External Liabilities and Crises

Luis A. V. Catão

IMF

Gian Maria Milesi-Ferretti[1]

IMF and CEPR

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Abstract

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, either measured unconditionally or as deviations from conventionally estimated "norms"; 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 stricto sensu.

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Authors' E-Mail Addresses: lcatao@imf.org; gmilesiferretti@imf.org

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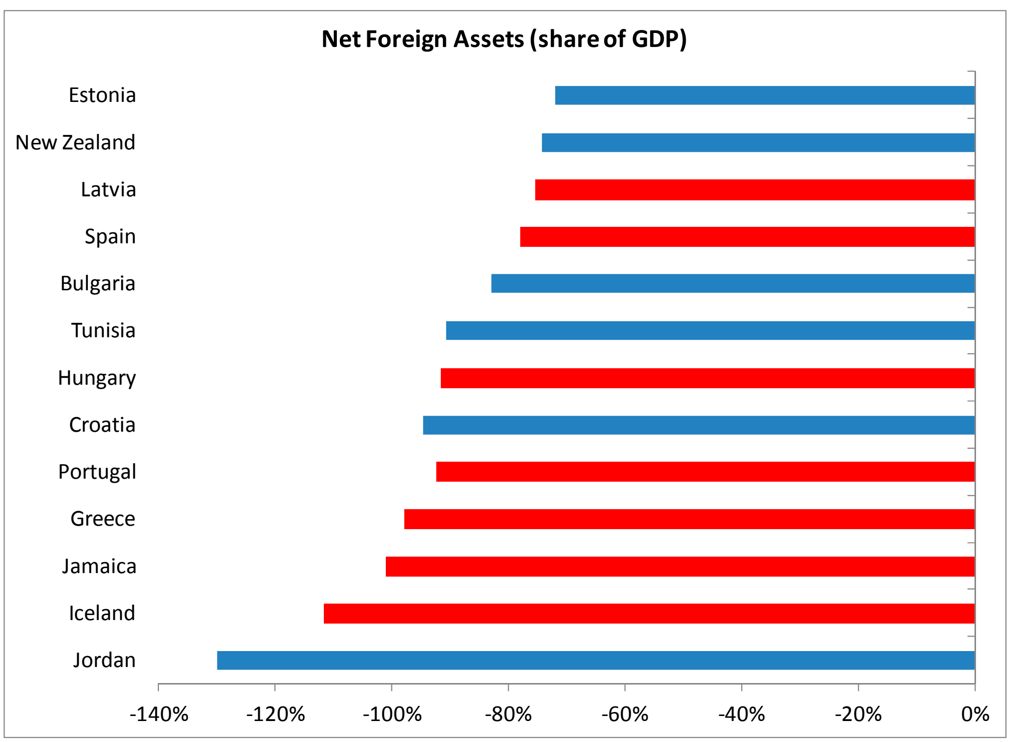
I. INTRODUCTION

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, bars marked in red).

Figure 1. Net Foreign Assets of Selected Countries, 2007



Against this background, we seek to answer three questions. The first is whether the level and composition of NFA matter for crisis risk. We focus strictly on external crises, which 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). 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—rather than net—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 are the more relevant metric.

The second question is whether we can identify a proximate threshold 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. This is done by computing those thresholds as points where the signal to noise ratio in crisis prediction is maximized conditional on all variables entering the model. Establishing whether external liabilities beyond certain levels appear to be particularly risky is a question with tangible policy implications and a crucial issue for country insurance and risk assessment. Our aim is to sharpen existing evidence on such "tipping points".

The third question is how an econometric model featuring these variables as well as a few other controls performs at predicting crises, both in- and out-of-sample, focusing in particular on the predictive accuracy over the recent crisis. Critics of previous work on crisis early warning systems (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) and Kraay and Nehru (2006)—and to a model featuring disaggregated NFA components and other controls not featured in earlier studies.

The main findings are as follows. First, we find evidence that higher net external liabilities increase crisis risk. In particular, crisis risk increases sharply as net foreign liabilities (NFL) exceed 50 percent of GDP and whenever the NFL/GDP ratio rises some 20 percentage points above the country-specific historical mean. Second, crisis risk rises as the composition of NFL is tilted toward net debt liabilities. In comparison, the effects of portfolio equity liabilities are more mixed and generally 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 current account "norm" using standard specifications of that latter. Fourth, higher foreign exchange reserves reduce 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. Also importantly, we find that many other variables featured in the previous literature on explaining 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 debt sustainability, as well as on country risk and sovereign default. Relative to work on early warning crisis systems (Frankel and Rose, 1995; Eichengreen et al., 1996; Kaminsky, Lizondo, and Reinhart, 1997; Kaminsky and Reinhart, 1999; Berg and Pattillo, 1999; Abiad, 2003), the main contributions of this paper lie in the use of a novel set of controls centered on level and composition of NFA, the availability of a sample including both advanced economies and emerging markets with a long time-series dimension, and the focus on external crises "stricto sensu". This allows us to probe into whether the poorer out of sample performance of earlier models were partly due to the choice of the dependent variable (currency/domestic financial crises there vs. large external crises here), as well as of independent variables and associated data limitations (e.g. disaggregated NFA data was not available at that time). Using longer time series data than most previous work also allows us to establish whether a higher weight on the crisis events of the late 1990s played a role. In focusing on the out-of-sample predictive performance on the post-2007 crises, this paper is closely related to Frankel and Saravelos (2012), who look at which variables highlighted in the pre-2007 EWS literature deliver the strongest signals in terms of predictive power over post-2007 events. Like us, they find that external debt levels are significant; yet they also find that reserves and real exchange rate gaps are the most robust predictors of the post-2007 crises. In comparison, our analysis suggests the predictive power of these two variables is significantly higher when combined with others, and that the current account is the most powerful predictor of all.

Our 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; Jorda et al., 2012). A main distinction between Kraay and Nehru (2006) and Pistelli et al. (2008) and our work is that we include advanced economies alongside emerging markets. In relation to the work on external sustainability and sudden stops, we focus on a crisis definition centered on major *external* credit events—typically a subset of sudden stop occurrences. Our analysis of external liability thresholds in crisis risk is closely related to the treatment effects model in Gourinchas and Obstfeld (2012). The main difference lies in our definition of external crisis, the use of a wider set of controls, and the model selection criterion (Receiver Operating Characteristic—ROC—analysis and extensive out-of-sample predictive criteria).

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 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 sample. Section III discusses the dynamics of NFL and its components in the run-up to external crises. We then identify thresholds above which crisis risk increases rapidly and use 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 large set of variables and probes into out-of-sample predictive power. Section V concludes.

II. Crisis Definition and Data

Our initial sample consists of 70 countries (of which 41 are emerging markets) spanning 1970-2011.[2] To facilitate comparability of regression results across distinct specifications, we eliminate observations for which data on NFA or its breakdown into equity and debt are problematic. Specifically, we drop Ireland because a debt/equity breakdown is heavily distorted by its sizable mutual fund industry, whose liabilities are statistically recorded as equity instruments but whose assets include both equity and debt instruments. We also drop Iceland after 2000 because of extremely large swings in NFL, jumping from around 110 percent in 2007 to close to 700 percent of GDP at end-2008, which would leverage our results.[3] The final country list is shown in Appendix I.

