a model encompassing alternative views of contagion by highlighting the different channels of transmission of financial crises in an unifying framework. We study investor behaviour when they are affected by external habit formation. It is shown how international portfolio choice in frictionless financial markets with habit formation is in itself a channel of contagion. The possible stabilization effects of capital controls and Tobin tax on the international transmission of financial crises are also discussed.

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1 Introduction

One of the main features of the financial crises of the nineties was their tendency to spread across countries. The Mexican devaluation of 1994 affected other Latin American countries (the Tequila effect); the currency crisis in Thailand of July 1997 spread across East Asia; several months after the Russian crisis of August 1998, the Brazilian crisis ended up with the floatation of Real.

Most of these crises seemed to be regional, with the notable exception of the Russian one, which spread far away, affecting economies with scant fundamental economic links with the origin country. In the last decade, a growing body of literature has tackled this problem of contagion or transmission of financial crises, with a propensity to split the explanations of contagion between causes related to real and financial links, called "fundamental based contagion" by Calvo and Reinhart (1996), and contagion due to the investors' behaviour. Glick and Rose (1999), for example, find that trade patterns and competitiveness on third markets can be the rationale for contagion and its regional character. On the other hand, an increasing number of empirical studies have shown that this neat distinction can be misleading. Kaminsky and Reinhart (2000) show that it is hard to distinguish between trade and financial links. Nonetheless, they find that the role of financial linkages among countries is crucial to understand the regional attribute of the Asian crisis of 1997 and the Latin American troubles of 1994-95. These authors emphasize the regional nature of financial arrangements needed to facilitate trade, mainly through commercial banks. In both the Latin American and the Asian crises, almost all the countries involved where heavily indebted towards clusters of commercial banks, Japanese in the case of the Asian countries, and American in the case of the Latin American countries. In other words, regional trade blocs depended on common lenders, thus becoming regional financial blocs. In this context, if a bank faces increasing non-performing loans in one country, it will likely withdraw money (or not rollover existing credit) from other countries in the same financial bloc to try to reduce its overall risk. This can happen as a result of the necessity to adjust its lending accordingly to its lower level of wealth. All this can make the case for cross country spill-overs determined by wealth effects. Eichengreen et al. (2001) reach the same conclusion through a disaggregated analysis of the volumes, spreads and maturities of emerging-markets sovereign bonds. They find ample evidence that adverse shifts in financial markets sentiment or flight to quality took place within the respective regions after the crises in Mexico and Asia. In the Russian crisis of 1998 the turmoil was not restricted within a same regional or financial bloc, but rather spread across countries, like Brazil, with small direct economic connections to Russia. Baig and Goldfajn (2001) find empirical support to the hypothesis of contagion through financial links. The high correlation of sovereign bond spreads during the crisis, in fact, suggests that foreign investors panicked for the Russian crisis and thus played a crucial role in the transmission of the crisis, adding to the pressure exerted by domestic savers and investors on the Brazilian financial markets.

With both types of causes, i.e. fundamental based and investors based, contagion can arise because of, or can be exacerbated by, self fulfilling beliefs of the private agents: crises spread just because agents believe they are going to spread. As reported above, Eichengreen et al. (2001) note that a change in investors' sentiment has been crucial in determining the spread of crises in all the major episodes of the 1990s. Park and Song (2001), as well, argue that foreign investors were responsible for deepening the crisis in Korea following the meltdown of the other East Asian countries by overreacting to the deterioration in the financial conditions of corporations and financial institutions. Masson (1999), extending a model introduced by Jeanne (1997), shows that a second generation model of speculative attacks can generate multiple equilibria as a consequence of the interaction between the government and the private sector, with contagion effects emerging as the expectations of devaluation of the currency of a competitor country enter the model. On the other hand, Goldstein and Pauzner (1999) demonstrate that the strategic interaction of investors holding equities of two different countries can generate multiple equilibria and contagious withdrawal of money from one country. This is the result of the expectations about the other investors' behaviour, analogous to what happens in the Dybvig and Diamond (1983) model of bank runs.

This suggests that a theoretical model of contagion should be able to account simultaneously for transmission mechanisms based on trade and financial links as well as on the investors' behaviour and sentiment shifting.

