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EXTERNAL LIABILITIES AND CRISES

Luis A. V. Catão and
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Luis A. V. Catão, IMF and JVI
Gian Maria Milesi-Ferretti, IMF and CEPR

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Centre for Economic Policy Research
77 Bastwick Street, London EC1V 3PZ, UK
Tel: (44 20) 7183 8801, Fax: (44 20) 7183 8820
Email: cepr@cepr.org, Website: www.cepr.org

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ABSTRACT

External Liabilities and Crises*

We examine the determinants of external crises, focusing on the role of foreign liabilities and their composition. Using a variety of statistical tools and comprehensive data spanning 1970-2011, we find that the ratio of net foreign liabilities to GDP is a significant crisis predictor. This is primarily due to the net position in debt instruments--the effect of net equity liabilities is weaker and net FDI liabilities seem if anything an offset factor. We also find that: i) breaking down net external debt into its gross asset and liability counterparts does not add significant explanatory power to crisis prediction; ii) the current account is a powerful predictor; iii) foreign exchange reserves reduce the likelihood of crisis more than other foreign asset holdings; iv) a parsimonious probit containing those and a handful of other variables has good predictive performance in- and out-of-sample. The latter result stems largely from our focus on external crises sensu stricto.

JEL Classification: E44, F32, F34, G15 and H63
Keywords: currency crises, current account imbalances, foreign exchange reserves, international investment positions and sovereign deebt

Luis A. V. Catão
International Monetary Fund
700 19th Street NW
20431 Washington, DC
USA

Email: lcatao@imf.org

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Gian Maria Milesi-Ferretti
International Monetary Fund
700 19th Street NW
20431 Washington, DC
USA

Email: gmilesiferretti@imf.org

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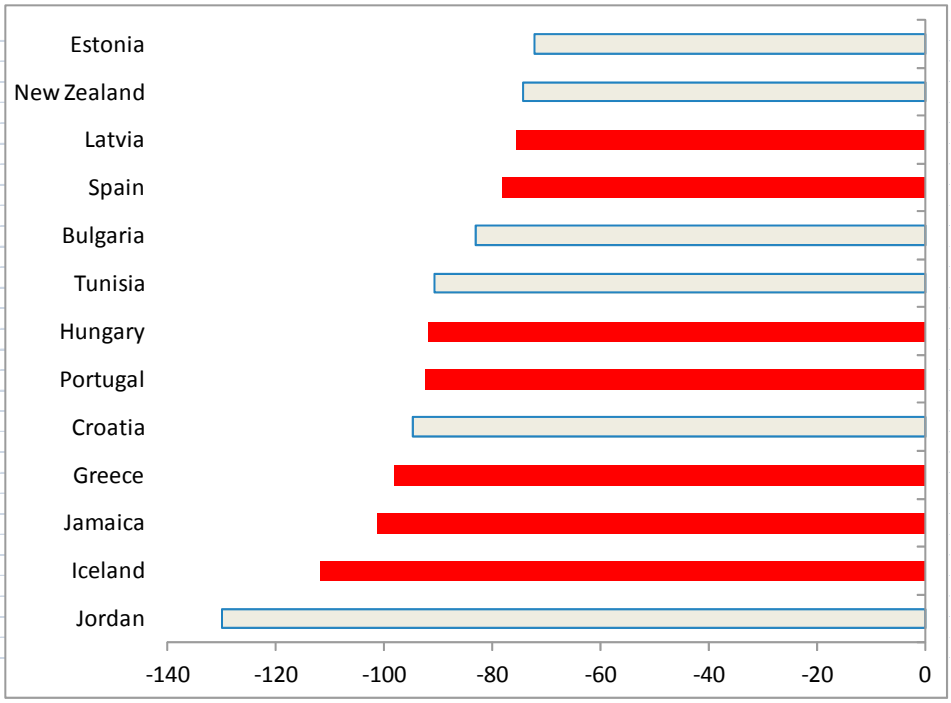
I. Introduction

Large current account imbalances over the past decade have given rise to sizeable cross-country differences in net foreign asset (NFA) positions, as documented by the extensive literature on global imbalances. While the global financial crisis was not associated with a "disorderly unwinding" of these imbalances, the potential role of high external liabilities in triggering crises was underscored by recent developments in the euro area: four countries at the epicenter of financial turmoil (Greece, Ireland, Portugal, and Spain) had NFA/GDP ratios between -70 percent (Ireland) and -90 percent (Portugal) at the onset of the crisis at end-2008. And a broader look at advanced and emerging economies with net foreign liabilities above 70 percent of GDP at the end of 2007 shows the high incidence of countries that have subsequently faced an external crisis (Figure 1, dark bars).

Figure 1. Net Foreign Assets of Selected Countries, 2007 (percent of GDP)



Source: Lane and Milesi-Ferretti, External Wealth of Nations Database

Against this background, we study whether the level and composition of NFA matter for crisis risk. Using an updated version of the Lane and Milesi-Ferretti (2007) dataset spanning the period 1970-2011 we break down NFA into net debt, net portfolio equity, and net foreign

direct investment (FDI), as well as between reserve and non-reserve assets, and examine the impact of each of these components on crisis risk. We also consider a similar breakdown of gross positions (see Shin, 2012). Distinguishing these components of a country's external balance allows us to test whether countries with high debt liabilities are more vulnerable to external crises than those with non-debt liabilities, particularly FDI, and whether gross vs. net positions is the more relevant metric.

We focus strictly on external crises, defined to include external defaults and rescheduling events as well as recourse to sizable multilateral financial support in the form of programs with the International Monetary Fund (IMF). The vast literature on prediction models of "crises" (early warning systems--EWS) has considered several definitions of crises, including currency crises (e.g. Frankel and Rose, 1996; Kaminsky and Reinhart, 1999; Berg and Pattillo, 1999); banking crises (e.g. Caprio and Klingebiel, 1996; Laeven and Valencia, 2012); sovereign crises (e.g. McFadden et al, 1985; Kraay and Nehru, 2006; Manasse and Roubini, 2009); and sudden stops/current account reversals (e.g. Milesi-Ferretti and Razin, 2000; Calvo et al., 2004). These crises are sometimes correlated, as shown, for example, in the twin crisis literature (e.g. Kaminsky and Reinhart, 1999), but this is not always the case—indeed, the proximate causes of each type of crisis may be different a priori. While our study focuses primarily on external crises as defined above, we also examine their correlation with currency and sovereign crises and the extent to which NFA and its composition help explain their occurrence.

We also seek to identify thresholds beyond which a further build-up of net external liabilities sharply raises the risk of external crises. We measure the significance of this threshold relative to absolute (cross-country) levels, as well as to country-specific levels, using a treatment effect model with country and time effects. In addition, and unlike previous studies, we use multivariate information to identify such thresholds in a probit. Establishing whether external liabilities beyond certain levels appear to be particularly risky is an important question for fiscal policy, financial stability, and macro-prudential supervision.

Finally, we investigate how an econometric model featuring these variables as well as a few other controls performs at predicting external crises, both in- and out-of-sample, focusing in particular on the predictive accuracy over the recent crisis. Critics of previous work on EWS pointed at their failure in predicting out of sample. We thus examine whether this criticism applies to a more focused definition of external crises—comprising debt defaults and major external lending from the IMF, along the lines of McFadden et al (1985), Kraay and Nehru (2006), and Manasse and Roubini (2009)—and to a model featuring disaggregated NFA components and other controls not featured in earlier studies.

The main findings are as follows. First, higher net foreign liabilities (NFL) increase the risk of external crises even after controlling for a wide range of other factors. In particular, crisis risk increases sharply as NFL exceed 50 percent of GDP and whenever the NFL/GDP ratio rises some 20 percentage points above the country-specific historical mean. Second, external crisis risk rises as the composition of NFL is tilted toward net debt liabilities. The effects of net portfolio equity liabilities are weaker, whereas higher FDI liabilities tend, if anything, to reduce crisis risk. Third, current account deficits have a higher predictive power than any other individual regressor in most specifications. This predictive power is higher for unconditional levels of the current account relative to deviations from a model-based "norm" using standard specifications of the latter. Fourth, higher foreign exchange reserves reduce external crisis risk by more than other asset holdings, in line with the results of Obstfeld et al. (2010) on the rationale for holding reserves as a precautionary/crisis prevention device. Finally, a multivariate but reasonably parsimonious probit model including all these controls has substantial predictive power, in and out of sample— particularly regarding the 2008-2011 crises. Importantly, we find that many other variables featured in the previous literature on explaining different types of crises do not add significant explanatory and predictive power.

These results speak to a large body of work on crisis early warning, current account and external debt sustainability, and sovereign risk. Main precursors of our empirical approach are the studies on early warning systems (EWS) which sought to identify macroeconomic indicators that help predict currency crises (Frankel and Rose, 1996; Eichengreen et al., 1996; Kaminsky et al., 1998; Kaminsky and Reinhart, 1999). These studies have singled out leading

indicators including the current account, foreign change reserves, and real exchange "gaps" alongside with a few domestic variables. Yet, disparate definitions of currency crises and sample selection criteria as well as weak predictive performance have also been widely recognized as Achilles heels of this literature (e.g., Berg and Pattillo, 1999; Abiad, 2003; Edison, 2003). Recent studies have examined whether those early warning indicators help predict countries' relative performance in the 2008-09 global financial crisis. Using a broad crisis definition encompassing large drops in real GDP growth, the stock market, the exchange rate, and in sovereign risk indicators, Rose and Spiegel (2009, 2011) are unable to identify variables that consistently explain the cross-country incidence and severity of the crisis. Obstfeld et al. (2009, 2010) find that the ratio of reserves to M2 (relative to their model's estimates of demand for reserves) is a useful predictor of currency depreciation; yet, the effect varies considerably across samples and the *unconditional* level of reserves/M2 does not fare as well. Using a crisis definition similar to Rose and Spiegel—but including resort to IMF financing and a slightly longer data sample—Frankel and Saravelos (2012) find that external debt, the current account, and credit growth have some predictive power, but the *unconditional* ratio of reserves to GDP or to external debt, as well as real exchange rate "gaps" are by far the most robust predictors. In contrast, Blanchard et al (2009) find that pre-crisis reserve accumulation is not a strong predictor of growth 'surprises' during the crisis.

Relative to these strands of literature, the main contributions of this paper are threefold. One is the use of level and composition of NFA, in addition to standard controls. The second is the use of data for both advanced and emerging markets for the period 1970-2011. *Inter alia,* this allows us to gauge whether previous results primarily reflect the influence of the external crisis events of the 1980s-1990s and probe the model's out-of-sample predictive performance over the post-2007 events. Finally, the paper focuses on external crises "sensu stricto". As shown below, the latter are positively but not tightly correlated with currency crises. A clear distinction between these types of crises, coupled with a wider set of controls and a longer time series, allow us to gauge the extent to which the poorer out of sample performance of earlier models was due to the choice of the dependent variable or of independent variables.

