



IMF Working Paper

Assessing Fiscal Stress

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Fiscal Affairs Department

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Abstract

This paper develops a new index which provides early warning signals of fiscal sustainability problems for advanced and emerging economies. Unlike previous studies, the index assesses the determinants of fiscal stress periods, covering public debt default as well as near-default events. The fiscal stress index depends on a parsimonious set of fiscal indicators, aggregated using the approach proposed by Kaminsky, Lizondo and Reinhart (1998). The index is used to assess the build up of fiscal stress over time since the mid-1990s in advanced and emerging economies. Fiscal stress has increased recently to record-high levels in advanced countries, reflecting raising solvency risks and financing needs. In emerging economies, risks are lower than in mature economies owing to sounder fiscal fundamentals, but fiscal stress remains higher than before the crisis.

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I. INTRODUCTION

Recent fiscal difficulties around the world brought to the fore the importance of assessing fiscal sustainability risks both in advanced and emerging economies. Based on the conceptual framework presented in Cottarelli (2011), these risks can lead to a sovereign debt rollover crisis in the absence of fiscal adjustment. Various factors can impact these fiscal sustainability risks, including: (i) whether current and projected fiscal policies are consistent with solvency and liquidity requirements (Baldacci, McHugh and Petrova, 2011); (ii) whether uncertainty around this baseline—reflecting shocks to macroeconomic assumptions, fiscal policy, and contingent liabilities—has heightened; and (iii) whether non-fiscal factors (such as current account imbalances) and global financial market risk appetite have increased the likelihood of a fiscal crisis (IMF, 2011).

In this paper, we build a new index of fiscal stress that provides early warning signals of fiscal sustainability problems for advanced and emerging economies. Unlike previous studies, the analysis is not confined to sovereign debt default or near-default events. Fiscal crisis periods are defined as episodes of outright fiscal distress—public debt default/restructuring, need to access large-scale official/IMF support, hyperinflation—as well as extreme financing problems—spikes in sovereign bond spreads. In these cases, fiscal solvency is endangered and the government is forced to alter its policies to regain fiscal sustainability.

Another innovation of this paper is that the fiscal stress index is based on a set of indicators that measure the risk of fiscal sustainability based on current fiscal variables and their baseline projections using a consistent conceptual framework (Baldacci, McHugh and Petrova, 2011). For each indicator, thresholds are estimated on the basis of a univariate procedure that maximizes the likelihood of predicting a fiscal crisis. The fiscal stress index measures the number of indicators exceeding these thresholds, weighted by their relative signaling power.

The index can be used to assess the degree of fiscal stress in advanced and emerging market economies over time. Results show that fiscal stress risks remain elevated in advanced economies and well above the pre-crisis years. This owes to high solvency risks related to fiscal fundamentals and aging-related long-term budget pressures as well as record-high budget financing needs. Fiscal stress is lower for emerging economies, due to the rebuilding of fiscal buffers and more positive growth prospects than in mature economies. However, risks remain higher than in pre-crisis years also for these economies and point to continued vulnerabilities to shocks.

The rest of the paper is organized as follows. The next section surveys the literature on early warning systems, focusing on studies of fiscal crises. Section III elaborates the early warning methodology applied to developing the fiscal stress index. Section IV describes the data used and main results, and Section V concludes.

II. LITERATURE REVIEW

There is an abundant literature on Early Warning System (EWS) models, mostly focused on currency and banking crises. These empirical studies differ according to: (i) the definition of crisis events; (ii) the methodology adopted; and (iii) the set of indicators used. Also country coverage tends to be limited by data quality, with only a few studies focusing on both advanced and emerging economies (and even in these cases limiting the analysis to relatively small samples).

Previous studies typically focused on financial crises, with a few papers assessing the risk of public debt default. In the latter studies, the definition of crisis events typically covers only tail events: for example, Detragiache and Spilimbergo (2001) define public debt crises as events of outright default or rescheduling, while Manasse, Roubini and Schimmelpfennig (2003) further add the provision of a large-scale official financing support to the definition of fiscal crises. However, extreme rollover problems are more common than public debt default episodes across advanced and emerging economies in the last decades. A broader definition of fiscal crises could provide better information about changes in underlying fiscal sustainability risks, even in the absence of outright debt default (or near-default events triggering financial support of the official sector). In this paper, we define fiscal stress events to capture crisis episodes that encompass public debt default and near-default events, as well as severe deteriorations in the fiscal solvency risk outlook leading to fiscal sustainability risks (Cottarelli, 2011; IMF, 2011).

The empirical literature also differs with respect to the methodology used in the studies. Two approaches are common: the univariate “signaling” approach and the multivariate regression analysis of the crisis determinants.² The “signaling” approach was proposed in a seminal paper by Kaminsky, Lizondo and Reinhart (1998) on determinants of currency crises. It entails using each potential indicator of crisis events separately, identifying critical thresholds that signal such events with the lowest prediction error, and then averaging the number of indicators exceeding this threshold into a composite index. This is based on weights proportional to the signaling power of each indicator. The methodology has been used in subsequent empirical studies, including to assess fiscal vulnerability indicators that help predict financial crises in emerging economies (Hemming, Kell and Schimmelpfennig, 2003) and to assess the risk of sudden stops (IMF, 2007). The multivariate regression approach uses panel regressions (probit or logit) with a binary dependent variable equal to one if a crisis occurs and zero otherwise. The impact of a set of determinants on the crisis probability is then derived by estimating the model and testing the coefficients’ significance. Berg and

² See Abiad (2003) for a survey, including other methodologies. Manasse, Roubini and Schimmelpfennig (2003) also use a non-parametric method based on binary recursive tree analysis to assess nonlinear combinations of factors affecting the likelihood of debt crises.

Patillo (1999) use this approach to predict currency crises and find that the crisis probability increases with changes in the predictive indicators.³

Various studies have attempted to compare the performance of these two methods based on their success in correctly predicting crises (Appendix Table 2). Berg and Patillo (1999) and Berg, Borensztein and Patillo (2005) find that the multivariate probit model outperforms the “signaling” approach both in-sample and in cross-country predictions, while the “signaling” approach has a better out-of-sample performance. Overall, no approach emerges as the clear winner and results depend on the type of crisis risk assessed.

In this paper, the “signaling” approach is used.⁴ This framework is relatively simple and allows for a transparent mapping from a large set of fiscal indicators into a composite index of fiscal stress. Another advantage of the methodology is that it easily accommodates differences in data availability across variables, while using panel multivariate regression models would limit the number of predictive variables owing to data gaps.⁵ One limitation of this approach is that individual predictive variables cannot be tested for their conditional statistical significance. However, each variable contributes to the fiscal stress index with a weight proportional to its power in predicting a fiscal stress event.

The literature suggests several indicators that can help predict which countries are most vulnerable to banking crises. Frankel and Saravelos (2010) point to the importance of the level of international reserves, the real exchange rate and the current account in predicting financial crises. Similarly, IMF (2007) finds that external sector variables are important, in particular reserve coverage, the current account and external debt relative to exports.

Only a few studies focus on fiscal variables determinant of fiscal crises. While fiscal data are not as widely available as monetary or financial data, fiscal variables are also found to be relatively less powerful in predicting crises.⁶ Hemming and Petrie (2002) discuss fiscal vulnerability and potential fiscal indicators that might increase fiscal risks and Hemming, Hell and Schimmelpfennig (2003) use a large set of fiscal variables for 29 emerging economies over the period 1970-2000 to assess risks of currency, debt and banking crises.

