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Self-Fulfilling Debt Crises in Theory and Practice

by

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Abstract*

This paper analyzes econometrically how a country's post-crisis debt ratio could be forecast, in the aftermath of a debt crisis, from the previous debt-to-GDP ratio. A critical parameter is simply the debt-to-PPP-GDP ratio, where PPP-GDP is, in current international dollars, the Summers-Heston value. In this formulation, this paper shows that the Latin American paradox disappears. This then leads to a simple conclusion: debt crises are more frequent in Latin American countries because they have more damaging consequences on the market value of GDP. This itself appears to be closely related to the fact that pre-crisis Latin American exchange rates are also overvalued (for a similar emphasis, see Calvo et al., 2003). As a simple consequence of this model, the paper suggests computing the debt-to-PPP-GDP ratio as a new standard for analyzing debt sustainability.

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1. Introduction

Debt crises never die, although they often change forms. Why do we observe that so many countries fall into the trap of debt crises, and especially so many in Latin America? Out of the past 48 debt crises that erupted over the last 30 years among emerging economies, 24 involved a Latin American country. Given the economic cost of financial crises, should we not expect more prudent behavior from these countries? Actually, the theoretical answer is: it depends.

Take the simplest form of a financial crisis driven by an exogenous shock. Spreads on sovereign bonds can be high because a given country is expected to be vulnerable to events such as an earthquake, or a commodity shock, which are beyond its control. The country should then indeed behave more prudently, to the extent that an earthquake will reduce the country's income afterwards: the more debt the country would have to repay, the heavier will be the cost of the earthquake, relative to the good state of nature. Yet, on the other hand, if the expected earthquake is so large that the country knows that it will actually have to default on its debt, then a "Panglosian attitude," as Krugman coined it, may become rational: the debt will lose all value after the earthquake, and it would then be absurd not to borrow more beforehand. Depending on the initial value of the debt and the parameters driving the risk of an exogenous shock, a country may either behave "very" prudently or instead simply ignore the underlying risk in building up its debt.

Assume now that crises are driven by financial markets' lack of confidence in a given country, self-fulfillingly making the country financially fragile. While self-fulfilling debt crises have been analyzed in different forms, in their purest form, they are the perverse outcome of a snowball effect through which the build-up of debt becomes unmanageable *because* of the fear that such a build-up can become unmanageable. Relying on an intuition developed in a simpler model in Cohen and Portes (2004), we show in this paper that snowball effects can only occur in cases where a debt crisis has the potential to diminish the fundamentals of the indebted country. If a crisis reduces the GDP of a country by 10 percent, for example, then it is clear that the lack of confidence towards a country can degenerate into a self-fulfilling crisis. With respect to the earthquake case, there is in this case an additional motive to behave prudently: as shown in Cole and Kehoe (2000) in a slightly different context, a country may wish to "invest" in debt decumulation so as to escape the danger zone where it is vulnerable to a confidence shock. Past a given threshold, however, the same Panglossian tragedy may occur: the country simply ignores the risk and behaves as if financial crises would not occur.

At any rate, what makes the earthquake case and the confidence shock similar is that the risk of a debt crisis cannot be assessed through a simple debt-to-GDP ratio. What matters most is the level of the debt-to-GDP ratio after the shock, whether it is a confidence or a commodity shock. As we show empirically, it is this simple theoretical point that will actually prove to be the critical factor in predicting financial crises.

We use a slightly modified version of the database that has been compiled by Kraay and Nehru (2004), which we have updated to cover all debt crises that occurred between 1970 and 2004. Following Kraay and Nehru (hereafter KN), we show that the likelihood of a debt crisis is well explained by three factors: the debt-to-GDP ratio, the debt-service-to-exports ratio, and the level of real income per capita.[1] We also show, however, that under this specification there is a systematic bias toward a higher frequency of financial crisis in Latin America than in other regions.

What we find most interesting, however, is the following fact: when analyzing the debt-to-GDP ratio before and after the crisis, conditions are worse after the debt crisis rather than beforehand. This is mainly explained by the fall of the denominator which is itself largely due to the collapse of the exchange rate after the debt crisis. In fact, we show that over the past three decades, one of four exchange rate crises comes in the aftermath of a debt crisis. These other "twin crises" then appear in fact to be a major determinant of the process at hand.

In order to dig deeper into this question, we have analyzed econometrically how the post-crisis debt ratio could be forecast, in the aftermath of a debt crisis, from the previous debt-to-GDP ratio. A critical parameter is simply the debt-to-PPP-GDP, where the PPP-GDP is, in current international dollars, the Summers-Heston value. In this formulation, we show that the Latin American paradox disappears. This then leads to a simple conclusion: debt crises are more frequent in Latin American countries because of the fact that they have more damaging consequences on the market value of GDP. This itself appears to be closely related to the fact that pre-crisis Latin American exchanges rates are also over-valued (for a similar emphasis, see Calvo et al., 2003). As a simple consequence of this model, we then suggest computing the debt-to-PPP-GDP ratio as a new standard for analyzing debt sustainability.

[1] This third factor was actually not discussed by KN.

2. A Panglossian Theory of Debt

Let us consider a one good economy in which output can take two values $\{Q_+, Q_-\}$, respectively the good and the bad state of nature. For simplicity we assume that the bad state is an attractor where the economy stays forever once it has been experienced. This is geared toward analyzing long-lasting shocks on the economy, rather than simply short-term fluctuations.

The transition matrix can then be written as:

$$\Pr[Q_{t+1} = Q_+ \backslash Q_t = Q_+] = 1 - p$$
$$\Pr[Q_{t+1} = Q_- \backslash Q_t = Q_+] = p$$
$$\Pr[Q_{t+1} = Q_+ \backslash Q_t = Q_-] = 0$$
$$\Pr[Q_{t+1} = Q_- \backslash Q_t = Q_-] = 1$$

We assume that the country has access to world financial markets where the riskless rate is a constant r. Furthermore, we also make the assumption that the debt is short-term and needs to be refinanced every year. We sketch below the implications of analyzing longer-term maturities. Finally, we assume that the country seeks to solve:

$$J_\varepsilon(D_t) = \max_{\{C_s\}_{s\geq t}} E_t\left\{\sum_{s=t}^{\infty} \beta^{(s-t)} u(C_s)\right\}$$

in which $\varepsilon \in \{+, -\}$ and represents the state of nature.