This paper is also related to a sizeable literature on external sustainability and the risk of sudden stops (Calvo, 1998; Milesi-Ferretti and Razin, 2000; Calvo et al., 2004; Edwards,

2004; Kraay and Nehru, 2006; Aguiar and Gopinath, 2006; Pistelli et. al., 2008; Gourinchas and Obstfeld, 2012; Jordá et al., 2011). A main distinction with Kraay and Nehru (2006), Pistelli et al. (2008), and Manasse and Roubini (2009) is that we include advanced economies alongside emerging markets. In relation to the work on external sustainability and sudden stops, we focus on major *external* credit events—a subset of sudden stops—and exclude events occurring in countries with no or limited market access, which can be noisier and more difficult to predict. Our analysis of external liability thresholds in crisis risk is closely related to the treatment effects model in Gourinchas and Obstfeld (2012). The main novelties of our contribution lie in our definition of crisis, a wider set of controls, and a rigorous and encompassing model selection criterion based on the Receiver Operating Characteristic—ROC—analysis.

Finally, our finding that NFL composition matters and that its effect on crisis risk is strongest for the debt component is consistent with standard sovereign debt models, which have long focused on the ratio of external *debt* liabilities to GDP as a key gauge of default risk (Eaton and Gersovitz, 1981; Sachs and Cohen, 1985; Wright, 2006; Arellano, 2008; Catão et al., 2009; Panizza et. al., 2009; Mendoza and Yue, 2012). We not only corroborate the robustness of this wisdom on the basis of a broader sample and wider set of controls, but also provide new evidence that *net* rather than gross external debt is the more relevant metric.

The paper is organized as follows. Section II presents our external crisis definition and data, and documents the overlap with currency crisis events. Section III discusses the dynamics of NFL and its components in the run-up to crises, identifies thresholds above which crisis risk increases rapidly, and uses treatment effect regressions to ask whether pre-crisis dynamics of key variables differ significantly from behavior in normal times. Section IV examines the joint predictive power using the ROC approach to pick the "best" combination of a set of variables, reports on extensive robustness tests, and probes into out of sample performance. Section V concludes.

II. Crisis Definition and Data

Our initial sample consists of 72 countries (of which 42 are emerging markets) spanning 1970-2011. We eliminate lower income countries, where borrowing is mainly official and/or on a concessional basis rather than market driven and also country/observations for which data on NFA or its breakdown into equity and debt are problematic.[2] Among advanced countries, this includes dropping Ireland since its debt/equity split is heavily distorted by its sizable mutual fund industry, whose liabilities are recorded as equity instruments but whose assets include both equity and debt. We also drop Iceland after 2000 because of the jump in NFL from around 110 percent in 2007 to some 700 percent of GDP at end-2008, which could leverage our results.[3] The final country list is shown in Appendix I.

Our definition of external crises encompasses defaults and rescheduling events (as per the definition of Beim and Calomiris, 2001 and Standard & Poor's, compiled in Borensztein and Panizza 2008, and updated by us) as well as events associated with large IMF support, defined as IMF loans at least twice as large as the respective country's quota in the IMF, when all net disbursements are computed from program's inception to end. This definition, in the spirit of McFadden et al. (1985) and Kraay and Nehru (2006), focuses on major external crisis events.

Another distinctive feature vis-à-vis previous work is that we treat these events as watershed-like occurrences, excluding from our sample episodes that are ramifications of the initial major crisis outbreak, all the way up to the year preceding market re-entry. As an illustration, take a country that defaulted in 1983 and had a non-trivial share of its debt stock in arrears up to market re-entry following the completion of the respective Brady deal in, say, 1992. In that case, our crisis indicator takes the value of 1 in 1983 and 0 in 1992, and we drop from the sample observations pertaining to the years 1984-91, so that any credit events associated with

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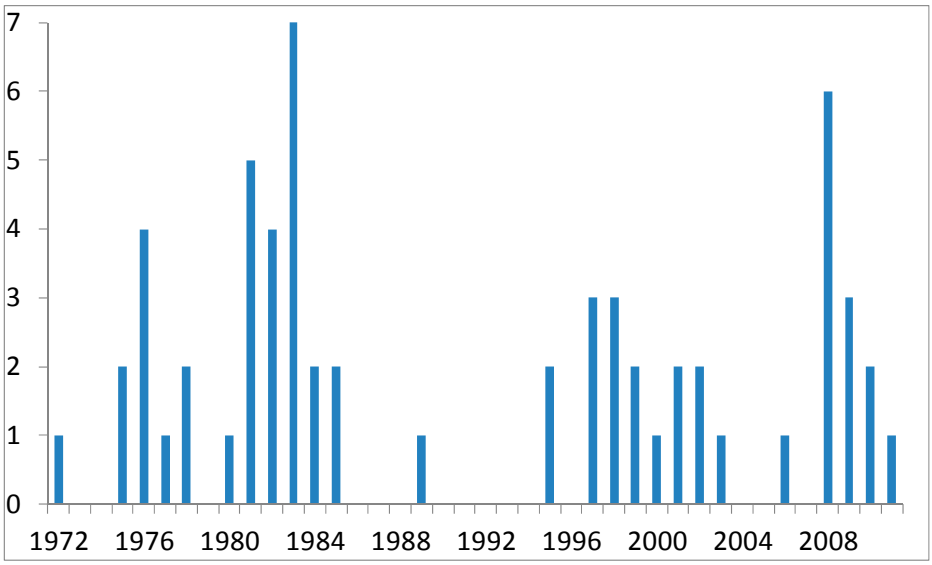
[2] There are two main advantages of excluding low income countries. The first is that the causal mechanisms in the theoretical literature on country borrowing require a reasonable degree of international capital market integration, so we can draw on that literature to derive testable implications and choice of covariates. The second is that we circumvent data limitations more prevalent in poorer countries.

[3] These countries experienced external crises in 2008 and 2010 respectively, so our sample would otherwise comprise 63 events. Both countries had large and increasing NFL before the crises.

partial repayments and partial defaults/reschedulings in the interim period (the so-called muddling-through) are not treated as separate crises. While this reduces the number of default observations relative to what is found in other studies, it is consistent with the conception of debt crises as major events of long-lasting consequences; and those are the events that are systemically important to predict. In addition, excluding observations between the initial default and market re-entry mitigates estimation biases from feedback effects of the crisis onto the explanatory variables, as discussed in Bussière and Fratzscher (2006), and makes crises more comparable by eliminating smaller credit events. We define market re-entry as either the year after S&P classifies the default to have ended or when the country's liabilities vis-à-vis the IMF decline for two consecutive years or fall below 200 percent of quota. This procedure for treating market exclusion spells is arguably more rigorous than those adopted elsewhere.[4] On this basis, our baseline sample has close to 2000 observations and 61 crisis events, implying an unconditional probability of crisis of 3 percent. Figure 2 plots the sample distribution of external crises, and a full list (broken down by default/rescheduling and large IMF lending) is provided in Appendix 1.

Figure 2. Distribution of External Crises (number of crises per year)



Note: External crisis: default/rescheduling event and/or IMF borrowing in excess of 200 percent of quota. Sample includes 71 countries for the period 1970-2011 for a total of 2042 observations.

[4] Gourinchas and Obtsfeld (2012) for instance, drop all observations within 4-years after default regardless of whether market re-entry may be longer or shorter. Yet, in several crises, notably those of the 1980s, full market re-entry took much longer than four years.

Since a previous literature on EWS has focused on currency crises rather than on external crises sensu stricto, it is instructive to document the overlap between the two crisis definitions. In light of the more limited time span of the databases used in Frankel and Rose (1996) and Kaminsky and Reinhart (1999) we report in Table 1 Spearman ranking correlations between our indicator of external crises and the indicator of currency crises of Laeven and Valencia (2012), whose sample is very similar to ours and whose definition of currency crises is similar to Frankel and Rose (1996). In addition to our definition of external crisis, we also include three measures of currency crises of our own: one in which the real effective exchange rate depreciates by no less than 15 percent in any given year or more than 20 percent over two consecutive years; another in which we add to the threshold for depreciation a requirement that real GDP growth is negative, and finally another wherein the REER depreciation combined with net IMF borrowing larger than 200 percent of quota and rising, in line with our external crisis definition.[5]

Table 1. Spearman Ranking Correlations between Distinct Crisis Indicators

(data averaged over a 3-year window)

	External Crisis	Own Currency Crisis	Own Currency & Growth Crisis	Own Currency & IMF program	Laeven-Valencia Currency Crises
External Crises	1.00				
Own Currency Crises	0.32	1.00			
Own Currency & Growth Crises	0.32	0.73	1.00		
Own Currency and IMF program	0.57	0.46	0.52	1.00	
Laeven-Valencia Currency Crises	0.33	0.40	0.47	0.42	1.00
	Number of observations: 2674				

Note: External crisis: default/rescheduling event or IMF borrowing in excess of 200 percent of quota. Own currency crisis: REER depreciation of 15 percent in a year or above 20 percent over two years. Own currency & growth crisis: same as own currency crisis plus negative real GDP growth. Own currency & IMF program: own currency crisis plus IMF borrowing above 200 percent of quota and rising. Laeven-Valencia currency crises: see Laeven and Valencia (2012).

While the correlation between external crises and currency crises is certainly positive and non-trivial, the two crises are far from being true twins, suggesting that a key difference

[5] Using 100 percent of quota rather than 200 percent is immaterial to the point.

between our results and previous EWS studies lies on the choice of the left hand side variable—a point we come back to below.[6]

III. Crisis Dynamics and Model-Free Threshold Estimates

We examine the pre- and post-crisis dynamics of a few variables that are most relevant for crisis risk (as corroborated in subsequent analysis in Section IV). As a first step, we performed a standard unconditional event analysis in which observations are averaged over each external crisis episode (often more than one crisis per country). We then computed such averages over an 11-year window centered on the crisis year (t=0) and spanning 5 years prior and after the crisis. The results, reported in Catão and Milesi-Ferretti (2013a, b), point to a deteriorating ratio of NFL to GDP in the run-up to crises: the ratio averages around 50 percent at the onset of crises, rising to closer to 70 percent for the post-2007 crises. The deterioration mostly reflects a worsening net external debt position (the difference between debt assets—debt securities, other investment, and foreign exchange reserves—and debt liabilities, comprising debt securities and other investment). Crisis countries start off with large current account deficits (around 4 percent of GDP), with later crises showing a larger current account before turning sharply around, and crises are preceded by a real exchange rate appreciation, followed by a depreciation of nearly 20 percent from peak to trough.

