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ABSTRACT

This paper investigates whether leading indicators can help explain the cross-country incidence of the 2008-09 financial crisis. Rather than looking for indicators with specific relevance to the current crisis, the selection of variables is driven by an extensive review of more than eighty papers from the previous literature on early warning indicators. The review suggests that central bank reserves and past movements in the real exchange rate are the two leading indicators that have proven the most useful in explaining crisis incidence across different countries and crises in the past. For the 2008-09 crisis, we use six different variables to measure crisis incidence: drops in GDP and industrial production, currency depreciation, stock market performance, reserve losses, or participation in an IMF program. We find that the level of reserves in 2007 appears as a consistent and statistically significant leading indicator of the current crisis, in line with the conclusions of the earlier literature. In addition to reserves, recent real appreciation is a statistically significant predictor of devaluation and of a measure of exchange market pressure during the current crisis. That our data on the crisis period include the first quarter of 2009 may explain why we find stronger results than earlier papers such as Obstfeld, Shambaugh and Taylor (2009, 2010) and Rose and Spiegel (2009a,b).

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1. Introduction

This paper places itself in the long line of the early warning indicators literature by attempting to identify variables that may help explain crisis incidence in 2008-09. This literature has recently achieved renewed relevance. At the height of the crisis in November 2008, the G20 group of nations asked the IMF to conduct new early warning exercises, followed by a call for the fund "to provide early warning of macroeconomic and financial risks and the actions needed to address them" in the April 2009 London summit.[1] An assessment of whether any variables can explain 2008-09 crisis incidence is highly relevant to evaluating the usefulness of such future exercises.

Aside from generating increased policymaker interest, the 2008-09 crisis is particularly well suited to undertaking an assessment of the potential usefulness of leading indicators. First, the very large magnitude of the current crisis makes it a good candidate against which the predictive power of various variables can be tested. Second, the crisis has been uniquely broad and relatively synchronized across the global economy. As such, a global sample can be used, and issues related to the timing of crisis incidence and the modeling of staggered spillover effects can be largely finessed.[2]

The next section of the paper conducts an extensive review of more than eighty papers from the early warning indicators literature. We ask whether any variables have consistently proven successful as leading indicators of crisis incidence in the past. This review drives the selection of variables for the empirical analysis of the 2008-09 crisis.

The third section of the paper conducts an empirical investigation into which countries proved most vulnerable during the 2008-09 crisis. We investigate whether any of the economic or financial variables were able to predict successfully the incidence of the financial crisis. The focus is on the variables identified in the literature review, rather than indicators specifically selected for the 2008-09 crisis. A country is considered more "vulnerable" if it experienced larger output drops, bigger stock market falls, greater currency weakness, larger losses in reserves, or the need for access to IMF funds. The fourth section of the paper evaluates the economic significance of the results and draws policy implications from our findings.

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[1] http://www.g20.utoronto.ca/2009/2009communique0402.html

[2] Rose and Speigel (2009b) distinguish between common shocks and the international transmission of shocks originating from a crisis country. This paper focuses on the former, and does not consider bilateral shocks between a crisis country and others.

2.1 The Challenges of the Early Warning Indicators Literature

The early warning indicators literature is extensive. However, identifying broad lessons from this empirical work is fraught with difficulties. First, the definitions of a financial crisis and the severity of incidence vary widely. These differences will be explored in more detail below. Second, the literature investigates different types of crisis, in different countries and over different time periods. The results from most of these studies therefore lack generality, and the lessons learned from one crisis and country may not be relevant for another. Third, and perhaps most importantly, the empirical work on leading indicators faces a problem of selection bias. The variables examined as indicators are selected with the benefit of hindsight, albeit usually based on some underlying economic reasoning. Even if these are identified as statistically significant, their usefulness can be questionable if they have been identified after the crisis has occurred.

To overcome the limitations above, the approach taken here is to identify the causes and symptoms of financial crises, if any, that have been most consistent over time, country and crisis. We conduct a broad review of the literature, and attempt to categorize systematically the empirical findings into a ranking of the indicators that have been found to be statistically significant. Rather than focusing on the specific causes of this crisis, we examine the success of the indicators identified in the earlier literature in predicting 2008-09 financial crisis incidence.

2.2 Definitions of "crisis" and "crisis incidence"

While the variety of independent variables used to explain crisis incidence has been extensive, the literature has converged on a narrower set of dependent variables used to measure the intensity and occurrence of crises. This notwithstanding, there is still wide variation in the way a crisis is defined, as highlighted by both Kaminsky, Lizondo and Reinhart (1996, henceforth KLR) and Abiad (2002).

The literature uses both discrete and continuous measures to define a crisis. Discrete measures are usually in the form of binary variables, which define a crisis as occurring once a

particular threshold value of some economic or financial variable has been breached. Frankel and Rose (1996) define a "currency crash" as a depreciation of the nominal exchange rate of more than 25% that is also at least a 10% increase in the rate of nominal depreciation from the previous year. Another measure, popularized by Eichengreen, Rose and Wyplosz (1995), defines an "exchange market crisis" as occurring when their index of speculative pressure moves at least two standard deviations above its mean. Continuous measures of crisis incidence overcome the problem of defining particular thresholds by measuring crisis intensity on a continuous scale.

The literature has focused on a relatively narrow set of variables that are used in defining a crisis. The vast majority of studies include some measure of changes in the exchange rate. These include bilateral nominal exchange rates predominantly against the US dollar (for instance Edwards 1989; Frankel and Rose 1996; Bruggemann and Linne 1999; Osband and Rijckeghem 2000), real exchange rates (Goldfajn and Valdes 1998; Esquivel and Larrain 1998; Apoteker and Barthelemy 2000), and changes in the SDR exchange rate (Rose and Spiegel 2009a, 2009b). Exchange rate changes have often been combined with movements in reserves to create indices of exchange market pressure that measure crisis intensity regardless of exchange rate regime (Sachs, Tornell and Velasco 1996a,b; Corsetti, et al, 1998; Fratzcher, 1998; KLR 1998; Berg and Pattillo 1999; Tornell 1999; Bussiere and Mulder 1999, 2000; Collins 2001; and Frankel and Wei (2005).) Some also include changes in interest rates, alongside changes in reserves and the exchange rate, to account comprehensively for central bank defense against speculative attacks (Eichengreen, Rose and Wyplosz 1995; Herrera and Garcia 1999; Hawkins and Klau 2000; Krkoska 2001). Less frequently used indicators have included the drop in GDP (Ghosh and Ghosh 2002) and equity market changes (Grier and Grier 2001). Some authors use regime-switching approaches that define a crisis endogenously by simultaneously identifying speculative attacks and the determinants of switching to speculative regimes (Cerra and Saxena 2000; Martinez Peria 2002).

2.3 Model Specifications

The different modeling approaches employed in the leading indicators literature can be broadly grouped into four categories. (See Abiad 2002; Hawkins and Klaw 2000; Collins 2001 for similar categorizations.) The first and most popular category uses linear regression or limited dependent variable probit/logit techniques. These are used to test the statistical significance of various indicators in determining the incidence or probability of occurrence of a financial crisis across a cross-section of countries. Some of the first studies to use these techniques include Eichengreen, Rose and Wypslosz (1995), Frankel and Rose (1996) and Sachs, Tornell and Velasco (1996a, b), but they have since been used widely.

The second category, known as the non-parametric, indicators, or signals approach was first popularized by KLR (1998) and further developed in studies such as Bruggemann and Linne (2000) and Edison (2003). The approach consists of selecting a number of variables as leading indicators of a crisis, and determining threshold values beyond which a crisis signal is considered to be given. While the statistical significance of the indicators used cannot be determined directly because the thresholds are determined within-sample, statistical tests can be undertaken to investigate the out-of-sample performance of these indicators. Tests of the out-of-sample significance of the KLR and other signal-based models have been undertaken by, among others, Berg and Patillo (1999), Bussiere and Mulder (1999) and Berg, Borenztein and Patillo (2004), who have shown these models to be moderately successful in predicting financial crises.

The third category employs a qualitative and quantitative analysis of the behavior of various variables around crisis occurrence by splitting countries into a crisis and non-crisis control group. These techniques were predominantly used in the earlier leading indicators literature, with Kamin (1988), Edwards (1989), Edwards and Montiel (1989), Edwards and Santaella (1993) using some of the largest samples. Unlike the more recent literature, these consist of panel studies where the emphasis is on trying to predict the date at which a crisis occurs, rather than on the cross-sectional incidence of crisis.

The fourth, and most recent, category encompasses the use of more innovative techniques to identify and explain crisis incidence, including the use of binary recursive trees to determine leading indicator crisis thresholds (Ghosh and Ghosh 2002; Frankel and Wei 2004), artificial neural networks and genetic algorithms to select the most appropriate indicators (Nag and Mitra 1999; Apoteker and Barthelemy 2001) and Markov switching models (Cerra and Saxena 2001; Martinez Peria 2002).

2.4 What We Know from the Literature

The wide range of estimation techniques notwithstanding, the literature has converged on a number of independent variables which are most frequently examined as leading indicators of crisis incidence. A useful starting point for an overview of previous work are the three extensive reviews conducted by KLR (1998) for studies up to 1997, Hawkins and Klau (2000) for studies up to 2000 and Abiad (2002) for studies up to 2001. These three reviews survey more than eighty papers conducted over a period covering crisis episodes from the 1950s up to 2002. Abiad (2002) does not however provide a systematic ranking of which indicators were found to be statistically significant across the various studies investigated. Furthermore, neither Abiad (2002) nor Hawkins and Klau (2000) include all of each other's studies in their reviews. This section integrates the findings of all three reviews, and provides a more systematic analysis of the indicators in the studies cited by Abiad (2002). We also evaluate the results of seven new papers published since 2002.

Table 1 below summarizes the number of times a particular indicator was found to be statistically significant across the reviews and additional studies cited above. The indicator listing is based on Hawkins and Klau (2000) with some modifications, and the footnotes to the table indicate which variables have been included in each indicator category. Appendix 1 includes a detailed breakdown of the criteria used to identify significant variables in the papers cited by Abiad (2002) and the most recent literature.

Based on the results below, foreign exchange reserves, the real exchange rate, the growth rate of credit, GDP and the current account are the most frequent statistically significant indicators in the papers reviewed. Different measures of reserves and of the real exchange rate in particular stand out as the top two most important leading indicators, being statistically significant determinants of crisis incidence in more than half of the 83 papers reviewed.

Such a meta-analysis of the literature is plagued with the usual limitations of a comparative exercise. First, a common feature of all studies is that some indicators are included

Table 1 Summary of pre-2008 Early Warning Indicators

Leading Indicator[1]	KLR (1998) [2]	Hawkins and Klau (2001)[3]	Abiad (2003)[4,6]	Others[5,6]	Total
Reserves[a]	14	18	13	5	50
Real Exchange Rate[b]	12	22	11	3	48
GDP[c]	6	15	1	3	25
Credit[d]	5	8	6	3	22
Current Account[e]	4	10	6	2	22
Money Supply[f]	2	16	1	0	19
Exports or Imports[1a, g]	2	9	4	2	17
Inflation	5	7	1	2	15
Equity Returns	1	8	3	1	13
Real Interest Rate[h]	2	8	2	1	13
Debt Composition[1b, i]	4	4	2	0	10
Budget Balance	3	5	1	0	9
Terms of Trade	2	6	1	0	9
Contagion[j]	1	5	0	0	6
Political/Legal	3	2	1	0	6
Capital Flows[1c, k]	3	0	0	0	3
External Debt[l]	0	1	1	1	3
Number of Studies	28	28	20	7	83

Notes

[1, 1a, 1b, 1c] Leading indicator categories as in Hawkins and Klau (2000), with exception of [1a]includes imports, [1b]debt composition rather than debt to international banks, [1c]capital flows rather than capital account.

