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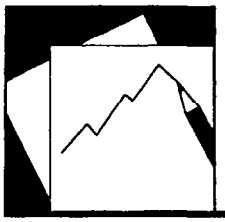

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Crises and Liquidity: Evidence and Interpretation

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Crises and Liquidity: Evidence and Interpretation

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Abstract

In a large panel of countries, we find that less liquid countries are more likely to default on their external debt. Specifically, for given total external debt, the probability of a crisis increases with the proportion of short-term debt and debt service coming due and decreases with foreign exchange reserves. This correlation, however, is consistent with a standard model of optimal default and need not be ascribed to self-fulfilling creditor runs. Also, the correlation with short-term debt appears to be driven by joint endogeneity. The policy implications are discussed.

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I. INTRODUCTION

The recent financial crises in Mexico and East Asia have brought the role of external liquidity to the attention of economists and policy-makers. Before the crises hit, these economies were regarded as successful, and had attracted large volumes of international capital in the form of bank loans, foreign direct investment, and portfolio investment. The reversal in capital flows was quite sudden and dramatic, out of proportion with observed changes in basic economic conditions (the so-called fundamentals), and a number of observers noticed that both Mexico and the Asian countries had large short-term external liabilities not matched by foreign assets of similar characteristics.[2]

This maturity mismatch has come to be regarded as a fundamental source of financial fragility, and international institutions such as the IMF have undertaken an effort to improve data collection and dissemination on short-term external liabilities, to step up monitoring of external liquidity, and to promote better external liquidity management.[3] Proposals to restrict inflows of short-term capital or to create an international lender of last resort have also been put forward (Sachs (1995), Fischer (1998)).[4]

In this paper, we study the relationship between liquidity and crises to look for support for these policy recommendations. On the theory front, the link between liquidity and crises has been rationalized through models of self-fulfilling creditor runs. In these models, a debtor needs to service a large amount of external obligations coming due. If creditors do not roll over some or all of the maturing debt, default is the optimal choice,

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[2] See, for instance, Sachs, Tornell, and Velasco (1996) for Mexico, and Chang and Velasco (1998) and Radelet and Sachs (1998) for East Asia. Others, such as Corsetti, Pesenti, and Roubini (1998) have emphasized fundamental economic imbalances as the main source of fragility in East Asia.

[3] For instance, the April 27, 1999 communiqué of the Interim Committee of the Board of Governors of the IMF called for "better data, including on private sector capital flows; strengthened monitoring of capital flows, in particular short-term flows" and asked the Fund and its member countries to intensify work to "adhere to sound principles of debt management, avoid excessive accumulation of short-term debt and, more generally, maintain an appropriate structure of liabilities; establish systems for high-frequency monitoring of private external liabilities; [...]maintain adequate foreign exchange liquidity."

[4] These policy recommendations, however, need to be qualified if short-term debt has advantages besides costs (Jeanne (2000), Rodrik and Velasco (1999), Chang and Velasco 2000, Diamond and Rajan (2000)).

while if the loan is rolled over the debtor country is better off repaying. Under these circumstances, if creditors are small and cannot coordinate, there may be a (Pareto-dominated) equilibrium in which no creditor rolls over and the country defaults. Thus, low liquidity may lead to insolvency because of coordination failures among creditors. This basic model was first sketched out by Sachs (1984). Later on Calvo (1988) and Alesina, Prati, and Tabellini (1990) developed the idea in the context of domestic nominal government debt, in which "default" takes place through surprise inflation, and expectations of high inflation can become self-fulfilling. More recently, self-fulfilling creditor runs have been studied in full-fledged models of sovereign debt by Cole and Kehoe (1996, 2000) and Detragiache (1996). Chang and Velasco (1998, 2000) model foreign creditor runs when the borrowers are domestic banks rather than the government. In all these models, the run is just one of many possible equilibria. Morris and Shin (1999) show that if information about the fundamentals is asymmetric, inefficient creditor runs may be the only equilibrium.

In all the models of self-fulfilling runs, if the amount of debt to be rolled over is small or the fundamentals are benign, the perverse equilibrium disappears. Thus, these models predict that measures of external liquidity should be significantly and negatively correlated with financial crises after controlling for other relevant parameters (including total indebtedness). A number of recent papers have tested this prediction. Sachs, Tornell, and Velasco (1996) tests if countries affected by the Tequila crisis had a higher share of short-term debt in total capital flows than other countries, and find weak evidence. According to Radelet and Sachs (1998) and Rodrik and Velasco (1999), the ratio of short-term debt to reserves helps predict large reversals of capital flows, but the samples used are small.[5] Frankel and Rose (1996) and Milesi-Ferretti and Razin (1998) uncover no evidence of a liquidity effect on currency crisis.[6] Finally, Eichengreen and Mody (1998, 1999) find risk spreads on emerging market syndicated loans and bonds to be increasing in the ratio of short-term debt to reserves in the issuing country. Thus, the empirical evidence so far is mixed.

In this paper, we attempt to improve on this literature in a number of dimensions. The first part of the paper refines the empirical work: first, more in line with theoretical models, we focus mainly on external debt crises. Second, we use a large data set, consisting of 69 countries over 1971-98. Third, we disentangle the role of the various components of liquidity by entering reserves, short-term debt, and debt service due (on long-term debt)

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[5] In most of the studies reviewed here short-term debt is defined on a residual maturity basis, i.e. it includes debt with original maturity of less than one year as well as amortization coming due within the year.

[6] If the sample is extended to include more recent crisis episodes, liquidity variables become significant (Berg and Pattillo (1999), and Bussière and Mulder (1999)).

as separate regressors. We also perform extensive sensitivity tests to gauge the robustness of the results to alternative estimation techniques, samples, and choice of control variables. Finally, since sorting out causality is key to interpret the regressions and to draw policy recommendations, we examine the question of the possible endogeneity of short-term debt, as countries approaching default may find it difficult to borrow long-term.

In the second part of the paper we question whether the negative correlation between measures of external liquidity and crises should be interpreted as a test of models of self-fulfilling runs against more standard models of external debt. Specifically, we show that, for plausible parameter values, a more liquid debtor is less likely to default also in a standard model of optimal borrowing in which creditor runs are ruled out by assumption and lengthening debt maturity is not Pareto-improving.

The paper is organized as follows: Section II contains an overview of the data, including a description of the debt crisis variable and of the regressors. The estimation results and the sensitivity analysis are presented in Section III. Section IV contains the theoretical model, and Section V concludes.