Formally, one can write:

$$J_+(D_t) = \max_{C_t} \{u(C_t) + \beta(1-p)J_+(D_{t+1}) + \beta p J_-(D_{t+1})\}$$

in which:

$$D_{t+1} = (1 + \varrho_{t+1})[D_t + C_t - Q_+] \qquad (1)$$

where D_t is the debt that has been accumulated at the beginning of time t, $C_t - Q_+$ is how much debt has been added during that period and ϱ_{t+1} is the risk-adjusted rate of interest which is charged on the sum of both and payable at time $t+1$ (see below for how it is determined).

In the low state of nature, the value function is simply:

$$J_{-}(D_t) = \max_{C_t} \{u(C_t) + \beta J_{-}(D_{t+1})\}$$

in which:

$$D_{t+1} = (1+r)[D_t + C_t - Q_{-}] \quad (2)$$

Indeed, if the country has not defaulted while in the state Q_{-} it will not either in the next period since lenders will prevent it (if only by keeping $D_{t+1} = D_t$). We shall assume that:

$$\delta > r \quad (3)$$

(See Section 2.3.1 for an explanation.)

2.1 Risk of Outright Default

Let us first assume the following repayment structure. When the country defaults (assume here: in the bad state of nature) then it suffers forever after a negative productivity shock of magnitude λ. In other words, post-default imposes:

$$C_{-}^{d} = (1-\lambda)Q_{-}$$

Furthermore, let us assume that no payment is performed after a default (see Section 2.3.2 for the case of a negotiated settlement). In the bad state of nature, the problem simply boils down to whether:

$$D \gtrless \bar{D}_{-} = \frac{\lambda Q_{-}}{r} \quad (4)$$

When the debt is above $\bar{D}_{-}$ then, in the bad state of nature, the country will prefer to default while, otherwise, it will keep borrowing until the debt reaches $\bar{D}_{-}$. From that point on, the country will to stick to a steady state characterized by:

$$C_{-} = Q_{-} - r\bar{D}_{-}$$

2.2 Equilibrium Strategy

2.2.1 The Riskless Path

Let us first analyze the dynamics of debt when the country is indefinitely offered the riskless rate. The problem in that case boils down to:

$$J_+(D_t) = \max_{C_t^+} u(C_t^+) + \beta(1-p)J_+[(1+r)(D_t + C_t^+ - Q_+)]$$
$$+ \beta p J_-[(1+r)(D_t + C_t^+ - Q_+)]$$
$$J_-(D_t) = \max_{C_t^-} \left\{u(C_t^-) + \beta\, J_-[(1+r)(D_t + C_t^- - Q_-)]\right\}$$

Call $q_t^+ = -J'_+(D_t)$ and $q_t^- = -J'_-(D_t)$ the marginal utility of wealth.

The Euler conditions are written as :

In the good state of nature:

$$q_t^+ = \beta(1+r)[(1-p)q_{t+1}^+ + pq_{t+1}^-] \qquad (5)$$
$$u'(C_t^+) = q_t^+$$

In the bad state of nature:

$$q_t^- = \beta(1+r)q_{t+1}^- \qquad (6)$$
$$u'(C_t^-) = q_t^-$$

The steady-state corresponding to the good state of nature, if there is one, is therefore a solution to:

$$q_\infty^+[1 - \beta(1+r)(1-p)] = \beta(1+r)pq_\infty^-$$

Call $\beta = \dfrac{1}{1+\delta}$. This yields, after a linear approximation:

$$\theta_\infty = \frac{q_\infty^-}{q_\infty^+} = \frac{\delta + p - r}{p}$$

Since $\theta_\infty \geq 1$, this only exists if and only if:

$$\delta > r$$

which is the assumption that we adopted above (see equation (3)). Otherwise, the country would actually indefinitely build up reserves while in the good state, in order to offset the potential cost of moving to the bad state. Under the above assumption, we reach a steady state which is a solution to:

$$J^+(D_\infty^+) = \frac{1}{\delta + p}[u(Q_+ - rD_\infty) + pJ^-(D_\infty)]$$

in which $J^-(D_\infty^+)$is the value function that corresponds to the build-up of debt in the deterministic case when output is indefinitely low. Take the iso-elastic case $u(x) = \frac{1}{1-R}x^{1-R}$, with $R = 1/\sigma$. We show in the Appendix Section A.1. that the solution can be approximated as:

$$rD_\infty^+ = Q_- - b(Q_+ - Q_-)$$

in which $b = \frac{1}{w^\sigma - 1}$ and $\frac{\delta}{r}[1 + \frac{\delta - r}{p}] = w$. In the simple case $\sigma = 1$, we have:

$$b = \frac{p}{\delta + p}\frac{r}{\delta - r}$$

Note here that the higher p, the lower D_∞^+: the risk of moving into the bad state lessens the extent of debt accumulation for the obvious reason that debt aggravates the cost of switching to the low state.

All that is then simply needed at this stage is to check whether the accumulated long-run debt is consistent with the non-default assumption.

This amounts to determining whether:

$$b(Q_+ - Q_-) < (1 - \lambda)Q_- \quad (7)$$

When this is the case, the no default trajectory is an equilibrium (when the trajectory starts with $D_0 < \bar{D}_-$). Otherwise there is an inner contradiction and the risk-adjusted scheme must be analyzed.

2.2.2 The Risky Trajectory

The debt enters into a risk of default as soon as:

$$D_{t+1} > \bar{D}_- = \frac{\lambda Q_-}{r}$$

In that case the optimal trajectory is a solution to:

$$J_+(D_t) = \max_{C_t^+} \{u(C_t^+) + \beta(1-p)J_+[(1+\varrho)(D_t + C_t - Q_+)] + \beta p J_-^d\}$$

in which J_-^d is the post-default path, in the bad state of nature (as studied in Section 2.1). We have:

$$1+\varrho = \frac{1+r}{1-p} \quad (8)$$

The first-order conditions are now :

$$q_t^+ = \beta(1+r)q_{t+1}^+ \quad (9)$$

$$u'(C_t^+) = q_t^+$$

In that case, the risk of default is no more internalized in the Euler equation (9), while it was in the riskless case (see equation (5)). This arises from the fact that default leads the country to a level of welfare independent of the amount of debt it has accumulated.