[2]As reported in Hawkins and Klau (2000), but M2/reserves added to reserves, interest rate differential added to real interest rate.

[3]S&P, JP Morgan, IMF Indices, IMF *WEO*, IMF ICM, IMF EWS studies have been excluded due to lack of verifiability of results. The following adjustments have been made to the authors' checklist: significant credit variables reduced from 10 to 8 as Kaminsky (1999) considers level rather than growth rate of credit; significant capital account variables reduced from 1 to 0 as Honohan (1997) variable not in line with definition used here; Kaminsky (1999) significant variables for external debt reclassified to debt composition as these variables relate to short-term debt.

[4]10 out of 30 studies excluded from analysis. 7 included in Hawkins and Klau (2000) and 3 due to absence of formal testing of variables.

[5]Includes Berg, Borenzstein and Pattillo (2004), Manasse and Roubini (2005), Shimpalee and Breuer (2006), Davis and Karim (2008), Bergmen et.al. (2009), Obstfeld, Shambaugh and Taylor (2009), Rose and Speigel (2009a).

[6]See App. 1 for criteria defining statistical significance in Abiad (2003) and Others studies. For rest see KLR (1998), Hawkins & Klau (2001)

Variables included in the leading indicator categories:

[a]Reserves: relative to GDP, M2, short-term debt, 12m change
[b]Real Exchange Rate: change, over/under valuation
[c]GDP: growth, level, output gap
[d]Credit: nominal or real growth
[e]Current Account: Current Account/GDP, Trade Balance/GDP
[f]Money Supply: growth rate, excess M1 balances
[g]Exports or Imports: relative to GDP, growth
[h]Real Interest Rate: domestic or differential
[i]Debt Composition: commercial/concess./variable-rate/ debt to internat. banks/short-term/multilat./official relative to total external debt. Short-term debt relative to reserves (rather than relative to total external debt) is in the reserves category
[j]Contagion: dummies for crisis elsewhere
[k]Capital Flows: FDI, short-term capital flows
[l]External Debt: relative to GDP

more frequently than others. This is usually due to differences in data availability or because some variables have a stronger theoretical or intuitive underpinning as crisis indicators. The small number of statistically significant variables for some indicators does not necessarily mean that they have been tested and found to be non-significant, but that in some cases they may have not been investigated as extensively in the literature. Political and legal variables, variables for financial openness and for the exchange rate regime stand out in this regard. In contrast, the current account stands out as a variable which, while frequently included as an independent variable, has not always exhibited statistical significance.

The second limitation is that the criteria used to determine which indicators are significant in KLR (1998), Hawkins and Klau (2000) and in the last two columns by us are different. KLR (1998) include variables that have been found to be significant in at least one of the tests conducted in each paper, Hawkins and Klau (2000) use varying criteria, and we identify those variables that are statistically significant in the absolute majority of the different regressions or other estimation techniques used.

These limitations notwithstanding, it is encouraging that a broadly similar ranking of statistical significance is generated across all three reviews considered and the more recent literature. Both reserves and the real exchange rate are the two most significant indicators across all the review groupings considered, while credit, GDP and the current account rank highly in most of the columns of the table. In addition, an aggregation exercise of this type has the benefit of ensuring robustness of results. Consistency of statistical significance of an indicator across different periods and using different estimation techniques and crisis definitions makes for a more reliable indicator for policy making purposes.

2.5 Recent Research on the 2008-09 Crisis

Empirical work on the 2008-09 crisis is still in its infancy, in part due to a lack of data and partly because the crisis had not yet concluded as of 2009. Most of the studies that have been undertaken have focused on analyzing the crisis in 2008. Obstfeld, Shambaugh and Taylor (2009, 2010) were among the first to investigate empirically the incidence of the crisis. The authors measure crisis incidence as the percentage depreciation of local currencies against the

US dollar over 2008, and find that the excess of reserves (as a proportion of M2) over the values predicted by their model of reserve demand is a statistically significant predictor of currency depreciation over 2008. These results notwithstanding, the unadjusted level of reserves/M2 is not found to be a statistically significant predictor of crisis incidence. Furthermore, the overall size of the sample is limited and their results lack statistical robustness across different country samples.

A second and broader empirical contribution to the literature are the papers by Rose and Spiegel (2009a; 2009b), who model crisis incidence as a combination of 2008 changes in real GDP, the stock market, country credit ratings and the exchange rate. The authors perform an extensive investigation into over sixty potential variables that could help explain cross-country crisis incidence (2009a) as well as country-specific contagion effects (2009b). The authors fail to identify *any* consistently statistically significant variables of crisis incidence, with the possible exception of stock market returns. Though the sample is broader than that used by Obstfeld, Shamaugh and Taylor (2009), the 2008 calendar year period over which the authors measure crisis incidence remains somewhat arbitrary. The crisis hit most of the global economy in the second half of 2008, with global output and financial markets continuing to contract in early 2009.

A more recent paper by Berkmen et al. (2009) measures crisis incidence differently as the change in 2009 growth forecasts by professional economists before and after the crisis hit. They find that countries with more leveraged domestic financial systems and more rapid credit growth tended to suffer larger downward revisions to their growth outlooks, while exchange-rate flexibility also helped reduce the impact of the shock. Interestingly, as in Rose and Spiegel (2009a) and Blanchard et al (2009), the authors find little evidence that international reserves played a significant role in explaining crisis incidence. These results notwithstanding, their measure of crisis incidence has its limitations, focusing on revisions to growth forecasts by professional economists rather than actual growth outturns. Data on actual economic performance was not available at the time.

3.1 Predicting the Incidence of the 2008-09 Financial Crisis

A consistent theme of the most recent literature is that the leading indicators that most frequently appeared in earlier reviews are not statistically significant indicators of crisis incidence. This section builds on the recent work on the financial crisis, with three key innovations. First, crisis incidence is measured using five different variables and over two different time periods, to help ensure robustness of results. Second, greater attention is given to the leading indicators that have been identified as useful by the literature prior to 2008, rather than focusing on variables that may be uniquely chosen for the current crisis. The main aim of this empirical exercise is to examine the consistency of these indicators in predicting crisis vulnerability over time, country and crisis. Finally, data encompassing financial market and economic developments up to the second quarter of 2009 are included in the financial crisis incidence measures used. Many equity markets and real output indicators continued to decline up to the first and second quarters of 2009 respectively, suggesting that the crisis continued beyond the end of 2008. As such a more accurate measurement of crisis incidence requires the inclusion of this period in the analysis.

3.2 The Dataset

Our data consists of 50 annual macroeconomic and financial variables for 2007 or earlier from the World Bank World Development Indicators database. This source is augmented by monthly real effective and nominal exchange rate data from the IMF International Financial Statistics database, the Klein-Shambaugh (2006) measure of exchange rate regime as of 2004 and the Chinn-Ito (2007) measure of financial openness updated to 2007. Data availability differs by country, with the most data points available for the level and growth rate of GDP (122 countries) and the least data available for various measures of short-term debt (67 countries). High frequency data for foreign exchange rates (156 countries), stock market indices (77 countries), industrial production (58 countries) and GDP (63 countries) up to the second half of 2009 are sourced from Bloomberg and Datastream for the financial and real data respectively.[3] The high frequency data are used to define crisis incidence from the second half of 2008

[3] Some industrial production and GDP data have been taken from national statistical sources. For industrial production, data for China, New Zealand and Ukraine were taken from national statistics. For GDP, the data for Poland are from national sources.

onwards, as analyzed in more detail below. All the independent variables are dated from 2007 or earlier, minimizing endogeneity issues.

3.3 Defining the 2008-09 Crisis

An important element of an analysis of leading indicators is how crisis incidence is defined. We interpret crisis incidence broadly, defining it both in terms of financial and real incidence. The key difference from the earlier empirical work is that we consider the crisis to have continued into 2009, rather than having ended in 2008. Many real output indicators and asset prices continued to decline after December 2008, while measures of market risk such as the VIX and sovereign bond spreads remained elevated (see appendix 2 for a graphical illustration). The crisis measures used are:

(a) *Nominal local currency percentage change* versus the US dollar from 15th September 2008 to 9th March 2009. The starting date is picked as the day of the Lehman Brothers bankruptcy. Though asset prices peaked and many measures of financial market risk started to rise prior to this date, financial market dislocations became particularly synchronized and abrupt after this date (see appendix 2). Identifying the end date is less straightforward, with different financial market variables beginning to recover on different dates. In this paper, the end date is identified as the bottom in the MSCI world equity index. The US dollar (as measured by the Federal Reserve broad trade-weighted dollar index) also peaked a few days earlier, perhaps signaling a peak in global risk-aversion and flight to quality.[4]

(b) *Equity market returns* in domestic stock market benchmark indices over the same period as above, adjusted for the volatility of returns.[5] This method is preferred to simple percent returns, to account for the differing risk-return characteristics of each

[4] Aït-Sahalia, et al (2010) also date the global phase of the financial crisis as beginning with collapse of Lehman Brothers on September 14, 2008, and ending March 31, 2009. As additional justification for the end-date, they point out that the G20 Leaders Summit on Financial Markets and the World Economy, which tackled the crisis, was held in London on April 1-2, 2009.

[5] Returns are calculated as the annualized percentage daily returns over the period divided by annualized volatility.

local stock market. All else equal, a more volatile stock market index will produce a risk-adjusted return that is closer to zero.

(c) *Percentage change in the level of real GDP* from end-June 2008 to end-June 2009. Though the NBER declared December 2007 as the start of the US recession, the global economy continued growing up to the second quarter of 2008 based on a number of high frequency variables such as industrial production and the institute of supply management's global purchasing manager index (PMI). Based on these indicators, output began to recover in the second quarter of 2009. It thus seems fitting to measure the fall in GDP in the four quarters to Q2 2009. Measuring GDP over four quarters also overcomes any seasonality problems.

(d) *Percentage change in industrial production* from end-June 2008 to end-June 2009. This is used as an alternative measure of real crisis incidence. The composition of GDP varies widely across economies, so industrial production may be a more consistent measure of the impact of the crisis across economies.

(e) *Recourse to IMF financing* from July 2008 to November 2009. This includes all countries that requested funds from the IMF under Stand-by Arrangements, the Poverty Reduction and Growth Facility and Exogenous Shock Facility (see appendix 3 for countries included). Countries with an established Flexible Credit Line are not included, as no funds have been drawn under this arrangement. The variable is a binary crisis indicator, taking the value 1 if a country participated in an IMF program and 0 otherwise.

Though the literature has frequently combined exchange rate moves with losses in international reserves as a measure of crisis incidence, reserves are not included in the baseline indicators above. There are two reasons. First, measured reserves go up when central banks draw credit under IMF programs. The level of reserves is thus affected by the large number of IMF programs initiated during the current crisis, with many countries showing large jumps in reserves at the peak of the crisis. Even if the IMF funds are stripped out, the drop in international reserves

is a biased measure of crisis incidence, as their level would have likely been much lower in the absence of an IMF program. Second, movements in exchange rates cause severe valuation distortions in reserves. If one chooses to value reserves in US dollars for instance, the data indicate large drops in reserves for many Eastern European countries. This however reflects not only a volume loss in reserves, but also a paper loss on their value: the appreciation in the US dollar during the crisis reduced the dollar value of reserves of European countries due to the large proportion of euros in their portfolios.