³ See Appendix Table 1 for comparison of the pros and cons of different approaches.

⁴ This is consistent with the method adopted by the IMF in the Early Warning Exercise (IMF, 2010a).

⁵ Data limitations and low degrees of freedom may limit the use of the multivariate approach in particular when the number of variables predicting a crisis is large.

⁶ For example, Manasse, Roubini, and Schimmelpfennig (2003) find that no fiscal variables are significant determinants of debt crises using a panel logit model in a sample of advanced and emerging economies. They find that the ratio of public debt to revenue is a better determinant of default risks when using a non-parametric method. Nonetheless, high values of these indicators are associated with sovereign debt crises in their findings only when other macroeconomic fundamentals are also weak.

They find that the best fiscal indicators are short-term public debt, foreign-currency debt as well as other deficit measures.

In this paper, we rely on a parsimonious set of fiscal indicators that have been identified by Baldacci, McHugh and Petrova (2011) to measure fiscal sustainability risks under the medium-term scenario of the *World Economic Outlook* baseline projections. These indicators measure solvency risks based on current deficit and debt levels, and projected growth-adjusted interest rate on public debt. Indicators of long-term budget pressure associated with demographic aging, such as projected change in health care and pension expenditures, are also included. In addition to the solvency risk outlook, the framework also cover risks to fiscal sustainability stemming from sovereign asset and liability composition and financing requirements.

III. METHODOLOGY

A. Fiscal Crisis Episodes

A fiscal crisis episode is identified in this study as a period of extreme government funding difficulties (Cottarelli, 2011). Funding pressures could arise as a result of public debt build-up, contingent liabilities that become outright fiscal costs, negative revenue shocks, or unaddressed demographic-related spending pressures. Financing constraints may also tighten due to market perception that the composition of public debt impedes the repayment capacity of the government. The surveyed literature suggests four types of criteria to capture such events: (i) debt default or restructuring; (ii) implicit default; (iii) recourse to exceptional official financing; and (iv) a sharp deterioration in market access.

Previous studies used a combination of the first three criteria to identify fiscal crises: public debt default or restructuring, hyperinflation, and large-scale IMF-supported programs. A limitation of this approach is that it misses fiscal distress episodes that are severe enough to alter the attainment of macroeconomic stability and growth but do not result in defaults or near-defaults. Fiscal crises can manifest themselves differently since the mid-1990s, with the development of bond markets and a lower reliance of countries on bank loans (see Pescatori and Sy, 2007). Notably, some episodes of severe difficulties may not trigger a debt default or restructuring and would not be captured by the standard definition used in the literature.

This paper combines the criteria above with indicators of severe spikes in financing costs to obtain a more comprehensive set of fiscal crisis events. To identify periods of public debt default, debt restructuring, and high levels of IMF financing support, the same definition is used for advanced and emerging economies. The definition of default follows Standard and Poor's, which classifies a sovereign in default if it is not current on its debt obligations (including exchange offers, debt equity swaps, and buybacks for cash). Restructuring and rescheduling are defined as any operation which alters the original terms of the debt-creditor

contract. Public debt defaults include both commercial and official creditors. Large IMF-supported programs are those with access above 100 percent of quota.⁷ These are typically non-concessional loans and are provided as part of an adjustment program. Exceptional financing covers situations where near-default was avoided through large-scale IMF-supported programs.⁸

Implicit domestic public debt defaults are identified by criteria for high inflation, differentiated between advanced and emerging economies. High inflation episodes are those where the inflation rate was above 35 percent per year in the case of advanced economies, and 500 percent per year for emerging economies.⁹ The threshold for advanced economies was chosen on the basis of the average haircut on public debt in case of external debt restructuring. This follows Sturzenegger et al. (2006) and aims to capture implicit domestic defaults. The threshold for emerging economies is based on results by Reinhart and Rogoff (2010).¹⁰

Severe government bond yield pressures are also considered. This captures situations in which the government faces significant short-term market financing constraints.¹¹ Periods when yield spreads exceeded two standard deviations above the country-specific mean were used to capture market financing pressure events for both advanced and emerging economies. In addition, for emerging economies periods were also included when the bond yield spreads exceeded 1,000 basis points (even if this level did not exceed two standard deviations from the mean) to capture countries that have exceptionally high credit risk spreads for long periods, reflecting high political risks and the consequences of past debt defaults (Pescatori and Sy, 2007).¹²

⁷ Starting in 2009, many high-access programs have exceeded this threshold. Changing the threshold for high-access programs does not alter the number of fiscal distress events significantly. Excluding precautionary arrangements from the definition does not change the results significantly, either.

⁸ While a large set of distress events enhances the statistical robustness of the analysis, it could also weaken the predictive capacity of the model. Results for the sensitivity analysis of fiscal distress events to changes in the definition used in the text confirm that lowering the thresholds for identifying crisis episodes worsens the predictive ability of the model, in particular for emerging economies.

⁹ Sensitivity analysis was performed for alternative inflation rates. An inflation rate which exceeds 100 percent in the case of emerging economies does not significantly affect the results.

¹⁰ These authors prefer this benchmark to Cagan's traditional definition of 50 percent inflation rate per month, because it allows for the use of annual data which are more widely available.

¹¹ We separate periods of fiscal pressure into distinct events by assuming that there should be at least two years of no fiscal distress between separate events. In addition, only the start year of the event is considered as the actual fiscal distress year.

¹² This threshold is not binding in the case of advanced economies, owing to their traditionally lower sovereign bond spreads.

The resulting definition of fiscal distress¹³ events for advanced and emerging economies is presented in Table 1.

Table 1. Definition of Fiscal Crisis Across Advanced and Emerging Market Economies

Event	Criteria	Advanced Economies	Emerging Economies
Public debt default or restructuring	Failure to service debt as payments come due, as well as distressed debt exchanges	S&P definition	S&P definition
Large financing	Large IMF-supported program	Access to 100 percent of quota or more	Access to 100 percent of quota or more
Implicit/Internal public debt default	High inflation rate	Inflation greater than 35 percent per annum	Inflation greater than 500 percent per annum
Extreme financing constraint of the sovereign	Sovereign yield pressure	Sovereign spreads greater than 1,000 basis points or 2 s.d. from the country average	Sovereign spreads greater than 1,000 basis points or 2 s.d. from the country average

Annual data for 29 advanced economies and 52 emerging economies covering 1970-2010 are used to identify fiscal stress events.¹⁴ Data on debt default and restructuring were obtained from Standard and Poor. Information about exceptional IMF-supported programs is based on the IMF's Finance Department database. Long-term domestic bond spreads and, where available, 5-year credit default swap (CDS) spreads are used to capture sovereign yield spikes in advanced economies. Data on spreads of long-term domestic bond spreads relative to comparable U.S. bonds are used for emerging economies. Sourced of data on sovereign bond yields at annual and monthly frequencies include the IMF's International Financial Statistics (IFS), Bloomberg, and Datastream.

On the basis of the definition used in the paper, there were 41 fiscal distress events in advanced economies and 135 events in emerging economies (Table 2).¹⁵ Advanced countries' events were identified mainly by government bond yield spikes, with only a few countries experiencing episodes of access to exceptional financing. Five countries experienced high-inflation events in the period; only 7 out of 29 countries had no crises. In contrast, fiscal stress events for emerging economies frequently involved multiple types of

¹³ This framework does not capture other fiscal risks, including the impact of high public debt levels on economic growth (Cottarelli, 2011).