This paper contributes to the knowledge of the mechanisms driving contagion in the context of a unifying macroeconomic framework analyzing fundamentals spill-overs as well as portfolio management considerations of international investors as causes of crises' spread. It highlights the role of capital flows in transmission of financial crises by studying the decisions of international investors, and pointing out that portfolio choices can in themselves be an important source of spread of crises. In our model, investor behaviour is affected by (a slow moving) habit time-varying subsistence level (see Abel (1990), Campbell and Cochrane (1999)). It is an external habit based on aggregate consumption rather than an internal habit based on past own consumption (see Constanides (1990), and Sundaresan (1989)). We follow the Campbell-Cochrane (1999) specification of external habit formation. The key insight of this model which they use to explain the equity premium puzzle, is that as investor wealth falls, the effective curvature of the utility function increases making the investors act as if they are more risk averse. This increases the risk premium that investors need to hold the risky assets. This is the mechanism through which financial linkages can act as an independent source of transmission of financial crisis. If there is a financial crises in one country if the wealth of the investors decreases sufficiently, then they will demand higher risk premia to hold risky assets of other countries even when there is no change in the fundamentals of these countries. This will increase the coverage ratio and make debt servicing more difficult and can act as a trigger for a financial crises. If the investors do not act as price takers they will recognize this and this will add an additional element of feedback in increasing the risk premia. In the current model we treat the investors as price takers and thus do not model this additional feedback effect. For this mechanism to be operative some conditions should be satisfied. Firstly, the portfolios of the investors should not be completely diversified so that the crisis in the first country has only an infinitesimal impact on their wealth. One implication of this is that the portfolios of investors should contain significant holdings of assets of the country which first experiences the crisis. Thus, this will also explain why some financial crises are not transmitted - they are fully absorbed by the investors. Secondly, the investors should be large or have large holdings of assets in the country where the financial crises is transmitted to. Otherwise, the increase in risk premia demanded will have minimal impact on other countries. Thus, understanding the pattern of portfolio holdings can give strong insights in to where financial crises are likely to spread through the wealth effects.

It is important to remark that the traditional way of modelling investor behaviour such as modelling their preferences by CARA preferences cannot account for these wealth effects. If there is a financial crises, and wealth of the investor declines then they will increase demand of assets which are negatively correlated with their wealth - this will reduce risk premia on the risky assets of other countries (*ceteris paribus*) and serve to limit the spread of the crisis. This is however counterfactual to the evidence where risk premium which can be measured by bond spreads increase in the event of a financial crises.

There are several reasons why treating the investors as habit forming can be justified in our context. Firstly, as noted above this specification has been used to explain the equity premium puzzle in closed economies. Thus, a similar specification should be used when understanding the asset prices in an open economy context. This is a behavioral view. Secondly, if we are to interpret the investors as large financial intermediaries or large firms then a similar behavior may be generated. There are two different reasons for this. The first is that if we interpret 'consumption' as payouts to claimants (either depositors or shareholders) then financial intermediaries will not want the payouts to drop below some level. The second is that if we can interpret the 'utility functions' as that of fund managers of the financial intermediaries. If the fund managers' performance is evaluated relative to some benchmark then a similar behavior will be generated. There can be a third class of reasons why the behavior we postulate can be rationalized. This has to do with portfolio insurance and risk management practices of the large investors. Under portfolio insurance, the investors do not want the value of the portfolio to fall below some level. In our model the investors do not want the withdrawals from the portfolio (consumption in our model) to fall below some threshold. The portfolio insurance models have the similar property that as the prices of assets fall the allocation to them falls (see Brennan and Schwartz (1988), and Grossman and Zhou (1996) for a general equilibrium model with portfolio insurance). The close relationship between the portfolio insurance and habit formation has already been noted in the literature (see for example Campbell and Viceira (2002)). Thus, there can be three entirely different mechanisms through which the behavior of the investors can be rationalized.

We elaborate on this behavioral approach in the context of a model of speculative attacks with self-fulfilling expectations built on Jeanne (1997) and Masson (1999). Other than introducing these behavioral considerations to the international finance literature, the paper innovates in several ways. First, it provides an explicit microeconomic foundation, based on an International Capital Asset Pricing Model (ICAPM), of the investors' behavior triggering contagion. Second, the portfolio choices deriving from the investor's optimizing behaviour add a further channel of contagion to the monsoonal and spillovers effects introduced by Masson (1999). Third, the model offers a theory for the jumps between multiple equilibria based on the possible wealth effects arising from the portfolio choice. Finally, the explicit modelling of the risk premium required by the investor introduces an additional source of nonlinearity in the multiple equilibria framework.

The rest of the paper is organized as follows. Section 2 presents the model and Section 3 some policy implications. Section 4 concludes.

2 The model

This section presents a simple contagion model built on Jeanne (1997) and Masson (1999). The main novelty consists in the formal representation of the investor's behaviour as a mean to derive an explicit expression of the risk premium. In modelling the investor behavior we closely follow the specification of Campbell and Cochrane (1989).

2.1 The investor's behaviour: Benchmark Case

There are M identical price-taking investors. The representative investor's behaviour is grounded in the context of an International Consumption-based Capital Asset Pricing Model (I-CAPM)[1]. By treating the valuation of emerging markets risky bonds through the I-CAPM, we implicitely assume that the Fisher equation holds; that is, we assume that arbitrage on interest rates will make the rate of return on bonds equal to that on equities, whereas the riskiness of both kinds of assets is assumed to be of the same magnitude[2]. The representative investor maximizes the period utility flow, which in turn depends on the consumption level. The intertemporal optimization makes the investor smooth consumption over time by holding securities, which allow him to transfer purchasing power from one period to another. Financial wealth will allow him to finance consumption when income is low by selling assets. However, as mentioned above, the specification of the preferences follows the external habit formation model of Campbell and Cochrane (1999). At the first instance we study the investor behaviour in the benchmark case *without habit formation.* In the benchmark case, the investor desires to hold

[1]The version used here follows Obstefld and Rogoff (1996), Ch. 5.