These two drawbacks notwithstanding, the inclusion of reserves as a measure of crisis incidence allows one to observe an increase in market pressure that may not otherwise be captured through exchange rate moves. This is particularly relevant for countries with fixed exchange rate regimes, where capital flight and crisis incidence are manifest through larger drops in reserves rather than exchange rate weakness.[6] We augment our analysis in Section 3.6 with an exchange market pressure index that does include reserves and attempts to correct for both of the problems highlighted above.

3.4 Independent Variables

The independent variables selected are based on the indicators identified in the literature review. The explanatory variables all refer to the 2007 calendar year, unless noted otherwise, and are grouped into the following categories:

Reserves

Reserves appeared as the most frequent statistically significant variable in the literature. The measures included in this study are reserves as percentage of GDP, reserves as a percentage of total external debt, reserves in months of imports, the ratio of M2 to total reserves and short term debt as percentage of total reserves.

Real Effective Exchange Rate

[6] The Baltic countries stand out in this regard. Despite a fixed exchange rate to the euro, they suffered from capital outflows, large reserve losses and severe recessions during the 2008-09 crisis. Poland, on the other hand, experienced currency weakness but smaller output drops.

The source of these data is the IMF's real effective exchange rate database. The variables used are the percentage change in the REER over the last five years, and the percentage deviation of the REER in December 2007 from its ten year average. A rise in the REER index represents a stronger local currency.

Gross Domestic Product

GDP growth in 2007, as well as the average GDP growth rates over 2003-07 (5 year average) and 1998-2007 (10 year average) are used. We also include the level of GDP per capita (expressed in 2000 constant US dollars).

Credit

The variables included are the five and ten year rise in domestic credit as a percentage of GDP. Sachs, Tornell and Velasco (1996a,b), who were among the first to popularize this measure, argue that it is a good proxy of banking system vulnerability, as rapid credit expansion is likely associated with a decline in lending standards. A credit depth of information index as well as the bank liquid reserves to bank assets ratio are also used, as alternative measures of banking system vulnerability.

Current Account

Variables under this category are the current account balance as a percentage of GDP in 2007, and the average balance in the five and ten years up to 2007. Net national savings as a percentage of GNI and gross national savings as a percentage of GDP are also included in this category.

Money Supply

The ten- and five-year growth rates of liquid liabilities (M3) and money and quasi-money (M2) are used. Alternative leading indicators relating to the money supply such as the money multiplier and excess M1 balances are not included due to a lack of data availability.

Exports and Imports

This includes exports, imports and the trade balance as a percentage of GDP.

Inflation

The two variables are the average CPI inflation rate over the last five and ten years.

Equity Returns

Equity market returns are measured as the five year percentage change in benchmark stock market indices expressed in local currencies, as well as the five year volatility-adjusted return. The source of these data is Bloomberg.

Interest Rate

The real interest rate as well as deposit rates are included.

Debt Composition

The variables included in this category are the amount of short-term debt as a percentage of exports and as a percentage of total external debt, public and publicly guaranteed debt service as a percentage of exports and of GNI, multilateral debt service as a percentage of public and publicly guaranteed debt service, aid as a percentage of GNI and gross financing via international capital markets as a percentage of GDP. Earlier research has mostly focused on the effects of short-term debt, finding a positive relationship with crisis incidence (Frankel and Rose 1996; Kaminsky 1999; among others). The relationship between crisis incidence and public debt or aid/debt owed to multilaterals has been examined less frequently. Some studies suggest a positive and negative effect of crisis incidence and public and multilateral debt respectively (Frankel and Rose 1996; Milesi-Ferretti and Razin 2000).

Legal/Business Variables

The variables under this category are the strength of legal rights index and business extent of disclosure index included in the World Development Indicators database.

Capital Flows

The variables measured are net foreign direct investment inflows, outflows and total FDI flows, as well as portfolio flows (debt and equity), all expressed as a percentage of GDP. The first two variables refer to net FDI by foreign companies into the domestic economy and by domestic

companies to foreign markets respectively. Total FDI flows are calculated as the sum of inflows and outflows. A larger amount of total FDI flows into the economy, considered a more stable source of balance of payments financing, is expected to have a negative relationship with crisis incidence. Larger portfolio flows, considered more easily reversible, are expected to be associated with higher crisis incidence.

External Debt

External debt is represented by total debt service as a percentage of GNI, and by the net present value expressed as a percentage of exports and GNI.

Peg/Financial Openness

The Chinn-Ito (2007) measure of financial openness updated to 2007 and the Klein-Shambaugh (2007) measure of exchange rate regime as of 2004 are used. The former is transformed into a binary variable, with a country considered financially closed if the index value belongs to the bottom 30th percentile. Twenty-three additional countries were included in the latter dataset, based on the authors' own calculations.

Regional/Income Dummy Variables

Dummy variables to account for three different income groups (lower, middle and upper) based on the World Bank definition were included. Regional dummy variables included South Asia, Europe and Central Asia, Middle East and North Africa, East Asia and the Pacific, Sub-Saharan Africa, Latin America and the Caribbean and North America.

3.5 Empirical Analysis

3.5.1 Dependent Variables

We start the empirical analysis with a quantitative description of the dependent variables used to define crisis incidence. Appendix 4 presents the top and bottom ten performing countries on each of the continuous variables used. Some of the usual suspects figure prominently. Many

Eastern European countries show up as suffering the most from the crisis. China stands out as a country that suffered less. Strikingly, it is the only country that appears in the list of best-performers across all four variables. While some of the differences in country rankings across indicators reflect different data availability,[7] the differences can be mostly attributed to country-specific economic factors.

The Baltic countries suffered some of the largest drops in industrial production and GDP, but the tenacity of their exchange rate pegs to the euro meant that their currencies did not depreciate versus the dollar in comparison with other emerging market currencies. Similarly, despite the large drops in Japan's GDP and industrial production, the Japanese yen was one of the top performing currencies during the crisis, largely due to the unwinding of the yen carry trade (as Rose and Spiegel 2009a also point out). The differences in the measurement of crisis incidence reinforces the need to use multiple definitions of crisis incidence against which the predictive power of various leading indicators can be tested.

Continuing the descriptive statistics, Appendix 5 presents correlation coefficients across the four continuous variables and the binary IMF variable. Unlike the rankings presented above, the results here offer a more consistent picture. All ten cross-correlations have the expected sign, and half are statistically significant at the 10% level or less. Unsurprisingly, the highest correlations are between the changes in GDP and industrial production. Stock market performance also appears to correlate well with changes in real output. On the other hand, the change in the exchange rate has the weakest correlation with the other variables, likely reflecting the presence of exchange rate pegs in the sample of countries examined.

3.5.2 Bivariate Regressions

We begin the statistical analysis by running bivariate regressions of the crisis incidence indicators on each independent variable. The bivariate tests are meant to be exploratory, though it would also be useful for practitioners to have simple rules of thumb phrased in terms of individual variables. For the exchange rate, equity market, industrial production and GDP

[7] Our sample does not included stock market returns for Ukraine for instance, so Ukraine does not show up in the bottom-ten list of the equity market indicator.

indicators we use ordinary least squares estimation. For the binary IMF recourse variable, a maximum likelihood probit model is estimated. The output is a total of 305 regressions, the results of which are reported in Appendix 6.

This initial approach offers some moderately encouraging results. Both reserves and the real effective exchange rate, identified as the two most useful leading indicators in earlier literature, appear as useful predictors of some measures of 2008-09 crisis incidence. For international reserves, all five measures have at least two statistically significant coefficients with consistent signs. More than half of all regressions are statistically significant at the 5% level or less. All regressions including the real effective exchange rate have the consistent signs (high past REER appreciation is associated with higher incidence), though they appear as statistically significant only when regressed against the exchange rate crisis indicator. Credit growth, the current account/savings rate, inflation, capital flows, the level and profile of external debt and the money supply also stand out as potentially useful variables, though full analysis is reserved for the section below.

3.5.3 Bivariate Regressions with Income Level as Control Variable

Looking across the various variables, the income group dummies as well as GDP per capita appear highly statistically significant across most crisis indicators. Though rich countries had a smaller probability of seeking IMF funds, the relationship is negative across all the continuous indicators, suggesting that richer countries suffered more from the 2008-09 crisis than poorer ones. This is a departure from historical patterns, but confirms the Rose and Speigel results (2009a). Based on this and following the aforementioned authors, we use the log of income per capita as a conditioning variable and re-run the regressions above. The results of these bivariate regressions are reported in table 2 below.

The coefficients on *reserves* remain statistically significant at the 5% level across more than half of the regressions performed, with reserves expressed relative to external debt, GDP, or short-term debt standing out as the most consistently significant indicators. (The coefficients on reserves expressed in months of imports are also statistically significant in two out of the five crisis measures.) Thus the variable that has shown up most frequently in the preceding literature

(recall Table 1) performs well in predicting vulnerability in 2008-09, contrary to Blanchard et al (2009), Rose and Spiegel (2009a,b)and others. Past appreciation as measured by the *real effective exchange rate* also appears as a significant leading predictor of currency weakness during the 2008-09 crisis, and has a correct and consistent sign in all other regressions.

Turning to the next indicators on the list, the *rise in credit* variables, they have the anticipated signs across all measures, and at both the five and ten year horizon: higher credit growth is associated with higher crisis incidence. Only three out of the ten regressions considered are statistically significant however. The rise in credit is particularly associated with greater subsequent stock market weakness. An indicator focusing more narrowly on the *liquidity of the banking system*, measured as banks' liquid reserves to bank assets ratio, also has a consistent and negative sign across all specifications. Though the latter variable does not figure prominently in the earlier literature, the finding is in line with Berkmen et al (2009), who conclude that countries with a more leveraged financial system and higher credit growth suffered more during the crisis.

Three other indicators from the analysis are worth mentioning. First, higher past *GDP* growth is associated with larger output drops during the current crisis, as well as a higher probability of recourse to the IMF. This appears somewhat counterintuitive, but may be attributable to a positive link between higher GDP growth rates and asset market bubbles and credit or commodity export booms.[8] Second, all five measures of the *current account* and *national savings* have consistent signs in all specifications. The coefficients are statistically significant in the majority of the regressions, suggesting that countries with a higher pool of national savings and less need to borrow from the rest of the world suffered comparatively less during the current crisis.

[8] From the data available, Macau, China, Latvia, Georgia and Belarus were the top five growth performers over 2003-07, but with the exception of China subsequently suffered large output drops.