¹⁴ The advanced economies in the sample are those covered by the IMF's *Fiscal Monitor*. The emerging economies are those covered in the Vulnerability Exercise for Emerging Market Economies (VEE) conducted by the IMF (2010). It should be noted that some countries have moved over time from emerging economy to advanced country status. In the paper, we classify these countries on the basis of the group they belong to in 2010.

¹⁵ Appendix Tables 3a and 3b report the duration of the event and the fiscal stress criterion that was used to identify the episode.

crises. About 60 percent of the cases relate to IMF-supported programs (79 events) and a third to outright defaults and restructuring (each 52 events). However, in the last decade fiscal stress events were increasingly identified through severe bond yield spikes in these economies.

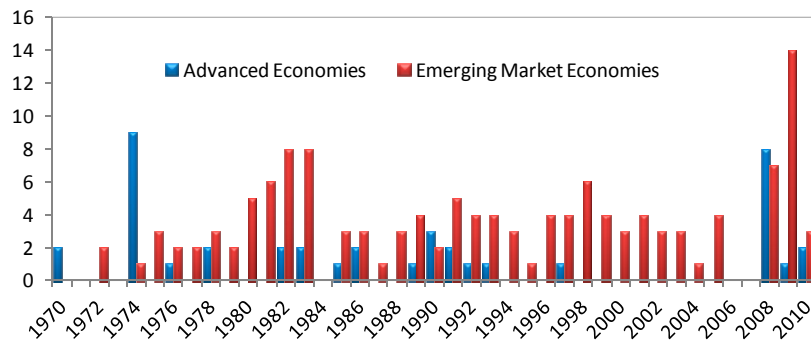
Table 2. Summary of Events Across Advanced and Emerging Economies

Start of Crisis	Fiscal Stress Events	Default or Restructuring	IMF-Supported Program	High Inflation	Bond Yield Pressure	Duration of Fiscal Stress (in years)
Advanced Economies	41	0	6	5	29	2.5
1970-79	14	0	1	4	7	2.6
1980-89	8	0	2	1	5	2.5
1990-99	8	0	2	0	6	2.3
2000-10	11	0	1	0	11	2.6
Emerging Economies	135	52	79	6	15	3.6
1970-79	15	8	9	1	0	3.1
1980-89	41	26	22	0	0	6.6
1990-99	37	12	20	5	5	2.6
2000-10	42	6	28	0	10	1.6

Source: Authors' calculations.

The incidence of new fiscal stress events is clustered around specific periods (Figure 1). Prior to the recent financial crisis, several advanced economies experienced fiscal stress as a result of the oil boom of 1973 and the recession of the early 1990s. Many countries entered into fiscal distress after the onset of the recent crisis in 2008, with a few more new crises occurring in 2009-10. Among emerging economies, fiscal stress events were clustered around the public debt crises in the early 1980s, the Latin American and Asian crises of the 1990s, and the recent global financial crisis.

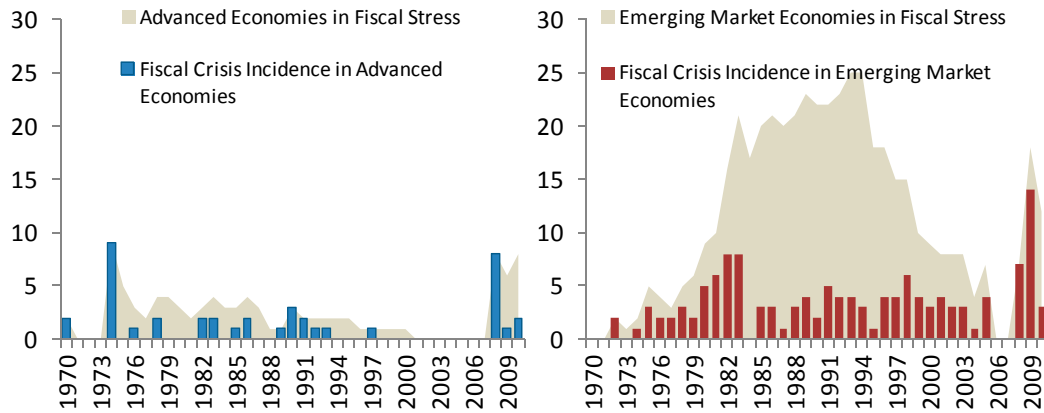
Figure 1. Incidence of Fiscal Crises



Sources: IMF International Financial Statistics; Bloomberg; Standard and Poor's; and authors' calculations.

The length of fiscal stress is on average 2½ years in advanced economies, and 3½ years in emerging economies. As a result the incidence of fiscal crises may not correspond to the number of countries which experience fiscal stress in any given year (Figure 2). Therefore, in discussing the results we present the number of countries in fiscal stress in parallel with the incidence of fiscal crisis events.

Figure 2. Countries in Fiscal Stress



Sources: IMF International Financial Statistics; Bloomberg; Standard and Poor's; and authors' calculations.

As expected, our approach identifies more crisis events than other studies (Table 3 and Appendix Tables 4a and 4b). This stems from a more comprehensive definition of crisis events and from the larger sample used. The differences in the events identified in the paper and those identified by Reinhart and Rogoff (2010) arise mainly from the use of access to large IMF-supported programs and of government yield spikes. Lastly, the timing of crises also differs occasionally from other datasets, either because of the differences in definitions or because of the window required between two separate events.

Table 3. Summary Comparison of Events Across Studies^{1, 2, 3}

	Fiscal Stress Index	IMF EWS	RR	HKS	MRS	LV
Number of events	176	28	48	16	32	22
Number of common events		20	30	13	33	33
Number of countries	81	48	66	29	47	102

¹ Events dated differently by only one year are considered common events. Events within our identified crisis durations are also considered common.

² IMF EWS refers to IMF (2007), RR to Reinhart and Rogoff (2010), HKS to Hemming, Kell and Schimmelpfenning (2003), MRS to Manasse, Roubini and Schimmelpfenning (2003), LV to Laeven and Valencia (2008).

³ The number of total events and missed events in other studies do not add to 164 due to differences in the sample of countries and dates covered.

B. Fiscal Stress Thresholds

The estimation of fiscal stress thresholds for each indicator is based on the “signaling” approach (IMF, 2007; IMF, 2010). This consists of defining cut-off values for each fiscal indicator that discriminates between predicted crisis and non-crisis periods. If an indicator exceeds the cut-off level, the model issues a signal of an upcoming fiscal distress episode. The optimal cut-off point should balance the two types of statistical errors. The lower the threshold, the more signals the model will send (i.e., type II errors will decrease), but at the same time, the number of wrong signals rises (i.e., type I errors will increase). Using a higher threshold reduces the number of wrong signals, but at the expense of increasing the number of missed distress episodes.

Formally one can define an indicator variable at time t , d_t , for the following j time periods as following:

$$d_t = \begin{cases} 1 & \text{for } \forall j, \quad \text{if } x_{t-1} > C \\ 0, & \text{otherwise} \end{cases}$$

where x_t refers to a fiscal indicator and is a monotonically increasing function of crises probabilities and C represents a fixed cut-off for x_t .¹⁶ As mentioned, the signaling window j is set to one year in the analysis.

Two methods are commonly used to determine the optimal value of C : the minimization of the total misclassified errors and the maximization of the signal-to-noise ratio. To illustrate these methodologies, the true versus predicted occurrence of crises are reported in Table 4. This shows also the occurrence of type II errors ($FN(C)$) and type I errors ($FP(C)$).