II. Empirical Methodology

The empirical tests are based on a "crisis equation" where the dependent variable is the occurrence of a debt crisis. The explanatory variables are liquidity indicators, variables controlling for the magnitude and structure of external debt, and a set of macroeconomics variables. All debt-related variables (with the exception of debt service due) are lagged by one year, since they are end-of-period stocks. Macroeconomic variables are similarly lagged by one period to limit simultaneity problems.

The data are annual from 1971 through 1998; the sample includes all the countries for which information was available with the exception of those with population of less than one million.[7] The external debt variables come from the 1999 electronic edition of *Global Development Finance* of the World Bank (GDF). The baseline sample includes 950 observations for 69 countries. Summary statistics and a correlation matrix for the variables in the sample are in Appendix I (Tables 5 and 6).

[7] Including also small countries increases the sample by 136 observations. Using this larger sample does not change the results.

A. Definition of Debt Crisis

An observation is classified as a debt crisis if either or both of the following conditions occur: 1) there are arrears of principal or interest on external obligations towards commercial creditors (banks or bondholders) of more than 5 percent of total commercial debt outstanding; 2) there is a rescheduling or debt restructuring agreement with commercial creditors as listed in the GDF. The 5 percent minimum threshold is to rule out cases in which the share of debt in default is negligible, while the second criterion is to include countries that are not technically in arrears because they reschedule or restructure their obligations before defaulting.[8] Also, since we are interested in defaults with respect to commercial creditors, arrears or rescheduling of official debt do not count as crisis events. Finally, observations for which commercial debt is zero are excluded from the sample because they cannot be crisis observations based on our definition.[9]

A second issue is how to distinguish the beginning of a new crisis from the continuation of the preceding one. In keeping with our crisis definition, an episode is considered concluded when arrears fall below the 5 percent threshold; however, crises beginning within four years since the end of a previous episode are treated as a continuation of the earlier event. In a sensitivity test we exclude all episodes that follow the first crises, so that each country has at most one crisis. Finally, since we seek to identify the conditions, which prompt a crisis rather than the impact of the crisis on macroeconomic developments, all observations while the crisis is ongoing are excluded from the sample.

These criteria identify 54 debt crises in the baseline sample. The episodes are listed in Appendix I, and Figure 1 shows their distribution over time. While events tend to cluster in the early 1980s, when most Latin American countries and several African countries defaulted on their syndicated bank debt following the borrowing boom of the 1970s, there are crises throughout the sample period. Notably, three of the recent Asian crises episodes (Indonesia, Korea, and Thailand) belong to the sample. Episodes of external payment difficulties that do not result in arrears or rescheduling, such as the Mexican crisis of 1995, are not captured by our definition of crisis even though they are considered as such in the policy debate.

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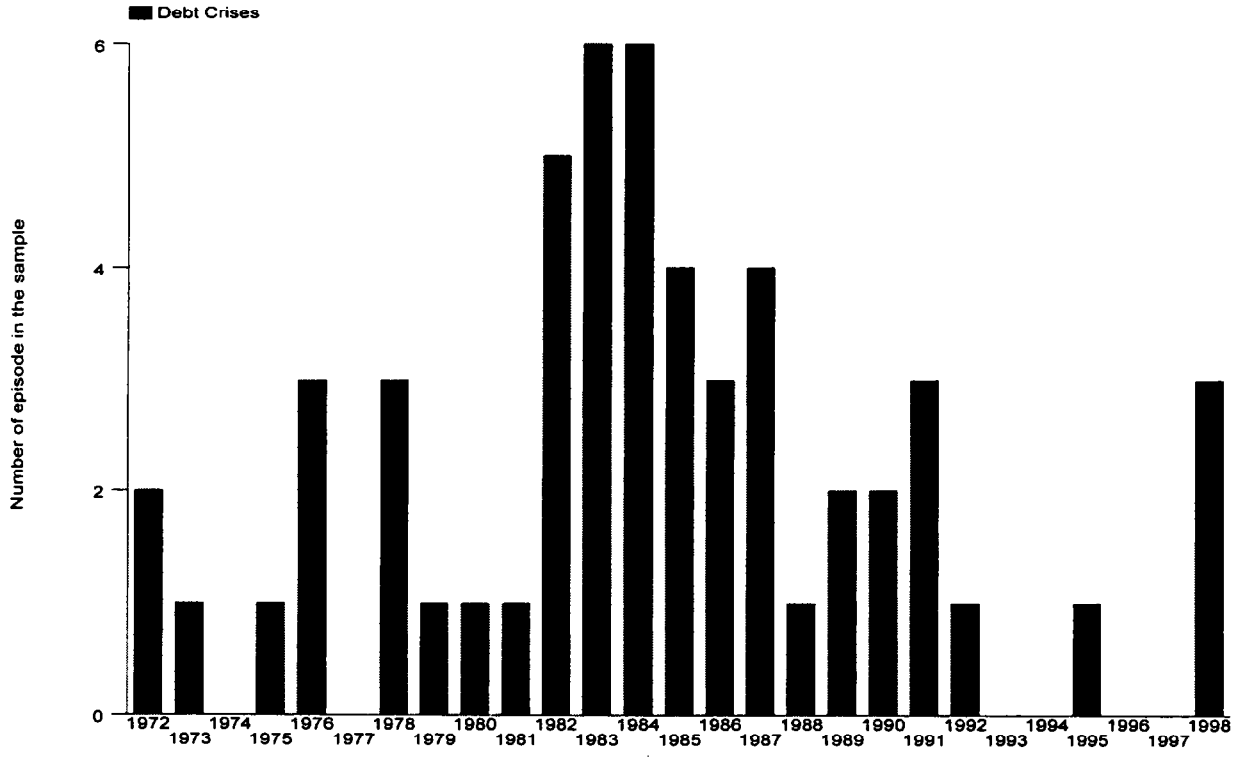
[8] As a sensitivity test, we set the minimum threshold on arrears at 15 percent of commercial debt service due.

[9] As a robustness test, the baseline regression was also estimated including these observations, and the results are reported in the following section.