As mentioned above, our baseline definition of external crises encompasses defaults and re-scheduling events (as per the definition of Bein and Calomiris, 2001 and Standard & Poor's, as compiled in Borensztein and Panizza, 2008, and

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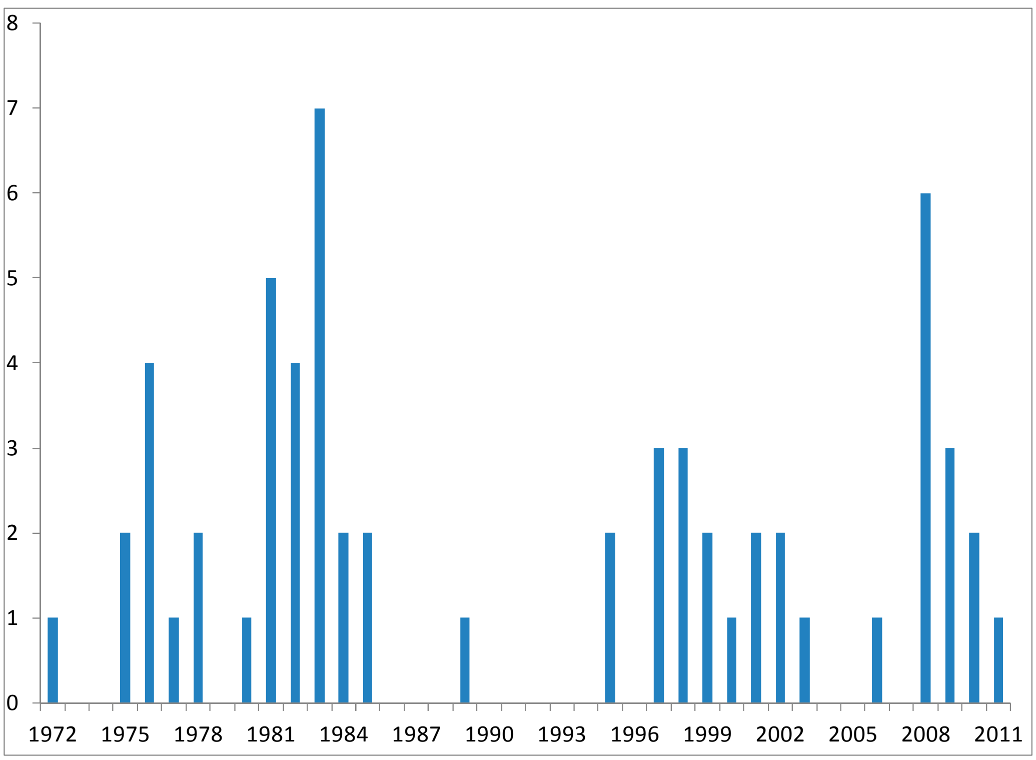
[2] In eliminating lower income countries, we are deliberately leaving aside a myriad of smaller crises and countries where borrowing is mainly official and/or on a concessional basis rather than market driven. There are three main advantages of doing so. One is that the causal mechanisms developed in the theoretical literature on country borrowing require a reasonable degree of integration with international capital markets, so we can draw on that literature to derive testable implications and choice of co-variates. Second, we circumvent data limitations more prevalent in poorer countries. Last but not least, focusing on major crises stacks the deck against finding a trivially lower threshold to foreign liability exposure.

[3] Because these are countries that experienced external crises as per our definition in 2008 and 2010 respectively, our sample would otherwise comprise 63 events. Note, of course, that both countries had large and increasing net external liabilities and experienced crises.

updated by us) as well as events associated with resort to large multilateral/IMF support. Large multilateral support is herewith 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. A hallmark of this crisis definition—in the spirit of McFadden et al. (1985) and Kraay and Nehru (2006)—is that it focuses on major external crisis events. Another distinctive feature vis-à-vis previous work is that we treat these events as discrete, watershed-like occurrences: we exclude from our sample observations 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, we do not treat credit events associated with partial repayments and partial defaults/re-schedulings (the so-called muddling-through) in the interim period as separate events. While the downside is to leave us with a smaller number of default observations than often found in other studies, this is consistent with the conception of debt crises as major events of long-lasting consequences; and those big-bangs are the events that are systemically important to predict. In addition, excluding country/year observations that lie between the initial default and market re-entry mitigates estimation biases arising from feedback effects of the crisis onto the explanatory variables, as discussed in Bussière and Fratzscher (2006), and makes crises more comparable as it eliminates a large number of smaller credit events. We define market re-entry as either the year after S&P classifies the default to have ended or—when the crisis categorization does not involve default but a large IMF loan—when the country's liabilities vis-à-vis the IMF are either brought down to below 200 percent of quota or, if remaining above 200 percent, decline by two consecutive years. We prefer this procedure for treating market exclusion spells to the one adopted by Gourinchas and Obtsfeld (2012) who, instead, drop all observations within 4-years after default regardless of whether market re-entry may be longer or shorter. In several crises, notably those of the 1980s, full market re-entry took much longer than four years.

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, with a full list (broken down by default/rescheduling and large IMF lending) provided in Appendix 1.

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



III. Crisis Dynamics and Model-Free Threshold Estimates

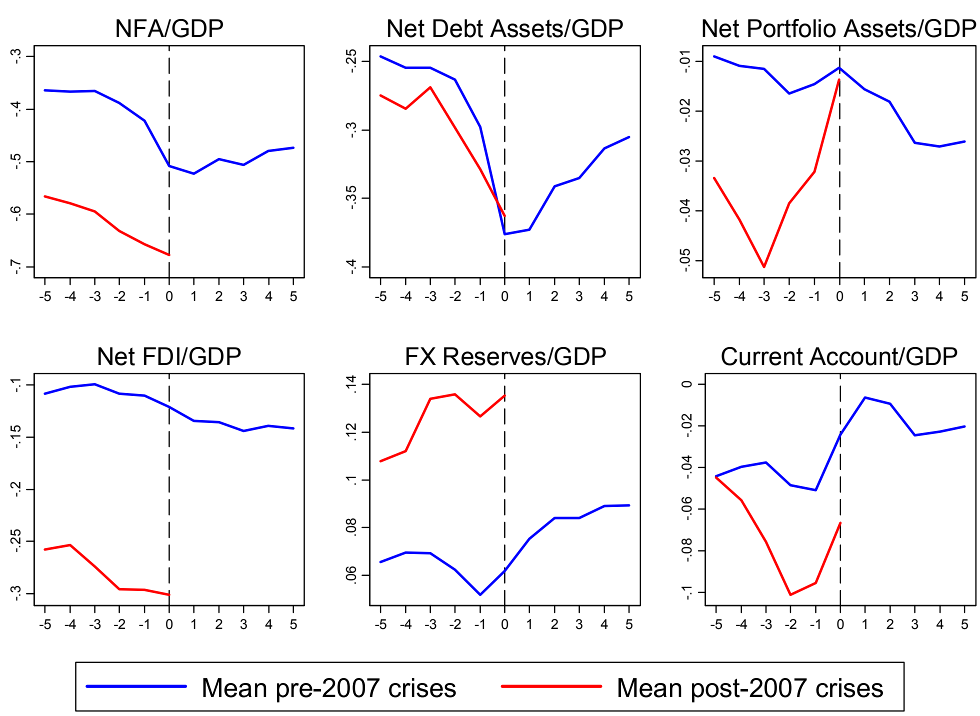
We start by examining the pre- and post-crisis dynamics of a few variables that are most relevant for crisis risk. Subsequent analysis in Section IV will corroborate this choice. Conditional on it, we proceed in two steps. First, we perform a standard event analysis in which observations for the variable in question are averaged over each external crisis episode (often more than one crisis per country). We compute such averages over an 11-year window centered on the crisis year (t=0) and spanning 5 years prior and after the crisis. Since we are also interested in predictive power using past information, we also ask whether the recent (post-2007) crises have been any different in that regard. Second, we look at statistical significance controlling for fixed country and time effects. This enables us to gauge what are levels of exposure appear riskier *relative to the country's own historical mean* net of time effects.

Figure 3 presents the unconditional evolution of the cross-country mean (over the 61 crisis episodes in our sample) of each of the variables of interest. The pre-2007 sample points to an average NFL to GDP ratio at the onset of crises of around 50 percent, rising to closer to 70 percent for the post-2007 crises. The subsequent four panels in Figure 3 disaggregate NFL, showing that the deterioration of the net foreign debt position (defined as the difference between debt assets—portfolio debt securities, other investment, and foreign exchange (FX) reserves—and debt liabilities, comprising portfolio debt and other investment) is typically sizeable in the run-up to crises; and that this deterioration is of a similar magnitude between pre- and post-2007 crises.[4] The (unconditional) dynamics of the net portfolio equity position, net FDI, and foreign exchange reserves are more mixed. In the case of portfolio equity, one observes a mild worsening in pre-2007 crises, but not in post-2007 episodes: the global stock market boom of 2004-2007 drove sharply up the value of such assets relative to others. Regarding FDI, the sharp difference

[4] As shown in section IV, our regression results indicate that ***net*** rather than gross external debt is the more relevant metric for crisis risk.

in levels comes from the fact that the net recourse to FDI financing has increased very sharply over the past two decades, particularly in Central and Eastern Europe. But again, unlike debt, the deterioration in the net FDI position in the run-up to crisis is modest. Similar considerations apply to reserves. The stylized facts on the current account balance are consistent with the evidence on NFL, and more generally with the large literature on current account reversals and sudden stops (Milesi-Ferretti and Razin, 2000; Calvo et al, 2004): both pre- and post-2007, crisis-stricken countries start off with large current account deficits of around 4 percent of GDP, with the later crises showing a larger deterioration in the current account until the eve of the crisis before turning sharply around.