Table 2 - Effect of Predictors on Five Different Measures of Country Performance in 2008-09 Crisis

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
RESERVES	*Reserves (% GDP)*	**0.083 (2.51)**	0.585 (1.22)	**-1.371 (-1.96)**	**0.101 (2.07)**	-0.001 (-0.05)	Yes
	Reserves (% external debt)	-0.000 (-0.61)	**0.000 (2.21)**	**-0.009 (-3.25)**	**0.000 (2.98)**	**0.000 (2.75)**	Yes
	Reserves (in months of imports)	0.002 (1.55)	**0.081 (4.34)**	**-0.168 (-3.25)**	0.004 (0.92)	0.001 (0.42)	Yes
	M2 to Reserves	0.000 (0.34)	**-0.016 (-1.87)**	-0.038 (-0.95)	0.000 (0.42)	0.001 (2.49)	
	Short-term Debt (% of reserves)	**-0.000 (-2.82)**	**-0.007 (-3.93)**	0.000 (1.23)	-0.000 (-1.22)	**-0.000 (-2.14)**	Yes
REER	*REER (5-yr % appreciation of local currency)*	**-0.290 (-5.13)**	-0.893 (-1.15)	0.927 (1.1)	-0.046 (-0.68)	-0.037 (-0.95)	
	REER (Deviation from 10-yr av)	**-0.297 (-3.11)**	-1.398 (-1.37)	1.371 (1.33)	-0.047 (-0.51)	-0.051 (-0.95)	
GDP	*GDP growth (2007, %)*	0.002 (1.36)	0.004 (0.07)	**0.041 (1.67)**	0.005 (1.07)	**-0.004 (-2.81)**	Yes
	GDP Growth (last 5 yrs)	0.002 (0.79)	0.022 (0.31)	**0.050 (1.58)**	0.003 (0.6)	**-0.007 (-2.86)**	
	GDP Growth (last 10 yrs)	0.004 (1.47)	-0.022 (-0.24)	0.035 (1.05)	0.009 (1.3)	-0.008 (-1.6)	
CREDIT	*Change in Credit (5-yr rise, % GDP)*	-0.027 (-0.7)	**-1.736 (-4.43)**	0.565 (1.03)	-0.054 (-0.96)	-0.055 (-1.66)	
	Change in Credit (10-yr rise, % GDP)	**-0.023 (-2.32)**	**-0.669 (-2.7)**	0.246 (1.45)	-0.013 (-0.41)	-0.010 (-0.53)	Yes
	Credit Depth of Information Index (higher=more)	-0.004 (-0.76)	-0.028 (-0.32)	**0.152 (2.13)**	0.011 (1.17)	-0.001 (-0.17)	
	Bank liquid reserves to bank assets ratio (%)	**0.000 (1.71)**	-0.002 (-0.11)	**-0.000 (-13.84)**	0.000 (0.71)	0.001 (1.66)	Yes
CURRENT ACCOUNT	*Current Account (% GDP)*	0.001 (1.63)	**0.063 (6.51)**	**-0.031 (-2.73)**	0.001 (1.4)	0.001 (1.14)	Yes
	Current Account, 5-yr Average (% GDP)	0.001 (1.29)	**0.066 (4.95)**	**-0.024 (-1.72)**	0.002 (1.38)	0.000 (0.67)	Yes
	Current Account, 10-yr Average (% GDP)	0.001 (0.98)	**0.083 (4.6)**	**-0.030 (-1.86)**	0.002 (1.11)	**0.002 (1.71)**	Yes
	Net National Savings (% GNI)	0.000 (0.88)	**0.038 (3.64)**	**-0.021 (-1.83)**	**0.002 (1.83)**	**0.002 (2.3)**	Yes
	Gross National Savings (% GDP)	0.001 (1.07)	**0.046 (3.95)**	**-0.025 (-2.24)**	**0.003 (2.45)**	**0.002 (2.62)**	Yes
MONEY	*Change in M3 (5-yr rise, % GDP)*	0.000 (0.27)	-0.019 (-1.5)	-0.001 (-0.13)	-0.002 (-1.64)	-0.001 (-1.29)	
	Change in M2 (5-yr rise, % GDP)	0.000 (0.19)	-0.024 (-1.56)	0.006 (0.52)	-0.002 (-1.3)	-0.002 (-1.23)	

Table 2 continued

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
TRADE	*Trade Balance (% GDP)*	0.000 (1.26)	**0.043 (3.43)**	**-0.015 (-1.77)**	0.000 (0.6)	0.000 (0.73)	Yes
	Exports (% GDP)	0.000 (1.02)	-0.001 (-0.34)	-0.000 (-0.11)	-0.000 (-0.62)	-0.000 (-0.53)	
	Imports (% GDP)	0.000 (0.15)	-0.005 (-1.17)	0.005 (1.62)	-0.000 (-0.82)	-0.000 (-0.83)	
INFL.	*Inflation (average, last 5 yrs)*	0.000 (0.11)	0.012 (0.26)	**0.071 (2.86)**	-0.004 (-1.25)	-0.004 (-1.67)	
	Inflation (average, last 10 yrs)	-0.001 (-1.32)	0.009 (0.4)	0.010 (1.21)	**-0.001 (-2.15)**	-0.000 (-0.67)	
STOCK MKT	*Stock Market (5 yr % change)*	-0.005 (-1.21)	-0.017 (-0.71)	0.005 (0.12)	-0.005 (-1.08)	-0.002 (-0.68)	
	Stock Market (5 yr return/st.dev.)	-0.038 (-1.51)	**-0.540 (-2.14)**	0.026 (0.08)	**-0.071 (-2.6)**	-0.021 (-1.02)	Yes
INT RATE	*Real Interest Rate*	-0.000 (-0.68)	**0.025 (1.91)**	-0.005 (-0.29)	0.001 (0.77)	**0.004 (2.05)**	Yes
	Deposit Interest Rate	**-0.006 (-2.44)**	**0.076 (2.21)**	0.032 (1.03)	0.001 (0.77)	-0.002 (-1.56)	
DEBT COMPOSITION	*Short-term Debt (% of exports)*	-0.000 (-0.91)	**-0.024 (-3.41)**	0.000 (0.01)	-0.000 (-1.61)	**-0.001 (-2.87)**	Yes
	Short-term Debt (% of external debt)	-0.001 (-1.14)	-0.012 (-0.55)	0.006 (0.83)	-0.000 (-0.13)	-0.000 (-0.02)	
	Public Debt Service (% of exports)	**0.001 (2.01)**	0.026 (0.95)	-0.012 (-1.19)	-0.001 (-0.75)	0.002 (1.33)	
	Public Debt Service (% GNI)	**0.001 (2)**	-0.003 (-0.11)	-0.031 (-0.73)	-0.005 (-0.74)	0.007 (1.18)	
	Multilateral Debt Service (% Public Debt Service)	0.000 (1.19)	-0.003 (-0.41)	0.001 (0.18)	0.000 (0.2)	0.000 (0.64)	
	Aid (% of GNI)	**0.000 (2.45)**	-0.035 (-1.11)	-0.012 (-1.16)	-0.000 (-0.12)	-0.007 (-0.48)	
	Financing via Int. Cap. Markets (gross, % GDP)	0.000 (0.69)	-0.022 (-0.94)	-0.003 (-0.51)	0.001 (0.66)	**-0.007 (-2.05)**	
	Legal Rights Index (higher=more rights)	**-0.008 (-1.99)**	**-0.112 (-2.15)**	0.009 (0.18)	-0.001 (-0.3)	-0.003 (-0.98)	Yes
	Business Extent of Disclosure Index (higher=more disclosure)	-0.005 (-1.54)	0.033 (0.65)	0.010 (0.24)	0.007 (1.39)	0.003 (1.31)	
CAPITAL FLOWS	*Portfolio Flows (% GDP)*	**-0.478 (-3.57)**	0.213 (0.07)	2.059 (0.68)	0.602 (1.23)	-0.733 (-0.96)	
	FDI net inflows (% GDP)	-0.000 (-0.09)	**-0.001 (-1.94)**	0.002 (1.02)	**-0.000 (-7.42)**	-0.000 (-0.24)	Yes
	FDI net outflows (% GDP)	-0.000 (-0.27)	**0.000 (2.3)**	-0.002 (-1.24)	**0.000 (7.66)**	-0.000 (-0.19)	Yes
	Net FDI (% GDP)	-0.000 (-0.2)	-0.002 (-0.47)	-0.009 (-0.98)	**0.001 (5.91)**	-0.000 (-0.9)	

Table 2 concluded

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
EXT DEBT	*External Debt Service (% GNI)*	0.000 (1.12)	**-0.062 (-2.23)**	-0.005 (-0.57)	-0.001 (-0.48)	**-0.004 (-4.42)**	Yes
	Present Value of External Debt (% exports)	-0.000 (-0.14)	**-0.007 (-4.23)**	-0.000 (-0.21)	-0.000 (-1.04)	**-0.000 (-2.28)**	Yes
	Present Value of External Debt (% GNI)	0.000 (0.02)	**-0.015 (-3.7)**	-0.000 (-0.49)	-0.000 (-0.89)	**-0.000 (-3.44)**	Yes
	Peg (1 = peg)	**0.058 (3.13)**	-0.379 (-1.56)	-0.272 (-1.05)	-0.038 (-1.52)	-0.016 (-1.13)	
	Financial Openness (0=open)	0.011 (0.51)	0.306 (0.92)	-0.163 (-0.64)	0.051 (0.98)	0.006 (0.19)	
REGION	*South Asia*	**0.067 (3.36)**	0.338 (0.84)	0.074 (0.15)	**0.139 (4.49)**	0.010 (0.29)	Yes
	Europe & Central Asia	**-0.076 (-3.9)**	**-1.017 (-4.19)**	**0.713 (2.5)**	**-0.063 (-3.21)**	**-0.048 (-3.43)**	Yes
	Middle East & North Africa	**0.078 (3.57)**	**0.509 (2.36)**	-0.536 (-1.04)	**0.058 (2.3)**	**0.066 (4.88)**	Yes
	East Asia & Pacific	0.020 (0.84)	**0.414 (1.81)**	**-1.001 (-2.13)**	**0.060 (2.09)**	**0.035 (2.63)**	Yes
	Sub-Saharan Africa	**-0.074 (-2.57)**	-0.089 (-0.26)	0.063 (0.2)	**0.053 (4.04)**	0.008 (0.78)	
	Latin America & Carribean	0.014 (0.44)	-0.314 (-0.75)	0.270 (0.59)	-0.009 (-0.35)	-0.040 (-1.53)	
	North America	0.035 (0.54)	**-0.568 (-3.08)**	-	0.010 (0.55)	**0.022 (2.92)**	

**OLS with heteroscedasticity robust standard errors performed for four continuous variables; probit for IMF recourse variable*
^At least two statistically signficant coefficients at 10% level, of which all must have consistent sign (consistent = same sign, with exception of coefficient on IMF recourse variable, which should have opposite sign)

Third, both the *level of external debt* and the *proportion of short term debt* appear useful leading indicators. The coefficients on short-term debt measured in terms of reserves (classified here in the reserves category), as a percentage of exports or relative to external debt have consistent signs across all specifications, with the first two measures also appearing as statistically significant in at least two of the five crisis incidence measures. The level of external debt appears particularly useful in explaining output and equity market drops, but not for the alternative crisis incidence measures.

Though no other indicators appear as consistently useful leading indicators, it is worth highlighting the estimation results of the *peg* and *financial openness* dummy variables. Countries

with a floating exchange rate were more likely to see currency weakness and to require access to IMF funds, though at the same time they suffered smaller GDP and stock market drops, the latter being in line with the findings of Berkmen et al (2009). Financial openness does not appear to be a statistically significant indicator of any of the crisis measures, though the signs on the coefficients are intuitively appealing, suggesting that financially open countries suffered more from the current crisis.

In sum, the results above are in line with the findings of the literature review, suggesting that international reserves were one of the most useful leading indicators of crisis incidence in 2008-09. Real exchange rate overvaluation, the other of the most popular indicators, is also useful, for predicting currency market crashes, which is the crisis measure on which the majority of studies in the literature have focused. High past credit growth was associated with higher incidence, perhaps via asset bubbles. Finally, the current account/national savings and the level of external and short-term external debt were also found to help consistently predict crisis incidence.

It is worth noting that each crisis incidence indicator is likely to be driven by different independent variables, though a more complete analysis is beyond the scope of this paper. The aim here has rather been to show that a limited set of variables –identified in earlier literature – can predict crisis incidence measured in five different ways.