Figure 1. Debt Crises



B. Liquidity Variables

As discussed in the introduction, the existing empirical literature on the role of external liquidity in financial crises usually examines just one measure of liquidity, the ratio of short-term debt (defined on a residual maturity basis) to foreign exchange reserves. To gain more insight on the determinants of crises, in the specification considered here short-term debt and reserves are entered as separate regressors, so that it is possible to disentangle the contribution of each component. Furthermore, within short-term debt we distinguish between debt service due (including principal maturing in the year and interest payments on debt with original maturity of more than one year) and short-term debt (debt with an original maturity of less than one year). Both components affect the amount of funds that the country needs to raise from abroad in a given year but, while debt service due is predetermined, short-term debt may be endogenous and jointly determined with the crisis probability. By separating the two components it is possible to address the potential simultaneity bias in a robustness check.[10] Another reason to separate the two components of liquidity is that statistics on short-term external debt are not very good, while information on debt service payments due on long-term debt is likely to be more accurate. Short-term debt is as reported in the GDF except that arrears of interest are excluded. Debt service due is the sum of interest and principal on commercial debt repaid plus any arrears on either principal or interest. We exclude debt service due to official creditors on the grounds that such creditors are unlikely to face coordination problems. Summary statistics and correlations for the liquidity variables (as well as for the other variables used in the baseline regression) are reported in Appendix I.[11]

C. Debt Variables

The size of the external debt is captured by the ratio of total debt to GDP.[12] Because the burden of servicing a given amount of debt is likely to depend on the nature of the obligations, we also control for debt characteristics such as the share of debt owed to commercial banks, the share of debt at concessional terms, and the share of debt owed

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[10] Much of the existing literature uses short-term debt data from the Bank of International Settlement, which defines short-term on a residual maturity basis.

[11] The data for reserves comes from IFS statistics line (.1L.D); the data for GDP in dollars come from the World Bank's *Global Development Indicators* (code NYGDPMKTPCD). We exclude from the sample three-outlier observations for which the reserve GDP ratio is bigger than 80 percent. The data on debt come from the World Bank's *Global Development Finance* (1999).

[12] The data for debt come from the GDF (code DTDODDECTCD). We exclude from the sample the few observations for which the debt to GDP ratio is implausibly bigger than 1.5.

to multilateral creditors. These variables are highly correlated among themselves (see Appendix I), and multicollinearity could lower the significance of each individual variable; nonetheless, we keep them in the regression because we are not particularly interested in their individual impact on the crisis probability. Also, they are strongly correlated with two of the liquidity variables (short-term debt and debt service due) so omitting them may bias the coefficient of those variables. To control for the interest rate due on debt outstanding, following Frankel and Rose (1996) we include a weighted average of interest rates on major international currencies, in which the weights are the shares of total external debt denominated in that currency.

D. Macroeconomic Characteristics

To control for other economic characteristics that are likely to affect the country's willingness or ability to service external obligations, we use two variables: openness, measured as the sum of exports and imports divided by GDP, and the overvaluation of the real exchange rate.[13] The latter is the log deviation of the real exchange rate from its moving average in the previous five years. Countries that are more open should be in a better position to service a large external debt through future export revenues, while an overvalued exchange rate is likely to hurt future export performance. Also, in a willingness to pay framework, more trade openness may make the country more vulnerable to creditor sanctions if it defaults (Bulow and Rogoff, 1988). We have tried several other control variables such as GDP growth, the fiscal surplus, inflation, terms of trade volatility, export growth, and the stock of direct foreign investment, but none of them is significant.[14] Since their inclusion does not change the main results much and reduces sample size substantially, we have excluded these additional regressors from the baseline specification. In a sensitivity test, we estimate a specification including a large number of macroeconomic controls as in Frankel and Rose (1996).

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[13] The real exchange rate is with respect to the U.S. dollar and it is calculated using the GDP deflator from the IMF's *IFS*. A CPI-based measure yields similar results but reduces the sample size significantly. The raw data for openness come from the IMF's *IFS* (line 70..d, 71..d) and World Bank' Global Development Indicators (NYGDPMKTPCD).

[14] The stock of direct foreign investment is from Lane and Milesi-Ferretti (1999).

III. Estimation Results and Sensitivity Tests

A. Results from the Baseline Regression

Table 1 reports estimation results for the baseline specification. Standard errors used to compute the z values are corrected for country-specific heteroskedasticity. The liquidity variables, short-term debt, debt repayment due, and reserves, are all highly significant and have the expected signs, and so does the stock of external debt relative to GDP. Thus, after controlling for the level of debt outstanding, the less liquid is a country the more likely it is to default on its external debt. All three components of liquidity have independent and significant effects. They are also jointly significant, and a test of the equality of the coefficients of short-term debt and of debt service due rejects that hypothesis. This confirms that it is useful to enter the two variables independently.

The baseline regression also indicates that countries with a larger external debt and a larger share of debt towards multilateral lenders are more likely to experience a crisis. The latter result likely reflects the fact that countries experiencing balance of payments problems are more likely to borrow from multilateral lenders. Countries with more overvalued exchange rates and a smaller measure of openness are also more likely to default, as expected.[15] The pseudo-R^2 of the regression is 13.2 percent, indicating that there remains substantial unexplained variation in the default probability. Another way to gauge the performance of the model is to look at its in-sample predictive ability. The convention is to classify an observation as predicting a crisis if the estimated probability exceeds the in-sample frequency of crises. Using this criterion, the model correctly predicts 76 percent of the crises and 67 percent of the noncrisis observations.[16]

B. Sensitivity Tests

As a first sensitivity exercise, we re-estimate the baseline excluding one country at a time. The fourth and fifth columns of Table 1 report the largest and smallest z value obtained in this exercise for each of the regressors. Most of the results go through even if the smallest z value is considered. A second robustness test involves using as controls all the variables used by Frankel and Rose (1996) in their currency crisis regressions. This lowers the sample

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[15] If observations with no commercial long-term debt are included in the sample, the share of short-term debt is not significant; this is probably because countries with no access to long-term private capital also have little short-term debt.

[16] Using a logit instead of a probit model yields slightly worse results in terms of model performance, but the debt and liquidity variables remain significant. The two probability models are by-and-large equivalent when the frequency of the event is not too far from 50 percent of the observations, but they can differ in case like ours, when the event is rare.