Figure 3. Unconditional Means of Selected Variables Around External Crises



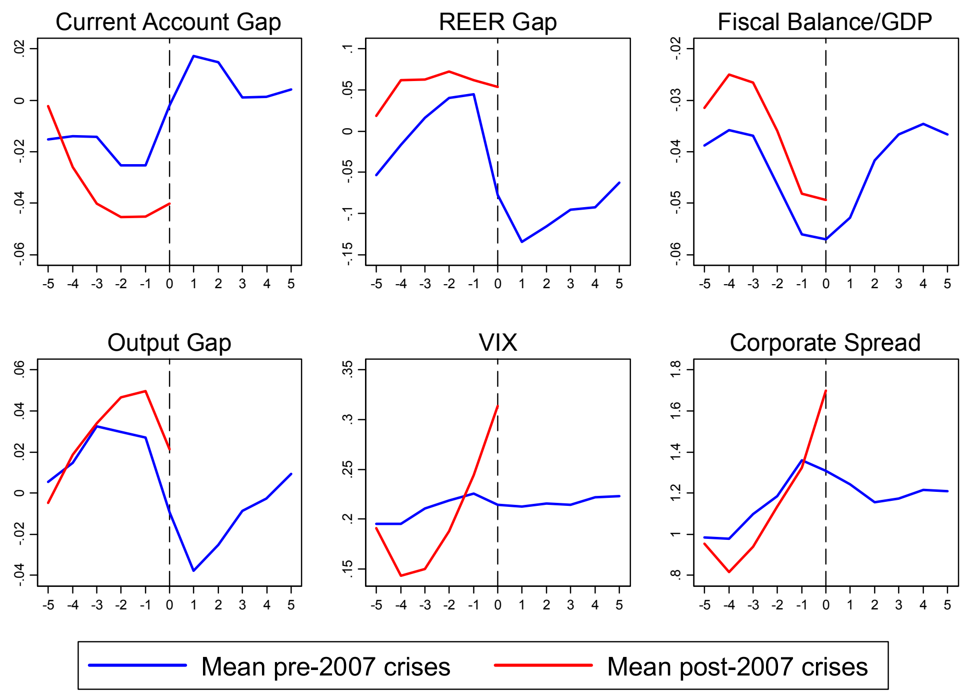


Figure 3 also looks at other pertinent variables, three of which (the real exchange rate, the fiscal balance and the output gap) featured prominently in early studies of early warning indicators and crisis risk (such as Berg and Pattillo, 1999, and Frankel and Saravelos, 2012). The first of these additional variables is the current account "gap", computed as the residual of a regression of the current account on its medium-term determinants, following closely the specifications in Lee and al (2008) and IMF (2012), once cyclical and other shorter-term influences are factored out (see Appendix II). The time pattern is very similar as that of the unconditional current account balance in Figure 1, except that levels are much less negative, particularly for the post-2007 sub-sample. The second is the real effective exchange rate (REER) "gap"—computed as the deviation of current REER levels to its 5-year moving average. Large real exchange rate appreciations can eventually trigger an economically painful reversal due to un-hedged balance sheet positions as in sudden stop models à la Calvo (1998). The REER gap shows a familiar pre-crisis pattern: an appreciation in the run-up to the crisis, followed by a depreciation (of nearly 20 percent from peak to trough). Finally, the pre-crisis period for both sets of crises is characterized by a deterioration in the cyclically-adjusted fiscal balance and an increase in GDP relative to potential.

Finally, the time clustering of crises highlighted in Figure 3 suggests that global factors are important. The last two panels of Figure 3 focus on two indicators of global financial conditions that have been emphasized in recent work—namely, 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 that the post-2007 external crises were mostly triggered by financial factors, it is not surprising the tightening of both financial condition indicators was particularly sharp for that sub-sample.

One criticism of inferences based on Figure 3 is that, because these are averages over crisis events only, they do not gauge the statistical significance of differential behavior between "crisis" and "tranquil" times. We address this concern by using a treatment-effect regression similar to Gourinchas and Obstfeld (2012):[5]

[5] This specification bears three differences relative to the one in Gourinchas and Obstfeld (2010). First, it allows for a time (year) effect throughout. This seems important since cross-country time-varying factors associated with the global business cycle and global financial markets volatility can bear a significant causal connection with crisis risk. For variables that (if accurately measured) should globally add to up zero at any point of time (such as NFA and the current account), keeping the time effect control might still be important since our regressions are not GDP weighted, so $\sum y_{it}$ may be far away from zero. Second, their specification also includes dummies for currency and systemic banking crises. However, they find that allowing for interaction effects with other types crises does not significantly affect the coefficients of interest. Accordingly, they end up with a specification that eliminates these interaction effects. The third difference is that they estimate their version of equation (1) separately for advanced and emerging countries. We consider that the anatomy of external crisis bears sufficient cross-country similarities, particularly for recent crises.

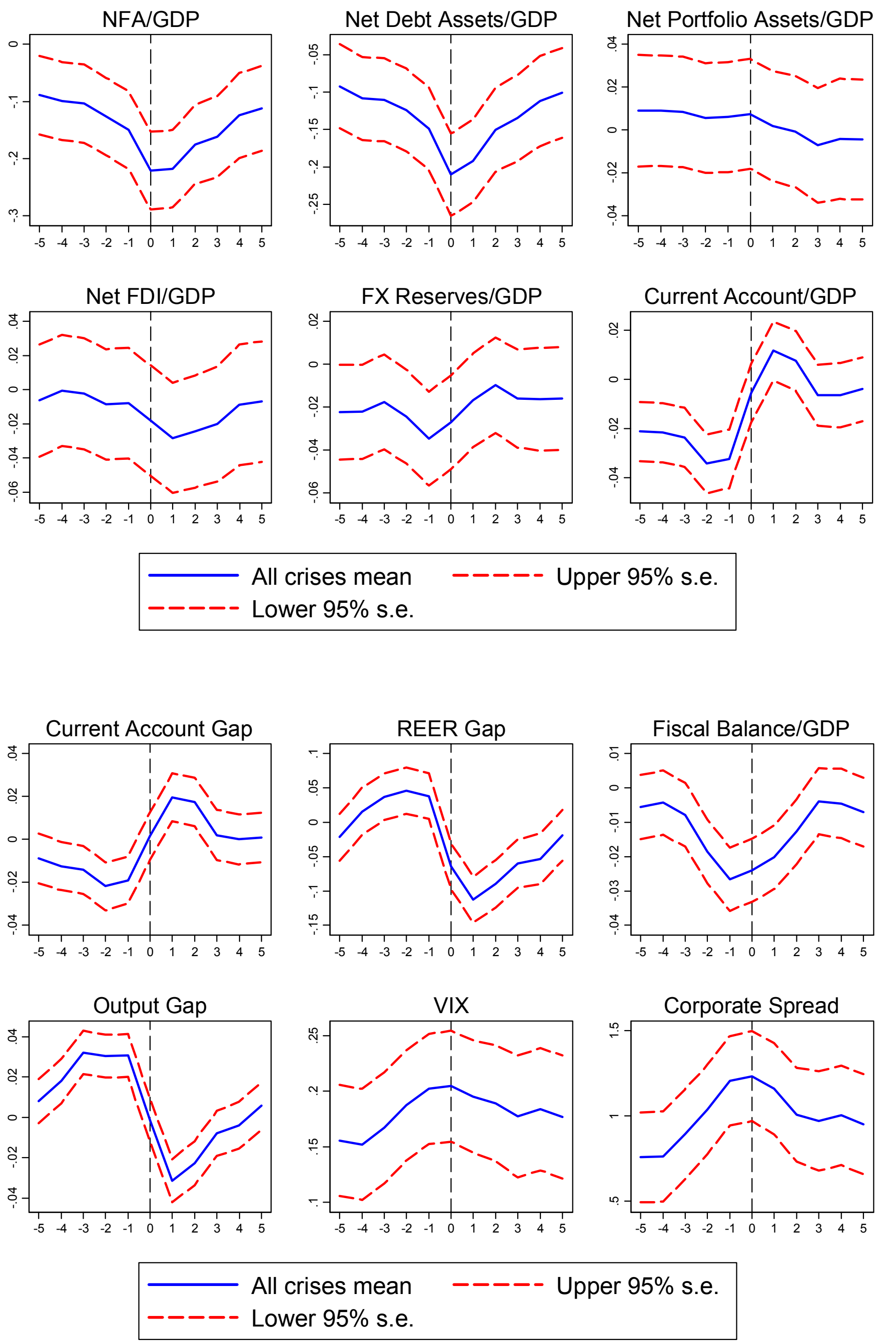
$$y_{it} = \alpha_i + \gamma_t + \sum_{s=-5}^{5} \beta_s D_{t+s} + \varepsilon_{it} \qquad (1)$$

where α_i and γ_t are fixed country and time effects, and the variables D_{t+s} (with s varying between -5 and 5) 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 outbreak. Because the first two terms on right of (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 of Figure 3 based on the "untreated" or absolute mean.