Table 4. True Versus Predicted Occurrence of Crises

		State of the World	
		Crisis	No Crisis
Predicted result	Signal (crisis)	True Positive	False Positive
	No signal (no crisis)	False Negative	True Negative
	Total	Total crises obs.	Total non-crises obs.

¹⁶ A fiscal indicator that crosses the optimal threshold in period $t-1$ signals a fiscal crisis in period t , thus implying that the level of fiscal stress in the current period is determined by the values of the fiscal indicators in the previous period.

Under the total misclassified errors (*TME*) method, for each cut-off point C , the *TME* value can be expressed as the sum of type I and type II errors,

$$TME(C) = \frac{FN(C)}{N_C} + \frac{FP(C)}{N_{NC}}.$$

The optimal threshold C^* is the value that minimizes $TME(C)$. Due to the small number of fiscal crisis events relative to non-crisis periods, the TME methodology places greater weight on misclassifying fiscal crisis events, thereby yielding relatively conservative thresholds compared to other methods.

The signal-to-noise (*SNR*) ratio can be defined as the ratio of the percentage of correctly classified crises observations (1-type II errors) to the percentage of incorrectly classified non-crises observations (type I errors). For each cut-off point C , the SNR can be expressed as:

$$SNR(C) = \frac{TP(C)/N_C}{FP(C)/N_{NC}}.$$

The optimal threshold C^* under this approach is the value that maximizes $SNR(C)$.

C. Fiscal Stress Index

A fiscal stress index is calculated based on the signaling power of each fiscal indicator. This entails two steps. In the first step, an index summarizing a cluster of fiscal indicators is calculated. If an indicator crosses its threshold, it is assigned a value of 1 in the cluster index and it is weighed proportionately to its predictive power. In the second step, the predictive power of the cluster indices is evaluated and the indicators are aggregated in the fiscal stress index based on their own predictive power and the predictive power of the cluster indices:

$$Overall\ index = \sum_g w_g \sum_i w_{i,g} d_i$$

where $w_{i,g}$ is the weight of each individual indicator i in group g , w_g is the weight of the group, and d_i is a dummy that takes the value of 1 if the indicator is above (below) the threshold, and zero otherwise.

IV. RESULTS

A. Data

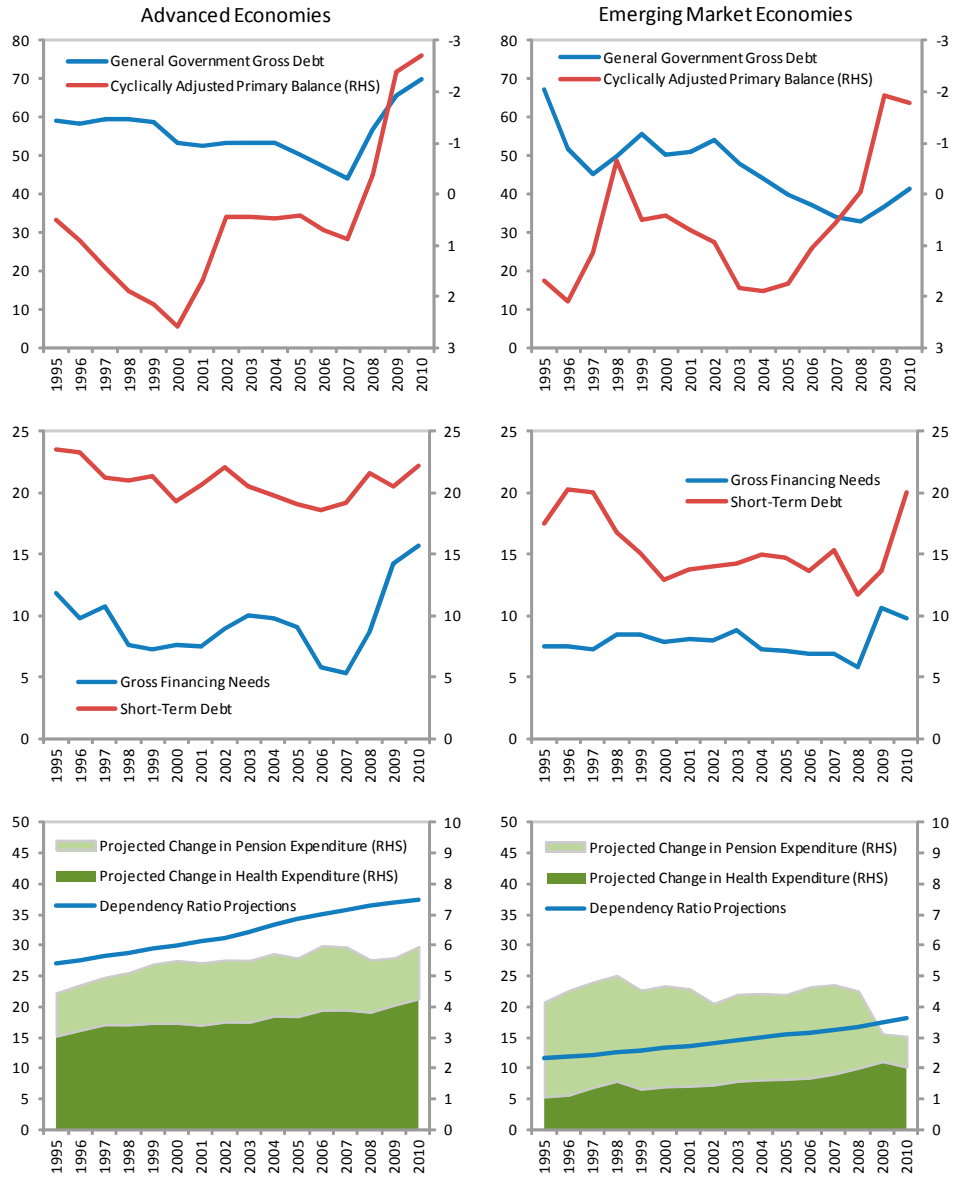
The analysis uses 12 fiscal indicators (Baldacci, McHugh and Petrova, 2011),¹⁷ classified into three clusters: basic fiscal variables, long-term fiscal trends, and asset and liability management (Appendix Table 5). The data were obtained from the IMF's *Fiscal Monitor*, the IMF's *World Economic Outlook* (WEO), the Bank of International Settlements (BIS), and United Nations databases. While some data are available for the period 1970-2010, most series start in the 1980s and are available for all countries only for the mid-1990s. Therefore, while the complete dataset is used to estimate the thresholds, the analysis focuses on the period after 1995.

The analysis of the fiscal indicators reveals that the global financial crisis started in 2008 has triggered a pronounced deterioration in the basic fiscal variables (e.g., public debt to GDP ratio and the cyclically adjusted primary balance as a ratio of potential GDP) in advanced countries, leading also to a sharp upturn in gross financing needs (Figure 3 and Appendix Table 6). With long-term pension and health expenditure costs on an upward trend, risks of fiscal stress are expected to have increased in recent years.

In emerging economies, the basic fiscal indicators show that the deterioration in the cyclically adjusted primary balance had started before the outset of the crisis. Nonetheless, public debt to GDP has remained lower than historical levels. Asset and liability management variables have deteriorated since 2008, mostly on account of large deficit financing needs. However, financing conditions have also worsened, with short-term debt reaching levels seen during the Latin American and the Asian crises of the mid 1990s. Variables measuring long-term fiscal challenges are also trending up in emerging economies, but to a lesser extent than in advanced economies.