Table 1. Liquidity and the Probability of Debt Crisis-Baseline Estimation

	dF/dx	z	P>|z|	zmax	zmin	dF/dx	z	P>|z|
Liquidity Variables:								
Short-Term Debt	0.131	2.291	0.022	1.980	2.780	0.159	2.198	0.028
Debt Service Due	0.250	2.359	0.018	1.561	2.739	0.286	2.189	0.029
Reserves	-0.451	-2.888	0.004	-3.430	-2.677	-0.495	-2.850	0.004
Debt and Debt Characteristics:								
Total Debt	0.096	5.126	0.000	4.767	5.450	0.111	4.421	0.000
Variable Share						0.040	0.455	0.649
Concessional Share	0.019	0.491	0.623	-0.045	0.823	0.069	1.262	0.207
Multilateral Share	0.127	2.474	0.013	2.090	3.574	0.157	3.173	0.002
Interest Rates	0.213	1.440	0.150	1.110	1.799	0.121	0.648	0.517
Macroeconomic Variables:								
FDI						-0.092	-0.187	0.852
Current Account Balance						-0.017	-0.156	0.876
Income Growth						0.015	0.110	0.912
Fiscal Surplus						0.169	1.192	0.233
Credit Growth						0.000	-0.169	0.865
OECD growth						-0.592	-1.298	0.194
Overvaluation	0.028	2.067	0.039	1.351	2.573	0.032	2.193	0.028
Openness	-0.046	-1.680	0.093	-2.222	-1.312	-0.019	-0.579	0.563
Constant	-0.191	-4.964	0.000	-5.276	-4.426	-0.221	-3.636	0.000
Chi2(3) (on liquidity variables)	14.360		0.002			13.920		0.003
Chi2(1) 1/	1.410		0.236			0.89		0.346
Number of Observations	950	(54 crises)				690	(43 crises)	
pseudo R2	0.132			0.124	0.15	0.165		

Notes: z and P>|z| are the test of the underlying coefficient being 0 (standard errors adjusted for clustering on country).
1/ Test of the hypothesis that the coefficients of short-term debt and debt service due are equal.

size substantially, but regression results change little: only openness loses its significance, while all the other controls do not have any independent effect on the crisis probability.

In the first regression in Table 2 the arrears threshold in the crisis definition is set at 15 percent of debt service due (rather than 5 percent of debt outstanding, as in the baseline). This modification decreases the number of crises in the sample from 54 to 50.[17] The share of short-term debt and overvaluation lose some significance, while the interest rate becomes more significant. When we exclude from the sample all years following the first crisis, thereby limiting the sample to one crisis per country, the number of crisis falls to 45, and the significance of short-term debt declines substantially, while the other two liquidity variables remain robust.

In the last regression of Table 2 the baseline regression is re-estimated for a sample starting in 1985, to test whether the crisis determinants and the role of liquidity have changed in more recent years. The number of crises now declines to 20, but the liquidity variables continue to be significant. Interestingly, now openness enters with the opposite sign, suggesting that in more recent years countries more open to international trade were more vulnerable.

Another set of sensitivity tests allows for possible country-specific and time-specific effects. This test is performed both using a random effect probit model and a fixed effect logit model (Table 3). Allowing for country random effects has little impact on the debt and liquidity variables, while the macroeconomic controls lose significance. With the country-specific fixed effects logit model, once again short-term becomes insignificant, while not much change for the other variables. However, in this estimation countries that never experienced debt crises over the period under consideration are excluded, so the sample becomes substantially smaller (Greene, 1997, p. 899).

C. Endogeneity of Short-Term Debt

A potential problem with this empirical specification is that the share of short-term debt may not be exogenous if countries more at risk of default become unable to borrow at long maturities or find borrowing at long maturities prohibitively expensive. If short-term debt is endogenous, then its coefficient is affected by simultaneity bias, and instrumental variable estimation is the correct approach. The existing literature on the role of liquidity

[17] Because we exclude from the sample observations for which the crisis is ongoing, when the definition of crisis changes the sample size may change as well.

Table 2 . Sensitivity Analysis: Alternative Definition of Crises

	Arrears > .10			Maximum 1 crisis			Only After 1984		
	dF/dx	z	P>|z|	dF/dx	z	P>|z|	dF/dx	z	P>|z|
Liquidity Variables:									
Short-Term Debt	0.079	1.480	0.139	0.063	0.965	0.334	0.145	2.882	0.004
Debt Service Due	0.208	2.330	0.020	0.220	2.044	0.041	0.257	2.621	0.009
Reserves	-0.381	-2.634	0.008	-0.343	-2.107	0.035	-0.368	-2.598	0.009
Debt and Debt Characteristics:									
Total Debt	0.092	5.589	0.000	0.108	4.866	0.000	0.085	3.933	0.000
Commercial Share	0.015	0.521	0.603	-0.029	-0.768	0.442	-0.014	-0.396	0.692
Concessional Share	-0.008	-0.240	0.811	-0.052	-0.987	0.323	0.077	3.176	0.001
Multilateral Share	0.113	2.596	0.009	0.164	2.774	0.006	0.033	0.971	0.331
Interest Rates	0.295	2.135	0.033	0.217	1.359	0.174	0.090	0.271	0.786
Macroeconomic Variables:									
Overvaluation	0.016	1.272	0.203	0.014	0.982	0.326	0.051	3.048	0.002
Openness	-0.039	-1.527	0.127	-0.057	-2.013	0.044	0.035	2.207	0.027
Constant	-0.177	-5.669	0.000	-0.160	-3.757	0.000	-0.167	-5.425	0.000
Chi2(3) (on liquidity variables)	12.610		0.006	8.510		0.036	31.950		0.000
Chi2(1)1/	1.950		0.163	2.630		0.105	1.230		0.267
Number of Observations	976	(50 crises)		803	(44 crises)		363	(20 crises)	
pseudo R2	0.150			0.149			0.250		

Notes: z and P>|z| are the test of the underlying coefficient being 0 (standard errors adjusted for clustering on country).
1/ Test of the hypothesis that the coefficients of short-term debt and debt service due are equal.