Figure 4 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 typically associated with NFA/GDP ratios between 15 and 20 percent below mean and declining in the run-up to crisis. The respective tolerance bands in dotted lines indicate that these effects are 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 between 15 to 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 in Figure 4 corroborate the evidence of the unconditional means of Figure 3: real exchange rate appreciations, rising fiscal deficits, and global financial market volatility are significant precursors of external crises.

Figure 4. Conditional Mean of Selected Variables Around Crises

(Treated by Fixed and Time Effects)



IV. CRISIS MODEL

A. Model Selection Criterion

We now turn to the question of how far NFL positions and their composition matter in determining crisis probabilities in a multivariate context. We build a reasonably parsimonious multivariate probit model robust enough to retain considerable predictive power out of sample, and ask how such model would predict the recent crises of 2008-2011 when estimated on data up to 2006.

We use the so-called ROC curve as a model selection tool. The ROC 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 positive signals (out of all negatives in the sample) along contiguous threshold settings. The best model according to this criterion is the one that delivers 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 minimizing missed good calls at any cost): distinct models deliver a distinct ROC curve and the overall "best" is the one that delivers the highest area under the curve, i.e., the higher outward frontier above the 45 degree line, where the latter traces out the good vs. false positive trade-off under random guesses. Recent applications of the ROC curve methodology to historical data on domestic bank credit in 14 advanced countries are provided in Schularick and

Taylor (2012) and Jordá, Schularick, and Taylor (2012), whereas Satchell and Wei (2006) present an earlier application to credit rating models. Yet, we are not aware of its use in the context of external crisis models.

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 years subsequent to a crisis up to the point 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 start looking at the ROC curve for the bivariate relationship between crisis probability and (lagged) NFA/GDP. . Figure 5 adds to the standard bi-dimensional ROC curve a third axis measuring NFA/GDP. Clearly, even a probit with lagged NFA/GDP as the only explanatory variable does much better than random guessing crisis risk, as the area under the ROC curve is substantial at 0.73 (Table 1). This is actually marginally higher predictive power than that obtained by Schularick and Taylor (2012, Figure 6) on domestic credit crisis using a fuller specification and a homogenous country sample, consisting only of a handful of advanced economies. Moving along the ROC curve in Figure 5, one can glean the trade-offs of setting NFA/GDP thresholds which are "risky": For highly negative NFA (in excess of -100 percent of GDP), the likelihood of a false alarm is trivial; conversely for highly positive NFA (in excess of 100 percent of GDP), which in our sample corresponds to financial centers like Hong Kong, Switzerland, and

Singapore.[6] 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, NFA is about -20 percent of GDP and, as a result, 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); yet, such an aggressive threshold would entail an even higher share of false alarms. As discussed below, we shall focus on the threshold where the signal to noise ratio is maximized, i.e., where the ROC curve is steepest.

Figure 5. ROC curve for NFA only model

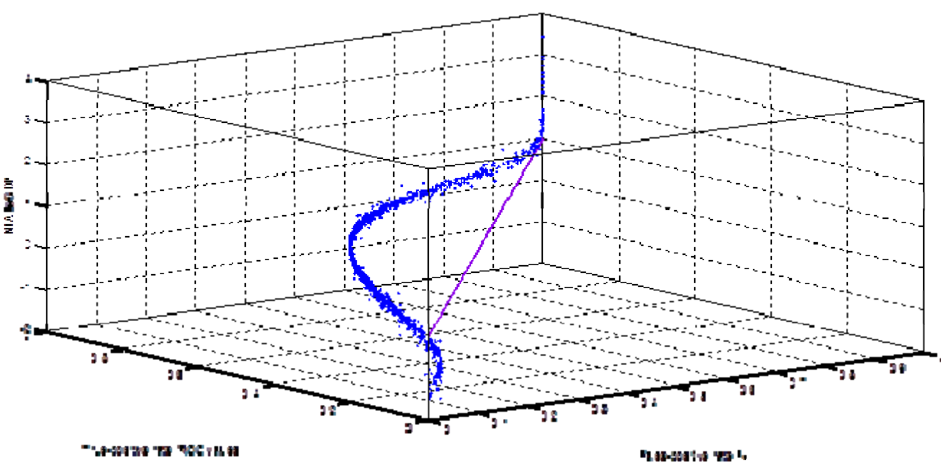


Table 1 shows how disaggregating NFA into debt and equity components improves model performance. Specifically, the area under the ROC curve (AUROC) rises to 0.75 from 0.73, and it rises further to 0.76 adding reserves separately. The biggest marginal jumps in the ROC curve are, however, due to the inclusion of the lagged current account (2-year average) and per capita income relative to the US (PPP basis) to take into account the distinction between

[6] The panel-wide standard deviation of NFA/GDP is 48 percent.

advanced and emerging countries. Adding global financial volatility (proxied by the VIX) as well as REER and fiscal gaps provide additional, even if smaller gains. Overall, this parsimonious model yields an AUROC of 0.90.

Table 1. AUROC Estimates for Various Model Specifications

1) NFA only:	0.73
2) Net Debt, Net Portfolio, FDI:	0.75
3) Adding Reserves:	0.76
4) Adding Per capita Income viz US:	0.82
5) Adding Current Account/GDP:	0.86
6) Adding REER gap:	0.88
7) Adding VIX	0.89
8) Adding Fiscal Balance Gap:	0.9

Table 2 reports the probit coefficients in the various specifications.[7] Consistent with previous work, variables enter the probit model lagged one year and robust standard errors are computed clustered at a country level. Consistent with the above AUROC estimates, net debt, the current account balance, and per capita income are key drivers of crisis risk. The strong significance of the current account is consistent with studies that have found it to be a significant predictor of external crises using a variety of definitions of the latter (Milesi-Ferretti and Razin, 2000; Pistelli et al., 2008). The inclusion of per capita income in turn has the important effect of making FX reserves holdings 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 the inclusion of per capita income controls for this quasi-fixed effect. More notably

[7] 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.

column (6) shows that the coefficient on FDI becomes positive and significant once the current account balance is included in the regression. That is, controlling for an increase in net liability exposure (as measured by the current account balance), higher net FDI liabilities tend to be associated with *lower* crisis risk. This is consistent with previous evidence that higher FDI liabilities are typically associated with improved economic prospects (Borezstein et al., 1998), help relax financing constraints and are a safer form of external financing (Hausmann and Fernandez-Arias, 2001)--the so-called "good cholesterol" view of FDI liabilities.