[2]See De La Grandville (2001), Ch. 2, for an arbitrage-based valuation of bonds.

an asset if its return is expected to be high when consumption is expected to be low. In the next section we change the model to cover habit formation.

The time horizon is infinite, there are N countries in the world, and each investor maximizes on any date t the expected utility function:

$$U_t = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} u(C_s) \right\} \quad (1)$$

where E_t is the expectation operator which averages over all possible future contingency plans for consumption and is conditioned on information known on date t, β is a constant subjective time-preference factor, $u(\cdot)$ is the period utility function, assumed to be twice continuously differentiable, strictly increasing, and strictly concave, i.e. $u'(\cdot) > 0$, $u''(\cdot) < 0$, C_s is consumption on period s.

The period-by-period budget constraint is given by:

$$B_{s+1} + \sum_{m=1}^{N} x_{m,s+1} D_s^m = (1 + r_s^*) B_s + \sum_{m=1}^{N} x_{m,s} (Y_s^m + D_s^m) - C_s \quad (2)$$

where B_s is the net (dollar denominated) risk-free bond purchase at time $s-1$, $x_{m,s}$ is the fractional share of country m's security purchased by the agent on period $s-1$, D_s^m denotes the date s market value in dollars of country m's security, r_s^* is the net real interest rate, expressed in dollars, on the risk-free bond B_s between period $s-1$ and s, and Y_s^m is the dividend payed on country m's security at time s. Equation (2) expresses the link between period s's saving and period $s+1$ financial wealth. One can think of B_s as the United States Treasury bill net purchase, of D_s^m as the market value of emerging country m's debt[3], and of Y_s^m as the coupon interest on debt. We make explicit here that our interest concentrates on the international transmission of an already occurred financial crisis rather than on its genesis within a country. This qualification allows us to assume that the supply of risky bonds is fixed over time and normalized to one, and that a no-arbitrage condition between risky assets of different emerging countries holds, so that the interest rates on emerging countries bonds are equal over countries when risk is taken into account.

[3]Note that here D_s^m is a price while in Masson (1999) it denotes the debt amount.

Maximizing the utility function (1) subject to the constraints (2) with respect to $x_{m,s+1}$ and B_{s+1}, gives the following first-order conditions on every date s:

$$u'(C_s)D_s^m = \beta E_s \left\{ u'(C_{s+1})(Y_{s+1}^m + D_{s+1}^m) \right\} \tag{3}$$

and

$$u'(C_s) = (1 + r_{s+1}^*)\beta E_s u'(C_{s+1}) \tag{4}$$

Equation (3) states that in equilibrium the marginal utility cost of investment, given by the l.h.s., must be equal to the expected marginal utility gain, given by the r.h.s.. Equation (4) is the stochastic Euler equation for riskless bonds, which can be rewritten as

$$\frac{\beta E_s u'(C_{s+1})}{u'(C_s)} = \frac{1}{(1 + r_{s+1}^*)}$$

that is, the expected intertemporal marginal rate of substitution equals $1/(1+r_{s+1}^*)$, the price of certain future consumption in terms of present consumption.

Now, define the annual net returns r_t^{*m} on country m risky bond as the sum of the (fixed) coupon interest and the change in market value per dollar invested, that is:

$$r_{t+1}^{*m} = \frac{Y_{t+1}^m}{D_t^m} + \frac{D_{t+1}^m - D_t^m}{D_t^m}$$

then, from (3), recalling that $E(XY) = Cov(X,Y) - E(X)E(Y)$, we obtain:

$$u'(C_s) = \beta Cov \left\{ u'(C_{s+1}), (1 + r_{s+1}^{*m}) \right\} + \beta E_s u'(C_{s+1}) E_s (1 + r_{s+1}^{*m})$$

Dividing both sides by $u'(C_s)$, using (4) to substitute out $\beta E_s u'(C_{s+1})/u'(C_s)$, and rearranging, we obtain, for $s = t$:

$$E_t(r_{t+1}^{*m}) - r_{t+1}^* = -(1 + r_{t+1}^*) Cov \left\{ \frac{\beta u'(C_{t+1})}{u'(C_t)}, r_{t+1}^{*m} \right\} \tag{5}$$

Equation[4] (5) is the crucial expression of the consumption-based CAPM. It says that the asset's risk premium, that is the expected excess return over

[4] In deriving it we have also used the fact that for any constant a_0, $Cov(X, Y + a_0) = Cov(X,Y)$.

the riskless bond, depends negatively on the covariance of the asset's rate of return with the rate of growth of the marginal utility of consumption. In other words, given the assumptions on the period utility function, the risk premium depends positively on the covariance of the asset's return with consumption level growth. If the covariance term is negative, the risk premium will be positive, meaning that the asset tends to yield unexpectedly high returns in states of nature when the marginal utility of consumption is unexpectedly low or, equivalently, when the level of consumption is high. Therefore, the asset does not provide a hedge against consumption fluctuations and the investor will require an expected return higher than the risk-free bond's return to be persuaded to hold the asset.