¹⁷ The following fiscal indicators are included: the difference between GDP growth and the imputed interest rate on government debt ($r-g$); cyclically adjusted primary balance; general government gross debt to GDP; gross financing needs; short-term debt (on a remaining maturity basis) to total debt; debt denominated in foreign currencies to total debt for emerging economies/debt held by nonresidents to total debt for advanced economies; weighted average maturity of government debt; short-term external debt to international reserves for emerging economies; deviation of fertility rate from 2.1; old age dependency ratio; and long-term projections of the change in public pension and health expenditure. See Appendix Table 5, and Baldacci, McHugh and Petrova (2011) and IMF (2011) for a detailed definition of these indicators.

Figure 3. Trends in Selected Fiscal Indicators



Sources: *World Economic Outlook*; Bank of International Settlements, Dealogic; and authors' calculations. See Appendix Table 5 for the definition of fiscal indicators.

B. Indicator Thresholds and Weights

The estimation of the indicator thresholds is based on the performance of the TME and SNR approaches. The TME method performs better, in line with previous results in the literature (IMF, 2007).¹⁸ Nonetheless, adjustments to the TME methodology are necessary for several reasons. First, occasionally the TME solution is located close to the median of the distribution and in some case on the tail of the distribution where values of the indicators indicate low risk of fiscal distress.¹⁹ Second, trends and structural breaks in the data are likely over long time periods. Finally, data are reliably available only since the mid-1990s.

To maximize the predictive power of the indicator, the thresholds are estimated separately for advanced and emerging economies under the constraints that they are located on the risk-prone side of each indicator's distribution relative to the 1995-2010 median (Figures 4a and 4b). This is obtained by removing a few outliers,²⁰ which allows more robust threshold estimation.²¹

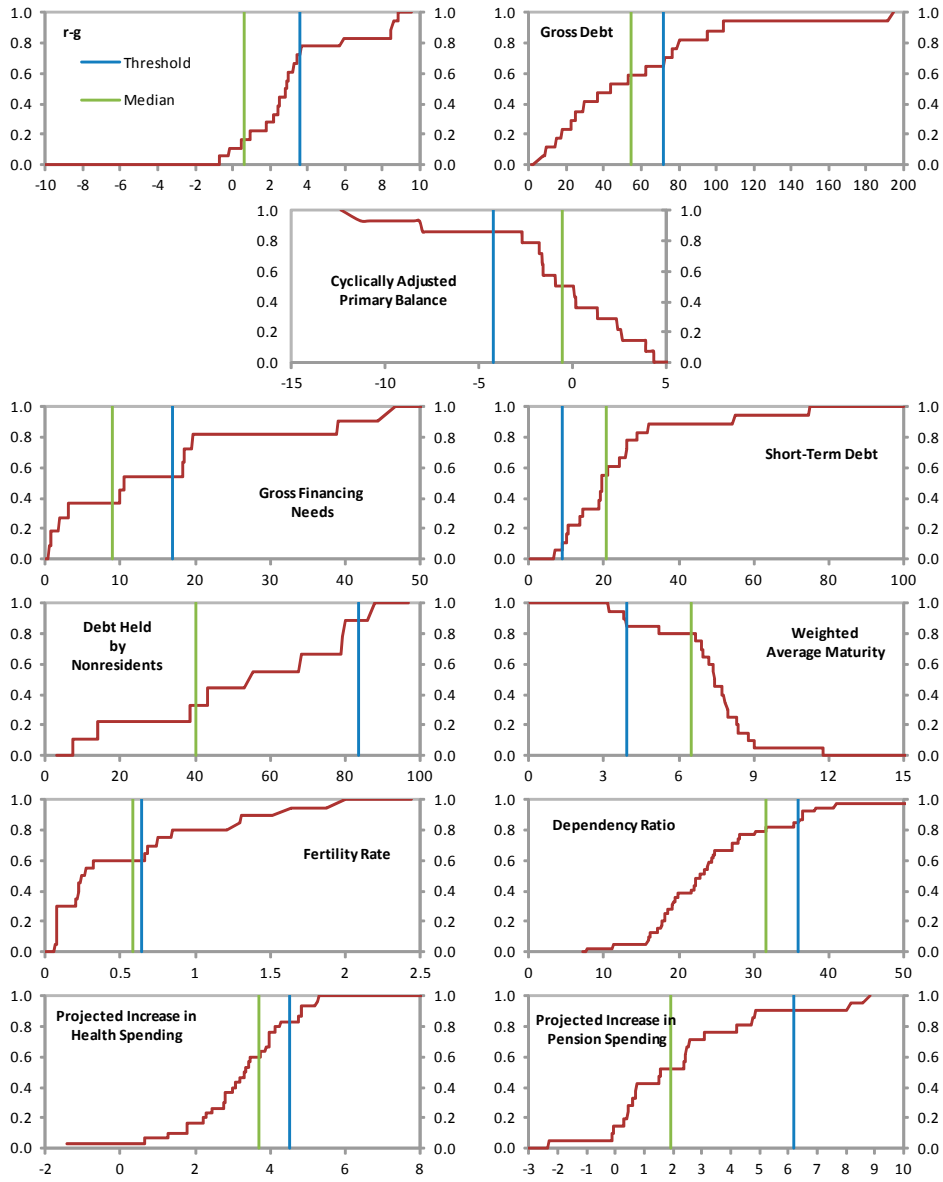
¹⁸ As expected, the SNR approach leads to higher total errors; specifically, this method can force the solution to very high type II errors, yielding thresholds with very high percentages of missed crises and misclassified non-crises.

¹⁹ In general, the indicators may not have an easily identified region that comes out of well-behaved CDFs, leading to corner solutions. Such cases were encountered when using a larger set of fiscal variables, including social spending and the slope of the yield curve. Solutions to such cases vary from using bootstrapping to assigning zero weights to the variables in the index. A preferred approach, however, was to use a parsimonious set of indicators, exhibiting well-behaved data properties.

²⁰ These are defined as observations with high absolute levels of the standardized score, based on subtracting the mean of the fiscal indicator distribution and dividing by its standard deviation.