Table 3. Sensitivity Analysis: Country and Time Specific Effects

	Random Effect Probit			Fixed Effects Logit			Instrumental variables		
	Coef.	z	P>|z|	Coef.	z	P>|z|	dF/dx	z	P>|z|
Liquidity Variables:									
Short-Term Debt	1.875	2.057	0.040	4.219	1.330	0.184	0.134	1.925	0.054
Debt Service Due	3.569	2.639	0.008	12.478	3.247	0.001	0.311	2.454	0.014
Reserves	-6.438	-2.832	0.005	-29.004	-3.199	0.001	-0.527	-3.028	0.002
Debt and Debt Characteristics:									
Total Debt	1.368	4.070	0.000	7.493	4.595	0.000	0.091	3.143	0.002
Commercial Share	-0.129	-0.201	0.841	-2.124	-0.933	0.351	-0.006	-0.129	0.898
Concessional Share	0.273	0.457	0.648	-10.910	-3.107	0.002	0.026	0.546	0.585
Multilateral Share	1.809	2.665	0.008	7.044	1.880	0.060	0.148	2.591	0.010
Interest Rates	3.041	1.298	0.194	1.906	0.282	0.778	0.556	0.750	0.453
Macroeconomic Variables:									
Overvaluation	0.396	1.530	0.126	0.506	0.489	0.625	0.052	3.345	0.001
Openness	-0.653	-1.483	0.138	-6.754	-2.532	0.011	-0.046	-1.563	0.118
Constant	-2.723	-5.328	0.000						
Chi2(3) (on liquidity variables)	16.380		0.000	18.890		0.000	15.650		0.001
Chi2(1) 1/	1.570		0.210	4.020		0.045	2.590		0.108
Number of Observations	950	(with 69 countries) (and 54 crises)		680	(with 44 countries)		744	(six years dropped) (and 54 crises)	

Notes: z and P>|z| are the test of the underlying coefficient being 0 (standard errors adjusted for clustering on country).
1/ Test of the hypothesis that the coefficients of short-term debt and debt service due are equal.

in financial crises has not addressed this potential source of bias, perhaps because, while practitioners often attribute the inability to borrow long term to high default risk, theoretical work has only recently begun to analyze this issue.[18] Also, as noted in the introduction, empirical studies often use BIS data in which short-term debt is defined on a residual maturity basis, so that the endogenous component (debt with an original maturity of less than one year) cannot be separated from the exogenous component (long term debt maturing in the year).

To find a set of instruments, we draw on Rodrik and Velasco (2000). This study contains an empirical estimation of the determinants of the share of short-term debt (defined on a residual maturity basis) for a sample of 32 countries. Short-term debt is found to be positively correlated with GDP-per-capita, the ratio of M2 to GDP, and the ratio of debt to GDP. The authors interpret the first two correlations as supporting theories in which short-term debt promotes efficient financial intermediation.[19] The same authors also note that the latest Basle capital adequacy standards have created a bias towards short-term debt on the part of international banks, as they give short-term loans a lower risk weight than long-term ones. These considerations suggest GDP per-capita, M2-to-GDP, and a dummy for the 1990's (when the new Basle capital adequacy standards were phased in) as possible instruments. Because these variables are not significantly correlated with the probability of a debt crisis in our sample, they qualify as valid instruments.

Aside from the choice of instruments, controlling for the endogeneity of short-term debt presents other estimation problems. First, the share of short-term debt is bounded between zero and one, so the error terms are not normally distributed. This problem can be easily addressed by transforming the dependent variable using the monotonic logistic transformation $y=\ln(x/(1+x))$. A more serious difficulty is that the computation of the standard errors is not straightforward when the second-stage regression is nonlinear. To calculate the appropriate standard errors, we use the two-step methodology proposed by Murphy and Topel (1985) as described in Greene (1997). The results from the instrumental variables estimation are reported in Table 4. The adjusted R-squared in the first stage.

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[18] See Jeanne (2000), Rodrik and Velasco (1999), Chang and Velasco (2000), and Diamond and Rajan (2000).

[19] Diamond and Rajan (2000) argue that external capital flows to emerging markets must be intermediated by the local banking sector, and that banks liabilities must be of short maturity to provide appropriate incentives. In this context, it is reasonable to suppose that countries with a larger banking sector should have more short-term external debt.

Table 4. Instrumental Variable Estimation

	Coef.	t	P>|t|	Coef.	z	P>|z|
	Dep. Variable: Short Term Share			Dep. Variable: Crisis		
Liquidity Variables:						
Predicted Short-Term Debt				0.342	0.518	0.604
GDP per Capita	0.000	2.128	0.034			
M2/GDP	1.375	2.088	0.037			
Dummy Variable	0.035	0.105	0.917			
Debt Service Due	-8.751	-4.535	0.000	2.847	1.834	0.067
Reserves	4.786	2.770	0.006	-5.963	-2.740	0.006
Debt and Debt Characteristics:						
Total Debt	2.657	5.560	0.000	1.180	3.898	0.000
Commercial Share	-6.761	-8.710	0.000	-0.208	-0.325	0.745
Concessional Share	-9.678	-13.774	0.000	-0.122	-0.174	0.862
Multilateral Share	0.627	0.661	0.509	1.581	2.232	0.026
Interest Rates	18.181	4.970	0.000	3.153	1.286	0.199
Macroeconomic Variables:						
Overvaluation	-0.343	-0.977	0.329	0.421	2.200	0.028
Openness	-2.873	-5.898	0.000	-0.602	-1.334	0.182
Constant	-0.348	-0.586	0.558	-2.227	-4.252	0.000
Chi2(3) (on instruments)	3.690		0.012			
R2	0.580			...		
Number of Observations	950			950	(54 crises)	

Notes: z and P>|z| are the test of the underlying coefficient being 0 (standard errors adjusted for clustering on country).

regression is 57.5 percent. Also, the three instruments are jointly significant, and GDP per capita and M2-to-GDP are also individually significant. In the second stage, while little changes for the other variables, the share of short-term debt now loses its significance, suggesting that the effect of this variable on the crisis probability may be driven by endogeneity.

IV. Liquidity in a Model of Sovereign Debt with Potential Repudiation

In this section, we develop a standard model of sovereign debt to verify whether less liquidity leads to a higher probability of default even in the absence of self-fulfilling creditor runs.[20]

In the model, the borrower is a benevolent government that maximizes the welfare of the representative consumer. There are two periods, t = 1, 2. Output at t, denoted by y_t, is the realization of the random variable Y_t: $[\underline{y}, Y] \rightarrow [0, 1]$. The cumulative distribution function of Y_t is $F(y_t)$ and the density is $f(y_t)$. L_2 is the amount of new funds that the country borrows from foreign creditors at date 1 and i_2 is the corresponding interest rate. Since there are only two periods, the funds are due at t=2. The country also has preexisting debt obligations maturing at t=1 and at t=2, with face value D_t and interest rate r_t. At each date the country has the option to default on its foreign debt. If debt is repudiated, the country is unable to borrow new funds and creditors can seize assets worth $s_t = s(y_t)$ in all future periods, where $s'(y_t) > 0$ and $0 < s(y_t) < y_t$ for all y_t. Alternatively, $s(y_t)$ can be interpreted as the amount that creditors manage to extract through the threat of sanctions if the sovereign intends to repudiate. Plausibly, if the sovereign is in a more favorable economic position (y_t is high), creditors extract a larger repayment.