Recall that $Cov(x, y) = \sigma(x)\sigma(y)\rho(x, y)$, where $\sigma(\cdot)$ denotes the standard deviation and $\rho(\cdot)$ the correlation coefficient. Then, we can rewrite eq. (5) as:

$$\begin{aligned} E_t(r^{*m}_{t+1}) - r^*_{t+1} &= -(1 + r^*_{t+1})\sigma_t \left(\frac{\beta u'(C_{t+1})}{u'(C_t)} \right) \sigma_t(r^{*m}_{t+1})\rho_t \left(\frac{\beta u'(C_{t+1})}{u'(C_t)}, r^{*m}_{t+1} \right) \\ &\approx \eta_t \sigma(\Delta c_{t+1})\sigma_t(r^{*m}_{t+1})\rho_t \left(\frac{\beta u'(C_{t+1})}{u'(C_t)}, r^{*m}_{t+1} \right) \qquad (6) \end{aligned}$$

where $\eta_t = -C_t u_{cc}(C_t)/u_c(C_t)$ denotes the local curvature of the utility function, and Δc_{t+1} is the log-difference of consumption, or consumption growth. The second relation is exact in continuous time[5].

2.2 Habit formation

In order to obtain a link between the risk premium and the probability of devaluation of the currency under consideration, we specify utility as a function of the investor's surplus of consumption with respect to an external habit, as in Campbell and Cochrane (1999). That is, we substitute $u(C)$ with $u(C-X)$ where X denotes the level of habit. Therefore, eq. (1) becomes:

$$U_t = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \frac{(C_s - X_s)^{1-\gamma} - 1}{1 - \gamma} \right\} \qquad (7)$$

[5]See Cochrane (2001), ch.1.

Define the surplus consumption ratio $S_t \equiv (C_t - X_t)/C_t$ and let lowercase letters denote the logs of uppercase letters, that is, for example, $s_t = \ln S_t$. We assume that the logarithm of the surplus follows an AR(1) process:

$$s_t = (1-\phi)\overline{s} + \phi s_t + \lambda(s_t)(c_{t+1} - c_t - g) \tag{8}$$

where g is the systematic part of consumption growth, given by:

$$\Delta c_{t+1} = g + v_{t+1}, \quad v_{t+1} \sim i.i.d.N(0, \sigma^2).$$

The specification of s_t means that consumption is always greater than habit, and we can let consumption affect habit differently in different states (see Campbell and Cochrane (1999), and Cochrane (2000)). In other words, following Campbell and Cochrane (1999), we allow surplus-consumption ratio to react slowly to changes in consumption. Furthermore, consumption affects surplus differently in different states, as implied by $\lambda(s_t)$. With habit in the utility function, the local curvature is given by:

$$\eta_t \equiv \frac{-C_t u_{cc}(C_t)}{u_c(C_t)} = \frac{\gamma}{S_t}$$

Therefore, eq. (6) becomes:

$$E_t(r^{*m}_{t+1}) - r^{*}_{t+1} \approx \frac{\gamma}{S_t}\sigma(\Delta c_{t+1})\sigma_t(r^{*m}_{t+1})\rho_t\left(\frac{\beta u'(C_{t+1} - X_{t+1})}{u'(C_t - X_t)}, r^{*m}_{t+1}\right), \qquad m = 1, ..., N. \tag{9}$$

Thus, it is clear that risk aversion is negatively related to surplus-consumption ratio: a recession, by making consumption fall towards habit, will increase the time-varying local curvature of utility function and, then, the risk premium required on the country m's asset.

2.3 Linkages through portfolio choice

As shown above, r^{*m}_{t+1} is the net rate of return on dollar denominated bonds. However, the international investor willing to purchase country m's bonds must take into account devaluation expectations on the local currency[6]. If

[6]This approach is justified as we consider that a large part of the capital flows to developing countries in the nineties involved assets denominated in domestic currency, exposing the external creditor to exchange rate risk, as documented by Agénor an Montiel (1999, Ch. 15).

$S_{m,t}$ is today's spot exchange rate (price of foreign currency in terms of domestic currency), and $S^d_{m,t+1}$ is its value next period if a devaluation has occurred, then, for securities denominated in local currency the ex ante (ln) return on the asset is[7]:

$$
\begin{aligned}
& E_t(r^{*m}_{t+1}) \approx E_t \ln\left(1 + r^{*m}_{t+1}\right) \\
= \;& E_t \ln[\left(1 + r^{m}_{t+1}\right) / \left(S^d_{m,t+1}/S_{m,t}\right)] \\
\approx \;& E_t(r^{m}_{t+1}) - \pi^m_{t+1} \ln\left(S^d_{m,t+1}/S_{m,t}\right) - \left(1 - \pi^m_{t+1}\right) \ln 1 \\
\approx \;& E_t(r^{m}_{t+1}) - \pi^m_{t+1}\delta \qquad (10)
\end{aligned}
$$

where we have used the approximation $r^{*m}_{t+1} \approx \ln\left(1 + r^{*m}_{t+1}\right)$, π^m_{t+1} is the probability of a devaluation occurring, and δ is the extent of the expected devaluation[8]. Therefore, from (9), and (10):

$$E_t(r^m_{t+1}) \approx r^*_{t+1} + \pi^m_{t+1}\delta + rp^m_{t+1} \qquad (11)$$

where rp^m_{t+1} denotes the risk premium required by the investor on country m's asset.