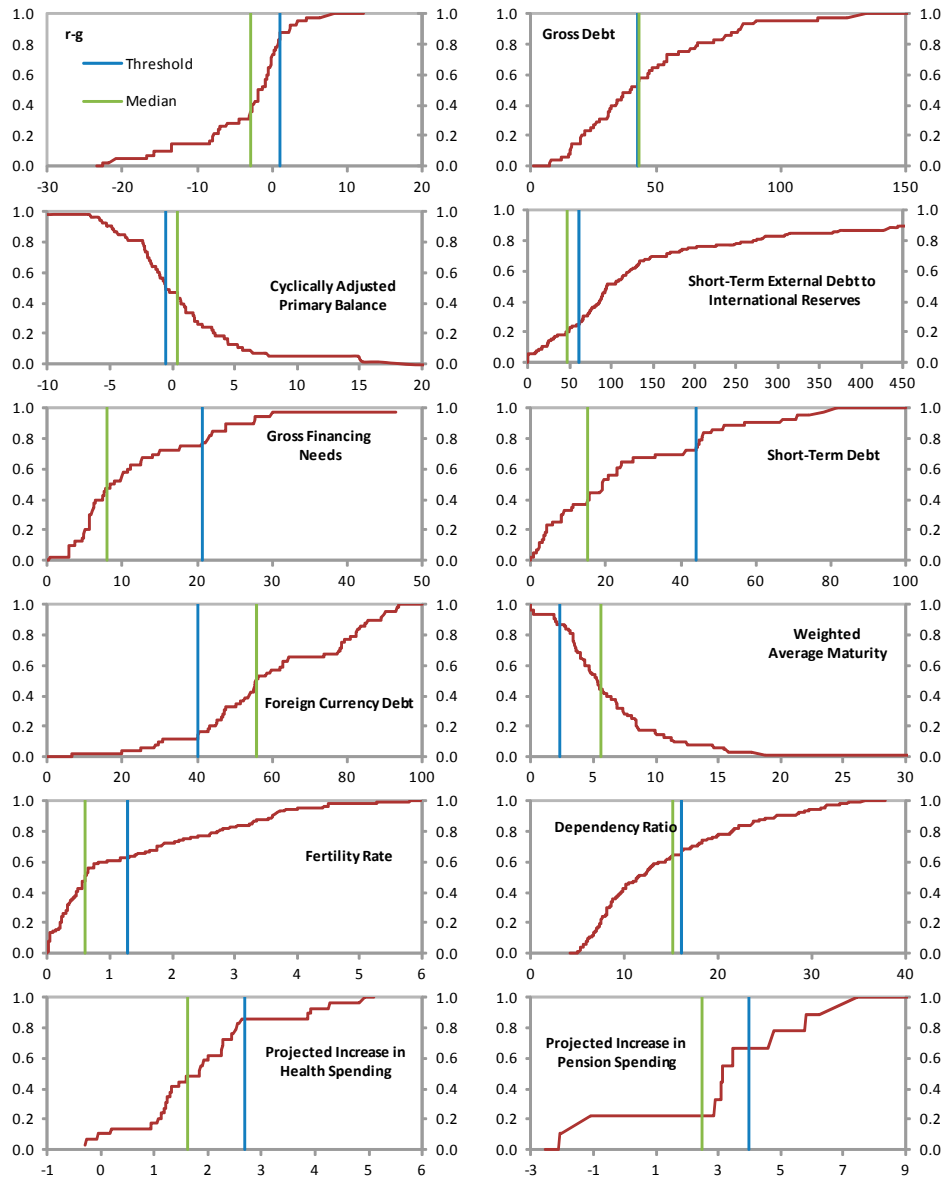
²¹ Basic fiscal variables are subject to such adjustment, as well as gross financing needs and the fertility rate indicator. In some cases (weighted average maturity and debt held by nonresidents to total public debt for advanced economies) the threshold is located in the crisis-prone side of the distribution and it is selected without further adjustment of the data. These adjustments make some of the thresholds more plausible, while increasing the precision of the estimates. Including outliers in the estimation of the threshold would reduce the explanatory power of some variables. Excluding the indicators for which outliers were removed would, however, have a larger impact on the results.

Figure 4a. Advanced Economies: Fiscal Indicator Medians and Thresholds



Note: Median for the period 1995-2010. See Appendix Table 5 for the definition of fiscal indicators.
 Source: Authors' calculations.

Figure 4b. Emerging Market Economies: Fiscal Indicator Medians and Thresholds



Note: Median for the period 1995-2010. See Appendix Table 5 for the definition of fiscal indicators. Source: Authors' calculations.

The estimated thresholds and the implied signaling power of the indicators determine the relative weight that a variable has in the fiscal stress index (Tables 5a and 5b). Signaling power is defined as one minus the total error and it is a measure of the statistical power of the variable. As discussed in Section II, predictive errors produced by EWS methodologies are typically non-negligible. The focus of the exercise, however, is on the relative performance of the fiscal variables and their role in detecting fiscal vulnerability. This is shown by the relative signal intensity for each variable (signaling power).

Table 5a. Advanced Economies: Thresholds and Relative Weights of Fiscal Indicators

INDICATOR	Direction to be safe	Crisis obs.	Non-crisis obs.	Threshold	Type 1 error	Type 2 error	Signaling Power	Index Weight
Basic Fiscal Variables								31.59
r-g (5 year average)	<	21	670	3.6	0.48	0.29		14.9
General government gross debt (percent of GDP)	<	15	561	72.2	0.22	0.67		7.3
Cyclically adjusted primary balance (percent of potential GDP)	>	5	137	-4.2	0.45	0.40		9.4
Asset and Liability Management								42.56
Gross financing needs (percent of GDP)	<	6	219	17.2	0.45	0.17		24.6
Share of short term debt as a ratio of total debt	<	15	506	9.1	0.96	0.00		2.8
Debt held by nonresidents (percent of total debt)	<	7	163	83.6	0.06	0.79		10.1
Weighted average maturity of general government debt (years)	>	18	535	3.9	0.09	0.83		5.0
Long-Term Fiscal Trend								25.85
Fertility rate (deviation from 2.1)	<	31	950	0.64	0.25	0.71		2.4
Long term projections of public health expenditure (percent of GDP)	<	28	749	4.5	0.53	0.32		9.4
Long term projections of public pension expenditure (percent of GDP)	<	21	600	6.2	0.09	0.76		9.6
Dependency ratio	<	37	1006	36.0	0.06	0.86		4.5

Source: Authors' calculations.

Table 5b. Emerging Economies: Thresholds and Relative Weights of Fiscal Indicators

INDICATOR	Direction to be safe	Crisis obs.	Non-crisis obs.	Threshold	Type 1 error	Type 2 error	Signaling Power	Index Weight
Basic Fiscal Indicators								23.72
r-g (5 year average)	<	52	471	1.1	0.58	0.25		11.3
General government gross debt (percent of GDP)	<	20	245	42.8	0.61	0.35		2.5
Cyclically adjusted primary balance (percent of potential GDP)	>	60	592	-0.5	0.33	0.52		9.9
Asset and Liability Management								43.56
Gross financing needs (percent of GDP)	<	29	287	20.6	0.27	0.69		2.8
Share of short term debt as a ratio of total debt	<	45	430	44.0	0.15	0.71		9.2
Debt denominated in foreign currencies (percent of total debt)	<	52	555	40.3	0.70	0.15		9.9
Weighted average maturity of general government debt (years)	>	40	370	2.3	0.11	0.85		2.6
Short term external debt (percent of gross international reserves)	<	101	1104	61.8	0.43	0.28		19.1
Long-Term Fiscal Outlook								32.73
Fertility rate (deviation from 2.1)	<	60	659	1.3	0.87	0.05		5.2
Long term projections of public health expenditure (percent of GDP)	<	28	245	2.7	0.38	0.50		8.2
Long term projections of public pension expenditure (percent of GDP)	<	5	47	4.0	0.60	0.20		13.4
Dependency ratio	<	81	830	16.1	0.40	0.51		5.9

Source: Authors' calculations.