Under the assumption that $\delta > r$, there is no interior solution to the long-run debt pattern; the country, in that case, takes as much debt as it can on the long-run, that is here:

$$\bar{D}_+ = \frac{\lambda Q_+}{r+p} \quad (10)$$

provided, obviously, that $\bar{D}_+ > \bar{D}_-$. In that case, there is henceforth a strong discontinuity between the riskless and the risky trajectory. In the risky trajectory, the pattern of debt becomes explosive (after some time) and brings the country to the limit. In that case, the country does not attempt to stabilize debt in response to a default risk. Instead, the exact opposite occurs: the default penalty makes the country reckless. This is the Panglossian result that we alluded to in the introduction.

2.2.3 Preliminary Conclusion

We then see, at this stage, that two cases can occur:

1. The country has access to market of risky debt, i.e.,

$$\bar{D}_+ = \frac{\lambda Q_+}{r+p} > \bar{D}_- = \frac{\lambda Q_-}{r} \quad (11)$$

In that case, either the country "voluntarily" stops short of the lower level (with no rationing taking place) or it builds up debt to the upper limit $\bar{D}_+ = \frac{\lambda Q_+}{r+p}$, and takes a risk of default of probability p.

2. The country has no access to the market of risky debt. This will happen when:

$$\bar{D}_+ = \frac{\lambda Q_+}{r+p} < \bar{D}_- = \frac{\lambda Q_-}{r} \quad (12)$$

In that case, the country is "too risky" (p is too large to warrant risky behavior). The country then, either voluntarily or involuntarily, stays out of the market of risky debt. In the involuntary case, the country is rationed at the riskless rate.

An interesting feature of this analysis is the perverse dynamics which are created when a country enters (is allowed to enter) the danger zone of high spreads and high debt (as in the case of equation (11)). In the model of Eaton and Gersovitz (1981) instead, high-risk countries are also "safer" countries. Indeed, in their model, a country that needs to smooth numerous contingencies will experience a higher cost of default and will consequently, *ceteris paribus*, default less.[2] Although it is true in our model as well that the precautionary motive will tend to reduce the exposure to risk, one also sees that this is true only up to a certain threshold after which the dynamics ignores that risk.

[2] This is the critical difference between Eaton and Gersovitz (1981) and Bulow and Rogoff (1989): in the latter case a defaulting country can smooth shocks through the accumulation of reserves.

2.3 The Potential for Multiple Equilibria

2.3.1 The Case of Outright Default

In order to see the potential for multiple equilibria in this economy, consider as a starting point the situation in which $D = D_\infty^+$ (such as determined in equation (10)), when the country is following the risk-free trajectory. If offered the riskless rate then the country will remain, by assumption, at D_∞^+. Assume instead the country is offered the risk-adjusted rate (defined in equation (8)). This will raise the demand for debt for *two* reasons. First, the precautionary motive of anticipating the bad shock disappears, and the country consequently seeks to consume more. Second, by the sheer effect of higher interest rates the debt will consequently grow faster.

Given these two effects, a *sufficient* condition for multiple equilibria is that:

$$D_{t+1} = \frac{1+r}{1-p}(D_\infty^+ + C_\infty - Q_+) > \frac{\lambda Q_-}{r} = \bar{D}_-$$

which is equivalent to:

$$\frac{D_\infty^+}{1-p} > \bar{D}_-$$

So that multiple equilibria are possible when:

$$(1-p)\bar{D}_- < D_\infty^+ < \bar{D}_- \qquad (13)$$

2.3.2 The Case of Negotiated Settlement

Let us now investigate the trajectory that is triggered by a risk of default, when lenders and borrowers are capable of a settlement *ex post*. Assume that, when the debt has become unsustainable, lenders are always capable of extracting $R_- = \lambda Q_-$ on every period after the shock has occurred. When the level of debt exceeds $\bar{D}_-$, the country is then subject to a constraint which is driven by a zero profit condition for the lenders:

$$[D_t + C_t - Q_+](1+r) = (1-p)D_{t+1} + p\frac{\lambda Q_-}{r} \qquad (14)$$

In that case the problem that the country must solve is:

$$J_+(D_t) = \max_{C_t^+} \left\{ u(C_t^+) + \beta(1-p)J_+\left[\frac{(1+r)(D_t + C_t^+ - Q_+) - p\frac{\lambda Q_-}{r}}{1-p} \right] + pJ_-^d \right\}$$

The law of motion of the marginal utility of wealth now becomes:

$$q_t^+ = \beta(1+r)q_{t+1}^+ \quad (15)$$

which is similar to the law of motion found in the case of outright default (see equation (9)). Indeed, the intuition is the same: the country does not incorporate the precautionary motive of a prudent strategy. What has changed, however, is the possibility of multiple equilibria.

The zero profit condition for the lenders (equation (negotiated-zero-profit)) shows indeed that :

$$D_{t+1} > \frac{\lambda Q_-}{r} \Rightarrow [D_t + C_t - Q_+](1+r) > \frac{\lambda Q_-}{r}$$

Contrary to the case of outright default one then sees that if a country is threatened by default at a risk-adjusted interest rate, it would also have been threatened at the riskless rate.

In brief: *multiple equilibria are only possible when the fundamentals upon which the debt is repaid are endogenous to the crisis.*

This is the result, obtained in a simpler model, by Cohen and Portes (2004). The intuition is simple: for a given set of fundamentals there can only be one equilibrium, at least in the simplest. This may be the key reason why corporate self-fulfilling debt crises are a curiosity. To the extent that appropriate bankruptcy procedure exists, the risk that financial crisis can endanger, out of their own making, the value of a firm is much reduced.