Eq. (11) says that the investor will expect a rate of return on country m 's asset equal to the sum of the rate of return on the risk-free bond, the expected currency devaluation times the probability it will occur, and the risk premium, in order to be persuaded to hold it.

The supply of bonds being fixed, a change in the rate of return required by the M identical investors will result in an equivalent change in the equilibrium rate of return through the market clearing condition.

Now consider that the representative international investor's dynamic budget constraint can alternatively be written as in eq. (2) or as:

$$W_{t+1} = (W_t - C_t)\left(1 + r^{*w}_{t+1}\right) \qquad (12)$$

where W_t denotes total wealth, $(1 + r^{*w}_{t+1})$ is defined to be the simple gross return on wealth invested from period t to period $t+1$, and $*$ still denotes dollar denominated returns. Given international portfolio diversification, the gross return will be given by:

[7] The foreign exchange regime needs not to be fixed as the argument holds for a floating or managed regime as well.

[8] Eq. (8) is nothing more than an Uncovered Interest Parity (UIP) relation.

$$(1 + r^{*w}_{t+1}) = q_{*,t+1}(1 + r^{*}_{t+1}) + \sum_{m=1}^{N} q_{m,t+1}(1 + r^{*m}_{t+1}) \tag{13}$$

where $q_{*,t+1}$ is the proportion of wealth invested in risk-free bond, and $q_{m,t+1}$ is the proportion of wealth invested in country m's asset at time t, implying that $q_{*,t+1} + \sum_{m=1}^{N} q_{m,t+1} = 1$.

Taking logarithms of expectations of both sides of (13) gives:

$$E_t r^{*w}_{t+1} \approx \log \left[q_{*,t+1}(1 + r^{*}_{t+1}) + \sum_{m=1}^{N} q_{m,t+1} \exp(E_t r^{*m}_{t+1}) \right] \tag{14}$$

We will use the log-linear approximation to the budget constraint proposed by Campbell (1992) to relate unexpected changes in consumption to changes in expectations about future returns.

Dividing (12) by W_t and taking logs (again indicated by lower case letters), we obtain:

$$\Delta w_{t+1} = r^{*w}_{t+1} + \log(1 - \exp(c_t - w_t)) \tag{15}$$

Taking a first-order Taylor expansion around the mean $(\overline{c} - \overline{w})$ of the second term on the right hand side of (14) we get:

$$\Delta w_{t+1} \approx r^{*w}_{t+1} + k + \left(1 - \frac{1}{\theta}\right)(c_t - w_t) \tag{16}$$

where $k = \log(1 - \exp(\overline{c} - \overline{w})) + \frac{\exp(\overline{c} - \overline{w})}{1 - \exp(\overline{c} - \overline{w})} \left[(c_t - w_t) - (\overline{c} - \overline{w})\right]$, and $\left(1 - \frac{1}{\theta}\right) = \frac{\exp(\overline{c} - \overline{w})}{1 - \exp(\overline{c} - \overline{w})}$.

Next, consider the equality:

$$\Delta w_{t+1} = \Delta c_{t+1} + (c_t - w_t) - (c_{t+1} - w_{t+1}) \tag{17}$$

Equating the left hand sides of (15) and (16), solving the resulting difference equation in $c_t - w_t$ forward and taking expectations at time t we obtain:

$$c_t - w_t = E_t \sum_{j=1}^{\infty} \theta^j (r^{*w}_{t+j} - \Delta c_{t+j}) + \frac{\theta k}{1 - \theta} \tag{18}$$

Finally, substitute out eq. (17) into (15) and (16) to obtain:

$$
\begin{aligned}
c_{t+1} - E_t c_{t+1} &= (E_{t+1} - E_t) \sum_{j=0}^{\infty} \theta^j r^{*w}_{t+1+j} \\
&\quad -(E_{t+1} - E_t) \sum_{j=1}^{\infty} \theta^j \Delta c_{t+1+j} \qquad (19)
\end{aligned}
$$

Recalling now that, by assumption, $(E_{t+1} - E_t)\Delta c_{t+1+j} = 0$, for $j = 1, ..., \infty$, eq. (18) simplifies to:

$$
c_{t+1} - E_t c_{t+1} = (E_{t+1} - E_t) \sum_{j=0}^{\infty} \theta^j r^{*w}_{t+1+j} \qquad (20)
$$

As explained by Campbell (1992), eq. (19) indicates that an unexpected increase (decrease) in consumption today must be determined by an unexpected change in return on wealth today, as shown by the first term in the sum on the right hand side of the equation, or by news that future returns will be higher (lower), as shown by the remaining terms in the sum.