3.6 Introducing an Exchange Market Pressure Index

The literature has often used exchange market pressure indices combining changes in exchange rates and international reserves to measure crisis incidence. Following a similar methodology to Eichengreen, Rose and Wyplosz (1995), we create an exchange market pressure index measured as a weighted average of exchange rate and reserve changes. The weights are determined by the inverse of the relative standard deviation of each series to compensate for the different volatilities of each series. The changes in the variables are measured from end-August 2008 to end-March 2009, to cover the most severe period of the financial crisis as identified in Section 3.3. The source of the data is the IMF International Financial Statistics database.

As highlighted earlier, the inclusion of reserves in such an index may bias crisis severity downwards due to the presence of a large number of IMF programs during the current crisis. At the same time, valuation distortions due to the large exchange rate movements that occurred over the period are also likely to misstate the true pressure on different countries' reserve holdings depending on their composition. We attempt to correct for these biases in two ways. First, for those countries that received IMF funding during the August-March period, reserves are treated as if they dropped to zero by the end of the period. In the absence of an IMF program, it is presumed that these countries would have suffered from a complete depletion of reserves. Second, to overcome the valuation problem, we make assumptions about their currency composition. First, we group countries by exchange rate arrangement following the IMF Annual Report on Exchange Arrangements 2008 categorization (IMF 2008). Currency and reserve changes in countries with exchange rate anchors to the USD, EUR and a composite basket are measured in terms of US dollars, euros and SDRs, respectively. Changes in the value of currencies and reserves for all other countries following alternative arrangements are measured in terms of US dollars.[9]

Table 3 below reports the results of regressions of the exchange pressure index against a number of leading indicators. The selection of the indicators in the first two regressions is driven by the findings of the literature review and the empirical results of the previous section. The second regression combining GDP per capita, reserves, past exchange rate appreciation and a peg dummy is used as the baseline specification. We experiment with sequentially adding variables belonging to each of the categories of leading indicators reported in table 2.

The coefficients on reserves and the real effective exchange rate retain their significance for the majority of the multivariate specifications considered. The coefficient on reserves relative to GDP maintains its statistical significance across regressions 1-3 when replaced with reserves

[9] The rationale for this categorization is as follows: those countries pegging to the US dollar or euro are likely to have the majority of their reserves denominated in these currencies. Therefore, it makes sense to measure exchange rate and reserve changes in terms of the foreign currency to which the local currency is pegged. The reserve composition and currency basket weights of most countries following composite anchors are not publicly disclosed. Currency and reserve changes are measured against the IMF Special Drawing Right (SDR) in this instance. SDR weights are constructed on the basis of global export and reserve holding patterns, and therefore provide a reasonable first attempt at proxying the composition of these countries' reserve holdings and currency basket weights. In the absence of a relative benchmark for the free-floating currencies, the US dollar is used, following the majority of the literature.

Table 3 - Multivariate Specifications

Effect of Predictors on Country Exchange Market Pressure in 2008-09 Crisis[1]

t-stat in parentheses

	Regression Specification			
	1	**2**	**3**	**4**
Independent Variables, as of 2007				
Real GDP per capita	0.0014	0.0043		0.0083
	(0.17)	*(0.33)*		*(0.58)*
Reserves (% GDP)	0.1642	0.1310	0.1247	0.0950
	*(3.63)***	*(2.03)***	*(2.00)***	*(1.56)*
Rise in REER[2] (%, 2003-07)		-0.3647	-0.3574	-0.4387
		*(-3.57)***	*(-3.45)***	*(-4.61)***
Peg Dummy (1=peg; else 0)		0.1013	0.1009	0.0547
		*(2.95)***	*(2.95)***	*(1.59)**
Net FDI (% GDP)				0.0020
				*(1.65)**
Number of Observations	151	65	66	54
R-squared	4%	31%	30%	37%

Heteroscedasticity robust standard erros calculated; OLS for all specifications

** if signficant at 10% level; ** if significant at 5% level*

[1]A higher index is associated with lower crisis incidence

[2]a higher REER is associated with local currency appreciation

measured in months of imports, but loses significance when reserves are measured in terms of short-term or external debt and M2.[10] Of the additional variables added to the baseline regression 2, only net foreign direct investment appears statistically significant at the 10% significance level. The results of this augmented specification are reported in the last column of table 3. The coefficient on real exchange rate appreciation retains its significance, but reserves lose their significance. As in the earlier analysis, reserves and the real effective exchange rate stand out as two of the most important leading indicators of crisis incidence.

[10] The number of data points falls significantly when reserves are measured in terms of short-term or external debt, perhaps explaining the loss in significance in these specifications.

3.7 Robustness Analysis

This section examines alternative crisis incidence measures to assess the robustness of the earlier analysis. In addition to the exchange market pressure index analyzed above, we introduce the following alternative crisis incidence measures: *Nominal local currency* changes versus the US dollar are measured from end-June 2008 to the end of June 2009 rather than over the September 15th – March 9th 2009 period. *Equity market returns* are measured in terms of percentage returns over September 15th – March 9th 2009, rather than in terms of risk-adjusted returns. The *recourse to IMF variable* is modified to include only access to Standby Arrangement programs, which are aimed at addressing immediate balance of payment financing shortfalls.

We repeat the bivariate analysis of Section 3.5.3 by regressing the exchange market pressure index and the modified crisis incidence measures on all independent variables while controlling for GDP per capita. The results are reported in Appendix 7. Comparing the four modified crisis incidence variables to those used in the earlier analysis, international reserves again stand out as a useful leading indicator. All measures of reserves with the exception of reserves relative to M2 remain statistically significant in at least two of the four modified measures used, as in the main body of the analysis. Past real effective exchange rate appreciation is still a significant variable in explaining currency weakness, and is also now significant in determining the probability of recourse to an IMF Standby Arrangement. The coefficients on the current account/national savings, credit growth, GDP, and total and short-term external debt all exhibit similar patterns of statistical significance to the main analysis, indicating that the results are robust to the methodology used to calculate crisis incidence. [11]

4 Economic Significance and Policy Implications

[11] The most notable differences are that the current account, national savings and the trade balance now appear as statistically significant when used as leading indicators of currency market weakness; the financial openness and peg dummies are significant as a leading indicator of recourse to IMF Standby arrangements

The econometric analysis above confirmed that the top two indicators identified in the literature review, the level of international reserves and real exchange rate overvaluation were also useful leading indicators of the 2008-09 crisis. Reserves appear consistently useful across the majority of the crisis measures used, while past real exchange rate appreciation play a significant role in explaining currency weakness as well as the broader measure of exchange market pressure.

Turning to the economic interpretation of these results, the estimates from the multivariate specifications in Table 3 help give a sense of the relative impact of reserves and past currency appreciation in explaining crisis incidence. A level of reserves equivalent to approximately 100% of GDP is associated with a one standard deviation fall in crisis intensity as measured through the exchange market pressure index. This is slightly more than the difference in 2008-09 crisis intensity experienced between China and India, or half the intensity difference between China and Russia. Similarly, a 45% appreciation in the real exchange rate over the five years prior to 2008 was also associated with approximately a one standard deviation move higher in crisis intensity during the crisis.

Two key policy implications can be derived from this analysis. First, the level of reserves stands out as a key leading indicator of crisis incidence as measured through a variety of variables. To the extent that a low level of reserves are a cause, rather than just an indicator of country vulnerability to external shocks, this would suggest that the large accumulation of reserves by many developing countries prior to 2008 may have played an important role in reducing their vulnerability during the latest crisis. It also comes in contrast with some of the recent research suggesting that reserves did not play a significant role in shielding countries from the crisis (Blanchard et al 2009; Rose and Spiegel 2009a). The results here lend credence to the usefulness of reserve accumulation policies as insurance during periods of crisis.

Second, this paper strikes a more positive note than other recent papers on the usefulness of leading indicators in predicting crisis incidence. In spite of the differences in financial crisis characteristics across time and geography, the literature review identified a number of indicators that have proven consistently useful in explaining crisis incidence. These findings were confirmed by the empirical investigation of the 2008-09 crisis. Nevertheless, the implication of these findings should be treated with caution. First, the variables identified as the most useful were not consistently significant across all crisis measured used. Second, the ideal early warning

system would not only be able to *explain* the incidence of crisis, as this – and most other papers - have attempted to do, but also *predict* incidence ahead of time. This requires the estimation of model parameters based on past crises episodes, so that early warning signals can be generated before the crisis is observed. Berg and Patillo (1999) and Berg, Borensztein and Patillo (2004), have spearheaded such out-of-sample assessments, and a relevant inquiry into how well existing early warning systems would have done in predicting the current crisis is an area of promising research.

5 Conclusion

This paper conducted an extensive review of the early warning indicators literature, and found a number of variables to be consistently useful in predicting financial crisis incidence across time, country and crisis in earlier work. These indicators were subsequently included in an empirical analysis of the 2008-09 crisis. International reserves and real exchange rate overvaluation, the top two indicators identified in the review, stood out as useful leading indicators of the current crisis. Reserves were robust to a number of crisis incidence definitions as well as the inclusion of additional independent variables in multivariate specifications using an exchange market pressure index as a measure of crisis incidence. Past exchange rate overvaluation only proved useful for measures of crisis incidence that defined a crisis in terms of the currency.

A number of other variables appear as potentially useful leading indicators during the current crisis, though their robustness across different crisis incidence measures and specifications was not as compelling. Lower past credit growth, larger current accounts/saving rates, lower external and short-term debt were associated with lower crisis incidence.

There remains fertile ground for further research into the effectiveness of early warning systems in predicting the 2008-09 crisis and beyond. The findings also highlight the potential economic significance of reserve levels and exchange rate policy in affecting crisis vulnerability.

6 Appendix

Appendix 1

Criteria Used to Identify Variable as Significant in Table 1

Study	*Criteria used/Variables Included*
Studies in Abiad (2003)	
Berg and Pattillo (1999b)	Indicators that are statistically signficant in 2 out of the 3 probit models used
Bruggemann and Linne (2000)	No statistical test on individual indicators, because composite indicator used, which includes real exchange rate overvaluation, export growth and reserves. These variables are included in table 1
Bussiere and Mulder (2000)	Variables significant in at least 5 out of 8 models used, table 2, p. 318
Bussiere and Mulder (1999)	Variables signficant in EWS model, table 6, Appendix 1
Collins (2001)	Variables statistically signficant in both tables 2 and 4, Appendix
Eliasson and Kreuter (2001)	Variables significant in both Asia and Latin America panels, in both dynamic and static specifications
Ghosh and Ghosh (2002)	Variables significant at 10% level or less in at least two out of three regressions in probit model, table 1
Herrera and Garcia (1999)	Five variables included in aggregate indicator. Statistical signficance not examined, but out of sample predictive power evaluated
Grier and Grier (2001)	Variables signficant in 2 out of 3 equations in table 1; stock market returns are also included based on results from table 2
Kamin, Mehrez and Schmukler (2000)	Significant variables in 3/4 regressions in all country tables 6(a),spec.1, 6(b), specs 1,2,3
Krikoska (2001)	Significant variables in 3/5 regressions in table 3