Table 2. Baseline Crisis Definition: Probit Estimates

VARIABLES	(1) crisis	(2) crisis	(3) crisis	(4) crisis	(5) crisis	(6) crisis	(7) crisis
Net Foreign Assets/GDP	-0.990***						
	(0.193)						
Net external debt assets /GDP		-1.750***	-1.579***	-1.662***	-0.987**	-1.404***	-1.223**
		(0.260)	(0.308)	(0.317)	(0.436)	(0.460)	(0.498)
Net ext. portfolio equity /GDP		-0.156	-0.274	-0.0929	0.314	0.431	0.534
		(0.416)	(0.427)	(0.476)	(0.989)	(1.053)	(1.213)
Net FDI/GDP		-0.301	-0.572	-0.0497	0.676*	0.870**	1.193***
		(0.292)	(0.384)	(0.385)	(0.361)	(0.369)	(0.412)
FX reserves/GDP			-2.200*	-2.828**	-3.230***	-3.704***	-3.984***
			(1.156)	(1.117)	(1.199)	(1.273)	(1.424)
Relative Per Capita Income				-1.497***	-1.602***	-1.905***	-2.294***
				(0.256)	(0.268)	(0.304)	(0.359)
CA balance/GDP (2-year MA)					-8.492***	-7.684***	-10.40***
					(1.950)	(1.901)	(2.439)
REER gap						2.105***	2.001***
						(0.440)	(0.468)
VIX						0.734***	0.697***
						(0.233)	(0.250)
Fiscal Gap							-5.069**
							(2.505)
Observations	2042	2042	2042	2042	2042	2042	1832
Pseudo R-squared	0.07	0.09	0.10	0.17	0.21	0.26	0.31

Also consistent with priors as well as with the evidence presented in Figures 3 and 4, all relative price and global variables are statistically significant. Finally, column (7) indicates that the addition of the fiscal gap (like the REER gap, measured as the general government balance in the given year relative to its five-year moving average) further contributes to crisis risk. In doing so, as one might expect, it reduces somewhat the net external debt and current account coefficients and, yet, both remain highly significant economically and statistically.

Table 3 reports the marginal effects of our final specification (column 6 of Table 2). Because crises are rare events, elasticities appear to be low when computed at the sample mean. However, the non-linearity of the probit specification implies that these elasticities can be substantial when computed at crisis proximity points, where NFA and – in particular – net debt positions are substantially lower than the panel average. This is indicative of the standard non-linearity embodied in probit specifications, except that our estimates indicate it to be particularly steep. The third and fourth column of Table 3 provide two alternative elasticity measures: in the year before a crisis actually materializes, and when crisis probability is higher than 10 percent. Both measures indicate that the elasticity of crisis risk to changes in the covariates can be substantial. For instance, a one standard deviation (SD) increase in net external debt to GDP (a 20 percentage point rise) raises the probability of external crises by over 6 percent and a one SD increase in the current account deficit by some 10 percent. The estimates also suggest a role for reserve accumulation as a crisis precaution device: leaving the net debt position unchanged, an increase in reserves of 7 percent of GDP—the sample standard deviation and a magnitude not far off that observed in some emerging markets over the past decade—reduces crisis risk by some 7 percent.

Table 3. Elasticity Estimates for Preferred Specification

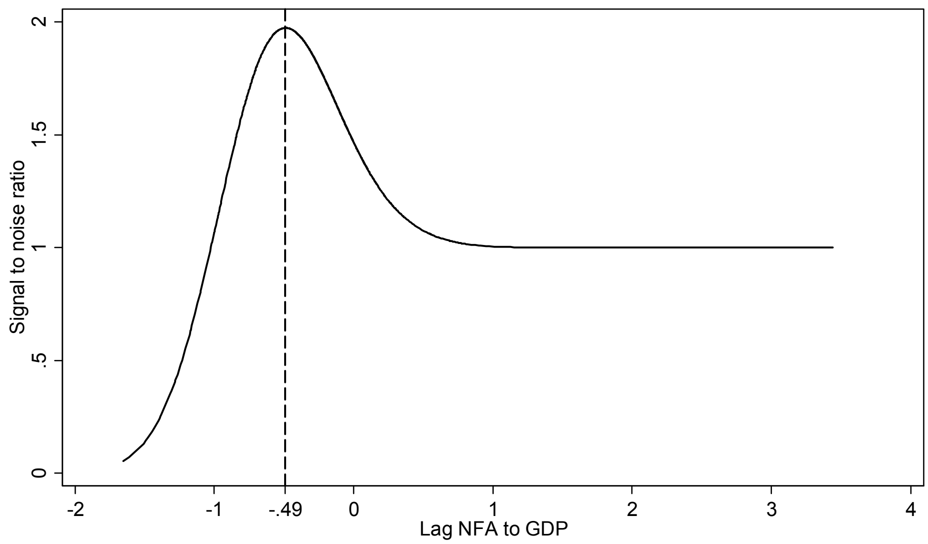
	SD[1/]	dP/dx At mean	dP/dx year prior to crisis	dP/dx when P>0.1
Net external debt assets/GDP	0.20	-0.008	-0.28	-0.32
Net external portfolio equity/GDP	0.10	0.004	0.12	0.14
Net Foreign Direct Investment/GDP	0.11	0.008	0.27	0.32
FX reserves/GDP	0.07	-0.027	-0.91	-1.05
CA balance/GDP (2-year MA)	0.04	-0.072	-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 issue of identifying crisis risk thresholds. All what is needed to pin down the respective tipping points for the various model variables is to combine the above model with the choice of point along the ROC curve. A criterion to select such a point that has been widely used in the EWS literature following the contributions of Lizondo et al., Kaminsky and Reinhart (1997) and Kaminsky and Reinhart (1998), is that of maximizing the signal to noise ratio, i.e., the ratio of true positive to false positives. This corresponds to point where the ROC curve is steepest (i.e. the first derivative is maximized). Using this criterion and a univariate probit of crisis on lagged NFA/GDP (column (1) of Table 2), we obtain a tipping point for NFA/GDP of -49 percent, as shown in Figure 6.

Figure 6. Univariate Model: Threshold for NFA/GDP that Maximizes Signal to Noise



We can also compute the respective tipping points for each of the stock variables in our baseline probit specification of column (7) in Table 2, now conditional on all the multivariate information included in the probit. This is done by computing points in the respective ROC curve where the latter is steepest; as noted above, these correspond to the region where the signal to noise rate is maximized. Because the ROC curve in an actual multivariate distribution is far from entirely smooth, in order to mitigate outliers we compute the region of maximal signal to noise over a symmetric seven-year window. The averaged values of each variable over that window are then reported in Table 4. As can be seen, 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.[8]

[8] Reinhart and Rogoff (2010) report a 60% threshold but referring to ***gross*** external debt—therefore excluding all debt assets such as official foreign exchange reserves, privately-held debt

(continued…)

Table 4: Baseline Multivariate Model: Tipping Point Estimates

Net Foreign Assets/GDP	Net Debt Assets/GDP	Net Portfolio Assets/GDP	Net FDI Assets/GDP	Net Reserve Assets/GDP
-53%	-35%	0%	-18%	4.6%

D. Robustness to Variable Omission

To test the robustness of our favored specification to potential variable omission, we add to the regression a large selection of variables featured in previous work on crisis risk (see Frankel and Saravelos, 2012 for a comprehensive list). As always, all variables enter the regression one-year lagged and robust standard errors are clustered at a country level (Table 5).

The first column adds the current account gap, defined as deviation of the current account from a fundamentals-based "norm" (see Appendix 2). The results indicate that this variable is highly collinear with the unconditional (2-year moving average) current account, but 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.

securities, and foreign loans and deposits by residents. As we show below, our regression results indicate that net external debt is the significant indicator for crisis risk.