3. Debt Dynamics and Risk: A Re-Interpretation

Our model leads to a reinterpretation of the risk of self-fulfilling financial crises. Assume, in the spirit of Cole and Kehoe (1996), that a financial crisis is triggered by sunspots which create the fear of a panic. Assume that sunspots occur with a probability p and have the "potential" to reduce the fundamentals from Q_+ to Q_-. This happens when lenders, leaving the country, destroy economic value if only by triggering an exchange rate crisis which has real effects on the economy.

This potential, however, is only turned into reality, when the country becomes insolvent in the bad state of nature. Otherwise, if the country is really safe (i.e., when $D < \bar{D}$ in the model), then it is reasonable to assume that the sunspot cannot self-fullfillingly create a debt crisis. The crisis is likely to be short-lived: worried investors determine that, even at the lowest end of their expectations, the country is still solvent.

When instead the sunspot occurs while the debt is above the sustainable level that is consistent with the bad state of nature, then the debt crisis occurs and the country self-fullfillingly "becomes" insolvent.

This re-interpretation of our model (which is elaborated upon in Appendix Section A.2) has implications very similar to those of the model that we spelled out above, except that it raises the zone where the country will want to act prudently. Beyond a new threshold however the same Panglossian attitude will emerge.

This model, and the one which precedes it, lead to a simple conclusion: it is not the current level of debt-to-GDP ratio that determines the risk of a debt crisis (as is usually assumed in the litterature), but rather the latent *ex post* ratio, i.e., the ratio that would occur either as the effect of exogenous shocks or as the outcome of a self-fulfilling crisis. It is this idea that we now try to bring to the data.

4. Dataset

4.1 Debt Crises

We now try to bring the insight of this theoretical model to the data. Our empirical strategy relies on a dataset of distress and normal times episodes, following the methodology of Kraay and Nehru (2004). More precisely, for a given year, a country is considered to be in debt crisis if at least one of the following three conditions holds:

1. the country receives debt relief from the Paris Club in the form of a rescheduling and/or a debt reduction;
2. the sum of its principal and interest arrears is large relative to the outstanding debt stock; or
3. the country receives substantial balance of payments support from the IMF through a non-concessional Standby Arrangement (SBA) or Extended Fund Facility (EFF).

We choose the same thresholds as Kraay and Nehru (2004) for the last two conditions; that is, a country is considered to be in crisis if its arrears are above 5 percent of the total stock of its outstanding debt, or if the total amount agreed under SBA/EFF is above 50 percent of the IMF quota of the country. Moreover, a country receiving Paris Club relief for a given year is also considered to be in crisis for the following two years, since the relief decision is typically based on three-year balance of payments projections by the IMF.

Having defined when a country is considered to be in crisis or not, we then define debt distress episodes as periods of at least three consecutive years of crisis. Moreover, we impose the restriction that a distress episode should be preceded by at least three years without crisis, so that we can consider macroeconomic variables before a crisis episode as being exogenous to the crisis. We also define normal times episodes as five consecutive years without any crisis (without imposing any other restriction).

For identifying debt distress and normal times episodes, we use the following data sources:

- the World Bank's *Global Development Finance* for data on debt levels and payment arrears,
- the Paris Club website for information on debt relief, and
- the IMF's *International Financial Statistics* for data on SBA/EFF commitments.

In our subsequent econometric models, we also use two other sources:

- the World Bank's *World Development Indicators* for general macroeconomic variables, and
- the *Penn Word Tables* (version 6.1) for data on Purchasing Power Parity (PPP) variables.

The set of countries for which computations are made consists of all the developing countries (as defined by the World Bank) except Sub-Saharan Africa (SSA), for a total of 90 countries. We chose to remove Sub-Saharan African countries, since their indebtedness situation is somewhat different from that of the rest of the developing world (in particular, the proportion of concessional lending is much higher in SSA); from the standpoint of the model, they probably fall into the category of those who have no access to risky markets (as in equation (12))), and their debt dynamics must therefore be somewhat different. Our data cover the whole period 1970-2004.

Prior to the elimination of certain observations in our econometric estimations (due to missing data), our largest sample therefore consists of 51 distress episodes and 222 normal times episodes. Restricting the sample to Latin America, this leads to 25 distress episodes (almost half of the entire sample) versus 79 normal times episodes.

4.2 Currency Crises

In addition to debt crises, we also study currency crises, which we define in the same way as Frankel and Rose (1996). For a given year, a country is said to undergo a currency crisis if the two following conditions hold:

1. the exchange rate (against the US dollar) has fallen by more than 25 percent since the previous year, and
2. this rate of depreciation of the exchange rate must be at least 10 percent greater than that of the previous year.

The second condition is specifically designed for countries constantly experiencing high inflation rates: were we to require only the first condition, these countries would be constantly considered as undergoing a currency crisis.

Over our sample of 90 countries and 35 years, we find 298 occurrences of currency crisis, which gives a crisis probability of 9.5 percent.[3] Among all these occurrences of crisis, 23 appear before a debt crisis (that is, during the three years immediately preceding a debt crisis), and 75 appear during a debt crisis episode (as defined above). Therefore, 7.7 percent of currency crises can be roughly considered as preceding a debt crisis, and 25.2 percent as coexisting with or immediately following a debt crisis. The remaining 67.1 percent seem, at first glance, to be unrelated to debt crises.

5. Empirical Analysis

5.1 Descriptive Statistics

The first two columns of these tables give means of several variables over different crises, the first column during the three years preceding the crisis, and the second during the first three

[3] This is actually an underestimate because of the many missing observations, in particular for the recently created CIS countries.

years of the crisis. The third column is simply the difference between the second and the first columns. The three last columns give the means of the same variables during the same years, but for the whole emerging world (being loosely defined as the developing world except Sub-Saharan Africa).

The first line should therefore be interpreted as follows: for countries experiencing a debt crisis, the growth rate is, on average, of 3.6 percent per year during the three years preceding the crisis, and of 1.9 percent during the first three years of the crisis episode. At the same time, the emerging world was growing at 3.8 percent and 3.5 percent, respectively; this means that a debt crisis somewhere in the emerging world is on average associated with a minor slowdown of growth in the emerging world as a whole.