Equation (19) provides the needed link between the risk premium and the probability of devaluation of country m' currency. An increase in the probability of devaluation of country m's currency will decrease the expected return in the reference currency (the dollar, in our example) through eq. (10), which in turn will decrease the expected return on total wealth $E_t r^{*w}_{t+1}$, as shown by eq. (14), eventually determining an unexpected decrease in consumption growth, as implied by eq. (19); finally, this recession process will increase the excess return required by the investor through eq. (8) and (11). Notably, the increase in the risk premium will involve all assets held by the investor since the recession state will affect his risk attitude towards all assets. Building on Masson (1999), we will specify now the process through which the risk premium will in turn affect the probability of devaluation providing a rationale for multiple equilibria outcomes. We will consider a world composed only two emerging markets and an industrialized country.

The interest rate in the industrialized country r^* is given. D^a_t is the price of the accumulated debt, and there are assumed to be no new net capital flows. Any current deficit (or surplus) is financed through changes in reserves R^a_t. Shocks on the trade balance T^a are the only source of uncertainty. If the reserves fall below a certain level $\overline{R}^a$, then a devaluation by δ occurs.

The law of motion of reserves is thus given by:

$$R_{t+1}^a - R_t^a = T_{t+1}^a - (r_{t+1}^* + \pi_{t+1}^a \delta + rp_{t+1}^a) D_t^a$$

A crisis occurs at $t+1$ if:

$$R_{t+1}^a - \overline{R}^a < 0$$

Therefore, the probability, formed at time t of a crisis in period $t+1$ is:

$$\pi_{t+1}^a = P_{t+1}[T_{t+1}^a - (r_{t+1}^* + \pi_{t+1}^a \delta + rp_{t+1}^a) D_t^a + R_{t+1}^a - \overline{R}^a < 0] \qquad (21)$$

Letting

$$\begin{aligned} b_t &\equiv T_t - r_t^* D_{t-1} + R_t - \overline{R}, \\ \alpha &\equiv \delta D_{t-1}, \\ \text{and } \phi_{t+1} &= E_t b_{t+1} \end{aligned}$$

then:

$$\begin{aligned} \pi_{t+1}^a = P_{t+1}\{ & T_{t+1} - r_{t+1}^* D_t^a + R_{t+1} - \overline{R} \\ & < (\pi_{t+1}^a \delta + rp_{t+1}^a) D_t^a \} \\ = P_{t+1}[& b_{t+1} < (\pi_{t+1}^a \delta + rp_{t+1}^a) D_t^a] \end{aligned} \qquad (22)$$

It is clear from eq. (22) that, even at this stage, only taking into account the portfolio management rules of a risk-averse investor, contagious currency crises with self-fulfilling expectations can arise; in fact, the devaluation probability of country a depends on itself and on the risk premium on country a 's asset, the latter depending, in turn, on the probability of devaluation of country a's and country$b$'s currencies as discussed above.

Assuming that the innovation in variable b_t, $\epsilon_t \equiv b_t - \phi_t$ has a normal cumulative distribution function F, we can write π_t as:

$$\pi_{t+1}^a = F[(\pi_{t+1}^a \delta + rp_{t+1}^a) D_t^a - \phi_{t+1}^a] \qquad (23)$$

Eq. (23) differs from the equivalent expression in Jeanne (1997) and Masson (1999) for the central term of the F function argument as well as for the composition of the parameter ϕ_{t+1}^a.

To give an intuitive idea of how the above model works, consider a representative investor holding risky assets issued by two emerging-market countries as well as a risk-free asset issued by a developed country (USA is a reasonable assumption). In keeping with the portfolio choice problems, the investor will require a risk premium for the risky assets returns to hold them. The risk premium is inversely related to unexpected changes in consumption growth, which in turn depends on the devaluation probability of the emerging-market currencies. Hence, an increase in the devaluation probability of country A's currency will decrease the expected consumption of the investor who will in turn ask for a higher risk premium for all the held assets, including those of country B. This will increase the interest rate on country B's assets thus worsening its fundamentals and raising the probability of devaluation of its currency.

Such a model can provide a theoretical framework useful to explain some of the empirical evidence reported in the introduction. For example, a commercial bank holding claims [9] issued by a number of countries in the same region (e.g. East Asia) may be hit by the devaluation of one of its debtors' currency and see its financial wealth reduced. This may lead the bank to reassess the risk premium required on the bonds issued by all the other countries in the region only because it *fears* (but this fear not necessarily has to correspond to the actual situation) that they may be less competitive after the first country's devaluation. The spreading of the currency crisis to the whole region is thus triggered by an investors' sentiment shift. On the other hand, international investors holding a widely geographically diversified portfolio can be induced to a reallocation of their wealth as it is hit by a currency devalutaion, consistently with the strong correlation of emerging markets sovereign spreads documented by Baig and Goldfajn (2001). The same model can help explain why other financial crises did not spread from the origin country, as it happened for Argentina in 2001-2002[10]. In that case, the sharp decline in the correlation between emerging markets sovereign spreads can be the result of a previous reallocation of the international investors' portfolios away from Argentine assets triggered by frequent signals of instability over the months preceding December 2001, the conventional starting date of the Argentine crisis. This shows how important is the

[9]We can think of corporate bonds.