Table 5. Robustness to Other Controls

VARIABLES	(1) crisis	(2) crisis	(3) crisis	(4) crisis	(6) crisis	(7) crisis	(8) crisis	(9) crisis	(10) crisis	(11) crisis	(12) crisis
Net external debt assets/GDP	-1.038	-1.314**	-1.197**	-1.221**	-1.156**	-1.160**	-1.181**	-1.247**	-1.165**		-1.209**
	(0.678)	(0.516)	(0.526)	(0.501)	(0.510)	(0.475)	(0.508)	(0.487)	(0.493)		(0.498)
Net external Porftolfio equity/GDP	1.184	0.285	0.459	0.287	0.519	0.517	0.580	0.583	0.603	0.483	0.452
	(1.192)	(1.200)	(1.207)	(1.168)	(1.229)	(1.274)	(1.176)	(1.165)	(1.129)	(1.237)	(1.272)
Net Foreign Direct Investment/GDP	1.145**	1.222***	1.313***	1.153***	1.263***	1.267***	1.263**	0.934**	1.220***	1.067**	0.440
	(0.572)	(0.451)	(0.427)	(0.417)	(0.401)	(0.425)	(0.508)	(0.475)	(0.411)	(0.489)	(0.549)
FX reserves/GDP	-4.161**	-3.347**	-3.958***	-3.589***	-3.939***	-3.917***	-4.090***	-3.470***	-3.752***	-5.362***	-4.539***
	(1.638)	(1.428)	(1.366)	(1.369)	(1.454)	(1.355)	(1.376)	(1.304)	(1.362)	(1.341)	(1.445)
CA balance/GDP (2 year MA)	-11.09**	-9.524***	-11.03***	-9.622***	-10.57***	-10.41***	-10.63***	-10.07***	-10.00***	-10.34***	-10.59***
	(5.232)	(2.398)	(2.807)	(2.474)	(2.428)	(2.393)	(2.448)	(2.446)	(2.378)	(2.446)	(2.365)
Relative Per Capita Income	-2.452***	-2.307***	-2.362***	-2.304***	-2.384***	-2.300***	-2.309***	-2.014***	-2.190***	-2.248***	-2.287***
	(0.410)	(0.375)	(0.365)	(0.359)	(0.385)	(0.362)	(0.372)	(0.384)	(0.377)	(0.376)	(0.374)
REER gap	2.389***	2.055***	2.173***	1.961***	1.885***	1.975***	2.011***	2.223***	2.019***	1.985***	1.921***
	(0.492)	(0.452)	(0.506)	(0.471)	(0.477)	(0.470)	(0.495)	(0.484)	(0.453)	(0.474)	(0.482)
VIX	0.920***	0.790***	0.705***	0.502*	0.688***	0.683***	0.705***	0.816***	0.752***	0.700***	0.710***
	(0.318)	(0.257)	(0.257)	(0.286)	(0.250)	(0.258)	(0.251)	(0.274)	(0.248)	(0.248)	(0.244)
Fiscal Gap	-4.557	-5.850**	-4.116	-4.638*	-4.788*	-5.168**	-4.398*	-5.149*	-5.514**	-5.106**	-5.208**
	(3.214)	(2.610)	(2.512)	(2.491)	(2.454)	(2.548)	(2.365)	(2.706)	(2.528)	(2.492)	(2.527)
Current Account gap	0.134										
	(4.853)										
Overall Public Debt/GDP		-0.325									
		(0.274)									
Growth of Credit/GDP (3-year MA)			-1.175								
			(1.829)								
US Corporate Credit Spread				0.265							
				(0.191)							
Trend Output Growth					-2.947						
					(4.245)						
Foreign Exchange Regime						-0.0551					
						(0.0577)					
(X+M)/GDP (5-year MA)							0.0977				
							(0.680)				
Capital Controls								0.496			
								(0.391)			
Institutional Quality (Polity)									-0.00571		
									(0.0124)		
External Debt Assets/GDP										-1.308***	
										(0.489)	
External Debt Liabilities/GDP										1.243**	
										(0.500)	
Outlier FDI dummy											0.919**
											(0.370)
Observations	1,489	1,780	1,729	1,832	1,826	1,784	1,764	1,739	1,819	1,832	1,832
Pseudo R-squared	0.32	0.30	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Column (2) of Table 5 adds the ratio of general government debt to GDP to the baseline regression. While the external component of the latter is contained in the external debt variable, this variable is a proximate control for the distinction between public and private external debt that has been documented as important to explain global imbalances, growth differentials, and hence (albeit indirectly) country risk (Alfaro et al. 2012). Yet, this yields the "wrong" sign and is highly imprecisely estimated.[9] This is due to colinearity with other controls already present in our favored specification. Indeed, once some other controls are dropped, the country's overall 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 (see, e.g., Catão, Fostel and Kapur, 2009).

Other controls proved to be insignificant. 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) to our favored specification. The point estimate is insignificant and wrongly signed. Again, this is due to the effects of credit growth on crisis risk taking place via other controls already in the baseline specification: dropping all variables but relative per capita income, the credit variable becomes a significant determinant of crisis risk at a 10 percent level. Similar considerations apply to inflation, (HP) trend output growth, trade and financial openness, and institutional quality (polity index): they are statistically insignificant at the 10 percent level (at least) but when entered alone (or when the baseline specification is pruned from other controls), they become significant and correctly signed.

[9] 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. This measurement problem can also contribute to the lack of significance of the public debt variable.

We also break down net positions into their gross counterparts. In the case of debt, this breakdown is clearly 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 but also in a similar vein, Reinhart and Rogoff (2011) focus on gross rather than net external debt in their evidence on the connection between debt and output growth (which, as shown in Figures 3 and 4, typically follows external crisis outbreaks).

Yet, the results in column (11) suggest that in a broad cross-section of countries over our sample period, net debt is what matters for crisis risk: the coefficients on gross debt assets and liabilities are virtually the same and with the opposite sign. Importantly, all the statistically significant coefficients in the baseline specification 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.[10]

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[10] As part of our robustness tests, we have also added fixed effects for every country. None of them changes the economic and statistical significance of the remaining coefficients in our baseline specification. We have also added a country-specific credit history defined as in Reinhart et al. (2004). In contrast with what Aizenman and Noy (2012) find for banking crises, this variable is insignificant in our regressions. One reason is that banking crises do not systematically coincide with external crises. 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. Finally, adding the world output gap, the weighted average of real short-term interest

(continued…)

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

As discussed earlier, our paper focuses on large external crises, rather than on financial crises in general or on sovereign defaults in particular. One might then ask: how would the strength of the above results change with alternative crisis definitions? Table 6 sheds light on this question. Alongside with our baseline crisis definition and preferred specification in column (1), we report probit estimates for three alternative crisis definitions. The first broadens the scope of "external crisis". Specifically, we augment the previous criterion to include any real exchange rate depreciation in excess to 15 percent in any single year or 20 percent in two consecutive years, coupled with negative real GDP growth and/or a drop in the output gap by more than one-standard deviation for each country.[11] In this broader definition, the number of crises rises from 61 to 80 (see Appendix 1). A comparison of columns (1) and (2) of Table 6 shows that the thrust of the earlier results stands. The pseudo- R^2 fit is only marginally worse but the estimated coefficients retain their significance and sign, except for net portfolio equity which becomes negatively signed (though still statistically insignificant).[12]

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rates of G-7 countries, and historical growth volatility (measured as 10-year moving averages of real GDP growth) does not improve on our baseline specification.

[11] Estimates of the output gap were computed as deviations of a HP trend with the smoothing factor set to 100.

[12] Two other differences are the higher coefficient on the current account and the lower coefficient on relative income per capita. Both are reasonably intuitive: the higher coefficient on the current

(continued…)

The other alternative definition, reported in column (3) of Table 6, is narrower: it only encompasses sovereign defaults and reschedulings. This is the definition more widely found in the sovereign debt literature (Borenzstein and Pannizza, 2008; Reinhart and Rogoff, 2009). Its downside is to exclude well-known external crises like Argentina and Mexico in 1995, Thailand and Korea in 1997/98, which would likely have turned into defaults in the absence of multilateral assistance. Be that as it may, many of our earlier results remain unchanged. The only significant differences are the coefficient on the current account and FDI (now smaller and less precisely estimated). On the other hand, the coefficient on debt is nearly twice as high and so is that on reserves. This is unsurprising since we are focusing more squarely on debt defaults and entirely in emerging markets, wherein reserve drainage often plays a much greater role (as in first generation crisis models à la Krugman). Also, net FDI liabilities play much less of a role in crisis prevention. Other probit coefficients are broadly consistent and the higher pseudo R^2 suggests that our specification if anything fits the data better.

The narrower crisis definition of column (3) sets the stage for a more direct comparison between our results and those of Gourinchas and Obtsfeld (2012). The differences between their default/rescheduling sample and ours are fourfold. First, they exclude advanced economies. Second, they include some emerging markets not included in our sample, some of which are repeat defaulters according to their definition (such as Cote d'Ivoire and Nigeria). Third, they include as new defaults credit events that in our sample are part of an earlier

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account is due to the inclusion in the broader sample definition of more episodes of current account reversals (which only sometimes are associated with defaults and reschedulings), so the current account plays a greater role. The lower coefficient on per capita income in the broad crisis definition is due to the inclusion of more advanced countries in the sample where such episodes took place (e.g. the European Monetary System crises of the early 1990s).

broader default episode--particularly in Latin America during the 1980s. Finally, they classify as defaults some credit events not labeled as such in other standard sources (such as South Africa in 1993 and Venezuela in 2005). As a result, one ends up with more crisis events for emerging markets and a total number of default observations comparable to ours. Column (4) reports probit results of this definition of crisis on our set of controls. Net debt, reserves and VIX retain significance, but the coefficient on the current account flips sign, and so does per capita GDP, albeit none is statistically significant at conventional levels. 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.