The top predictors of fiscal stress are different for advanced and emerging economies.²² In the advanced economies, government rollover pressures are associated with the size of financing needs and fiscal solvency concerns, while for emerging economies liquidity constraints are the main signal of fiscal stress. This finding underlies the different economic structure and weaknesses that characterize these countries. When advanced economies are vulnerable to market financing shocks, this is generally in response to evidence of an unsustainable debt path. With about one third of the fiscal stress index determined by international liquidity and the currency composition of government debt, emerging economies are more exposed to “original sin” problems and spillovers from financial markets.²³

A logit regression is used to assess the ability of the fiscal stress index to provide early warning signals on fiscal sustainability risks. This is done by plotting the fiscal stress index and the probability of entering into fiscal stress (and remaining in stress after an episode has started). The fiscal stress index components are all significant determinants of fiscal stress episodes. The correlation is higher with basic fiscal variables, whereas the other components of the index have a lower correlation—although their coefficients are highly significant (Figure 5a).²⁴

In emerging economies, the relationship between fiscal crises and the fiscal stress index follows a similar pattern, with a narrower confidence interval than for advanced countries (Figure 5b). The correlation between the fiscal stress index and probability of experiencing a fiscal crisis is driven primarily by the asset and liability management variables for these countries.²⁵

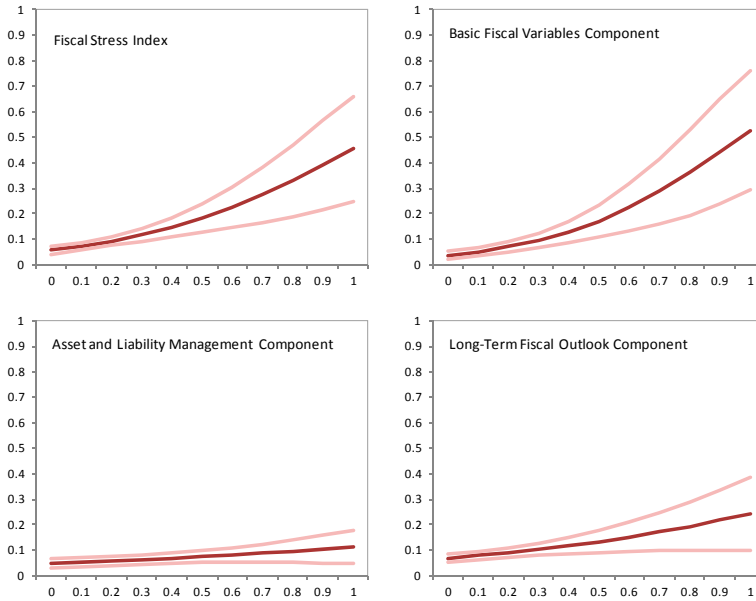
²² In both advanced countries and emerging economies the nature of fiscal sustainability risks has changed over time as population aging has emerged as a key fiscal risk and economies have gained market access. This is reflected in the changes over time in the weights that the indicators have on the fiscal stress index when they are calculated for sub-periods of time.

²³ “Original sin” is the inability of emerging market economies to finance externally in domestic currency (Eichengreen, B., Hausmann, R., Panizza, U., 2002). With a small domestic investor base, a government that resorts to heavy external borrowing is exposed to substantial foreign currency risk.

²⁴ Notice that the dependent variable in this case includes the periods of fiscal stress after the first year in which a crisis occurs. This is different from the definition of fiscal stress episodes used for the construction of the index and can help assess how the index helps predict the level of risk once the event has occurred. This also explains why basic fiscal variables have a stronger weight in the regression results than in the fiscal stress index, as they are associated with more persistent stress spells.

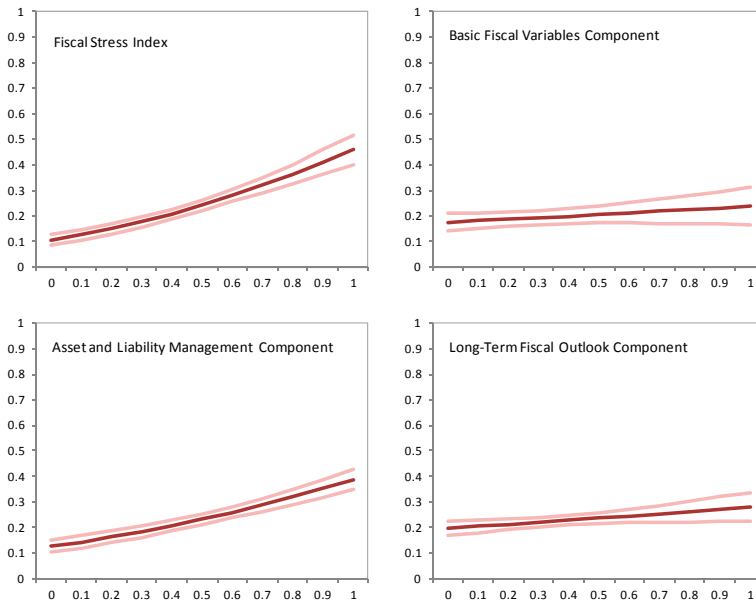
²⁵ Multivariate logit regressions confirm these results, with basic fiscal variables having the largest marginal effect in advanced economies, and the asset and liability management component having the largest marginal effect in emerging market economies.

Figure 5a. Advanced Economies: Probability of Fiscal Crisis at Different Levels of the Fiscal Stress Index



Note: Cumulative marginal effect of the fiscal stress index and its components with 95-percent confidence bands.
 Source: Authors' estimations.

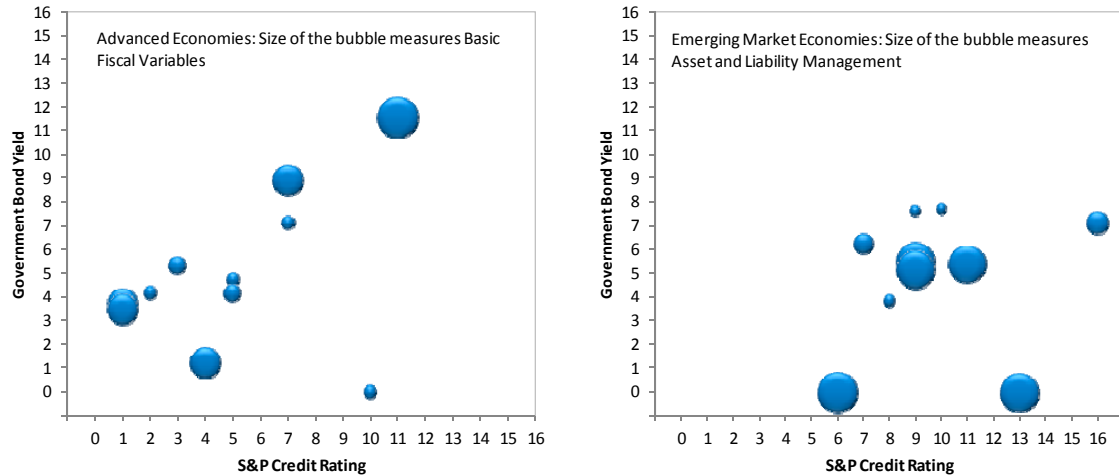
Figure 5b. Emerging Economies: Probability of Fiscal Crisis at Different Levels of the Fiscal Stress Index



Note: Cumulative marginal effect of the fiscal stress index and its components with 95-percent confidence bands.
 Source: Authors' estimations.

The fiscal stress index has also a positive correlation with government bond yields and credit ratings.²⁶ In advanced economies, the correlation of the fiscal stress index estimated for 2011 with sovereign bond yields as of March 2011 is significantly different from zero at 0.4, while it is lower (0.24) but still significant with credit ratings. However, the correlation of the basic fiscal variables component with bond yields and credit ratings is stronger at 0.5 and 0.4, respectively (Figure 6). In emerging economies, the fiscal stress index has a lower correlation with market risk prices and ratings. The correlation of the asset and liability management component of the index is, however, the strongest among the three subcomponents of the index.