The last line should be interpreted as follows: on average, countries experiencing a debt crisis also experience a currency crisis during at least one of the three years preceding the debt crisis in 34.2 percent of the cases, and at least in one of the first three years of the crisis episode in 55.3 percent of the cases.

The first table is for the whole sample of crises, and the second is limited to crises in Latin America.

Means over 38 Crises (all values in %)

	Countries in crisis			Emerging world		
	Before	After	Δ	Before	After	Δ
g(GDP)	3.6	1.9	−1.8	3.8	3.5	−0.4
g(E)	13.2	31.1	17.8	15.3	16.9	1.6
g(D)	15.6	10.4	−5.2	18.5	14.8	−3.7
g(X)	6.5	8.7	2.2	8.6	8.6	−0.0
Debt/GDP	46.8	67.8	21.1	44.3	52.5	8.2
Debt/X	264.5	310.9	46.4	195.4	221.0	25.6
r	5.7	5.6	−0.1	4.6	4.8	0.2
Debt/PPP-GDP	22.3	26.7	4.5	19.3	21.6	2.3
PPP-GDP/US$-GDP	224.9	264.3	39.3	251.8	267.7	15.8
Currency crisis	34.2	55.3		22.4	25.0	

Means over 22 Crises in Latin America (all values in %)

	Countries in crisis			Emerging world		
	Before	After	Δ	Before	After	Δ
g(GDP)	2.4	1.3	− 1.1	3.9	3.3	− 0.5
g(E)	16.2	40.9	24.6	12.9	18.2	5.3
g(D)	15.7	9.1	− 6.6	18.5	14.0	− 4.5
g(X)	4.4	10.0	5.6	7.8	8.4	0.5
Debt/GDP	46.3	66.9	20.6	44.0	54.7	10.6
Debt/X	259.9	301.2	41.3	196.2	233.5	37.3
r	6.9	6.6	− 0.3	4.9	4.9	− 0.1
Debt/PPP-GDP	24.4	28.8	4.4	19.7	22.4	2.8
PPP-GDP/US$-GDP	195.5	237.8	42.3	246.2	267.7	21.5
Currency crisis	45.5	59.1		21.5	26.1	

The key results can be summarized as follows:

1. One does observe a slowdown of growth after the crisis, which is not present in the other countries. On average, one cannot impute to a worldwide slowdown the key cause behind a debt crisis.
2. When looking at exports, there is an increase in export growth after the crisis (above the corresponding level in other emerging countries) which is presumably the effect of the crisis.
3. The critical change indeed is the collapse of the exchange rate, whose depreciation rate is about twice the levels that were reached before the crisis. It is here quite obvious that debt crises contribute to an exchange rate crisis.
4. Whatever the causality (whether debt crises cause exchange crises or the other way around), the most significant factor is the large increase in the debt-to-GDP indicator *after* the crisis. While the ratio is essentially identical to the other countries before the crisis (46.8 percent as opposed to 44.3 percent) it shoots up after a crisis: not because of the debt build-up,

which is in fact reduced below the levels which are in the other countries, but instead because of the collapse of the exchange rate level.

5. Lastly, regarding the interest rate (which is paid on average by the debtor countries), it stands about 100 basis point over that of other countries prior to the crisis, although this does not appear to create a snowball effect as such.

These facts, we believe, go in the direction of the model that we highlighted at the end of our theoretical model. Debt indicators worse after the crisis rather than beforehand. Interestingly, however, the bulk of this shock comes from the exchange rate rather than from a slowdown of growth per se. Similarly, the snowball effect triggered by the interest rate is less important that the exchange rate shock. This clearly raises the question of whether debt crisis are just one instance of an exchange rate crisis, or whether they have a life of their own.

5.2 Determinants of a Debt Crisis

From this raw data, let us then analyze the determinants of a debt crisis. We follow Kraay and Nehru's approach but slightly change their sample in two dimensions. First, we update their data to 2004, which is a relatively minor change but allows to include, for instance, the Ecuadorian debt crisis of 2000. Second, we restrict our analysis to the countries which are emerging countries not in Sub-Saharan Africa. We consequently exclude the richest and the poorest countries from the sample, since neither belong to the standard emerging market category.

In equation (1.1), as shown in Table 1 below, we first investigate the predictive power of the debt-to-GDP ratio and income per capita in explaining the crisis. All variables are significant, and we show a Latin American bias. In equation (1.2), we follow KN and add the debt-service-to-exports ratio in order to measure the influence of a liquidity risk on predicting a debt crisis. We do find a significant influence, although this leaves the Latin American bias unchanged. When the debt-to-exports ratio (not reported here) is added, we find that it is not significant and that the debt-service-to-exports ratio is really what matters. In view of the fact that exchange rates are highly variable and appear to move quite a bit either before or after the debt crisis, we test the significance of the debt-to-GDP ratio when the latter is measured in PPP terms. This is reported in equation (1.3), and we find a very significant influence. When both debt ratios are put together, as in equation (1.4), both are significant, but the debt-to-GDP ratio is actually wrongly signed! This may be readily explained as follows: when the debt-to-GDP ratio is low, while holding constant the debt-to-PPP-GDP ratio, this simply means that the exchange rate is overvalued, in which case an exchange rate crisis is inevitable.

This interpretation is given in equation (1.5), which is equivalent to (1.4) except for the interpretation of the coefficients, in which we present the debt-to-PPP-GDP ratio and the PPP to current exchange rate ratio: high debt and overvalued currencies create the risk of a debt crisis.

The question we then want to investigate is whether an overvalued currency simply serves as a proxy of forthcoming exchange rate crises in general, or whether it plays a role specific to debt crises. In order to investigate this question, we also control for the event of an exchange rate crisis occurring in any of the three years preceding the debt crisis. This is reported in equation (1.6): we find that the dummy exchange rate crisis is significant (though only at the 4 percent level) but does not change the significance nor the order of magnitude of the exchange rate indicator on the risk of a debt crisis. This allows us to conclude that there is a specific interaction between exchange rate and debt crises, which is not just due to the fact that an exchange rate crisis raises the risk of a debt crisis (although it does), but suggests that there is indeed a specific risk of exchange rate misalignments on debt crises. Such interaction is consistent with the self-fulfilling model that we highlighted: debt crises are vulnerable to shocks that lower the fundamentals upon which debt is serviced, whether exogenous or endogenous to the crisis itself.