[10]The lack of contagious effects from the Argentine crisis ha been documented, among others, by the IMF (2002), and Boschi (2002).

role of portfolio diversification in reducing the probability of contagion, as suggested by our model.

2.4 Adding linkages through competitiveness effects

To allow for competitiveness effects, we assume that:

$$T_t^a = \overline{T} + \beta RER_t^a + \epsilon_t^a \tag{24}$$

$$RER_t^a = (1 - w^a)e_t^{a*} + w^a e_t^{ab} \tag{25}$$

where RER is the logarithm of the real exchange rate, which gives a weight w^a on country b, and $(1 - w^a)$ on the United States; e_t^{a*} and e_t^{ab} are the logarithms of the nominal exchange rates vis-a-vis the US dollar and the country b currency. That is:

$e_t^{a*} = \log(S_t^{a*}) = \log(a's\ currency/US\$)$,

and $e_t^{ab} = \log(S_t^{ab}) = \log(a's\ currency/b's\ currency)$.

Analogously, for country b:

$$RER_t^b = (1 - w^b)e_t^{b*} + w^b e_t^{ba}$$

Both the currencies of a and b are, at least initially, pegged to the dollar. Now, $S_t^{a*}/S_t^{b*} = S_t^{ab}$, i.e. $e_t^{a*} - e_t^{b*} = e_t^{ab}$. Then:

$$\begin{aligned} RER_t^a &= (1 - w^a)e_t^{a*} + w^a(e_t^{a*} - e_t^{b*}) \\ &= e_t^{a*} - w^a e_t^{b*} \end{aligned} \tag{26}$$

From the expression above we note that a devaluation of country b's currency vis-a-vis the US\$ (that is, an increasing competitivity of country b on the american market) decreases RER_t^a, that is the general competitivity of country a. We can refer to this link as to a competitiveness effect. Prices are fixed: nominal devaluation produces an improvement in competitiveness.

The investor knows that with probability π_t^b the country b will devalue its currency, that is, with probability π_t^b, $e_{t+1}^{b*} = e_t^{b*} + \delta$ (we are assuming that the size of the devaluation is the same in both countries). Hence, with probability π_t^b, $RER_{t+1}^a = e_t^{a*} - w^a \left(e_t^{b*} + \delta\right)$.

Now the probability of devaluation in country a depends on the possibility of devaluation in b π_t^b through a further channel:

$$\pi_{t+1}^{a} = \left(1 - \pi_{t+1}^{b}\right) P_{t+1}[\overline{T} + \beta(e_{t+1}^{a*} - w^{a} e_{t+1}^{b*}) + \epsilon_{t+1}^{a}
- [r_{t+1}^{*} + \pi_{t+1}^{a}\delta + rp_{t+1}^{a}]D_{t}^{a} + R_{t+1}^{a} - \overline{R}^{a} < 0]
+ \pi_{t+1}^{b} P_{t+1}[\overline{T} + \beta(e_{t+1}^{a*} - w^{a} e_{t+1}^{b*} - w^{a}\delta) + \epsilon_{t+1}^{a}
- [r_{t+1}^{*} + \pi_{t+1}^{a}\delta + rp_{t+1}^{a}]D_{t}^{a} + R_{t+1}^{a} - \overline{R}^{a} < 0]$$

or

$$\pi_{t+1}^{a} = \left(1 - \pi_{t+1}^{b}\right) F[(\pi_{t+1}^{a}\delta + rp_{t+1}^{a})D_{t}^{a} - \phi_{t+1}^{a}]
+ \pi_{t+1}^{b} F[(\pi_{t+1}^{a}\delta + rp_{t+1}^{a})D_{t}^{a} - \phi_{t+1}^{a} - \beta w^{a}\delta]$$

where now $\phi_{t+1}^{a} = \overline{T} + \beta(e_{t+1}^{a*} - w^{a} e_{t+1}^{b*}) - r_{t+1}^{*} D_{t} + R_{t+1} - \overline{R}$. This equation shows how contagion can occur because of trade competitiveness as well as wealth effects. The specification of the two countries' trade balance as dependent on the real exchange rate makes the devaluation expectations sensitive to trade competitiveness. This framework can give a complete picture of how contagion works. In fact, a portfolio effect, a competitiveness effect, or both can increase the probability of devaluation in one country as a consequence of the expected devaluation in another country. The link between the expectations of devaluation in the two countries is provided by the inclusion of the risk premium, which in turn is endogeneized by using an International Capital Asset Pricing (ICAPM) model, and by trade competitiveness on a third market. Finally, the crisis can also be triggered simultaneously in the two countries by a common global shock captured by the rate of interest of a risk-free asset. The empirical evidence provided by Glick and Rose (1999), according to which contagion tends to occur as a consequence of trade links and competitiveness effects, is consistent with the theoretical model here presented.

3 Stabilizing the system

A number of authors has invoked some sort of restrictions on capital mobility in order to stabilize the international financial system. For example, Krugman (1999) argues that countries which cannot adopt either currency unions or free floating should limit capital flows. Stiglitz (1999) endorses the same view with special reference to developing countries. A different mean by which reducing macroeconomic instability was proposed by James Tobin (1978), who argues that a foreign exchange transactions tax would help prevent destabilizing speculation in international financial markets. This view was broadly discussed in the aftermath of the frequent currency crises of the 1990s. In this Section we analyze the effects of such restrictions on the probability of transmission of crises in the context of our model.