Here, we corroborate and sharpen this evidence by examining the statistical significance of such pre-crisis dynamics controlling for fixed country and time effects, as in Gourinchas and Obstfeld (2012). This enables us to gauge what levels of exposure appear riskier *relative to the country's own historical mean* net of time effects—consistent with the notion that external debt thresholds may well be country-specific (Reinhart et al., 2003). For a list of variables y we run

$$y_{it} = \alpha_i + \gamma_t + \sum_{s=-5}^{5} \beta_s D_{t+s} + \varepsilon_{it} \qquad (1)$$

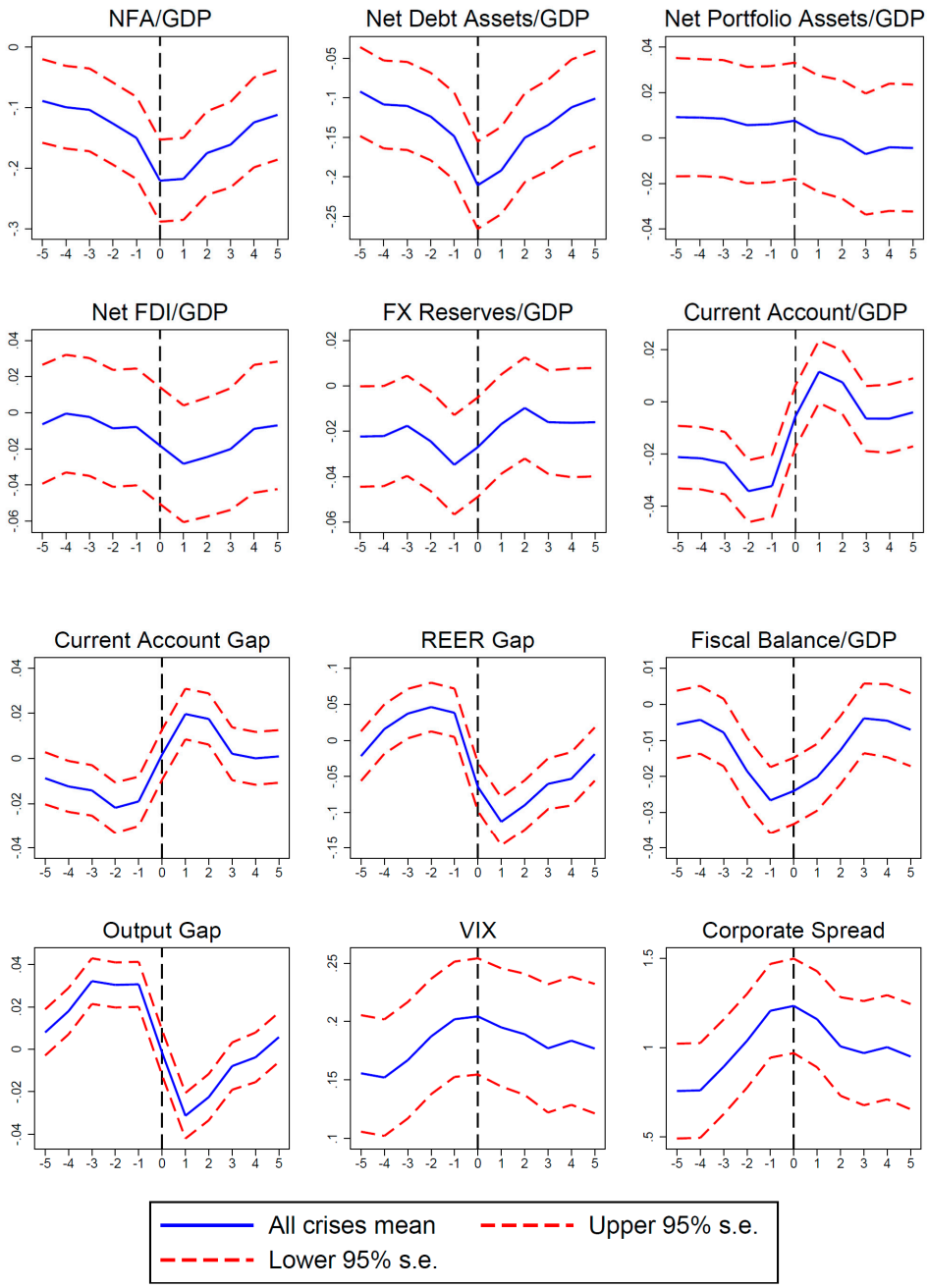
[6] In a similar vein, Bordo et al. (2001) document that the frequency of currency crises relative to those of debt and banking crises also oscillated considerably once one averages their relative incidences over longer historical epochs starting from the late 19th century.

where α_i and γ_t are fixed country and time effects, respectively, and the variables D_{t+s} are 11 dummy variables taking the value of 1 when a crisis occurs at time *t*. Hence the β_s coefficients measure how proximity to a crisis changes the behavior of variable y within an 11-year window centered on the year of the crisis. Because the first two terms on right of Eq. (1) capture country-specific and global (time) effects, the coefficients β_s gauge how much a rise/fall in the variable affect crisis risk, *relative to the country-specific as well as the global mean*. So, this metric provides a complementary gauge to those based on the absolute mean.

Figure 3 plots the estimates of β_s for each y, together with the respective 2 standard error bands. The first panel shows that external crises have been preceded by NFA/GDP ratios 15-20 percent below mean and declining, with these effects statistically significant at 5 percent. The subsequent three panels indicate that this effect is due to debt accumulation: crises are significantly associated with a reduction in net debt assets by 15-20 percent of GDP on average. Results for FX reserves and the current account are likewise strong: crises tend to occur in countries with reserves lower than the mean by around 2 percent of GDP and with current account deficits around 3 percent of GDP larger than the country specific/global mean and deteriorating. The remaining panels also show that REER appreciations and rising fiscal deficits—two classical crisis indicators of the literature—add significantly to crisis risk, including when measured relative to the respective country mean. Finally, the time clustering of crises highlighted in Fig. 2 suggests the importance of global factors. The last two panels focus on two indicators of global financial conditions: global stock market volatility (proxied by the VIX index) and the interest rate spread between AAA- and BAA- rated U.S. corporates. Neither indicator is featured in the previous literature on early warning crisis models, but they seem to be relevant as common triggering factors. Given the nature of the 2008-09 global financial crisis, it is not surprising the tightening of both financial condition indicators was particularly sharp for that sub-sample. Finally, crises are preceded by a deterioration in the cyclically-adjusted fiscal balance and an increase in GDP relative to potential.

Figure 3. Conditional Mean of Selected Variables Around Crises

(Treated by Fixed and Time Effects)



IV. CRISIS MODEL

A. Model Selection Criterion

We now examine how NFL and their composition affect crisis probabilities in the context of a parsimonious multivariate probit model, and ask how such a model would predict the 2008-2011 crises when estimated on data up to 2006. We use the so-called ROC curve as a model selection tool. This curve plots the fraction of true positives (crisis=1) that a given model signals (out of all positives in the sample) vs. the fraction of false positives (out of all negatives in the sample) along contiguous threshold settings. The best model according to this criterion is the one delivering the highest trade-off frontier between true and false alarms. Within that frontier, the analyst can choose—based on his/her utility—a threshold A in which a probit/logit estimated value p>A is interpreted as a crisis signal. Such a choice will be guided by the relative cost of failing to predict a crisis vs. that of a false alarm (credibility cost). But provided that such a choice is along the ROC curve, the trade-off cannot be improved upon. A clear advantage of this approach over model/variable selection criteria previously used in the EWS literature is that the analyst does not have to take a stand a priori on which region of the trade-off to pick (e.g. minimizing noise to signal ratios or missed calls). Instead, each model deliver a distinct ROC curve and the overall "best" is the one featuring the highest area under the curve (AUROC). Relative to standard measures of goodness of fit with binary data, such as the pseudo R^2, the AUROC suitably up-weighs them to allow for crises being infrequent.[7] The ROC curve methodology (see Fawcett, 2006 for a general exposition) was recently applied to historical data on domestic bank credit in 14 advanced countries by Schularick and Taylor (2012) and Jordá et al. (2011), whereas Satchell and Wei (2006) present an earlier application to credit rating models. We are not aware of its use in external crisis models.

[7] In technical parlance, the AUROC is robust to "class skew". This stems from using the ratio of true positives (TPs) to false positives (FPs) as metric, rather than, say, a standard accuracy measure which is the ratio of true positives plus true negatives to the total observations When crises become rarer but the model continues to predict the same ratio of TPs and the same ratio FPs ratio, then the accuracy metric changes; yet, the ROC metric does not. For an illustration and further discussion, see Fawcett (2006) and references therein.

B. Estimates

We construct ROC curves for a probit where crisis=1 the year of the external crisis outbreak and crisis=0 during normal times (a logit specification yields similar results). As discussed in Section II, we drop from the sample the post-crisis years up to when the country regains market access. All explanatory variables are lagged one year to mitigate endogeneity biases and also because we are interested in predicting crises at least one year ahead. We first look at the ROC curve for the bivariate relationship between crisis probability and (lagged) NFA/GDP. Clearly, even this bivariate probit does much better than random guessing crisis risk, as the area under the ROC curve (AUROC) is 0.73 (Table 1). This is actually marginally higher predictive power than that obtained by Schularick and Taylor (2012, Figure 6) on domestic credit crises using a fuller specification and a homogenous country sample of a few advanced economies.

Table 2 shows how disaggregating NFA into debt and equity improves model performance--the AUROC rises to 0.75, and the χ^2 statistics show how significant statistically these are relative to the 45 degree line (AUROC=0.5). The biggest marginal jumps in the ROC curve are due to the inclusion of the lagged current account and per capita income relative to the US to account for the distinction between advanced and emerging countries. The final model without fixed country effects yields an AUROC of 0.91. The parametric ROC curves for the pooled probit specifications (1), (2) and (8) of Table 2 are plotted in the left panel of Figure 4 below.

Table 2. AUROC Estimates for Various Model Specifications

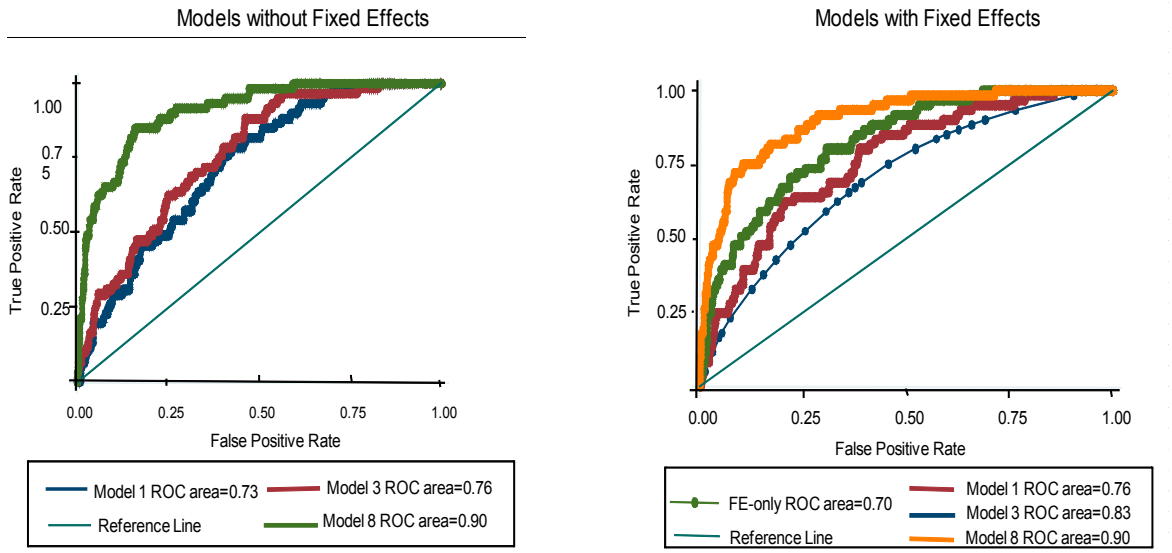
I. Without Full Fixed Effects:	***AUROC***	***Std. Error***	$\chi^{2\ 1/}$	$P>\chi2^{\ 1/}$	***obs***
1) NFA only:	0.73	0.03	64.59	0.00	1832
2) Net Debt, Net Portfolio, FDI:	0.75	0.03	76.01	0.00	1832
3) Adding Reserves:	0.76	0.03	90.04	0.00	1832
4) Adding Per capita Income vs US:	0.82	0.03	117.98	0.00	1832
5) Adding Current Account/GDP:	0.87	0.02	293.52	0.00	1832
6) Adding REER gap:	0.89	0.02	349.06	0.00	1832
7) Adding VIX	0.90	0.02	419.02	0.00	1832
8) Adding Fiscal Balance Gap:	0.91	0.02	429.90	0.00	1832
II. With Full Fixed Effects:	***AUROC***	***Std. Error***	$\chi^{2\ 2/}$	$P>\chi2^{\ 2/}$	***obs***
1) NFA only:	0.76	0.03	6.71	0.01	882
2) Net Debt, Net Portfolio, FDI:	0.81	0.03	11.76	0.00	882
3) Adding Reserves:	0.83	0.02	14.51	0.00	882
4) Adding Per capita Income vs US:	0.88	0.02	24.81	0.00	882
5) Adding Current Account/GDP:	0.88	0.02	24.59	0.00	882
6) Adding REER gap:	0.88	0.02	25.57	0.00	882
7) Adding VIX	0.89	0.02	30.44	0.00	882
8) Adding Fiscal Balance Gap:	0.90	0.02	33.75	0.00	882