Table 1. Probability of a Debt Crisis (Probit models)

	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)	(1.6)
Log Debt/GDP (t-3)	0.626**	0.371		-1.481**		
	(0.196)	(0.211)		(0.480)		
Log Debt/PPP-GDP (t-3)			0.823***	2.121***	0.680**	0.744**
			(0.233)	(0.493)	(0.242)	(0.245)
Log PPP/current exchange rate ratio (t-3)					-1.330**	-1.245**
					(0.461)	(0.463)
Currency crisis (t-3...t-1)						0.674*
						(0.325)
Log Real PPP GDP per capita (t)	-0.555**	-0.616**	-0.933***	-1.226***	-1.182***	-1.299***
	(0.203)	(0.221)	(0.253)	(0.281)	(0.276)	(0.287)
Latin America	0.658**	0.602*	0.613*	0.392	0.409	0.414
	(0.244)	(0.262)	(0.263)	(0.274)	(0.273)	(0.276)
Debt-Service/Exports (t-3)		3.474***	3.178***	3.816***	3.765***	3.215***
		(0.832)	(0.821)	(0.893)	(0.888)	(0.938)
Number of observations	200	200	200	200	200	200
Correct predictions	81.5%	82.5%	87.5%	86.5%	85.0%	88.0%
Pseudo R^2	0.098	0.198	0.255	0.307	0.299	0.320

6. Conclusion

We have shown that debt crises are most often accompanied by exchange rate crises, which add to the deterioration of a country's solvency. This has the potential of creating self-fulfilling debt crises, although at this stage of our research it is clearly too early to conclude that this is the only factor at hand.

Our results are clearly in line with those obtained in many other papers emphasizing the impact of the financial crisis on the exchange rate and the potential for increasing that impact. Calvo et al. (2003), for instance, emphasize the fact that Argentina, having a smaller tradable sector than other countries of similar income, is more prone to an exchange rate collapse: it is an idea on which we hope to focus in subsequent work. The view that exchange rate overvaluation reflects prior mismanagement, as in Burnside et al. (2001), is also certainly a factor that needs to be tested in future work.

At this stage, we hope that our paper will have shown why conventional measures of debt sustainability need to be revised, and how such a revision can be attempted. At the very least, it is not obvious why international PPP-adjusted measures of GDP should be used to assess solvency (indeed, see Cohen and Soto, 2002, on why this should not be done in general). More work is clearly needed to further our understanding of this new indicator.

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A. Appendix

A.1. The Riskless Path

In order to characterize the parameters that determine the steady state of the economy, let us simply assume here that:

$$J_-(D_\infty) = \frac{1}{\delta}u(Q_- - rD_\infty)$$

which amounts to neglecting the dynamics of debt accumulation in the bad state of nature. In that case, one can write:

$$J_+(D_\infty) = \frac{1}{\delta + p}[u(Q_+ - rD_\infty) + p\frac{1}{\delta}u(Q - rD_\infty)]$$

We obtain:

$$q_\infty^- = \frac{r}{\delta}u'(Q_- - rD_\infty)$$

and:

$$q_\infty^+ = \frac{r}{\delta + p}u'(Q_+ - rD_\infty) + \frac{rp}{\delta}u'(Q_+ - rD_\infty)$$

or:

$$q_\infty^+ = \frac{r}{\delta}[\frac{\delta}{\delta + p}u'(Q_+ - rD_\infty) + \frac{p}{\delta + p}u'(Q_- - rD_\infty)]$$

The steady-state is therefore a solution to:

$$\frac{u_\infty^-}{u_\infty^+} = \frac{\delta}{rp}(\delta + p - r) = \frac{\delta}{r}[1 + \frac{\delta - r}{p}] = w$$

The sequence proceeds as in the text.

A.2. The Transition to a Riskless Zone

The difference between the model that is presented in the text and the one which is sketched in section re-interpretation comes from the fact that a country whose debt dynamics may self-fulfillingly create a crisis may want to restrain its debt build-up. This is point is made in Cole and Kehoe (2000). When threatened by a confidence shock, the country can decide to invest in reducing its debt so as to escape the risky zone. We present the dynamics in continuous time.

Start from a central situation in which $D_0 > \bar{D}$ (and take for simplicity here the borderline case $r = \delta$). Let us write the problem in continuous time. In that case the country may seek to implement a consumption pattern $\hat{C}$, which is a solution to:

$$J = \int_0^T pe^{-pt}\left[\int_0^t e^{-\delta s}u(\hat{C})ds + e^{-\delta t}J_d\right]dt$$
$$+ e^{-pT}\left[\int_0^T e^{-\delta t}u(\hat{C})dt + e^{-\delta T}\frac{1}{\delta}u(C_T)\right]$$

in which T is the time that the country is willing to spend on a "tough" adjustment pattern $\hat{C}$. C_T is the level of consumption achieved when $D_T = \bar{D}_-$ and when the risk-free rate is offered to the country, that is:

$$C_T = Q_+ - r\bar{D}_-$$

Over the adjustment program $[0, T]$ the law of motion of debt is driven by:

$$\dot{D}_t = (r+p)D_t + \hat{C} - Q_+$$

Let us call $\hat{D}$ the solution to:

$$\hat{C} = Q_+ - (r+p)\hat{D}$$

The law of motion of debt can then be written as:

$$D_t - \hat{D} = e^{(r+p)t}(D_0 - \hat{D})$$

so that the time T at which the adjustment ends is a solution to:

$$e^{(r+p)T} = \frac{D_T - \hat{D}}{D_0 - \hat{D}}$$

which gives a direct relationship between the length of the adjustment program and the effort which is undertaken by the country.