Study	*Criteria used/Variables Included*
Kumar, Moorthy and Perraudin (2002)	Significant variables in 3/4 regressions , table 1
Kwack (2000)	Results in table 1 report no statistical significance for relevant variables
Martinez Peria (2002)	Budget deficit (statistically significant in both table 1 & 2) and interest rate (significant in table 1) are included
Mulder, Perrelli and Rocha (2002)	All Berg and Patillo (1999) variables with exception of export growth and reserve change are significant in Appendix table 6 regressions
Nag and Mittra (1999)	Common variables selected for all three countries through authors artificial neural network analysis
Nitithanprapas and Willett (2000)	Variables signficant in three out of five specifications in tables 1-5
Osband and Van Rijckeghem (2000)	Variables in best three filters in table 1 (highest number of extractions)
Weller (2001)	Statistically signficant variables in 3 out of 4 regressions, table 5
Zhang (2001)	No indicators found to be individually statistically signficant
Studies in 'Others' category	
Berkmen et. al. (2009)	Variables significant in at least 2 out of 3 regressions in table 1
Borensztein, Pattillo and Berg (2004)	All variables in the EWS model (augmented KLR) that performs best out of sample included

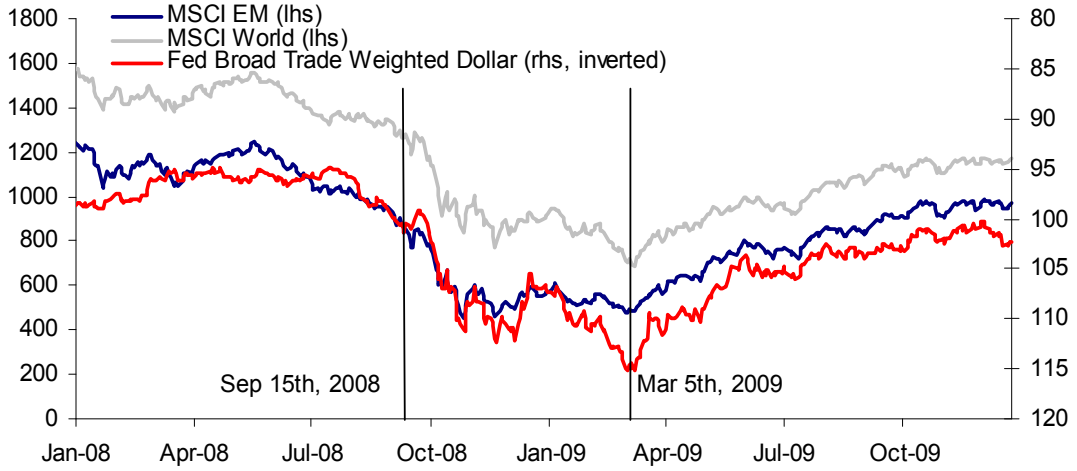
Study	*Criteria used/Variables Included*
Davis and Karim (2008)	Variables significant at 10% level or less in both regressions reported in Table 7, regression 6
Manasse and Roubini (2005)	Variables classified by authors as sufficient for classification and prediction of crisis
Shimpalee and Breuer (2006)	Variables significant in 2 out of 3 estimations, based on information in tables 2-4 and footnote 9
Rose and Spiegel (2009a and 2009b)	Stock market returns and GDP per capita are found to be the only significant indicators by the authors
Obstfeld et. al. (2009)	The authors show that the excess of international reserves over their model predictions is a good predictor of currency performance during the 2008 crisis. Reserves is therefore included as a variable

Statistical significance defined as t-statistic greater than 2 in absolute value unless otherwise noted.

Appendix 2 – Financial Market Indicators Over Crisis Period Chosen

Figure 1: Equity Market Volatility and Bond Spreads

Figure 2: Equity Markets and US Trade Weighted Dollar



Appendix 3

Countries with Access to IMF funds from July 1st 2008 to November 30th 2009

Stand By Arrangements

Angola	El Salvador	Latvia	Sri Lanka
Armenia	Gabon	Mongolia	Ukraine
Belarus	Georgia	Pakistan	
Bosnia and Herzegovina	Guatemala	Romania	
Costa Rica	Hungary	Serbia	
Dominican Republic	Iceland	Seychelles	

Poverty Reduction and Growth Facility and Exog. Shock Facility

Burundi	Ethiopia	Sao Tome and Principe
Comoros	Ghana	Senegal
Congo, Rep.	Kyrgyz Republic	Tajikistan
Cote d'Ivoire	Malawi	Tanzania
Djibouti	Mozambique	

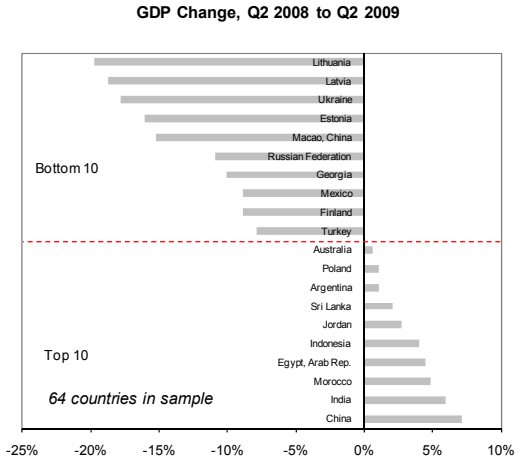
*Flexible Credit Lines**

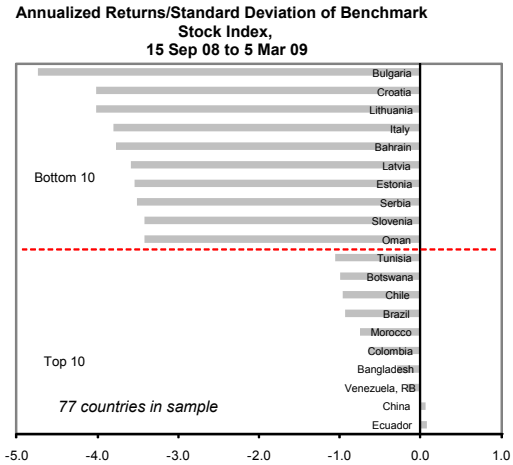
Colombia
Mexico
Poland

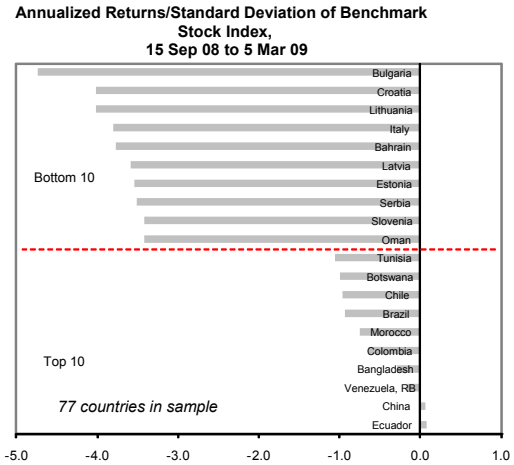
**Not included in recourse to IMF dummy*

source: IMF Financial Activities - Update December 31, 2009
http://www.imf.org/external/np/tre/activity/2009/123109.htm

Appendix 4 – Best and Worst Performing Countries by Crisis Incidence Indicator







Appendix 5 – Cross-correlations of Crisis Incidence Indicators

	Industrial Production	Foreign Exchange Rate^	GDP	Equity Market	Recourse to IMF^^
Industrial Production	100%				
Foreign Exchange Rate^	**11%**	100%			
GDP	**68%***	**17%**	100%		
Equity Market	**48%***	**4%**	**49%***	100%	
Recourse to IMF^^	**-13%**	**-20%***	**-23%***	**-9%**	100%

^ change in LCU versus USD; ^^1=if recourse to IMF; 0 otherwise
** indicates statistical signficance at the 10% level or more; bolded if 'correct' sign*

Appendix 6

Table Appendix 6: Effect of Predictors on Five Different Measures of Country Performance in 2008-09 Crisis

Coefficients of Bivariate Regressions of Crisis Indicators on Each Independent Variable* (t-stat in parentheses)

bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
RESERVES	*Reserves (% GDP)*	**0.082 (2.52)**	0.850 (1.6)	**-1.020 (-1.92)**	**0.155 (2.22)**	0.008 (0.27)	Yes
	Reserves (% external debt)	-0.000 (-1.42)	**0.000 (2.11)**	**-0.010 (-3.42)**	**0.000 (3.62)**	**0.000 (3.07)**	Yes
	Reserves (in months of imports)	0.002 (1.58)	**0.103 (4.71)**	**-0.089 (-3.31)**	0.006 (1.48)	0.001 (0.75)	Yes
	M2 to Reserves	0.000 (0.14)	**-0.026 (-3.81)**	-0.067 (-1)	**-0.001 (-2.46)**	0.000 (1.44)	Yes
	Short-term Debt (% of reserves)	**-0.000 (-2.6)**	**-0.007 (-4.45)**	0.000 (1.18)	-0.000 (-1.7)	**-0.000 (-2.93)**	Yes
REER	*REER (5-yr % appreciation of local currency)*	**-0.293 (-5.4)**	-0.303 (-0.32)	0.889 (0.99)	-0.000 (-0.01)	-0.029 (-0.85)	
	REER (Deviation from 10-yr av)	**-0.292 (-2.93)**	-0.920 (-0.81)	0.671 (0.58)	-0.000 (-0.01)	-0.041 (-0.91)	
GDP	*GDP growth (2007, %)*	**0.003 (1.7)**	0.078 (1.58)	0.039 (1.63)	**0.010 (2.59)**	-0.002 (-1.21)	Yes
	GDP Growth (last 5 yrs)	0.002 (1.08)	**0.118 (2.14)**	**0.052 (1.68)**	**0.009 (2.14)**	-0.003 (-1.21)	
	GDP Growth (last 10 yrs)	0.005 (1.59)	0.087 (1.06)	0.042 (1.2)	**0.016 (2.63)**	-0.004 (-0.76)	
	GDP per capita (2007, constant 2000$)	-0.003 (-0.7)	**-0.296 (-4.69)**	**-0.221 (-3.23)**	**-0.027 (-2.48)**	**-0.010 (-1.74)**	
CREDIT	*Change in Credit (5-yr rise, % GDP)*	-0.029 (-0.83)	**-1.979 (-5.42)**	0.139 (0.37)	-0.092 (-1.67)	**-0.065 (-2.34)**	Yes
	Change in Credit (10-yr rise, % GDP)	**-0.024 (-2.84)**	**-0.904 (-3.9)**	-0.011 (-0.08)	-0.046 (-1.58)	-0.019 (-1.13)	Yes
	Credit Depth of Information Index (higher=more)	-0.005 (-1.34)	**-0.115 (-1.72)**	0.009 (0.19)	0.006 (0.57)	-0.003 (-0.47)	
	Bank liquid reserves to bank assets ratio (%)	0.000 (1.52)	0.022 (1.51)	**-0.000 (-13.97)**	**0.002 (2.34)**	**0.001 (2.58)**	Yes
CURRENT ACCOUNT	*Current Account (% GDP)*	0.001 (1.57)	**0.032 (2.18)**	**-0.032 (-3.46)**	0.000 (0.42)	0.000 (0.78)	Yes
	Current Account, 5-yr Average (% GDP)	0.001 (1.31)	0.030 (1.66)	**-0.032 (-2.76)**	0.000 (0.53)	0.000 (0.42)	
	Current Account, 10-yr Average (% GDP)	0.000 (0.72)	0.034 (1.46)	**-0.038 (-2.63)**	0.000 (0.15)	0.001 (1.59)	
	Net National Savings (% GNI)	0.000 (0.9)	**0.048 (4.5)**	**-0.020 (-1.88)**	**0.003 (2.42)**	**0.002 (2.92)**	Yes
	Gross National Savings (% GDP)	0.000 (0.76)	**0.047 (3.9)**	**-0.028 (-2.51)**	**0.003 (1.99)**	**0.002 (2.52)**	Yes
MONEY	*Change in M3 (5-yr rise, % GDP)*	0.000 (0.16)	-0.018 (-1.41)	-0.001 (-0.14)	-0.002 (-1.49)	-0.001 (-1.05)	
	Change in M2 (5-yr rise, % GDP)	0.000 (0.09)	-0.023 (-1.5)	0.007 (0.63)	-0.002 (-1.14)	-0.001 (-0.91)	