1/ $\chi2$ statistics relative to the baseline model (AUROC=0.50)
2/ $\chi2$ statistics relative to the reference model with country fixed effects (AUROC=0.70)

The lower panel of Table 2 also considers a model with country fixed effects. In this case, the extra predictive power of adding NFA and main components should no longer be benchmarked to an AUROC of 0.5 but rather of 0.7. A main short-fall with the fixed effects model is the loss of observations for countries that never experienced a crisis (the fixed effect dummy becomes a perfect predictor). That aside, the addition of NFA and then of its components add significant predictive power in sample. A main difference compared to the pooled model is that now adding the current account does not significantly improve fit. One reason is that most countries that defaulted at least once ran current account deficits for much

of the period—and our sampling procedure excludes the aftermath of defaults (when the current account usually turns positive) until full market re-entry. Once again, the final model with fixed effects yields a high AUROC of 0.9. The ROC curves for these fixed effect specifications are plotted in the right panel of Figure 4. [8]

Figure 4. ROC Curves for Various Model Specifications



We now turn to the estimated probit coefficients, focusing on a pooled probit.[9] Table 3 reports results for the various specifications. As in previous studies, variables enter lagged one year and robust standard errors are computed clustered at a country level.[10] Consistent with the above AUROC estimates, net debt, the current account, and per capita income are key drivers of crisis risk. The strong significance of the current account is consistent with studies that

[8] The plotted ROC curve is derived from the parametric approximation coded in STATA through the "rocreg" and "rocregplot" commands.

[9] We do so for a number of reasons. One is to avoid non-crisis countries being dropped and retain emphasis on explaining cross-section variation. This is widely acknowledged in applications where the within-group variation is small relative to the between-group variation, in which case the standard errors of the fixed effects coefficients tend to be unduly high. Further, the fixed effect logit is not amenable to the computation of marginal effects. Finally, the estimated fixed effect suffers from the incidental parameter problem associated with using sample estimates to compute the fixed effects: since in non-linear models estimation of the model parameters cannot be readily separated from the estimation of country effects, estimation errors in the latter contaminate all other parameters. Wooldridge (2010, ch. 15, section 7) provides a further rationale for reliance on pooled probit by showing that neglecting unobserved heterogeneity can still produce consistent estimates, provided that the omitted heterogeneity is normally distributed and independent of the included regressors.

[10] Because portfolio equity liabilities for Jordan before 2000 are not reported (and amount to over 20 percent of GDP in 2000), observations for Jordan for pre-2000 years have been dummied out.

have found it to be a significant predictor of external crises (Milesi-Ferretti and Razin, 2000; Pistelli et al., 2008). Including per capita income in turn has the important effect of making FX reserves more significant as well as making the FDI coefficient less negative. This is not surprising, since richer countries typically have a much higher average share of FDI in GDP so per capita income controls for this quasi-fixed effect. Column (6) shows that the coefficient on FDI becomes positive and significant once the current account is included in the regression—conditional on other controls, higher net FDI liabilities tend to be associated with *lower* crisis risk. This is consistent with previous evidence that higher FDI liabilities are associated with improved economic prospects (Borensztein et al., 1998), help relax financing constraints, and are a safer form of external financing.

Table 3. Baseline Crisis Definition: Probit Estimates
(Estimation period: 1970-2011; robust country-clustered SEs in parenthesis)

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Net Foreign Assets/GDP	-0.99***						
	(0.16)						
Net external debt assets /GDP		-1.75***	-1.58***	-1.66***	-0.99**	-1.40***	-1.22**
		(0.26)	(0.31)	(0.32)	(0.44)	(0.46)	(0.50)
Net ext. portfolio equity /GDP		-0.16	-0.27	-0.09	0.31	0.43	0.53
		(0.42)	(0.43)	(0.48)	(0.99)	(1.05)	(1.21)
Net FDI/GDP		-0.30	-0.57	-0.05	0.68*	0.87**	1.19***
		(0.29)	(0.38)	(0.39)	(0.36)	(0.37)	(0.41)
FX reserves/GDP			-2.20*	-2.83**	-3.23***	-3.70***	-3.98***
			(1.16)	(1.12)	(1.20)	(1.27)	(1.42)
Relative Per Capita Income				-1.50***	-1.60***	-1.91***	-2.29***
				(0.26)	(0.27)	(0.30)	(0.36)
CA balance/GDP (2-year MA)					-8.49***	-7.68***	-10.4***
					(1.95)	(1.90)	(2.44)
REER gap						2.11***	2.00***
						-0.44	(0.47)
VIX						0.73***	0.70***
						(0.23)	(0.25)
Fiscal Gap							-5.07**
							(2.51)
Observations	2042	2042	2042	2042	2042	2042	1832
Pseudo R^2	0.07	0.09	0.10	0.17	0.21	0.26	0.31

Note: Dependent variable is probability of external crisis (baseline definition). Probit coefficients, with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Also consistent with priors, as well as with the evidence presented in Figure 3, all relative price and global variables are statistically significant. Finally, column (7) indicates that the

fiscal gap (the general government balance in a given year relative to its five-year moving average) further contributes to crisis risk. Adding this variable reduces somewhat the coefficients on net external debt and current account, but both remain highly significant economically and statistically.

Table 4 reports the marginal effects of our final specification (col. 7 of Table 3). Because crises are rare, elasticities computed at the sample mean are low, but the non-linearity of the probit implies that these elasticities can be large when computed in proximity to crises, where NFA and net debt are much lower than the panel average. The third and fourth columns compute elasticity measures in the year before a crisis, and when the crisis probability is above 10 percent. Both indicate that the elasticity of crisis risk to changes in the covariates can be high. For instance, a one standard deviation (SD) increase in net external debt to GDP (a 20 pp rise) raises the crisis probability by some 6 percent (20 percent times 0.28 or 0.32) and a one SD increase in the current account deficit by 10 around percent. The estimates also suggest a role for FX reserves as a crisis prevention device: leaving net debt unchanged, an increase in reserves of 7 percent of GDP—the sample SD and a magnitude observed in some emerging markets over the past decade—reduces crisis risk by around 7 percent.

Table 4. Elasticity Estimates for Preferred Specification

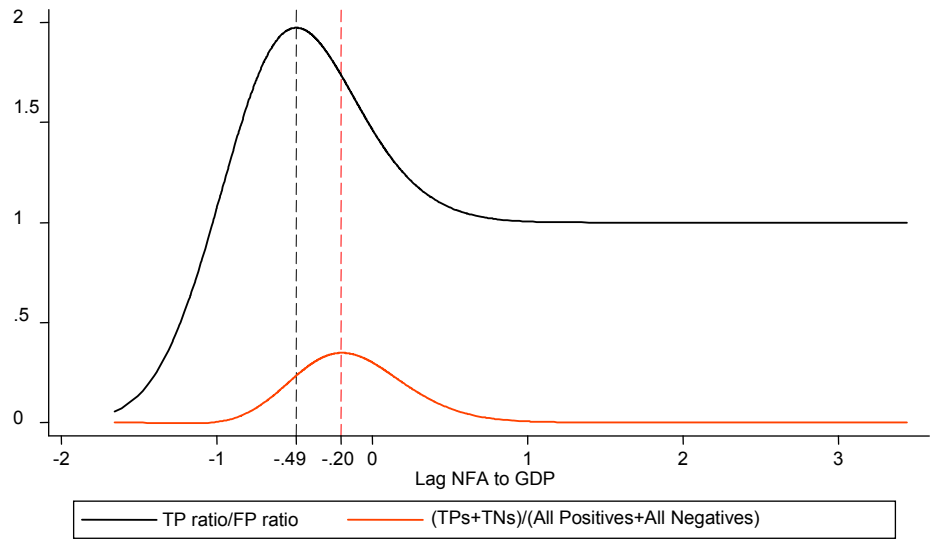
		dP/dx		
	SD[1/]	At mean	year prior to crisis	when P>0.1
Net external debt assets/GDP	0.20	-0.008	-0.28	-0.32
Net ext. portfolio equity/GDP	0.10	0.004	0.12	0.14
Net FDI/GDP	0.11	0.008	0.27	0.32
FX reserves/GDP	0.07	-0.027	-0.91	-1.05
CA balance/GDP (2-year MA)	0.04	-0.072	-2.37	-2.75
Relative Per Capita Income	0.06	-0.016	-0.52	-0.61
REER gap	0.12	0.014	0.46	0.53
VIX	0.29	0.005	0.16	0.18
Fiscal Gap	0.03	-0.035	-1.16	-1.34

1/ Computed from a pooled regression with fixed effects for each variable.

C. Model-Based Threshold Estimates

On the basis of the above model, we revisit the identification of crisis risk thresholds. To pin down the respective tipping points for the various model variables we need to combine the above model with the choice of point along the ROC curve. A criterion to select such a point widely used in the EWS literature following Kaminsky and Reinhart (1999), is that of maximizing the "signal to noise" ratio, defined as the ratio of true positives (TPs), i.e., the share of crises correctly classified, to the ratio of false positives (FPs), i.e., the share of observations incorrectly classified as "crises" (false alarms) out of all non-crisis observations. A counterpart in ROC space corresponds to the point of the ROC curve where the slope from origin is steepest. Using this criterion and a univariate probit of crisis on lagged NFA/GDP (col. 1 of Table 2), we obtain a tipping point for NFA/GDP of -49 percent. This is shown in Figure 5.

Figure 5. Univariate Model:
Thresholds for NFA/GDP Using Distinct Selection Criteria



TPs=true positives (observations correctly classified as crises or "good calls")

FPs=false positives (observations incorrectly classified as crises or "false alarms")

TP ratio=TPs/total number of crises; FP ratio=FPs/total number of non-crises

Yet, this is just one possible criterion for setting NFA/GDP risk thresholds. One can readily glean the respective trade-offs of this as well as other criteria by looking at Figures 4 and 5.