Solving the program yields the equation:

$$u(C_T) - u(\hat{C}) + p[J_T - J_0] = u'(\hat{C})\frac{(r+p)(D_0 - D_T)}{1 - e^{-(r+p)T}}$$

which has a finite solution T for low enough values of $D_0 - D_T$ or high enough values of $p[J_T - J_0]$. In that case the pattern of adjustment is a low value $\hat{C}$ while $D_t \in [D_T, D_0]$ and then jumps to $C_T = Q_+ - rD_T$ when the adjustment is over.

B. Debt and Exchange Rate Crises

The following tabulations give the complete list of the crisis episodes identified along the methodology explained above. For each crisis episode, the first three columns give the country, the year of the crisis outbreak, and the number of years it lasted. The columns labeled "type of crisis" provide some precision about the type of debt crisis, such as whether it was characterized by Paris Club relief, accumulated arrears or IMF intervention (or several of these options). The table also shows if the debt crisis was accompanied by a currency crisis, whether before (during any of the three preceding years) or during the crisis episode.

The remaining columns give several macroeconomic indicators about the country: the debt/GDP ratio at three points in time (three years before the outbreak, the year of the outbreak and three years later), the debt/PPP GDP ratio (at the same dates), the debt service/exports ratio, the annual rate of depreciation of the exchange rate (before and after the crisis), the mean annual growth before the crisis and the mean effective interest rate charged on the debt before the crisis.

Country	Year	Length	Type of crisis			Currency crisis			D/GDP		
			Paris Club	Arrears	SBA/EFF	Before	During	Any	t-3	t	t+3
Haiti	1970	4	N	Y	N	N	N	N	NA	10.9	7.2
Indonesia	1970	3	Y	N	N	NA	N	NA	NA	46.9	42.3
Chile	1972	5	Y	Y	Y	Y	Y	Y	33.1	30.7	76.4
Pakistan	1972	5	Y	N	N	N	Y	Y	34.0	43.7	50.7
Philippines	1976	3	N	N	Y	N	N	N	27.4	35.3	48.3
Egypt, Arab Rep.	1977	4	N	N	Y	N	N	N	24.5	80.2	83.5
Jamaica	1977	24	Y	Y	Y	N	Y	Y	60.4	51.7	71.4
Peru	1977	4	Y	N	Y	Y	Y	Y	38.8	64.4	45.4
Guyana	1978	27	Y	Y	Y	N	Y	Y	65.2	119.1	159.5
Haiti	1978	3	N	N	Y	N	N	N	18.3	25.3	31.7
Panama	1978	3	N	N	Y	N	N	N	50.4	93.8	77.7
Turkey	1978	7	Y	N	Y	N	Y	Y	10.9	22.3	28.9
Bangladesh	1979	3	N	N	Y	Y	N	Y	19.8	19.5	28.0
Honduras	1979	23	Y	Y	Y	N	Y	Y	27.1	52.6	63.5
Costa Rica	1980	16	Y	Y	Y	N	Y	Y	42.9	56.8	133.1
Morocco	1980	15	Y	Y	Y	N	Y	Y	50.8	51.7	93.5
Pakistan	1980	4	Y	N	Y	N	N	N	50.0	41.9	41.9
India	1981	3	N	N	Y	N	N	N	12.4	12.1	16.5
Romania	1981	5	Y	N	Y	NA	NA	NA	NA	NA	NA
Argentina	1983	13	Y	Y	Y	Y	Y	Y	35.3	44.2	49.5
Brazil	1983	3	Y	N	Y	Y	Y	Y	30.4	48.5	40.7
Chile	1983	7	Y	N	Y	Y	Y	Y	43.8	90.7	119.3
Dominican Republic	1983	17	Y	Y	Y	N	Y	Y	30.2	34.0	60.2
Ecuador	1983	14	Y	Y	Y	N	N	N	50.4	67.9	90.5

Country	Year	Length	Type of crisis			Currency crisis			D/GDP		
			Paris Club	Arrears	SBA/EFF	Before	During	Any	t-3	t	t+3
Mexico	1983	10	Y	N	Y	Y	Y	Y	27.9	59.5	74.5
Nicaragua	1983	22	Y	Y	Y	N	Y	Y	102.3	148.9	234.6
Uruguay	1983	4	N	N	Y	Y	Y	Y	16.4	64.8	66.7
Egypt, Arab Rep.	1984	12	Y	Y	Y	N	Y	Y	94.3	105.1	109.0
Lebanon	1986	6	N	Y	N	NA	Y	Y	NA	NA	37.7
Paraguay	1986	9	N	Y	N	Y	Y	Y	25.2	58.9	54.6
Tunisia	1986	6	N	N	Y	N	N	N	48.6	65.9	69.0
Myanmar	1988	17	N	Y	N	NA	NA	NA	NA	NA	NA
Trinidad and Tobago	1988	5	Y	Y	Y	Y	N	Y	19.6	46.7	46.7
Vietnam	1988	17	Y	Y	Y	Y	Y	Y	0.4	2.4	243.4
Cambodia	1989	16	Y	Y	N	NA	Y	Y	NA	156.1	92.4
Jordan	1989	16	Y	Y	Y	N	Y	Y	78.2	177.2	149.8
Venezuela, RB	1989	4	N	N	Y	Y	Y	Y	56.4	74.3	62.6
El Salvador	1990	3	Y	N	N	N	N	N	50.2	44.7	29.2
Algeria	1994	4	Y	N	Y	Y	Y	Y	62.3	71.1	64.5
Djibouti	1994	11	Y	Y	N	N	N	N	49.6	54.0	54.4
Pakistan	1994	10	Y	N	Y	N	N	N	51.4	52.8	48.2
Georgia	1995	3	N	Y	Y	Y	N	Y	2.1	46.0	45.6
Indonesia	1997	8	Y	Y	Y	N	Y	Y	61.0	63.1	87.5
Thailand	1997	3	N	N	Y	N	Y	Y	45.3	72.7	64.9
Brazil	1998	7	N	N	Y	N	Y	Y	22.8	30.7	45.5
Colombia	1999	3	N	N	Y	N	N	N	29.7	39.9	40.7
Turkey	1999	6	N	N	Y	Y	Y	Y	44.1	55.6	71.3
Ecuador	2000	5	Y	N	Y	N	N	N	65.2	86.0	62.0
Kyrgyz Republic	2002	3	Y	N	N	Y	N	Y	139.0	115.3	NA
Solomon Islands	2002	3	N	Y	N	N	N	N	49.7	75.6	NA
Uruguay	2002	3	N	N	Y	N	Y	Y	35.8	86.4	NA