Letting c_t denote consumption at t, the preferences of the representative consumer at t=1 are described by the following utility function

$$U(c_1, c_2) = u(c_1) + \delta E c_2,$$

where $\delta \in (0, 1)$ is the intertemporal discount factor, $u(c_t)$ is a concave utility index, and E is the expectation operator. The assumption that utility is linear in second period consumption is to simplify the algebra. To derive the equilibrium, consider first the default decision in the last period. Since no new borrowing can take place at this date, if the country defaults it consumes $c_2 = y_2 - s(y_2)$, while if it repays in full it consumes $c_2 = y_2 - (1+r_2)D_2 - (1+i_2)L_2$.

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[20] For a survey of the theoretical literature on sovereign debt, see Eaton and Fernández (1995).

Hence, if the cost of sanctions exceeds debt service due the country prefers full repayment and vice versa. Let y* be the level of output for which the debtor is indifferent between defaulting and repaying at t=2. Then $s(y^*) = (1+r_2)D_2 + (1+i_2)\,L_2$. Since the function $s(\cdot)$ is monotonically increasing, the sovereign prefers to default for all $y_t < y^*$ and to repay otherwise. Then, the maximum utility that the sovereign expects to receive at t=2 is

$$\int_{\underline{y}}^{y^*} [y_2 - s(y_2)] f(y_2) dy_2 + \int_{y^*}^{Y} [y_2 - (1+r_2)D_2 - (1+i_2)L_2] f(y_2) dy_2.$$

Next, consider the expected zero-profit condition of a creditor making a new loan at t=1. To keep the algebra simple, it is assumed that new creditors have a junior claim on the default proceeds, so that they receive nothing unless old creditors are fully satisfied. Let β be the discount factor of creditors, and define y** as the realization of second period output such that $s(y_2) = (1+r_2)D_2$. Since the function s is increasing, y** is smaller than y*. The break-even condition for a prospective lender lending L_2 at interest rate i_2 is

$$\beta[1 - F(y^*)] + \beta \int_{y^{**}}^{y^*} [s(y_2) - D_2(1+r_2)] f(y_2) dy_2 - L_2 = 0, \qquad (1)$$

and the maximum utility that the sovereign can obtain if it repays t = 1 is the solution to

$$\max_{L_2, i_2} u(y_1 - (1+r_1)D_1 + L_2) + \delta \int_{\underline{y}}^{y^*} [y_2 - s(y_2)] f(y_2) dy_2 +$$
$$\delta \int_{y^*}^{Y} [y_2 - (1+r_2)D_2 - (1+i_2)L_2] f(y_2) dy_2$$
$$s.to \quad (1), \quad L_2 \le \bar{L}.$$

where $\bar{L}$ is a ceiling on new borrowing. Because the maximum that a new creditor can expect to obtain as repayment is the present discounted value of the cost of sanctions net of the value of senior debt, the ceiling is $\bar{L} = \beta[E\, s(y_2) - (1+r_2)D_2]$. Solving the expected zero profit condition of the creditor with respect to $[1-F(y^*)]\,(1+i_2)L_2$ and substituting in the objective function, the maximum utility that the sovereign can obtain if it repays at t=1 is:

$$V^r(D_1, D_2, r_1, r_2, y_1) \equiv \max_{L_2 \le \bar{L}} u(y_1 - (1+r_1)D_1 + L_2) + \delta E y_2 - \left(\frac{\delta}{\beta}\right) L_2 -$$
$$\delta \int_{\underline{y}}^{y^{**}} s(y_2) f(y_2) dy + \delta[1 - F(y^{**})](1+r_2)D_2. \qquad (2)$$

To make the theoretical model closer to our empirical one, define total debt outstanding at the beginning of the first period as $D=D_1+D_2$ and debt repayment due in the first period as $B_1 = (1+r_1)\,D_1$. Then, B_1/D corresponds to the ratio of debt service due to total debt in the empirical specification.

Definition: *The sovereign is more liquidity the smaller is B_1/D for any given level of D.*

Given the above definitions of D and B_1, second period debt can be rewritten as $D_2 = D-(B_1/(1+r_1))$, and the maximum utility from repaying is

$$V^r(B_1, D, r_1, r_2, y_1) \equiv \max_{L_2 \leq \bar{L}} u(y_1 - B_1 + L_2) + \delta E y_2 - \left(\frac{\delta}{\beta}\right) L_2 -$$

$$\delta \int_{\underline{y}}^{y^{**}} s(y_2) f(y_2) dy - \delta[1 - F(y^{**})](1 + r_2)\left(D - \frac{B_1}{1 + r_1}\right).$$

Notice for future reference that the first order condition for a maximum yields

$$u'(y_1 - B_1 + L_2) \geq \frac{\delta}{\beta}. \tag{3}$$

The inequality is strict only if the credit ceiling is binding. The maximum utility from defaulting at t=1 is:

$$V^d(y_1) \equiv u(y_1 - s(y_1)) + \delta E(y_2 - s(y_2)).$$

Let $\hat{Y}$ denote the set of values of first period output for which

$$V^r(B_1, D, r_1, r_2, y_1) = V^d(y_1), \tag{4}$$

i.e. the debtor is indifferent between repaying and defaulting. The next Lemma shows that the set $\hat{Y}$ has at most one element, so that the default state in the first period is unique, and, furthermore, that the sovereign defaults for all $y_1 < \hat{y}$ and repays otherwise, so that the probability of default is $F(\hat{y})$.

Lemma 1. *If there exists a value of first period output $\hat{y}$ such that the sovereign is indifferent between repayment and default, then this value is unique, and the probability of default is $F(\hat{y})$.*

Proof. See Appendix II.

With Lemma 1 in hand, it is straightforward to prove the following:

Proposition 1. *The probability of a debt crisis at t=1 increases when liquidity declines if and only if*

$$(1 + r_1) > \beta[1 - F(y^{**})](1 + r_2). \tag{5}$$

Proof. See Appendix II.

The right-hand side of this inequality captures how a marginal increase in the stock of debt due at t=2 changes the expected present discounted value of repayment: if the debt is prepaid with certainty ($F(y^{**}) = 0$), this value is just the present value of the interest factor. On the other hand, if future repayment is uncertain, the expected burden of increasing future debt is smaller, and unless the debt maturing at t=2 happens to carry a much higher coupon rate than the debt maturing at t=1, the inequality is likely to hold. The intuition is the following: when debt maturity is lengthened, the debtor has a lower burden of overall debt because she can earn the risk-free rate on the payment saved today. This is the effect captured by the discount factor β in inequality (5). Furthermore, future debt may not be serviced at all if output turns out to be low; so the expected cost of servicing the extra dollar of future debt is less than the face value of the obligation. This effect is captured by the term $[1-F(y^{**})]$. If the burden of repaying the debt is less, then default is less likely.