3.1 Capital controls

As mentioned above, one way to stabilize international financial markets could be by means of imposing restrictions on capital flows. We model this restriction introducing a no-short-selling constraint on risky bonds:

$$x_{m,s} \geq 0 \tag{27}$$

When the constraints (27) are added to the model, the Euler equation (3) changes as follows:

$$u'(C_s)D_s^m = \beta E_s \left\{ u'(C_{s+1})(Y_{s+1}^m + D_{s+1}^m) \right\} + v_{m,s+1} \tag{3'}$$

where $v_{m,s+1}$ is the Lagrange multiplier associated with constraint (22) at time $s+1$. The term $v_{m,s+1}$ is equal to the increase in expected lifetime utility that would result if the current constraint were relaxed by one unit. Going through the steps discussed in Subsection 2.1 again, leads to the following expression for the risk premium under capital control:

$$\begin{aligned} \overline{rp}_{t+1}^m &= -(1+r_{t+1}^*)Cov\left\{ \frac{\beta u'(C_{t+1})}{u'(C_t)}, r_{t+1}^{*m} \right\} - \frac{v_{m,t+1}(1+r_{t+1}^*)}{D_t^m u'(C_t)} \\ &= rp_{t+1}^m - \Theta_{t+1}^m \end{aligned} \tag{28}$$

where $\Theta_{t+1}^m = \frac{v_{m,t+1}(1+r_{t+1}^*)}{D_t^m u'(C_t)}$. Therefore:

$$E_t(r_{t+1}^m) \cong r_{t+1}^* + \pi_{t+1}^m \delta + rp_{t+1}^m - \Theta^m \tag{9'}$$

Given π_{t+1}^b, country a's probability of devaluation will thus be lowered by a decrease in the argument of the F function. In fact, the new expression for the "fundamentals" variable is:

$$\overline{b}_t \equiv T_t - [r_t^* - q_{a,t+1}\Theta^a]D_{t-1} + R_t - \overline{R}$$

and the resulting expression for π_{t+1}^a is:

$$\overline{\pi}_{t+1}^a = F[\overline{\pi}_{t+1}^a \alpha - \overline{\phi}_{t+1}^a] \tag{18'}$$

Intuitively, capital controls will decrease the probability of devaluation, and thus of contagion, by means of a decrease in the expected returns on developing countries' securities.

3.2 Tobin tax

In this Subsection, we apply the above model to answer the following question: does a Tobin tax, i.e. a foreign exchange transactions tax, reduce the probability of contagion of financial crises?

Remembering that the budget constraint is expressed in dollars, the introduction of a tax with rate τ^m on each foreign exchange transactions modifies the investor's budget constraint in the following way:

$$\begin{aligned} B_{s+1} + \sum_{m=1}^{N} x_{m,s+1}(1-\tau^m)D_s^m &= (1+r_s^*)B_s + \\ &\quad \sum_{m=1}^{N} x_{m,s}[(1-\tau^m)Y_s^m + (1-\tau^m)D_s^m] \quad (20) \end{aligned}$$

and the FOC (3) remains unchanged since:

$$1 + r_{s+1}^{\tau * m} = \frac{(1-\tau^m)Y_{s+1}^m + (1-\tau^m)D_{s+1}^m}{(1-\tau^m)D_s^m} = 1 + r_{s+1}^{*m}$$

where $r_{s+1}^{\tau * m}$ is the rate of return on country m's security under taxation, which is equal to the rate of return without taxation. In other words, the introduction of a tax on foreign exchange transactions does not change the equilibrium behaviour of the representative investor, thus leaving unchanged the probability of transmission of crises.

4 Conclusion

The existing literature on contagion presents an unsatisfactory partition of the phenomenon explanations between theories based on fundamentals and theories based on the investors' behaviour. The model presented in this paper nests both the main sources of contagion of financial crises, adds another dimension of non-linearity to the Jeanne-Masson model increasing the likelihood of self-fulfilling equilibria, and offers a theory of how jumps between multiple equilibria may occur through wealth effects. It shows that financial crises can be transmitted across seemingly unrelated countries (e.g. Russia and Brazil) through the risk attitudes of international investors. Thus, to understand financial crises it is not sufficient to look at the countries in question, but also at the portfolios of international investors. International business cycle considerations through the wealth effects can also play a role in the incidence of financial crises. The model also suggests that bond spreads, in the event of a financial crisis, would change in emerging markets depending on the pattern of portfolio holdings of international investors. Better risk-management can help reduce the incidence of financial crises. The model can help better understand the transmission of crises across markets which do not seem to be directly related to each other by emphasizing the role of capital flows and thus, integrating international trade and finance considerations. Finally, an extension of the model to introduce a no-short-selling constraint shows that frictions in the international capital flows can help reduce the instability originating from the self fulfilling expectations of rational investors.

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