Final sensitivity tests are reported in the last two columns of Table 6, with the baseline specification estimated over the pre-2007 period. Column (5) shows that eliminating the 2008-11 sovereign crises from the sample does not alter the thrust of the results: in particular, net external debt continues to be a strong predictor of external crises, with a coefficient of broadly similar magnitude. One change relative to the baseline specification of column (1) is that the coefficient on net portfolio equity now becomes negative (i.e., higher net portfolio equity liabilities increases crisis risk), albeit still statistically insignificant. Also, the statistical significance of the net FDI position is due to outlier emerging markets: moving from column (5) to (6) of Table 6, the size of the FDI/GDP coefficient drops and its statistical significance vanishes. This is consistent with what already shown in column (12) of Table 5, the main difference being that, when sample is truncated at 2006, the FDI coefficient generally rises. One reason is that several post-2007 crises occurred in countries with large negative FDI positions (such as those in Central and Eastern Europe).

Table 6. Robustness to Sample Definition and Estimation Period

	(1) baseline crisis definition	(2) broader crisis definition	(3) defaults/ reschedulings only	(4) POG-MO default crisis definition	(5) baseline crisis definition	(6) exc. FDI liability outliers
VARIABLES	1970-2011	1970-2011	1970-2011	1970-2011	1970-2006	1970-2006
Net external debt assets/GDP	-1.223**	-0.991**	-2.103***	-1.269**	-1.847***	-1.678***
	(0.498)	(0.424)	(0.380)	(0.526)	(0.613)	(0.581)
Net ext. portfolio equity/GDP	0.534	-0.741	1.090	1.659	-0.433	-0.543
	(1.213)	(0.584)	(1.737)	(1.803)	(1.181)	(1.258)
Net FDI/GDP	1.193***	1.429***	0.0648	0.395	1.744***	1.154
	(0.412)	(0.398)	(0.490)	(0.373)	(0.510)	(0.803)
FX reserves/GDP	-3.984***	-2.083*	-4.586**	-9.937***	-6.113**	-7.471***
	(1.424)	(1.104)	(1.970)	(2.046)	(2.399)	(2.193)
CA balance/GDP (2 year MA)	-2.294***	-7.518***	-5.612*	4.050	-11.04***	-12.09***
	(0.359)	(2.166)	(2.940)	(2.771)	(3.342)	(3.324)
Relative Per Capita Income	-10.40***	-1.764***	-2.641***	0.493	-2.116***	-2.057***
	(2.439)	(0.305)	(0.536)	(0.454)	(0.360)	(0.373)
REER gap	2.001***	1.898***	2.353***	0.908	2.303***	2.160***
	(0.468)	(0.524)	(0.698)	(0.882)	(0.438)	(0.442)
VIX	0.697***	0.653***	0.517*	0.497*	1.218***	1.092***
	(0.250)	(0.222)	(0.265)	(0.267)	(0.357)	(0.351)
Fiscal Gap	-5.069**	-8.550***	-8.211***	-7.241***	-6.430**	-5.999*
	(2.505)	(2.808)	(2.732)	(2.147)	(3.040)	(3.142)
Observations	1832	1,778	1,797	1,062	1,510	1,442
Pseudo R-squared	0.31	0.26	0.35	0.22	0.34	0.36

To sum up, while distinct definitions of crises and sample breakdowns can have non-trivial effects on point estimates for some of the explanatory variables, including portfolio equity and FDI, the estimated coefficients for net debt, FX reserves, fiscal deficits and global financial conditions (as proxied by the VIX) remain sizeable and statistically significant throughout. No less importantly, regardless of the classification of default or the inclusion or not of large multilateral assistance, AUROC estimates indicate outstanding predictive performance for any of these alternative crisis definitions, once our set of explanatory variables is maintained (Table 7)

Table 7. AUROC for Baseline Probit Using Different Crisis Definitions and Sample Periods

1) Baseline External Crisis Definition, 1970-2011	0.90
2) Broader External Crisis Definition, 1970-2011	0.90
3) Our Default/Reschedulings Definition, 1970-2011	0.89
4) POG-MO default definition, 1970-2011	0.85
5) Baseline External Crisis Definition, 1970-2006	0.91

E. Predictive Power

Table 8 provides the respective goodness of fit statistics of the final specification for our baseline crisis definition (first column of Table 6). We follow the usual practice in the literature of classifying as correct predictions or "good alarms" if the model predicts a crisis probability above a chosen cut-off point and a crisis actually occurs 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 objectives of the analyst/policy maker given the relative cost of missing a crisis vs. giving a false alarm. It is natural to set such cut-off point above the unconditional crisis probability (3 percent in our sample). Table 8 reports on two alternatives: 11 percent (the cut-off that the ROC curve indicates to be the one that maximizes the signal to noise ratio) and 20 percent.

At the more conservative 20 percent 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 now correctly predicts 42 out of 61 observations; so it correctly calls out more than two thirds of all crises. The cost is of course a larger share of false alarms. Overall, the model gets it right 94% of the time.

Table 8. 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 = 10.5% 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%

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 much more heavily parameterized model that correctly predicts (at their chosen 25 percent threshold) 43 percent of crises and correctly classifies 86 percent of observations. Modifications of the Frankel and Rose specification by Berg and Pattillo (1999) increase the share of correct calls at the cost of a high share of false alarms, and overall correct classifications remain around 86 percent. Further, predictive performance is reasonably well-balanced across regions and emerging markets vs advanced economies, with much of the shortfall in in-sample predictive performance being associated with a few episodes in the Africa/Middle East region.

Table 9. Share of Good Signals to Total Crises by Regions

Advanced Countries	Africa & Middle East	Emerging Asia	Emerging Europe	Latin America
67%	40%	77%	60%	70%

Last but not least, we look at the out-of-sample predictive performance over 2007-2011.[13] Using the model estimates over 1970-2006 for the baseline crisis definition (shown in column 5 of Table 6), Table 10 reports the estimated crisis probabilities for the more conservative 20 percent cut-off. In the same table we also include countries and years where and when a crisis actually took place but for which the model fell short of predicting a crisis on the basis of the 20 percent threshold.

[13] Of course what we call out-of-sample performance is not genuinely out of sample in the sense that the events that we seek to predict have already taken place and, hence, our choice of variables could have been informed by this knowledge. Yet, our choice of variables is standard from the viewpoint of theory and the previous empirical literature on debt crises, and does not include variables proxying bank exposures or other financial vulnerability variables found in post-2007 studies seeking to explain 2008-09 events.

Table 10. Out-of-Sample Predictive Power over 2008-2011 Crises

Country	year	crisis	Predicted	Output Gap t	Output Gap t+1	Lagged Debt/Y	Lagged Equity/Y	Lagged FDI/Y	Previous 2 years' CA/Y	Lagged FxRes/Y	Lagged REER gap	Previous year's GGB/Y
Dominican 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 percentage terms.

Color legend:

Crisis correctly predicted

Crisis in an adjacent year

No "formal" crisis but severe economic distress

Crisis missed

The model correctly predicts the Greece and Portugal debt crises events, and also singles out Spain as a high-risk case, with signals "flashing red" since 2008, and relying solely on information on pre-crisis fundamentals. It also correctly predicts the 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 strict crisis definition, the model correctly picks up the major recession that ensued, as indicated by large negative output gaps in the crisis outbreak year as well as the year after that (-8 percent 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 a “proper” external crisis. Overall, our parsimonious model does a reasonable job at predicting out-of-sample the bulk of the 2008-2011 crises, while relying on a parsimonious set of fundamentals without heavy emphasis on financial sector exposures.

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 among all components of NFA and that their contribution to crisis risk is highly statistically significant and reasonably stable across specifications. Second, we find that 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, we also find that 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 the size of current account deficits, is also key. We find that this speed effect is strong for both conditional and unconditional measures of the current account "gap", but also find that the unconditional measure of current account balance performs better than standard regression-based estimates of current account mis-alignment. 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.