In models of self-fulfilling creditor runs, keeping short-term debt small and avoiding bunching of maturities can eliminate the bad equilibrium and lead to a Pareto-improvement. In the model presented here, on the other hand, lengthening the maturity profile of preexisting debt does not yield any special benefits because it is equivalent to borrowing short-term.

Proposition 2. *Lengthening the maturity of preexisting debt is not Pareto-improving at t=0.*
Proof. See Appendix II.

The intuition for this result is the following: in the absence of creditor runs or other frictions, lengthening debt maturity serves only to move consumption from repayment states in period two to period one. But the debtor can achieve the same result by taking on a short-term loan at t=1. So altering the maturity of preexisting debt, unless it is done at terms that make creditors worse off, is not welfare-improving for the debtor. To sum up, in this section it has been shown that looking at the empirical correlation between liquidity variables and the occurrence of debt crises is not a valid empirical test of theories of debt crises based on self-fulfilling creditors runs, as such a correlation is also implied by models of optimal default in which runs do not occur by assumption. Furthermore, the policy conclusion that liquidity ought to be pursued through active debt management does not go through in theoretical models without creditors runs.

V. CONCLUSIONS

In this paper, we analyze the relationship between debt crises and external liquidity, and discuss the interpretation of the empirical regularities using a theoretical model. In contrast with existing empirical studies, but more in line with the theoretical basis of these studies, we consider external debt crises, identified by the occurrence of a default, a rescheduling, or a debt reduction agreement. Using a sample of 69 countries over 1970-98 containing 950 observations and 55 crisis episodes, we investigate how the probability of a crisis depends on external liquidity after controlling for the structure of the external debt and for macroeconomics variables. Each of the three liquidity variables considered (share of short-term debt, debt coming due, and foreign exchange reserves) tends to be positively correlated with debt crises. However, the share of short-term debt is generally less robust than the other variables, and it is no longer significant once its likely endogeneity is controlled for using instrumental variables. Finally, macroeconomics variables not related to external debt are generally weakly significant, and the coefficients are sensitive to the specification and to the estimation technique. Thus, our results indicate that monitoring all three components of external liquidity can be useful to predict external debt crises, and that current efforts to improve data collection and monitoring in this area are indeed justified.

The empirical finding that liquidity matters in explaining financial crises has been interpreted by the current literature as evidence in favor of multiple equilibria models, in which a low level of external liquidity creates the conditions for suboptimal creditor runs. These models have the policy implication that discouraging short-term capital inflows and avoiding bunching of maturities help preventing crises. In this paper we have shown that a negative correlation between liquidity and crises is also implied by a standard model of optimal borrowing even without creditor runs. In this theoretical model, altering the maturity structure of the debt only affects the allocation of consumption over time, and does not lead to any Pareto-improvement.

Future research is needed to investigate further the causal relationship between the share of short-term debt (and, more generally, the maturity profile of external debt) and the probability of a debt crisis. If countries more at risk of default become unable to borrow at long maturities at reasonable interest rates, than causality may go from economic weakness to illiquidity, and not the other way around. In this case, controls on short-term capital inflows would hamper the ability of a country hit by an adverse shock to access external funds, potentially accelerating an external payments crisis. Our results suggest that there is merit to this conjecture, as short-term debt is no longer correlated with the probability of crisis once endogeneity is controlled for through instrumental variable estimation. However, questions about the suitability of the instruments in the absence of a well-developed theory and the poor quality of data on short-term obligations suggest that further work in this area would be useful.

Data Appendix

Table 5. Episodes of Debt Crisis by Year and Country

Year	Country	Year	Country	Year	Country
1991	Algeria	1984	El Salvador	1984	Niger
1983	Argentina	1995	El Salvador	1972	Nigeria
1978	Bangladesh	1987	Ethiopia	1986	Nigeria
1991	Bangladesh	1985	Guatemala	1987	Panama
1983	Brazil	1983	Haiti	1984	Paraguay
1982	Burkina Faso	1976	Honduras	1983	Peru
1986	Burundi	1982	Honduras	1984	Philippines
1979	Cameroon	1998	Indonesia	1984	Senegal
1985	Cameroon	1989	Jordan	1989	Senegal
1973	Chile	1990	Kenya	1972	Sierra Leone
1983	Chile	1998	Korea	1992	Sri Lanka
1985	Colombia	1990	Lesotho	1976	Sudan
1981	Costa Rica	1980	Madagascar	1998	Thailand
1987	Cote D'Ivoire	1982	Malawi	1988	Trinidad & Tobago
1976	Dominican Rep.	1987	Malawi	1991	Tunisia
1982	Dominican Rep.	1982	Mexico	1984	Venezuela
1983	Ecuador	1985	Morocco	1975	Zaire
1986	Egypt	1978	Nicaragua	1978	Zambia

Table 6. Summary Statistics of Sample Variables

Variable	Number of Observations	Mean	Standard Deviation	Min.	Max.
Debt Crisis	950	0.057	0.232	0.000	1.000
Short term debt	950	0.150	0.113	0.000	0.798
Debt coming due	950	0.070	0.061	0.000	0.469
Reserves	950	0.078	0.075	0.000	0.646
Total Debt	950	0.410	0.229	0.012	1.498
Commercial share	950	0.245	0.181	0.000	0.839
Concessional share	950	0.273	0.242	0.000	0.952
Multilateral share	950	0.180	0.140	0.000	0.848
Interest rates	950	0.075	0.031	0.022	0.164
Overvaluation	950	-0.037	0.321	-1.873	2.424
Openness	950	0.481	0.267	0.071	1.898

Table 7. Correlation Matrix

	Debt Crisis	Short Term Debt	Debt Service Due	Reserves	Total Debt	Commercial Share	Concessional Share	Multilateral Share	Interest Rates	Overvaluation
Debt Crisis	1.000									
Short Term Debt	0.001	1.000								
Debt Service Due	0.0317	0.1020*	1.000							
Reserves	-0.1258*	0.0979*	0.019	1.000						
Total Debt	0.1264*	-0.1587*	-0.1170*	-0.0869*	1.000					
Commercial Share	-0.0233	0.1911*	0.3612*	0.0866*	-0.0267	1.000				
Concessional Share	0.024	-0.5477*	-0.4902*	-0.1223*	0.0543*	-0.6721*	1.000			
Multilateral Share	0.047	-0.4088*	-0.3858*	0.0154	0.0486	-0.4609*	0.5666*	1.000		
Interest Rates	0.0930*	0.028	0.04	-0.1224*	0.0618*	0.0819*	0.024	-0.0204	1.000	
Overvaluation	0.015	0.1881*	0.1730*	0.0179	-0.2684*	0.2013*	-0.2039*	-0.1950*	0.1801*	1.000
Openness	-0.0592*	0.003	0.1387*	0.5569*	0.1819*	0.0764*	-0.1799*	0.0736*	-0.0149	0.0385

Note: If a variable that is significant at 10 percent or more is indicated with an asterisk.