Country	Year	D/PPP-GDP			TDS/X	Exch. rate depreciation		Growth	Interest rate
		t-3	t	t+3		avg(t-3...t)	avg(t...t+3)	avg(t-3...t-1)	avg(t-3...t-1)
Haiti	1970	NA	3.4	2.7	7.0	0.0	0.0	0.2	0.9
Indonesia	1970	NA	15.5	17.2	13.0	29.7	4.3	6.9	1.0
Chile	1972	20.1	20.2	31.8	27.3	29.4	182.1	4.9	3.5
Pakistan	1972	14.4	17.1	18.2	33.2	6.6	17.8	5.8	2.0
Philippines	1976	7.1	11.2	16.9	22.5	3.2	-0.3	6.0	3.3
Egypt, Arab Rep.	1977	8.0	28.3	28.2	16.3	5.6	7.8	8.7	1.7
Jamaica	1977	56.0	51.1	53.0	37.2	0.0	22.4	-3.7	6.9
Peru	1977	18.1	25.1	18.3	42.5	25.8	41.2	4.9	5.0
Guyana	1978	25.5	49.4	63.1	6.4	1.4	3.8	2.5	3.9
Haiti	1978	7.3	9.9	13.2	8.1	0.0	0.0	2.2	2.0
Panama	1978	30.0	57.1	49.7	NA	0.0	0.0	1.5	4.4
Turkey	1978	7.2	15.7	14.9	19.1	17.5	52.6	7.0	5.6
Bangladesh	1979	6.5	7.1	8.4	28.8	0.7	9.1	5.1	1.9
Honduras	1979	13.0	28.6	33.7	29.1	0.0	0.0	10.3	5.1
Costa Rica	1980	25.1	39.0	53.8	22.0	0.0	52.3	6.7	5.0
Morocco	1980	24.3	29.6	31.6	19.1	-4.5	19.7	4.4	4.8
Pakistan	1980	18.8	15.9	13.9	31.9	0.0	8.3	5.3	2.5
India	1981	4.4	4.3	4.7	16.1	2.9	9.4	2.4	2.7
Romania	1981	2.0	16.6	9.3	NA	NA	NA	NA	4.3
Argentina	1983	15.8	24.3	24.9	107.4	101.6	149.8	-2.2	8.8
Brazil	1983	15.9	18.8	15.6	69.4	79.8	105.5	1.8	12.1
Chile	1983	34.4	48.0	45.3	43.0	23.4	29.9	0.9	11.7
Dominican Republic	1983	17.8	19.8	22.9	29.8	0.0	35.5	3.9	9.1
Ecuador	1983	27.5	29.5	33.7	34.0	0.0	0.0	2.4	9.4

Country	Year	D/PPP-GDP			TDS/X	Exch. rate depreciation		Growth	Interest rate
		t-3	t	t+3		avg(t-3...t)	avg(t...t+3)	avg(t-3...t-1)	avg(t-3...t-1)
Mexico	1983	18.6	23.4	24.1	52.6	55.2	54.1	5.7	12.0
Nicaragua	1983	38.2	53.8	77.3	22.1	7.0	84.5	3.1	4.5
Uruguay	1983	12.9	25.6	24.8	19.6	44.5	49.4	-0.8	9.2
Egypt, Arab Rep.	1984	29.3	32.2	37.7	19.9	7.6	10.5	7.0	4.3
Lebanon	1986	NA	NA	NA	NA	NA	85.4	NA	8.0
Paraguay	1986	15.0	19.5	16.2	13.7	42.2	23.8	1.3	4.0
Tunisia	1986	17.5	22.2	21.9	22.2	5.2	6.0	5.4	5.9
Myanmar	1988	NA	NA	NA	NA	NA	NA	-0.7	2.3
Trinidad and Tobago	1988	14.6	23.4	20.5	11.0	15.0	3.3	-4.0	7.6
Vietnam	1988	NA	NA	34.4	NA	143.0	85.9	3.4	0.5
Cambodia	1989	NA	NA	NA	NA	NA	57.7	NA	0.0
Jordan	1989	53.9	80.3	62.4	32.8	16.5	5.6	2.7	6.0
Venezuela, RB	1989	39.5	29.7	28.0	42.3	48.5	22.6	5.3	8.6
El Salvador	1990	15.6	14.3	10.5	34.6	12.5	4.4	1.8	3.9
Algeria	1994	24.3	26.7	22.0	68.9	21.4	16.6	-0.5	7.1
Djibouti	1994	NA	NA	NA	NA	0.0	0.0	-1.2	2.0
Pakistan	1994	13.6	13.0	11.9	25.4	9.9	8.6	4.8	3.6
Georgia	1995	NA	NA	6.2	0.0	333.8	14.4	-28.2	0.6
Indonesia	1997	16.8	16.4	17.0	30.4	9.9	35.4	7.9	5.0
Thailand	1997	18.5	26.2	19.5	14.0	7.4	8.2	8.0	4.3
Brazil	1998	15.1	20.7	NA	39.7	7.8	23.6	3.4	6.2
Colombia	1999	13.3	14.9	NA	36.6	17.6	11.8	2.0	6.4
Turkey	1999	19.8	22.3	NA	28.0	54.7	42.6	5.9	5.7
Ecuador	2000	34.4	29.2	NA	31.2	0.0	0.0	-0.0	6.0
Kyrgyz Republic	2002	12.2	NA	NA	20.9	6.2	NA	4.8	3.3
Solomon Islands	2002	NA	NA	NA	5.0	11.1	NA	-7.9	1.9
Uruguay	2002	21.7	NA	NA	28.0	20.9	NA	-2.6	6.8