Moving along the ROC curve from its south-west (0,0) origin, the highly negative values of NFA (in excess of -100 percent of GDP) around that neighborhood are associated with a trivial likelihood of a false alarm; conversely for highly positive ones (in excess of 100 percent of GDP), which in our sample corresponds to financial centers like Hong Kong, Switzerland, and Singapore. The indifference point between the two errors is given by the point in the curve at 90 degrees of the non-discrimination (45 degree) line. At that point, one is maximizing a standard measure of "accuracy"– defined as number of true positive (TPs) plus true negatives (TNs), or equivalently minimizing the total rate of errors. As shown in Figure 5, at this point NFA is about -20 percent of GDP. The downside of choosing such a lower threshold is that a large share of false alarms (just under 50 percent) is generated. As NFA enters positive territory and approaches high positive values, any chosen threshold in that range of the ROC curve will entail no missed calls (as no crises in our sample have been associated with positive NFA) but would entail an even higher share of false alarms. Our aim here is not to take a stand on the best criterion (which will be critically dependent on assessing the relative cost of missing crisis vs. giving a false alarm) but to report the respective discrepancies and connections with previous work.

We can also compute the respective tipping points for each of the variables in our baseline probit specification (col. (7) in Table 2), now conditional on all the multivariate information included in the probit. For comparability with earlier work, we stick to the region where the signal to noise rate is maximized. Because the ROC curve in an actual multivariate distribution is far from being entirely smooth, in order to mitigate outliers we compute the region of maximal signal to noise over a symmetric seven-year window. The multivariate model delivers an estimate for the NFA/GDP threshold which is very similar to its pre-crisis average, around -50 percent. As for the main components of NFA, we obtain a tipping point for net external debt liabilities around 35 percent of GDP.[11]

[11] Reinhart and Rogoff (2010) report a 60% threshold for ***gross*** external debt. As we show below, our regression results indicate that net external debt is the significant indicator for crisis risk.

D. Robustness to Variable Omission

To test the robustness of our favored specification to potential variable omission, we add to the regression several variables featured in previous work on crisis risk (see Frankel and Saravelos, 2012 for a comprehensive list). All are lagged one year. The first column of Table 5 adds the deviation of the current account from a fundamentals-based "norm" (see Appendix 2). This gap variable, highly collinear with the (2-year moving average) current account, is dominated by the latter. This is consistent with the asymmetric effect that current account deviations from their "norm" have on crisis risk: countries with a positive current account balance may well have a negative current account gap, and yet be much less vulnerable than a country that has the same negative CA gap and a negative CA balance. Hence the actual current account balance is a more precise indicator of crisis risk.

Column (2) of Table 5 adds the ratio of general government debt to GDP. While the external component of the latter is contained in net external debt, this variable is a proximate control for the distinction between public and private external debt that has been documented as important in explaining global imbalances, growth differentials, and hence (albeit indirectly) country risk (Alfaro et al. 2011). Yet, the coefficient has the "wrong" sign and is highly imprecisely estimated.[12]

[12] The appropriate control for this regression is the net financial position of the government. However, data on government financial assets are unavailable on a systematic basis.

Table 5. Robustness to Other Controls

VARIABLES	(1)	(2)	(3)	(4)	(5)
Net external debt assets/GDP	-1.04	-1.31**	-1.20**		-1.21**
	(0.68)	(0.52)	(0.53)		(0.50)
Net ext. portfolio equity/GDP	1.18	0.29	0.46	0.48	0.45
	(1.19)	(1.20)	(1.21)	(1.24)	(1.27)
Net FDI/GDP	1.15**	1.22***	1.31***	1.07**	0.44
	(0.57)	(0.45)	(0.43)	(0.49)	(0.55)
FX reserves/GDP	-4.16**	-3.35**	-3.96***	-5.36***	-4.54***
	(1.64)	(1.43)	(1.37)	(1.34)	(1.45)
CA balance/GDP (2 year MA)	-11.1**	-9.52***	-11.0***	-10.3***	-10.6***
	(5.23)	(2.40)	(2.81)	(2.45)	(2.37)
Relative Per Capita Income	-2.45***	-2.31***	-2.36***	-2.25***	-2.29***
	(0.41)	(0.38)	(0.37)	(0.38)	(0.37)
REER gap	2.39***	2.06***	2.17***	1.99***	1.92***
	(0.49)	(0.45)	(0.51)	(0.47)	(0.48)
VIX	0.92***	0.79***	0.71***	0.70***	0.71***
	(0.32)	(0.26)	(0.26)	(0.25)	(0.24)
Fiscal Gap	-4.56	-5.85**	-4.12	-5.11**	-5.21**
	(3.21)	(2.61)	(2.51)	(2.49)	(2.53)
Current Account gap	0.13				
	(4.85)				
Overall Public Debt/GDP		-0.33			
		(0.27)			
Growth of Credit/GDP (3-year MA)			-1.18		
			(1.83)		
External Debt Assets/GDP				-1.31***	
				(0.49)	
External Debt Liabilities/GDP				1.24**	
				(0.50)	
Outlier FDI dummy					-0.92**
					(0.37)
Observations	1489	1780	1729	1832	1832
Pseudo R-squared	0.32	0.30	0.31	0.31	0.31

Dependent variable is probability of external crisis (baseline definition)
Probit coefficients, with robust std errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

This is due to collinearity with other controls. Indeed, once some other controls are dropped, the level of public debt becomes a significant determinant of crisis risk—as typically found to be the case in regressions on the determinants of sovereign spreads (e.g., Catão et al., 2009). Motivated by the results of Schularick and Taylor (2012), who find that credit growth is significant predictor of financial and growth crisis, column (3) adds the first difference of the credit to GDP ratio (a three-year moving average). The point estimate is insignificant and

wrongly signed. Again, collinearity plays a role: dropping all variables but relative per capita income, the credit variable becomes significant at a 10 percent level.

We also break down net positions into their gross counterparts. This breakdown is well motivated theoretically for the reasons discussed in Shin (2012)—who suggest that for advanced countries at least, gross debt exposures may matter as much or more than net exposures. More broadly and in a similar vein, Reinhart and Rogoff (2010) focus on gross rather than net external debt in their evidence on the connection between debt and output growth. In our full sample, gross and net external debt liabilities are only mildly correlated (a panel-wide correlation coefficient of 0.25). However, there is a significant difference between advanced and emerging countries—for the latter, the correlation coefficient is 0.51, and for the former 0.10. Given this factual backdrop, column (4) of Table 5 suggests that net debt is what matters the most for crisis risk: the coefficients on gross debt assets and liabilities are virtually the same and with the opposite sign. Importantly, all coefficients in the baseline specification that are statistically significant change little in magnitude with the addition of further controls (and despite some fluctuation in the number of observations due to data availability for some variables). One exception is the coefficient on FDI. This is shown in column (12) of Table 5 which adds a dummy for countries with FDI liabilities in excess of 2 standard deviations from the mean (55 percent of GDP). By and large, this dummy captures observations associated with small countries with financial centers such as Panama, Jordan, and Malta which have very high net FDI liabilities relative to sample mean. The FDI coefficient drops by more than one-half and is no longer statistically significant at conventional levels.

Several other robustness tests are reported in Catão and Milesi-Ferretti (2013a). Inflation, (HP) trend output growth, trade and financial openness, and institutional quality (polity index) are also statistically insignificant at the 10 percent level, although when entered alone (or when the baseline specification is pruned from other controls), they become significant and correctly signed. Likewise, adding the world output gap, the weighted average of real short-term interest rates of G-7 countries, historical growth volatility, and credit history (defined as

in Reinhart et al., 2003) does not improve on our baseline specification.[13] To sum up, barring some instability of the coefficients on net equity positions—and in particular the sensitivity of the FDI coefficient to a few observations for financial centers—the results indicate that our estimates are robust to a variety of controls, including to the breakdown between gross and net external positions.

E. Robustness to Crisis Definition and Sample Breakdown

We next examine whether the strength of our results would "carry through" to different samples and crises definitions. Table 6 sheds light on this question, reporting our baseline crisis definition and preferred specification in column (1), as well as probit estimates for four alternative crisis definitions. The first only encompasses sovereign defaults and reschedulings—the definition more widely found in the sovereign debt literature (Borensztein and Panizza, 2008; Reinhart and Rogoff, 2009). Its downside is to exclude external crises like Mexico and Argentina in 1994/95 and Thailand and Korea in 1997/98, which would likely have turned into defaults in the absence of multilateral assistance. Be that as it may, the thrust of our results remains unchanged. The coefficient on FDI is now smaller and less precisely estimated and the coefficient on GDP per capita is much smaller. On the other hand, the coefficients on debt, reserves, and the current account are larger, although some are less precisely estimated. This is unsurprising since we are focusing on debt defaults and entirely in emerging markets, where reserve drainage often plays a much greater role. Other probit coefficients are broadly consistent and the higher pseudo R^2 indicates, if anything, a better fit.

[13] In contrast with what Aizenman and Noy (2012) find for banking crises, a reason behind the insignificance of the credit history variable is the low correlation between banking crises and external crises sensu stricto (such correlation results being available from the authors upon request). Another reason is that the positive effect of crises on savings, documented by Aizenman and Noy, is already controlled for by the inclusion of the current account in our regressions. Also possibly proxying for potentially omitted individual country effects, we estimated a fixed effect logit as well as population averaged GEE estimator on a probit distribution (the xtgee command in Stata coupled with the vce(robust) option for robust SEs). The thrust of the inference remains the same, particularly regarding net debt liabilities and the current account. As a compromise to a full set of fixed effects which nearly halves the sample size, we have also added regional dummies for emerging Asia, Africa and Middle East, and Latin America, none of which were significant at 5%.

Column (3) compares our results with those of Gourinchas and Obstfeld (2012), using their definition of crisis and our controls. Their sample excludes advanced economies and includes as new defaults credit events that in our sample are part of an earlier broader default episode--particularly in Latin America during the 1980s. As a result, one ends up with more crisis events for emerging markets and a number of default observations comparable to ours. Column (3) reports probit results of their definition of crisis on our set of controls. Net debt, reserves and VIX retain significance, but the coefficients on the current account and per capita GDP become statistically insignificant and flip sign. The positive coefficient on the current account is explained by the inclusion of several additional default episodes in oil exporters (two in Venezuela and two in Nigeria) occurring with current account surpluses, as well as by the inclusion of "repeat defaults" which occur when a country may be running a current account surplus due to being cut out from international capital markets. The change in coefficient on GDP per capita instead reflects the exclusion of advanced economies—where GDP per capita is much higher and the incidence of crises much lower.