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Appendix 1: Sample

	Overall Sample				Crisis Sample (baseline definition)			Crisis Sample (broader crisis definition)	
Country	ifs_code	em	adv		Country	Year	Default	Country	Year
Australia	193	0	1	1	Argentina	1982	1	Argentina	1975
Austria	122	0	1	1	Argentina	1995	0	Argentina	1982
Belgium	124	0	1	1	Argentina	2001	1	Argentina	1995
Belize	339	1	0	1	Belize	2006	1	Belize	2006
Brazil	223	1	0	1	Brazil	1983	1	Argentina	2001
Bulgaria	918	1	0	1	Brazil	1999	0	Brazil	1983
Canada	156	0	1	1	Brazil	2001	0	Brazil	1999
Chile	228	1	0	1	Chile	1972	1	Brazil	2001
China	924	1	0	1	Chile	1983	1	Chile	1972
Colombia	233	1	0	1	Costa Rica	1981	1	Chile	1983
Costa Rica	238	1	0	1	Dominican R	1982	1	Costa Rica	1981
Croatia	960	1	0	1	Dominican R	2003	1	Dominican Republic	1982
Cyprus	423	0	1	1	Dominican R	2009	0	Dominican Republic	2003
Czech Republic	935	1	0	1	Ecuador	1983	1	Dominican Republic	2009
Denmark	128	0	1	1	Ecuador	1999	1	Ecuador	1983
Dominican Republic	243	1	0	1	Ecuador	2008	1	Ecuador	1999
Ecuador	248	1	0	1	Egypt	1984	1	Ecuador	2008
Egypt	469	1	0	1	Greece	2010	0	Egypt	1984
El Salvador	253	1	0	1	Hungary	2008	1	Finland	1993
Estonia	939	1	0	1	Iceland	1976	0	Greece	2010
Finland	172	0	1	1	India	1984	0	Guatemala	1985
France	132	0	1	1	Indonesia	1998	1	Hungary	2008
Germany	134	0	1	1	Israel	1976	0	Iceland	1975
Greece	174	0	1	1	Italy	1975	0	Iceland	1983
Guatemala	258	1	0	1	Jamaica	1978	1	India	1984
Hong Kong	532	0	1	1	Jamaica	2010	1	India	1991
Hungary	944	1	0	1	Jordan	1989	1	Indonesia	1998
India	534	1	0	1	Jordan	1997	0	Israel	1976
Indonesia	536	1	0	1	Jordan	2002	0	Italy	1975
Israel	436	0	1	1	Korea	1975	0	Italy	1993
Italy	136	0	1	1	Korea	1980	0	Jamaica	1978
Jamaica	343	1	0	1	Korea	1997	0	Jamaica	2010
Japan	158	0	1	1	Latvia	2008	0	Jordan	1989
Jordan	439	1	0	1	Mexico	1982	1	Jordan	1997
Korea	542	0	1	1	Mexico	1995	0	Jordan	2002
Latvia	941	1	0	1	Morocco	1981	0	Korea	1975
Lithuania	946	1	0	1	Pakistan	1981	0	Korea	1980
Malaysia	548	1	0	1	Pakistan	1998	1	Korea	1997
Malta	181	0	1	1	Pakistan	2008	0	Korea	2009

Appendix 1: Sample (cont.)

	Overall Sample			
Country	ifs_code	em	adv	
Mexico	273	1	0	1
Morocco	686	1	0	1
Netherlands	138	0	1	1
New Zealand	196	0	1	1
Norway	142	0	1	1
Oman	449	1	0	1
Pakistan	564	1	0	1
Panama	283	1	0	1
Peru	293	1	0	1
Philippines	566	1	0	1
Poland	964	1	0	1
Portugal	182	0	1	1
Romania	968	1	0	1
Russia	922	1	0	1
Serbia	942	1	0	1
Singapore	576	0	1	1
Slovak Republic	936	1	0	1
Slovenia	961	0	1	1
South Africa	199	1	0	1
Spain	184	0	1	1
Sweden	144	0	1	1
Switzerland	146	0	1	1
Taiwan	528	0	1	1
Thailand	578	1	0	1
Turkey	186	1	0	1
Ukraine	926	1	0	1
United Kingdom	112	0	1	1
United States	111	0	1	1
Uruguay	298	1	0	1
Venezuela	299	1	0	1

Crisis Sample (baseline definition)		
Country	Year	Default
Panama	1983	1
Peru	1978	1
Peru	1982	0
Philippines	1976	0
Philippines	1983	1
Poland	1981	1
Portugal	1977	0
Portugal	2011	0
Romania	2009	0
Serbia	2009	1
South Africa	1985	1
Thailand	1981	0
Thailand	1985	0
Thailand	1997	1
Turkey	1976	0
Turkey	2000	0
Turkey	2008	0
Ukraine	1998	1
Ukraine	2008	0
Uruguay	1983	1
Uruguay	2002	0
Venezuela	1983	1

Crisis Sample (broader crisis definition)	
Country	Year
Latvia	2008
Malaysia	1986
Malaysia	1998
Mexico	1982
Mexico	1995
Morocco	1981
Oman	1987
Pakistan	1972
Pakistan	1981
Pakistan	1998
Pakistan	2008
Panama	1983
Peru	1978
Peru	1982
Philippines	1976
Philippines	1983
Philippines	1998
Poland	1981
Portugal	1977
Portugal	2011
Romania	1999
Romania	2009
Serbia	2009
South Africa	1985
Sweden	1993
Thailand	1981
Thailand	1985
Thailand	1997
Turkey	1976
Turkey	1994
Turkey	2000
Turkey	2008
Ukraine	1998
Ukraine	2008
United Kingdom	2009
Uruguay	1972
Uruguay	1983
Uruguay	2002
Venezuela	1983
Venezuela	1996
Venezuela	2002

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, 2011).

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

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

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

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

where ω_i is the respective share of country i in world GDP so that globally $\sum_{j=1}^{N} \omega_j^i = 1$, $\forall$i. The model then closes with a policy rule that relates each country's real interest rate r to the output gap $\tilde{y}_{i_t}$ 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:

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

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

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:

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

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 $\tilde{y}_{i_t} - \tilde{y}_t^{wo}$ 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	0.0452***	0.0455***	0.0442***	0.0465***	0.0452***	0.0473***
	(0.00346)	(0.00351)	(0.00398)	(0.00353)	(0.00346)	(0.00370)
Relative PPP GDPpc	0.0467***	0.0480***	0.0459***	0.0445***	0.0465***	0.0185***
	(0.00563)	(0.00592)	(0.00584)	(0.00582)	(0.00566)	(0.00592)
Oil Balance Dummy	0.287***	0.285***	0.291***	0.277***	0.287***	0.356***
	(0.0471)	(0.0471)	(0.0475)	(0.0466)	(0.0472)	(0.0700)
Old Age Depency Ratio	-0.143***	-0.145***	-0.140***	-0.140***	-0.142***	-0.0802***
	(0.0246)	(0.0250)	(0.0250)	(0.0257)	(0.0246)	(0.0245)
Population Growth	-0.402**	-0.413**	-0.407**	-0.423**	-0.400**	-0.460**
	(0.174)	(0.177)	(0.175)	(0.184)	(0.174)	(0.191)
Polity Index	-0.000747***	-0.000769***	-0.000726***	-0.000781***	-0.000746***	-0.000214
	(0.000189)	(0.000194)	(0.000186)	(0.000206)	(0.000190)	(0.000192)
Trend Growth	-0.262***	-0.264***	-0.260***	-0.265***	-0.262***	-0.291***
	(0.0574)	(0.0575)	(0.0588)	(0.0555)	(0.0574)	(0.0675)
General Gov. Balance (cyc.adj)	0.375***	0.375***	0.369***	0.456***	0.377***	0.452***
	(0.0580)	(0.0583)	(0.0556)	(0.0578)	(0.0585)	(0.0616)
Quinn Index of Capital Controls	0.0226***	0.0228***	0.0232***	0.0224***	0.0227***	0.0160***
	(0.00469)	(0.00473)	(0.00462)	(0.00499)	(0.00480)	(0.00575)
Aging Speed		-0.0131				
		(0.0203)				
Financial Center Dummy			0.00395			
			(0.00654)			
Trade Openness (5-year MA)				-0.00222		
				(0.00598)		
Reserve Currency Dummy					0.000841	
					(0.00300)	
Social Protection Index						-0.0132
						(0.00938)
Constant	0.0103***	0.0106***	0.00943***	0.0104***	0.0102***	0.00498**
	(0.00227)	(0.00231)	(0.00270)	(0.00313)	(0.00239)	(0.00232)
Observations	2,300	2,300	2,300	2,134	2,300	1,891
R-squared	0.319	0.319	0.319	0.341	0.319	0.344

Robust SEs in parentheses

*** p<0.01, ** p<0.05, * p<0.1