Table Appendix 6 continued

Coefficients of Bivariate Regressions of Crisis Indicators on Each Independent Variable* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
TRADE	*Trade Balance (% GDP)*	0.000 (0.44)	0.013 (1.2)	**-0.018 (-2.38)**	-0.000 (-0.78)	0.000 (0.01)	
	Exports (% GDP)	0.000 (0.2)	-0.004 (-1.42)	-0.004 (-1.08)	-0.000 (-1.21)	-0.000 (-1.42)	
	Imports (% GDP)	-0.000 (-0.04)	**-0.007 (-1.67)**	0.003 (1.01)	-0.000 (-1.18)	-0.000 (-1.46)	
INFL.	*Inflation (average, last 5 yrs)*	0.000 (0.36)	**0.080 (3.33)**	**-0.000 (-2.91)**	0.003 (1)	-0.000 (-0.23)	Yes
	Inflation (average, last 10 yrs)	-0.000 (-1.25)	**0.038 (1.81)**	-0.000 (-0.92)	0.000 (0.03)	0.000 (0.31)	
STOCK MKT	*Stock Market (5 yr % change)*	-0.004 (-1.05)	0.022 (0.99)	0.046 (1.04)	0.001 (0.37)	-0.000 (-0.14)	
	Stock Market (5 yr return/st. dev.)	-0.012 (-0.59)	-0.166 (-0.74)	0.436 (1.47)	-0.005 (-0.22)	-0.004 (-0.2)	
INT RATE	*Real Interest Rate*	-0.000 (-0.46)	**0.036 (3.18)**	0.006 (0.36)	0.001 (0.87)	**0.004 (2.07)**	Yes
	Deposit Interest Rate	**-0.005 (-2.08)**	**0.107 (2.84)**	0.001 (0.18)	0.002 (0.99)	-0.000 (-0.49)	
DEBT COMPOSITION	*Short-term Debt (% of exports)*	-0.000 (-0.88)	**-0.023 (-3.66)**	0.000 (0.09)	**-0.000 (-2.03)**	**-0.001 (-3.99)**	Yes
	Short-term Debt (% of external debt)	-0.001 (-1.41)	-0.014 (-0.64)	0.001 (0.18)	-0.000 (-0.2)	-0.000 (-0.26)	
	Public Debt Service (% of exports)	**0.001 (3.3)**	0.022 (0.85)	-0.004 (-0.44)	-0.001 (-0.76)	0.003 (1.41)	
	Public Debt Service (% GNI)	**0.001 (3.02)**	-0.010 (-0.33)	-0.031 (-0.83)	-0.005 (-0.68)	0.008 (1.1)	
	Multilateral Debt Service (% Public Debt Service)	0.000 (1.41)	-0.001 (-0.2)	0.004 (1)	0.000 (0.97)	0.000 (0.65)	
	Aid (% of GNI)	**0.000 (2.67)**	-0.019 (-0.93)	0.001 (0.18)	0.002 (1.09)	-0.001 (-0.09)	
	Financing via Int. Cap. Markets (gross, % GDP)	0.000 (0.79)	-0.026 (-1.1)	-0.003 (-0.45)	0.001 (0.39)	**-0.008 (-2.61)**	
	Legal Rights Index (higher=more rights)	**-0.009 (-2.71)**	**-0.125 (-2.58)**	-0.040 (-0.91)	-0.006 (-1.45)	**-0.005 (-1.8)**	Yes
	Business Extent of Disclosure Index (higher=more disclosure)	-0.005 (-1.61)	-0.009 (-0.18)	-0.023 (-0.62)	0.006 (1.38)	0.002 (1.15)	
CAPITAL FLOWS	*Portfolio Flows (% GDP)*	**-0.499 (-2.92)**	0.344 (0.11)	1.433 (0.55)	0.726 (1.38)	-0.474 (-0.57)	
	FDI net inflows (% GDP)	-0.000 (-0.67)	**-0.003 (-3.73)**	0.000 (0.2)	**-0.000 (-15.13)**	-0.000 (-1.52)	Yes
	FDI net outflows (% GDP)	0.000 (0.24)	**0.002 (5.59)**	0.001 (0.61)	**0.000 (13.09)**	0.000 (1.31)	Yes
	Net FDI (% GDP)	-0.000 (-0.05)	0.004 (0.97)	0.004 (0.43)	**0.001 (7.06)**	-0.000 (-0.05)	

Table Appendix 6 continued

Coefficients of Bivariate Regressions of Crisis Indicators on Each Independent Variable* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
EXT DEBT	*External Debt Service (% GNI)*	0.000 (0.76)	**-0.058 (-2.39)**	-0.007 (-0.65)	-0.001 (-0.74)	**-0.005 (-6.32)**	Yes
	Present Value of External Debt (% exports)	0.000 (0.31)	**-0.007 (-3.99)**	-0.000 (-0.08)	-0.000 (-1.67)	**-0.000 (-2.77)**	Yes
	Present Value of External Debt (% GNI)	0.000 (0.11)	**-0.014 (-3.7)**	-0.000 (-0.61)	-0.000 (-1.29)	**-0.000 (-4.77)**	Yes
	Peg (1 = peg)	**0.057 (3.41)**	**-0.577 (-2.47)**	-0.363 (-1.48)	**-0.053 (-2.17)**	-0.021 (-1.55)	
	Financial Openness (0=open)	0.023 (1.34)	**0.899 (4.56)**	0.230 (1.03)	0.085 (1.6)	0.020 (0.63)	
INCOME	*Euro Area*	-0.009 (-1.06)	**-0.901 (-4.9)**	-	**-0.055 (-2.29)**	-0.006 (-0.68)	Yes
	Low Income Country	0.021 (1.16)	**0.729 (2.45)**	0.376 (1.54)	-	-	
	Middle Income	-0.025 (-1.58)	**0.821 (3.7)**	**0.398 (1.85)**	**0.067 (3.19)**	0.017 (1.17)	
	Upper Income	0.013 (0.86)	**-0.982 (-4.83)**	**-1.079 (-3.27)**	**-0.067 (-3.19)**	-0.017 (-1.17)	
	OECD	**-0.042 (-2.29)**	**-0.709 (-3.69)**	-0.478 (-1.27)	**-0.051 (-2.39)**	-0.005 (-0.47)	Yes
REGION	*South Asia*	**0.063 (3.63)**	**0.799 (2.71)**	0.185 (0.4)	**0.195 (17.65)**	0.015 (0.37)	Yes
	Europe & Central Asia	**-0.078 (-4.9)**	**-1.038 (-5.13)**	0.306 (1.34)	**-0.071 (-3.45)**	**-0.052 (-4.29)**	Yes
	Middle East & North Africa	**0.074 (4.18)**	0.092 (0.31)	-0.673 (-1.39)	**0.058 (2.03)**	**0.074 (5.63)**	Yes
	East Asia & Pacific	0.017 (0.8)	**0.494 (1.75)**	**-0.953 (-2.12)**	0.056 (1.55)	**0.038 (2.64)**	Yes
	Sub-Saharan Africa	**-0.049 (-2.12)**	**0.549 (2.79)**	**0.513 (2.17)**	**0.068 (5.93)**	**0.017 (2.47)**	
	Latin America & Carribean	0.024 (0.94)	-0.634 (-1.53)	-0.320 (-0.81)	-0.018 (-0.73)	**-0.046 (-1.82)**	
	North America	0.016 (0.26)	**-1.003 (-5.2)**	-	**-0.027 (-2.25)**	0.006 (0.91)	Yes

**OLS with heteroscedasticity robust standard errors performed for four continuous variables; probit for IMF recourse variable*
^At least two statistically signficant coefficients, of which all must have consistent sign (consistent = same sign, with exception of coefficient on IMF recourse variable, which should have opposite sign)

Appendix 7

Table Appendix 7

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower

	Independent Variable	Exchange Market Pressure	Currency % Changes (H208-H109)	Recourse to IMF (SBA only)	Equity %Chng (Sep08-Mar09)	Equity % Chng (H208-H109)	Significant and Consistent Sign?^
RESERVES	*Reserves (% GDP)*	**0.164 (3.63)**	**0.087 (2.98)**	**-1.069 (-1.66)**	0.011 (0.12)	0.010 (0.14)	Yes
	Reserves (% external debt)	0.000 (1.06)	0.000 (1.1)	**-0.006 (-2.29)**	**0.000 (1.81)**	**0.000 (2.65)**	Yes
	Reserves (in months of imports)	**0.004 (2.25)**	**0.003 (1.95)**	**-0.119 (-3.01)**	0.006 (1.32)	**0.009 (2.32)**	Yes
	M2 to Reserves	0.000 (0.27)	0.000 (0.76)	-0.044 (-0.91)	0.000 (0.02)	-0.000 (-0.09)	
	Short-term Debt (% of reserves)	**-0.000 (-1.97)**	**-0.000 (-4.22)**	**0.000 (2.13)**	**-0.001 (-2.89)**	**-0.001 (-3.11)**	Yes
REER	*REER (5-yr % appreciation of local currency)*	**-0.440 (-5.55)**	**-0.210 (-3.19)**	**1.728 (2.15)**	-0.182 (-1.24)	-0.185 (-1.61)	Yes
	REER (Deviation from 10-yr av)	**-0.475 (-3.96)**	**-0.230 (-2.47)**	**2.654 (2.56)**	**-0.316 (-1.71)**	**-0.316 (-2.1)**	Yes
GDP	*GDP growth (2007, %)*	-0.000 (-0.2)	0.001 (0.94)	**0.070 (2.58)**	-0.001 (-0.1)	-0.007 (-0.71)	
	GDP Growth (last 5 yrs)	-0.003 (-0.81)	0.000 (0.26)	**0.084 (2.4)**	-0.003 (-0.26)	-0.014 (-1.15)	
	GDP Growth (last 10 yrs)	0.000 (0.14)	0.001 (0.43)	**0.064 (1.66)**	-0.012 (-0.67)	-0.020 (-1.12)	
CREDIT	*Change in Credit (5-yr rise, % GDP)*	-0.021 (-0.36)	-0.035 (-0.98)	0.552 (1.02)	**-0.274 (-2.97)**	**-0.248 (-4.13)**	Yes
	Change in Credit (10-yr rise, % GDP)	-0.017 (-0.93)	-0.011 (-1.05)	0.210 (1.03)	-0.089 (-1.65)	**-0.089 (-2.35)**	
	Credit Depth of Information Index (higher=more)	-0.008 (-1.06)	0.000 (0.05)	**0.224 (2.4)**	-0.006 (-0.37)	-0.018 (-1.33)	
	Bank liquid reserves to bank assets ratio (%)	**0.000 (3.84)**	0.000 (0.5)	**-0.000 (-11.44)**	-0.002 (-0.54)	-0.002 (-0.79)	Yes
CURRENT ACCOUNT	*Current Account (% GDP)*	0.001 (1.48)	**0.002 (2.7)**	**-0.023 (-2.09)**	**0.009 (3.84)**	**0.007 (3.95)**	Yes
	Current Account, 5-yr Average (% GDP)	0.000 (0.48)	**0.001 (1.82)**	**-0.025 (-1.72)**	**0.007 (2.4)**	**0.006 (2.74)**	Yes
	Current Account, 10-yr Average (% GDP)	0.000 (0.14)	0.002 (1.39)	**-0.035 (-2.11)**	**0.008 (2.21)**	**0.007 (2.44)**	Yes
	Net National Savings (% GNI)	0.002 (1.6)	**0.001 (2.33)**	-0.013 (-1.22)	**0.006 (2.92)**	**0.004 (2.28)**	Yes
	Gross National Savings (% GDP)	**0.003 (2.01)**	**0.001 (2.53)**	-0.015 (-1.36)	**0.008 (3.42)**	**0.006 (3.03)**	Yes
MONEY	*Change in M3 (5-yr rise, % GDP)*	0.000 (0.46)	-0.000 (-0.16)	-0.000 (-0.08)	-0.004 (-1.08)	**-0.004 (-2.79)**	
	Change in M2 (5-yr rise, % GDP)	0.000 (0.33)	-0.000 (-0.29)	0.006 (0.51)	-0.005 (-1.25)	**-0.006 (-2.86)**	