Mathematical Appendix

Proof of Lemma 1. Consider the two value functions V^r and V^d as functions of first period output. We will show first that V^r is monotonically increasing, and then that for any value of y_1 such that $V^r = V^d$ the function V^r is steeper than V^d, so that the two function can intersect at most once. The derivatives of V^r and V^d with respect to first period output are

$$\frac{\partial V^r}{\partial y_1} = u'(y_1 - (1+r_1)D_1 + L_2), \quad \frac{\partial V^d}{\partial y_1} = u'(y - s(y_1))[1 - s'(y_1)].$$

So V^r is monotonically increasing. A sufficient condition for the first expression to exceed the second at $y_1=\hat{y}$ is

$$u(\hat{y} - (1+r_1)D_1 + L_2) \leq u(\hat{y} - s(\hat{y}_1)), \tag{A1}$$

where L_2 is understood to be the optimal choice of first period borrowing. Since the two values functions are equal at $y=\hat{y}$, we can write

$$u(\hat{y} - s(\hat{y})) + \delta E y_2 - \delta \int_{\underline{y}}^{y^*} s(y_2) f(y_2) dy =$$

$$u(\hat{y} - (1+r_1)D_1 + L_2) + \delta E y_2 - \left(\frac{\delta}{\beta}\right) L_2 - \delta \int_{\underline{y}}^{y^{**}} s(y_2) f(y_2) dy - [1 - F(y^{**})](1+r_2)(D - D_1).$$

Notice that the maximum utility under full repayment cannot be less than utility from repaying at t=1, borrowing L_1, and then defaulting with probability one at t=2, hence

$$u(\hat{y} - s(\hat{y})) + \delta E y_2 - \delta \int_{\underline{y}}^{y^*} s(y_2) f(y_2) dy \geq u(\hat{y} - (1+r_1)D_1 + L_2) + \delta E y_2 - \delta \int_{\underline{y}}^{y^*} s(y_2) f(y_2) dy.$$

Thus, the sufficient condition (A1) is satisfied, and we have established that at any default state the value function under repayment is steeper than the value function under default. But since V^r is monotonic, the two functions cannot cross twice, and the default state is unique. Furthermore, it must be $V^d > V^r$ for all $y_1 \leq \hat{y}$, so the probability of default is $F(\hat{y})$.

Proof of Proposition 1. A decline in liquidity corresponds to an increase in B_1. So the effect of an increase in liquidity on the probability of default at t=1 is just $f(\hat{y})\,(d\hat{y}/dB_1)$. Implicitly differentiating (4),

$$\frac{\partial V^r}{\partial B_1} dB_1 + \frac{\partial V^r}{\partial \hat{y}} d\hat{y} = \frac{\partial V^d}{\partial \hat{y}} d\hat{y}$$

where the derivatives are computed at $y_1 = \hat{y}$. Hence

$$\frac{d\hat{y}}{dB_1} = -\frac{\left(\frac{\partial V^r}{\partial \hat{y}} - \frac{\partial V^d}{\partial \hat{y}}\right)}{\frac{\partial V^r}{\partial B_1}}.$$

From the results of Lemma 1, the numerator is positive, so the expression has the sign of

$$-\frac{\partial V^r}{\partial B_1} = u'(\hat{y} - B_1) - \delta[1 - F(y^{**})]\left(\frac{1+r_2}{1+r_1}\right).$$

Using the first order condition (3), and rearranging yields the result.

Proof of Proposition 2. If the realization of y_1 is such that the sovereign prefers to default at t=0, then the maturity of preexisting debt is irrelevant, of course. So we will look at the effect of a change in maturity on the value function in states in which there is repayment at t=1. The experiment will be to reduce first period debt by dD_1 and increase second period debt by $dD_2 = -kdD_1$, where k is a parameter that captures the rate at which short-term debt is exchanged for long-term debt. First, we will derive the minimum value of k for which the sovereign is better off, and then we will show that lenders are always worse off for all values of k above that threshold. The value function under repayment at t=0 is defined in (2). Differentiating that expression

$$dV^r(D_1, D_2, r_1, r_2, y_1) = dD_1\left[u'(y_1 - (1+r_1)D_1 + L_2)(1+r_1) - k\delta(1 - F(y^{**}))(1+r_2)\right]$$

Thus, the debtor's expected utility increases with an increase in maturity if and only if

$$k < \frac{u'(\cdot)(1+r_1)}{\delta[1 - F(y^{**})](1+r_2)} \equiv k^*.$$

The expected return to creditors holding preexisting debt at t=0 is

$$\Pi(D_1, D_2, r_1, r_2, y_1) = (1+r_1)D_1 + \beta \int_{y}^{y^{**}} s(y_2) f(y_2) dy_2 + \beta[1 - F(y^{**})](1+r_2)D_{21}$$

Hence, the effect of lengthening maturity on creditors' expected return is given by

$$d\Pi(D_1, D_2, r_1, r_2, y_1) = dD_1 \left[-(1+r_1) + k\beta(1 - F(y^{**}))(1+r_2) \right]$$

This expression is positive if and only if

$$k > \frac{(1+r_1)}{\beta[1 - F(y^{**})](1+r_2)} \equiv k^{**}.$$

At an interior optimum, $u'(\cdot)=\delta/\beta$, so $k^*=k^{**}$, and the result is proved. If the debtor is credit constrained at t=0, on the other hand, it must be because there is default with probability one at t=1; in that case, lengthening maturity would make creditors worse off, because shifting debt to the next period will not increase expected repayment. So lengthening maturity makes the debtor better off only at the expense of the creditors.

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