Table 6. Robustness to Crisis Definition and Estimation Period

	(1) baseline crisis definition	(2) defaults and resched. only	(3) POG-MO crisis definition	(4) Currency Crises (LV definition)	(5) Curr.Crises outside Debt Crises	(6) baseline crisis definition	(7) baseline exc. FDI liability outliers
VARIABLES	1970-2011	1970-2011	1970-2011	1970-2010	1970-2010	1970-2006	1970-2006
Net external debt assets/GDP	-1.22**	-2.10***	-1.27**	-0.13	-0.68*	-1.85***	-1.68***
	(0.50)	(0.38)	(0.53)	(0.24)	(0.37)	(0.61)	(0.58)
Net ext. portfolio equity/GDP	0.53	1.12	1.66	0.97	1.22	-0.43	-0.54
	(1.21)	(1.74)	(1.80)	(0.83)	(0.99)	(1.18)	(1.26)
Net FDI/GDP	1.19***	0.06	0.40	1.43***	1.55***	1.74***	1.15
	(0.41)	(0.49)	(0.37)	(0.43)	(0.47)	(0.51)	(0.80)
FX reserves/GDP	-3.98***	-4.59**	-9.94***	-4.58***	-3.79**	-6.11**	-7.47***
	(1.42)	(1.97)	(2.05)	(1.54)	(1.65)	(2.40)	(2.19)
CA balance/GDP (2 year MA)	-2.29***	-5.63*	4.05	-5.39***	-5.28***	-11.04***	-12.1***
	(0.36)	(2.94)	(2.77)	(1.55)	(2.05)	(3.34)	(3.32)
Relative Per Capita Income	-10.4***	-2.64***	0.49	-1.21***	-1.28***	-2.12***	-2.06***
	(2.44)	(0.53)	(0.45)	(0.29)	(0.30)	(0.36)	(0.37)
REER gap	2.00***	2.35***	0.91	1.44***	2.04***	2.30***	2.16***
	(0.47)	(0.69)	(0.88)	(0.39)	(0.51)	(0.44)	(0.44)
VIX	0.70***	0.52*	0.50*	0.40**	0.41*	1.22***	1.09***
	(0.25)	(0.26)	(0.27)	(0.20)	(0.23)	(0.36)	(0.35)
Fiscal Gap	-5.07**	-8.21***	-7.24***	-4.59**	-5.84***	-6.43**	-6.00*
	(2.51)	(2.70)	(2.15)	(2.13)	(2.63)	(3.04)	(3.14)
Observations	1832	1821	1051	2056	1762	1510	1473
Pseudo R^2	0.31	0.35	0.22	0.16	0.20	0.34	0.36
AUROC	0.90	0.89	0.85	0.82	0.84	0.92	0.92

Table reports probit coefficients, with robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Alternative definitions of crises: defaults and rescheduling episodes only (col. (2)); crisis definition of Gourinchas and Obstfeld (2012) (col. 3); currency crisis definition of Laeven and Valencia (2012) (col. 4); currency crisis definition of Laeven and Valencia (2012) excluding those occurring during debt crises (col. 5); baseline definition excluding from sample observations with extreme values for net FDI liabilities (over two SD higher than sample mean) (col. 7).

We also test how well our model fares in predicting currency crises, using the Laeven-Valencia definition, which not only spans the whole 1970-2010 period but also correlates well with the definition used in Frankel and Rose (1996). We also consider a sub-sample excluding currency crises occurring during debt crises, while countries have limited market access, including under large IMF programs as per our external crisis definitions. Column (4) shows that net external debt is no longer significant but other external variables are. Importantly, the fit is much worse than under our external crisis definition, indicating that currency crises (many of them non systemic events) are harder to predict than major external crises.

However, when we excludes currency crises occurring during debt crises (column 5), the fit improves and external debt once again becomes significant, albeit with a smaller coefficient.[14] Two other sensitivity tests are reported in Table 6. Column (6) shows that eliminating the 2008-11 crises from the sample does not alter the thrust of results: in particular, net debt continues to be a strong predictor of external crises, with a coefficient of similar magnitude. The coefficient on net portfolio equity now becomes negative but still statistically insignificant. Also, the statistical significance of net FDI is due to outlier emerging markets: moving from column (6) to (7), the size of the FDI coefficient drops and becomes insignificant--consistent with what shown in column (5) of Table 5.

To sum up, while distinct definitions of crises and sample breakdowns have non-trivial effects on point estimates for some explanatory variables, the estimated coefficients for net debt, reserves, fiscal deficits, and global financial conditions remain sizeable and statistically significant when we seek to explain external crises sensu stricto. Furthermore, regardless of the classification of default or the inclusion of large multilateral assistance, AUROC estimates (last row of Table 6) indicate good predictive performance for these alternative crisis definitions, once our set of explanatory variables is maintained. In contrast, currency crises appear harder to predict, suggesting that the choice of the dependent variable partly explains the limited predictive power of early warning models of currency crises.

E. Predictive Performance

Table 7 provides further diagnostics on the fit of the final specification for our baseline crisis definition (column (7) in Table 3). Following the literature, we classify as correct predictions those model estimates of crisis probability above a chosen cut-off level with a crisis occurring within a 2-year window. *Mutatis mutandis* for a definition of false alarm. As noted above, the 'optimal' chosen cut-off will depend on the relative cost of missing a crisis vs. giving a false

[14] We also considered a broader crisis definition combining our external crisis definition with that of currency crises (defined as encompassing real exchange rate depreciations exceeding at least 15% in one year and 20% over two successive years accompanied by an absolute drop in output or at last in the output gap exceeding one standard deviation). The results using this crisis definition (reported in Catao and Milesi-Ferretti, 2013a) are very similar as those of our baseline definition.

alarm. The Table reports on two alternative cut-offs: 11 percent (the cut-off that the ROC curve indicates to be the one maximizing the signal to noise ratio) and 20 percent. At the higher cut-off, the model correctly predicts 33 out of the 61 crises. This may seem mediocre predictive performance but the flip side is that false alarms are rather infrequent: the model correctly classifies 99 percent of all non-crisis observations and 97 percent of all observations. For the 11 percent cut-off, the model correctly predicts 42 out of 61 crises. The cost is of course a larger share of false alarms. Overall, the model gets it right 94% of the time.

Table 7. Baseline Probit Model: In-Sample Predictive Performance

At 20% cut-off

	No Crisis	Crisis	Total	
Predicted Tranquility	1747	28	1775	Share of good calls =54%
Predicted Crisis	24	33	57	Share of false alarms=1%
Total Obs.	1771	61	1832	Correctly Classified =97%

At Max Signal-to-Noise = 11% cut-off

	No Crisis	Crisis	Total	
Predicted Tranquility	1683	19	1702	Share of good calls =69%
Predicted Crisis	88	42	130	Share of false alarms=5%
Total Obs.	1771	61	1832	Correctly Classified =94%

Note: predicted tranquility and crisis observations on the basis of probit model (7) in Table 3.

This is better in-sample predictive power than in earlier studies on EWS using various probit specifications. For instance, Frankel and Rose's (1996) classic paper uses a more heavily parameterized model that correctly predicts (at their chosen 25 percent threshold) 43 percent of crises and correctly classifies 86 percent of observations. The specification in Berg and Pattillo (1999) increases the share of correct calls at the cost of a high share of false alarms, and overall correct classifications remain around 86 percent.

Last but not least, we look at the out-of-sample predictive performance over 2007-2012. [15] Using the model estimates over 1970-2006 for the baseline crisis definition (col. 6 of Table

[15] Of course we seek to "predict" past events and our choice of variables could have been informed by this knowledge. Yet, such choice is standard from the viewpoint of theory and the previous empirical literature on

(continued…)

6), Table 8 reports countries and years where and when a crisis actually took place, as well as countries and years for which estimated crisis probabilities exceeded the 20 percent cut-off.

Table 8. Out-of-Sample Predictive Power over 2008-2011 Crises

Country	year	crisis	Predicted crisis prob.	Output Gap t	Output Gap t+1	Debt/Y (t-1)	Equity/ Y (t-1)	FDI/Y (t-1)	CA/Y (avg t-1, t-2)	FX/Y (t-1)	RER gap (t-1)	GGB/Y (t-1)
Dom. Rep.	**2009**	**1**	**22**	**0**	**2**	**-10**	**0**	**-37**	**-8**	**6**	**11**	**-3**
Ecuador	2008	1	0	3	-1	-4	0	-22	4	7	-12	2
Greece	*2008*	*0*	*47*	*8*	*5*	*-72*	*-23*	*-7*	*-13*	*0*	*4*	*-7*
Greece	*2009*	*0*	*87*	*5*	*3*	*-70*	*-2*	*0*	*-15*	*0*	*5*	*-10*
Greece	**2010**	**1**	**92**	**3**	**-2**	**-88**	**-1**	**-1**	**-13**	**0**	**5**	**-16**
Hungary	2008	1	0	4	-3	-46	-6	-46	-7	22	11	-5
Jamaica	*2009*	*0*	*51*	*-1*	*-3*	*-44*	*-1*	*-69*	*-18*	*17*	*9*	*-8*
Jamaica	*2010*	*1*	*24*	*-3*	*-2*	*-46*	*-3*	*-69*	*-15*	*19*	*-1*	*-11*
Latvia	**2008**	**1**	**21**	**14**	**-8**	**-46**	**0**	**-35**	**-23**	**15**	**8**	**1**
Lithuania	2009	0	32	-8	-6	-28	1	-23	-14	17	9	-3
Pakistan	2008	1	7	2	1	-16	-5	-17	-6	4	2	-5
Portugal	*2008*	*0*	*29*	*0*	*-3*	*-69*	*-11*	*-21*	*-10*	*1*	*3*	*-3*
Portugal	*2009*	*0*	*69*	*-3*	*-1*	*-70*	*-10*	*-15*	*-11*	*1*	*2*	*-4*
Portugal	*2010*	*0*	*84*	*-1*	*-3*	*-87*	*-14*	*-20*	*-12*	*2*	*1*	*-10*
Portugal	**2011**	**1**	**56**	**-3**	**0**	**-85**	**-12**	**-20**	**-10**	**1**	**-1**	**-10**
Romania	**2009**	**1**	**18**	**0**	**-4**	**-15**	**-1**	**-33**	**-13**	**25**	**13**	**-5**
Serbia	**2009**	**1**	**41**	**2**	**0**	**-26**	**-1**	**-32**	**-20**	**37**	**12**	**-2**
Spain	2008	0	25	2	-3	-69	-15	0	-9	1	5	2
Spain	2009	0	72	-3	-3	-66	-9	0	-10	1	6	-4
Spain	2010	0	80	-3	-3	-83	-14	0	-7	1	4	-11
Spain	2011	0	43	-3	0	-85	-9	2	-5	2	0	-9
Turkey	2008	1	2	1	-4	-17	-10	-22	-6	10	19	-2
Ukraine	2008	1	0	4	-7	5	-1	-22	-3	17	7	-2

Note: all variables in percent. Color legend:

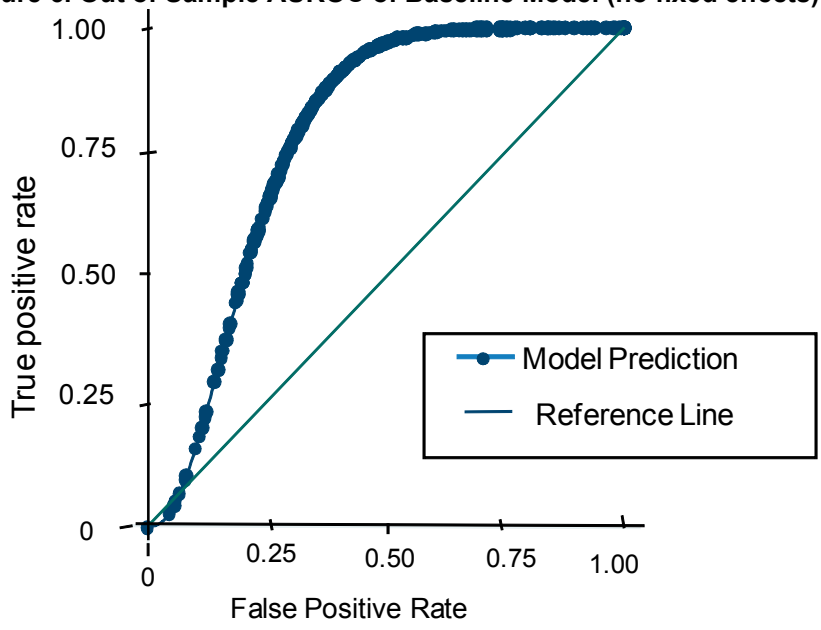
Crisis correctly predicted
Crisis in an adjacent year
No formal crisis but severe economic distress
Crisis missed

debt crises, and does not include measures of bank exposures or other financial vulnerabilities found in post-2007 studies seeking to explain 2008-09 events.