Table Appendix 7 continued

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower

	Independent Variable	Exchange Market Pressure	Currency % Changes (H208-H109)	Recourse to IMF (SBA only)	Equity %Chng (Sep08-Mar09)	Equity % Chng (H208-H109)	Significant and Consistent Sign?^
TRADE	*Trade Balance (% GDP)*	**0.001 (1.73)**	**0.001 (1.78)**	-0.014 (-1.51)	**0.006 (2.72)**	**0.003 (1.97)**	Yes
	Exports (% GDP)	0.000 (0.93)	**0.000 (1.97)**	-0.002 (-0.53)	0.000 (0.02)	-0.000 (-0.83)	
	Imports (% GDP)	-0.000 (-0.15)	0.000 (0.57)	0.002 (0.79)	-0.000 (-0.73)	-0.000 (-1.36)	
INFL.	*Inflation (average, last 5 yrs)*	**-0.006 (-1.76)**	-0.001 (-0.75)	**0.094 (3.4)**	0.000 (0.01)	0.002 (0.26)	Yes
	Inflation (average, last 10 yrs)	**-0.002 (-2.03)**	-0.001 (-1.54)	**0.017 (2.04)**	-0.000 (-0.16)	0.000 (0.18)	Yes
STOCK MKT	*Stock Market (5 yr % change)*	-0.006 (-0.86)	-0.006 (-1.34)	0.035 (0.74)	**-0.016 (-3.72)**	**-0.018 (-5.59)**	Yes
	Stock Market (5 yr return/st.dev.)	0.010 (0.31)	-0.024 (-1.02)	-0.394 (-1.17)	**-0.097 (-1.92)**	-0.042 (-0.93)	
INT RATE	*Real Interest Rate*	-0.001 (-0.79)	-0.000 (-0.42)	-0.022 (-1.05)	**0.005 (1.81)**	**0.004 (1.85)**	Yes
	Deposit Interest Rate	**-0.014 (-4.43)**	**-0.003 (-1.72)**	**0.058 (1.78)**	**0.019 (3.33)**	0.009 (1.39)	
DEBT COMPOSITION	*Short-term Debt (% of exports)*	-0.000 (-0.04)	-0.000 (-1.43)	0.000 (0.36)	**-0.004 (-3.28)**	**-0.003 (-2.82)**	Yes
	Short-term Debt (% of external debt)	-0.001 (-1.41)	**-0.001 (-2.1)**	0.009 (1.17)	-0.001 (-0.34)	-0.000 (-0.03)	
	Public Debt Service (% of exports)	**0.002 (3.04)**	0.000 (1.18)	-0.036 (-1.14)	0.008 (1.22)	0.005 (0.98)	
	Public Debt Service (% GNI)	**0.001 (2.37)**	0.000 (0.97)	-0.050 (-0.71)	0.003 (0.33)	0.002 (0.3)	
	Multilateral Debt Service (% Public Debt Service)	**0.001 (1.77)**	0.000 (0.52)	0.001 (0.17)	-0.001 (-1.05)	0.000 (0.01)	
	Aid (% of GNI)	**0.002 (2.81)**	0.000 (1.22)	**-0.141 (-3.23)**	-0.007 (-0.77)	-0.001 (-0.15)	Yes
	Financing via Int. Cap. Markets (gross, % GDP)	-0.000 (0)	-0.000 (-0.48)	-0.011 (-0.57)	**-0.012 (-2.14)**	-0.005 (-1)	
	Legal Rights Index (higher=more rights)	-0.009 (-1.49)	-0.006 (-1.46)	0.008 (0.15)	-0.017 (-1.52)	**-0.015 (-1.78)**	
	Business Extent of Disclosure Index (higher=more disclosure)	-0.002 (-0.39)	-0.001 (-0.32)	-0.024 (-0.52)	-0.001 (-0.13)	-0.000 (-0.1)	
CAPITAL FLOWS	*Portfolio Flows (% GDP)*	**-0.616 (-2.88)**	**-0.435 (-3.33)**	2.090 (0.74)	-0.979 (-0.77)	-0.889 (-0.77)	Yes
	FDI net inflows (% GDP)	**-0.000 (-2.05)**	-0.000 (-0.87)	-0.000 (-0.04)	**-0.000 (-2.57)**	**-0.000 (-2.05)**	Yes
	FDI net outflows (% GDP)	**0.000 (1.8)**	0.000 (0.81)	-0.000 (-0.45)	**0.000 (3.38)**	**0.000 (2.84)**	Yes
	Net FDI (% GDP)	0.001 (1.15)	0.000 (0.44)	-0.002 (-0.27)	-0.000 (-0.13)	-0.000 (-0.27)	

Table Appendix 7 concluded

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower

	Independent Variable	Exchange Market Pressure	Currency % Changes (H208-H109)	Recourse to IMF (SBA only)	Equity %Chng (Sep08-Mar09)	Equity % Chng (H208-H109)	Significant and Consistent Sign?^
EXT DEBT	*External Debt Service (% GNI)*	0.000 (0.91)	0.000 (0.05)	-0.000 (-0.04)	**-0.016 (-5.11)**	**-0.013 (-4.87)**	Yes
	Present Value of External Debt (% exports)	0.000 (0.08)	-0.000 (-0.38)	-0.000 (-0.06)	**-0.001 (-3.55)**	**-0.001 (-3.92)**	Yes
	Present Value of External Debt (% GNI)	0.000 (0.16)	-0.000 (-0.82)	0.000 (0.38)	**-0.003 (-4.39)**	**-0.002 (-3.8)**	Yes
	Peg (1 = peg)	**0.100 (3.89)**	**0.055 (3.34)**	**-0.577 (-1.89)**	-0.075 (-1.67)	-0.041 (-1.04)	Yes
	Financial Openness (0=open)	**0.083 (2.76)**	0.023 (1.16)	**-0.587 (-1.72)**	0.059 (0.68)	0.003 (0.05)	Yes
REGION	*South Asia*	0.045 (0.81)	**0.045 (2.12)**	0.476 (0.99)	**0.158 (1.81)**	0.033 (0.54)	Yes
	Europe & Central Asia	**-0.150 (-4.43)**	**-0.095 (-5.61)**	**0.636 (2.09)**	**-0.202 (-4.43)**	**-0.167 (-4.64)**	Yes
	Middle East & North Africa	**0.080 (2.7)**	**0.061 (2.86)**	-	0.003 (0.05)	0.049 (0.84)	Yes
	East Asia & Pacific	**0.071 (2.71)**	0.034 (1.58)	-0.629 (-1.34)	**0.135 (2.63)**	0.054 (1.08)	Yes
	Sub-Saharan Africa	-0.006 (-0.14)	-0.024 (-0.83)	-0.424 (-0.98)	-0.068 (-0.89)	0.047 (0.72)	
	Latin America & Carribean	-0.014 (-0.23)	-0.013 (-0.39)	0.205 (0.47)	-0.049 (-0.84)	-0.048 (-0.93)	
	North America	0.061 (0.92)	0.041 (0.91)	-	0.030 (1.1)	0.024 (0.95)	

**OLS with heteroscedasticity robust standard errors performed for four continuous variables; probit for IMF recourse variable*
^At least two statistically signficant coefficients, of which all must have consistent sign (consistent = same sign, with exception of coefficient on IMF recourse variable, which should have opposite sign)

Appendix 8 – The Effect of Financial Market Development on Crisis Incidence

Though not figuring prominently in the earlier literature, variables relating to financial market development may be particularly relevant given the origins of the current crisis. This appendix examines the relationship between financial market development and crisis incidence. We measure levels of financial sector development by domestic credit, M2 and M3 expressed as a percentage of GDP. Market capitalization as a percentage of GDP is also included as an indicator of domestic financial market size. A more developed financial system may increase its resilience to external shocks, therefore suggesting a negative relationship between these variables and crisis incidence. At the same time, countries with more developed financial markets may have been more exposed to the current crisis given that it originated among developed-world financial institutions. The effect of financial market development on 2008-09 crisis incidence at first sight therefore seems ambiguous.

The table below reports the results of regressing measures of financial market development on our five crisis incidence variables. The results show a strong negative relationship between measures of financial market development and crisis incidence, suggesting that countries with larger or more developed financial markets suffered less from the crisis. All three *level of credit* variables appear to be statistically significant leading indicators of crisis incidence measured either in terms of GDP drops or recourse to the IMF. The level of broad money measured in terms of M2 or M3 also appears as a highly statistically significant predictor of crisis incidence measured either in terms of GDP drops or recourse to the IMF, as well as exchange rate drops. The measure of *equity market capitalization* provides similar results.

Table Appendix 8 - Financial Market Development and 2008-09 Crisis Incidence

Coefficients of Regressions of Crisis Indicators on Each Independent Variable and GDP per Capita* (t-stat in parentheses)
bolded number indicates statistical signficance at 10% level or lower, darker color shading equivalent to higher statistical significance

	Independent Variable	Currency Market	Equity Market	Recourse to IMF	Industrial Production	GDP	Significant and Consistent Sign?^
FINANCIAL MKT DEVELOPMENT	*M3 (% GDP)*	**0.000 (5.45)**	0.001 (0.45)	**-0.019 (-3.47)**	**0.000 (2.07)**	**0.000 (2.78)**	Yes
	M2 (% GDP)	**0.000 (5.26)**	0.001 (0.57)	**-0.019 (-3.37)**	**0.000 (1.9)**	**0.000 (2.8)**	Yes
	Domestic Credit (% GDP)	0.025 (1.4)	-0.258 (-1.29)	**-0.628 (-2.78)**	**0.042 (1.74)**	**0.031 (2.46)**	Yes
	Domestic Credit Provided by Banks (% GDP)	0.000 (1.65)	-0.001 (-1.01)	**-0.007 (-3.28)**	0.000 (1.41)	**0.000 (2.43)**	Yes
	Domestic Credit to Priv. Sector (% GDP)	0.000 (1.22)	-0.002 (-1.56)	**-0.013 (-3.04)**	**0.000 (1.97)**	**0.000 (1.74)**	Yes
	Market Cap of Listed Companies (% GDP)	0.000 (1.39)	**0.002 (2.85)**	-0.007 (-1.43)	0.000 (1.25)	**0.000 (2.27)**	Yes

**OLS with heteroscedasticity robust standard errors performed for four continuous variables; probit for IMF recourse variable*
^At least two statistically signficant coefficients at 10% level, of which all must have consistent sign (consistent = same sign, with exception of coefficient on IMF recourse variable, which should have opposite sign)

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