Relying on parameters estimated only with pre-crisis fundamentals, the model correctly predicts the Greece and Portugal crises, and also singles out Spain as a high-risk case since 2008. It also correctly predicts crises in the Dominican Republic, Jamaica, Latvia, Romania (at an 18 percent threshold), and Serbia. While it gives a false alarm for Lithuania as per our crisis definition, the model correctly picks up the major recession that ensued, with large negative output gaps in the crisis outbreak year and the following (-8 and -6 percent respectively).

The model clearly misses the crisis events in Ecuador, Hungary, and the Ukraine (for Pakistan, the estimated 7 percent probability is below the threshold but more than twice the sample's unconditional crisis probability of 3 percent). A special case is Turkey: because of the disbursement of the pre-approved final tranche of IMF lending in 2008 brought its IMF exposure over 200 percent of quota, our coding classifies it as a crisis event, even though Turkey country risk was clearly dropping and the country did not experience an external crisis. Overall, our simple model does a reasonable job at predicting out-of-sample the bulk of the 2008-2012 crises, while relying on a parsimonious set of fundamentals without heavy emphasis on financial sector exposures. Figure 6 displays the out of sample ROC curve, with an AUROC of 0.83 with an estimated standard error of 0.06.

Figure 6. Out of Sample AUROC of Baseline Model (no fixed effects)



V. Concluding Remarks

Conventional wisdom associates large external debt liabilities with the likelihood of external crises. This paper corroborates and sharpens this wisdom on four fronts. First, a simple decomposition of the net foreign asset position of a country into its net debt and net equity components shows that *net* debt liabilities are the most important determinant of crisis risk and that their contribution is highly statistically significant and reasonably stable across specifications. Second, net foreign liabilities in excess of 50 percent of GDP in absolute terms and higher than 20 percent of the country specific historical mean are associated with steeper crisis risk. All else constant, such a tipping point is typically associated with net external debt liabilities above 35 percent of GDP. Third, the speed at which overall foreign liabilities accumulate, as measured by the size of current account deficits, is also key. Fourth, we find some support for the role of reserve accumulation in crisis prevention, and no evidence that higher net FDI liabilities—controlling for other factors such as the current account balance—increase crisis risk.

Finally, we show that a parsimonious probit specification including these NFA components as well as the current account balance and a handful of other variables does a very respectable job in explaining external crises. In particular, when estimated over the period 1970-2006, such a model correctly predicts out-of-sample most of the 2008-11 crises. This suggests that while the triggers of the global financial crisis may have been different from previous crisis episodes, the countries experiencing an external crisis had macroeconomic and external balance sheet characteristics similar to those associated with past crisis episodes.

REFERENCES

Abiad, Abdul, 2003. Early Warning Systems: A Survey and a Regime-Switching Approach, IMF Working Paper 03/32.

Aguiar, Mark and Gopinath, Gita, 2006. Defaultable debt, interest rates and the current account, Journal of International Economics, 69(1), 61-89.

Alfaro, Laura, Sebnem Kalemli-Ozcan, and Vadym Volosovych, 2011, Sovereigns, Upstream Capital Flows, and Global Imbalances, NBER Working Paper 17396.

Arellano, Cristina, 2008. Default risk and income fluctuations in emerging economies, American Economic Review, 98(3), pp. 690-712

Aizenman, Joshua and Ilan Noy, 2012. Macroeconomic Adjustment and the History of Crises in Open Economies, NBER working paper 18527.

Beim, David O., and Charles W. Calomiris, 2001. Emerging Financial Markets (New York: McGraw-Hill/Irwin).

Berg, Andrew and Catherine Pattillo, 1999. Are Currency Crises Predictable? A Test, IMF Staff Papers, 46, No. 2.

Blanchard, Olivier, Hamid Faruqee, and Vladimir Klyuev, 2009. Did Foreign Reserves Help Weather the Crisis, IMF Survey, Oct. 8th.

Michael Bordo, Barry Eichengreen, Daniela Klingebiel, Maria Soledad Martinez- Peria, and Andrew Rose, 2001. Is the Crisis Problem Growing More Severe, Economic Policy 16 no. 32, pp. 53-82

Borensztein, Eduardo, Jose de Gregorio, and J-W Lee, 1998. How Does Foreign Direct Investment Affect Economic Growth?, Journal of International Economics 45, pp.115-135.

Borensztein, Eduardo and Panizza, Ugo, 2008. The Costs of Sovereign Defaults, IMF Working Paper 08/238.

Bussière, Matthieu and Marcel Fratzscher, 2006. Towards a New Early Warning System of Financial Crises, Journal of International Money and Finance 25(6), pp. 953-973.

Calvo, Guillermo, 1998. Capital Flows and Capital Market Crises: The Simple Economics of Sudden Stops, Journal of Applied Economics 1 (1), pp. 35-54.

Calvo, Guillermo, Alejandro Izquierdo, and Luis Mejia, 2004. On the Empirics of Sudden Stops, Proceedings, Federal Reserve Bank of San Francisco, June.

Caprio, Gerard, and Daniela Klingebiel, 1996. Bank Insolvencies: Cross-Country Experience. Policy Research Working Paper No.1620. Washington, D.C.: World Bank.

Catão, Luis A.V., Ana Fostel, and Sandeep Kapur, S. 2009. Persistent Gaps and Default Traps, Journal of Development Economics, 89, pp.271-84.

Catão, Luis A.V, and Gian Maria Milesi-Ferretti, 2013a. External Liabilities and Crises, IMF working paper 13/113.

Catão, Luis A.V, and Gian Maria Milesi-Ferretti, 2013b. External Liabilities and Crisis Risk, VOX-EU, 4th September.

Chinn, Menzie and Eswar Prasad, 2003. Medium-term Determinants of Current Accounts in Industrial and Developing Countries, Journal of International Economics 59(1), pp. 47-76

Chinn, Menzie, Barry Eichengreen, and Hiro Ito, 2014. A Forensic Analysis of Global Imbalances, Oxford Economic Papers 66 (2), 465-90.

Eaton, Jonathan, and Mark Gersovitz, 1981, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," Review of Economics and Statistics, Vol. 48, pp. 284–309.

Edison, Hali J. 2003. Do indicators of financial crises work? An evaluation of an early warning system, International Journal of Finance & Economics 8(1), pp. 11-53.

Edwards, Sebastian, 2004. Thirty Years of Current Account Imbalances, Current Account Reversals, and Sudden Stops, IMF Staff Papers, 51, pp. 1-49.

Eichengreen, Barry, Andrew K. Rose, and Charles Wyplosz, 1996. Contagious Currency Crises, NBER Working Paper No. 5681.

Fawcett, Tom, 2006. An Introduction to ROC Analysis, Pattern Recognition Letters 27, pp. 861-74.

Frankel, Jeffrey A., and Andrew K. Rose, 1996. Currency Crashes in Emerging Markets: An Empirical Treatment, Journal of International Economics 41, pp. 351–66.

Frankel, Jeffrey A. and George Saravelos, 2012. Can Leading Indicators Assess Country Vulnerability? Evidence from the 2008–09 Global Financial Crisis, Journal of International Economics 87 (2), pp. 216-231.

Gourinchas, Pierre-Olivier, and Maurice Obstfeld. 2012. Stories of the Twentieth Century for the Twenty-First. American Economic Journal: Macroeconomics 4(1): 226-65.

Jordá, O, Alan M. Taylor and Moritz Schularick, 2011. Financial Crises, Credit Booms, and External Imbalances: 140 Years of Lessons, IMF Economic Review 59, pp.340-378

Kaminsky, Graciela, Saul Lizondo, and Carmen Reinhart, 1998. Leading Indicators of Currency Crises, IMF Staff Papers 45, pp. 1-48.

Kaminsky, Graciela and Carmen M. Reinhart, 1999. The Twin Crises: The Causes of Banking and Balance-of-Payments Problems, American Economic Review, 89(3), pp. 473-500

Kraay, Aart, and Vikram Nehru, 2006. When is External Debt Sustainable? World Bank Economic Review, 20, pp.341-365.

Laeven, Luc and Fabián Valencia, 2012. Systemic Banking Crises Database: An Update, IMF working paper WP/12/163

Lane, Philip R. and Gian Maria Milesi-Ferretti, 2007. The External Wealth of Nations Mark II: Revised and Extended Estimates of External Assets and Liabilities, Journal of International Economics, vol.73, pp. 223-50.

Lee, Jaewoo, Gian Maria Milesi-Ferretti, Jonathan Ostry, Alessandro Prati, and Luca Ricci, 2008. Exchange Rate Assessments: CGER Methodologies, IMF occasional paper 261.

Manasse, Paolo and Nouriel Roubini, 2009. “Rules of thumb" for sovereign debt crises, Journal of International Economics 78 (2), pp. 192-205.

McFadden, Daniel, Richard Eckaus, Gershon Feder, Vassilis Hajivassiliou and Stephen O’Connell (1985). Is There Life After Debt? An Econometric Analysis of the Creditworthiness of Developing Countries, in Gordon Smith and John Cuddington, eds., International Debt and the Developing Countries. World Bank: Washington, DC.

Mendoza, Enrique and Vivian Yue, 2012. A General Equilibrium Model of Sovereign Default and Business Cycles, Quarterly Journal of Economics, 127, pp. 889-946.

Milesi-Ferretti, Gian Maria and Assaf Razin, 2000. Current Account Reversals and Currency Crises: Empirical Regularities, in Krugman, P (ed.), Currency Crises, Chicago: University of Chicago Press for NBER.

Obstfeld, Maurice, and Kenneth Rogoff, 1996. Foundations of International Macroeconomics, (Cambridge, Massachusetts: MIT Press).

Obstfeld, Maurice, Jay Shambaugh, and Alan Taylor, 2009. Financial Instability, Reserves, and Central Bank Swap Lines in the Panic of 2008, American Economic Review, 99, no.2, pp. 480-86.

Obstfeld, Maurice, Jay Shambaugh, and Alan Taylor, 2010. Financial Stability, the Trilemma, and International Reserves, American Economic Journal: Macroeconomics, 2, pp. 57-94.

Panizza, Ugo, Jeromin Zettelmeyer and Federico Sturzenegger, 2009. The Economics and Law of Sovereign Debt and Default, Journal of Economic Literature, 47(3), pp. 651–698.

Pistelli, Alfredo, Jorge Selaive, and Rodrigo Valdés, 2008. Stock, Flows, and Valuation Effects of Foreign Assets and Liabilities: Do They Matter?, in Cowan, K et al. (eds), Current Account and External Finance, Central Bank of Chile.

Reinhart, Carmen and Kenneth Rogoff, 2009. This Time is Different. Eight Centuries of Financial Folly, Princeton University Press.

Reinhart, Carmen and Kenneth Rogoff, 2010. Growth in a Time of Debt, American Economic Review, Papers and Proceedings 100, pp. 573-578.

Reinhart, Carmen and Kenneth Rogoff, and Miguel Savastano, 2003. Debt Intolerance, Brookings Papers on Economic Activity, 34(1), pp. 1-74.

Rose, Andrew, and Mark Spiegel, 2009. The Causes and Consequences of the 2008 Crisis: Early Warning, NBER Working Papers 15357.

Rose, Andrew, and Mark Spiegel, 2011. The Causes and Consequences of the 2008 Crisis: An Update, European Economic Review 55(3), pp. 309-324.

Sachs, Jeffrey, and Daniel Cohen, 1985. LDC Borrowing with Default Risk, Kredit und Kapital, pp. 211–35.

Satchell, Steven and Xia Wei, 2006. Analytic Models of the ROC curve: Applications to Credit Rating Model Validation, Working paper 181, University of Technology Sydney.

Schularick, Moritz and Alan M. Taylor, 2012. Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008, American Economic Review 102(2), pp. 1029-61.

Shin, Hyun Song, 2012. Global Banking Glut and Loan Risk Premium, IMF Economic Review 60, pp.155-192.

Wooldridge, Jeffrey, 2010. Econometric Analysis of Cross-Section and Panel Data, second edition, (Cambridge, Massachusetts: MIT Press).

Wright, Mark, 2006. Private Capital Flows, Capital Controls and Default Risk, Journal of International Economics, 69, pp. 120-149.

Overall Sample

Advanced	Emerging
Australia	Argentina
Austria	Belize
Belgium	Brazil
Canada	Bulgaria
Cyprus	Chile
Denmark	China
Finland	Colombia
France	Costa Rica
Germany	Croatia
Greece	Czech Rep.
Hong Kong	Dominican Rep.
Iceland	Ecuador
Israel	Egypt
Italy	El Salvador
Japan	Estonia
Korea	Guatemala
Malta	Hungary
Netherlands	India
New Zealand	Indonesia
Norway	Jamaica
Portugal	Jordan
Singapore	Latvia
Slovenia	Lithuania
Spain	Malaysia
Sweden	Mexico
Switzerland	Morocco
Taiwan	Oman
United Kingdom	Pakistan
United States	Panama
	Peru
	Philippines
	Poland
	Romania
	Russia
	Serbia
	Slovak Rep.
	South Africa
	Thailand
	Turkey
	Ukraine
	Uruguay
	Venezuela

Crisis Sample (baseline definition)

Country	Year	Default	Country	Year	Default
Argentina	1982	1	Korea	1980	0
Argentina	1995	0	Korea	1997	0
Argentina	2001	1	Latvia	2008	0
Belize	2006	1	Mexico	1982	1
Brazil	1983	1	Mexico	1995	0
Brazil	1999	0	Morocco	1981	0
Brazil	2001	0	Pakistan	1981	0
Chile	1972	1	Pakistan	1998	1
Chile	1983	1	Pakistan	2008	0
Costa Rica	1981	1	Panama	1983	1
Dominican Rep.	1982	1	Peru	1978	1
Dominican Rep.	2003	1	Peru	1982	0
Dominican Rep.	2009	0	Philippines	1976	0
Ecuador	1983	1	Philippines	1983	1
Ecuador	1999	1	Poland	1981	1
Ecuador	2008	1	Portugal	1977	0
Egypt	1984	1	Portugal	2011	0
Greece	2010	0	Romania	2009	0
Hungary	2008	1	Serbia	2009	1
Iceland	1976	0	South Africa	1985	1
India	1984	0	Thailand	1981	0
Indonesia	1998	1	Thailand	1985	0
Israel	1976	0	Thailand	1997	1
Italy	1975	0	Turkey	1976	0
Jamaica	1978	1	Turkey	2000	0
Jamaica	2010	1	Turkey	2008	0
Jordan	1989	1	Ukraine	1998	1
Jordan	1997	0	Ukraine	2008	0
Jordan	2002	0	Uruguay	1983	1
Korea	1975	0	Uruguay	2002	0
			Venezuela	1983	1

Appendix 2. Estimates of Current Account Gaps

This reports the methodology and econometric estimates of current accounts based on the macroeconomic balance approach to the estimation of current account "norms" implemented in the IMF (see Lee et al, 2007; http://www.imf.org/external/np/res/eba/).

The approach hinges on the inter-temporal Saving-Investment model starting with Obstfeld and Rogoff (1996), empirically implemented and extended in several subsequent contributions (see, e.g., Chinn & Prasad, 2003; Chinn et al, 2014).

The model can be concisely written by combining the I-S behavioral relation with intra-temporal (accounting) and inter-temporal constraints in four equations:

I-S:
$$\frac{CA}{Y}(reer, \tilde{y}^{wo}) = \frac{S}{Y}(nfa, r, x_s) - \frac{I}{Y}(r, reer, x_I) \tag{1}$$

BOP constraint:
$$\frac{CA}{Y}(reer, \tilde{y}^{wo}) + \frac{FA}{Y}(r - r^{wo}, x_{CF}) = \Delta \operatorname{Res}(r - r^{wo}, x_{RS}) \tag{2}$$

Solvency Constraint:
$$nfa_t = -E_t \sum_{j=1}^{\infty} \prod_{k=1}^{\infty} \rho_{t+k} \left[tb_{t+j} + \frac{s_{t+j} a_{t+j}}{\rho_{t+j}(1 + r^*_{t+j})} \right] \tag{3}$$

Multilateral Constraint:
$$\sum_{i=1}^{N} CA_i = \sum_{i=1}^{N} \frac{CA_i}{Y_i} \omega_i = 0 \tag{4}$$

where CA stands for the current account, FA for the financial account, $reer$ for the real effective exchange rate, Res for the stock of foreign exchange reserves, and nfa for the ratio of net foreign assets to GDP. In addition, ω_i stands for the share of country i in world GDP (so that globally $\sum_{j=1}^{N} \omega_j^i = 1$, $\forall$i), a_t is the ratio of *gross* foreign assets to GDP, s_t is the (average) interest rate spread between external assets and liabilities, ρ_t is the growth-adjusted discount factor, and r_t^* is the interest rate on external liabilities. The model then closes with a policy

rule that relates each country's real interest rate r to the output gap $\tilde{y}_{it}$ and the world interest rate r^{wo}. If the country floats its exchange rate and follows (approximately) an IT regime, this relationship can be written as:

$$ca_{it} = f[nfa_{it}, \tilde{y}_{it} - \tilde{y}_t^{wo}, \mathbf{x}_{I_{it}} - \mathbf{x}^{wo}{}_{I_t}, \mathbf{x}_{S_{it}} - \mathbf{x}^{wo}{}_{S_t}, \mathbf{x}_{CF_{it}} - \mathbf{x}^{wo}{}_{CF_t}]$$

$$r_t = r^N + (\alpha_y + \lambda)\tilde{y}_t + \varsigma_t \tag{5a}$$

If instead, the country pegs, this becomes:

$$\begin{aligned} r_t &= i_t^{wo} - E(\pi_{t+1}) = r_t^{wo} - E(\pi_{t+1} - \pi_{t+1}^{wo}) \\ &= r_t^{wo} - f(\tilde{y}_t, \tilde{y}_t^{wo}) \end{aligned} \tag{5.b}$$

In reduced-form, the model solves for the current account ratio to GDP:

$$ca_{it} = f[nfa_{it}, \tilde{y}_{it} - \tilde{y}_t^{wo}, \mathbf{x}_{I_{it}} - \mathbf{x}_{I_t}^{wo}, \mathbf{x}_{S_{it}} - \mathbf{x}_{S_t}^{wo}, \mathbf{x}_{CF_{it}} - \mathbf{x}_{CF_t}^{wo}, \mathbf{x}_{RS_{it}} - \mathbf{x}_{CF_t}^{wo}] \tag{6}$$

where $\mathbf{x}$'s are:

$\mathbf{x}_s$ = the consumption/saving shifters, which include income per capita, demographics, expected income (shifts in permanent income), social insurance, and the budget balance;

$\mathbf{x}_I$ = the investment shifters, which include income per capita, TFP (or output trend growth as usually measured), governance, and other indicators that can be plausibility assumed to drive domestic capital formation.

$\mathbf{x}_{CF}$ = capital account shifters, which include indicators of global risk aversion, and capital controls.

$\mathbf{x}_{RS}$ = reserve accumulation shifters, which include all precautionary as well as policy factors (including capital controls), driving reserve accumulation.

Note that multilateral constraint (4) implies that each country's variable should be measured relative to a (current GDP) weighted world average of the same variable. This implies that the world interest rate term will drop out. If the emphasizes is long-run equilibrium, the output gap term will $\tilde{y}_{it} - \tilde{y}_t^{wo}$ will also drop out. So will cyclical influences associated with bouts of global risk aversion and asymmetric reserve accumulation.

The first column of Table A2 reports our baseline estimate of equation (6), using standard proxies for the various savings and investment shifters, and annual panel data for 1970-2011. Columns (2) to (6) reports alternative specifications. They indicate that the chosen baseline is robust to those alternative controls. In the main text, we use the residuals of specification (1) as our measure of the country's current account gap.

Table A2. Panel Estimates of Current Account Norms

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	CA/Y	CA/Y	CA/Y	CA/Y	CA/Y	CA/Y
Lagged NFA/Y	0.05***	0.05***	0.04***	0.05***	0.05***	0.05***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Relative PPP GDP pc	0.05***	0.05***	0.05***	0.05***	0.05***	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Oil Balance Dummy	0.29***	0.29***	0.29***	0.28***	0.29***	0.36***
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)
Old Age Dependency Ratio	-0.14***	-0.15***	-0.14***	-0.14***	-0.14***	-0.08***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)
Population Growth	-0.40**	-0.41**	-0.41**	-0.42**	-0.40**	-0.46**
	(0.17)	(0.18)	(0.18)	(0.18)	(0.17)	(0.19)
Polity Index	-0.001***	-0.001***	-0.001***	-0.001***	-0.001***	-0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trend Growth	-0.26***	-0.26***	-0.26***	-0.27***	-0.26***	-0.29***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.07)
General Gov. Balance (cyc.adj)	0.38***	0.38***	0.37***	0.46***	0.38***	0.45***
	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)	(0.06)
Quinn Index of Capital Controls	0.02***	0.02***	0.02***	0.02***	0.02***	0.02***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.01)
Aging Speed		-0.01				
		(0.02)				
Financial Center Dummy			0.003			
			(0.01)			
Trade Openness (5-year MA)				-0.002		
				(0.01)		
Reserve Currency Dummy					0.001	
					(0.003)	
Social Protection Index						-0.01
						(0.01)
Constant	0.01***	0.01***	0.01***	0.01***	0.01***	0.005**
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	2300	2300	2300	2134	2300	1891
R-squared	0.32	0.32	0.32	0.34	0.32	0.34

Dependent variable is ratio of current account to GDP. Robust SEs in parentheses
*** p<0.01, ** p<0.05, * p<0.1.