Figure 6. Advanced Economies: Government Bond Yields, Credit Ratings and Fiscal Stress, 2011



Source: Authors' estimations.

Standard and Poor's Credit Rating Legend															
AAA	AA+	AA	AA-	A+	A	A-	BBB+	BBB	BBB-	BB+	BB	BB-	B+	B	B-
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

C. Fiscal Stress Index Trends

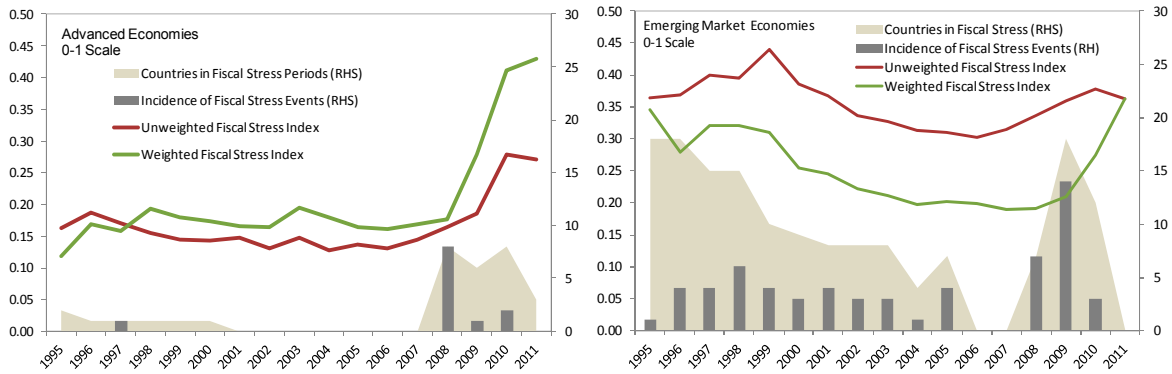
Fiscal stress has increased more rapidly in advanced than in emerging economies. In 2011, the fiscal stress index—weighted with countries' PPP-GDP—is higher in advanced countries (Figure 7).²⁷ Overall, in advanced economies the fiscal stress index has doubled since 2006 and is at record-high levels. In contrast, in emerging economies the fiscal stress index is

²⁶ Similar high correlations are also found with alternative measures of sovereign credit risk, including credit risk spreads and fiscal adjustment requirements to achieve prudent debt levels (IMF, 2011).

²⁷ The unweighted average index is useful in gauging how the index fares compared to the incidence of fiscal crisis and the number of countries in fiscal stress. The weighted average is useful in assessing the systemic importance of the fiscal stress index dynamics.

elevated, but still slightly below the peak experienced during the financial crises of the late 1990s.²⁸

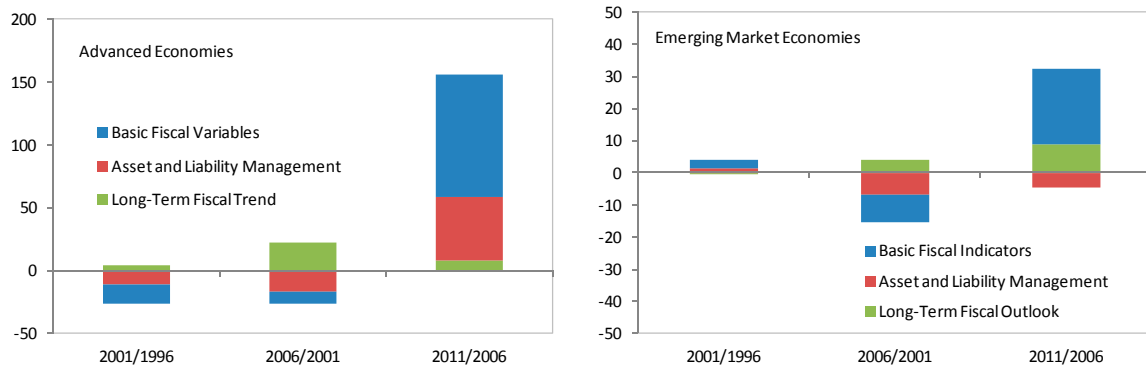
Figure 7. Fiscal Stress Index, 1995-2011



Note: PPP-GDP weights used to calculate the weighted average index.
Source: Authors' calculations.

Decomposing the fiscal stress index for advanced economies reveals that its increase since the mid-2000s is a result of a sharp deterioration in the basic fiscal variables—mainly debt to GDP and the cyclically adjusted primary balance (Figure 8). The asset and liability management component has also peaked, contributing for about half of the increase in the index. Long-term fiscal indicators have also exerted continuous pressure on the fiscal stress index. In emerging economies, the main factors behind the increase in the fiscal stress index have been the basic fiscal variables, followed by the long-term fiscal trends. The asset and liability management component—mostly due to declining short-term debt to international reserves—has kept the index from increasing further.

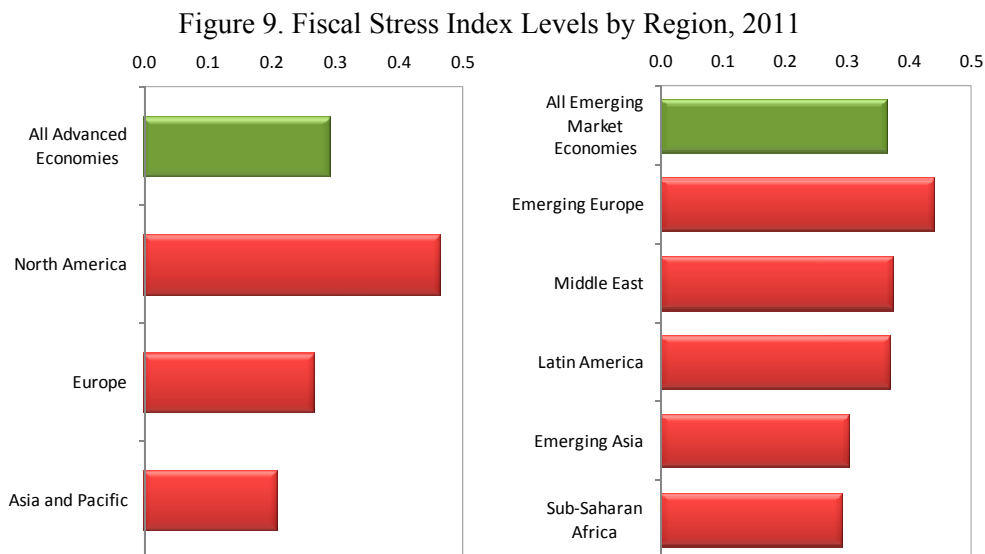
Figure 8. Contribution of the Fiscal Stress Index Components, 1996-2011



Note: Unweighted fiscal stress index. It measures the change in the index compared to the base year in percent.
Source: Authors' calculations.

²⁸ As the two indices are constructed independently and therefore also have different levels, using a common scaling year helps compare the behavior of fiscal stress across country groupings. The trends in the indices, when commonly scaled, are indicative of the developments in fiscal vulnerability among the two groupings.

Focusing on the regional differences (Figure 9), in advanced economies, the fiscal stress index is highest in North America, although the peak levels of the index are observed in peripheral euro countries. In emerging economies, the fiscal stress index is markedly higher in Emerging Europe, followed by countries in the Middle East and North Africa.



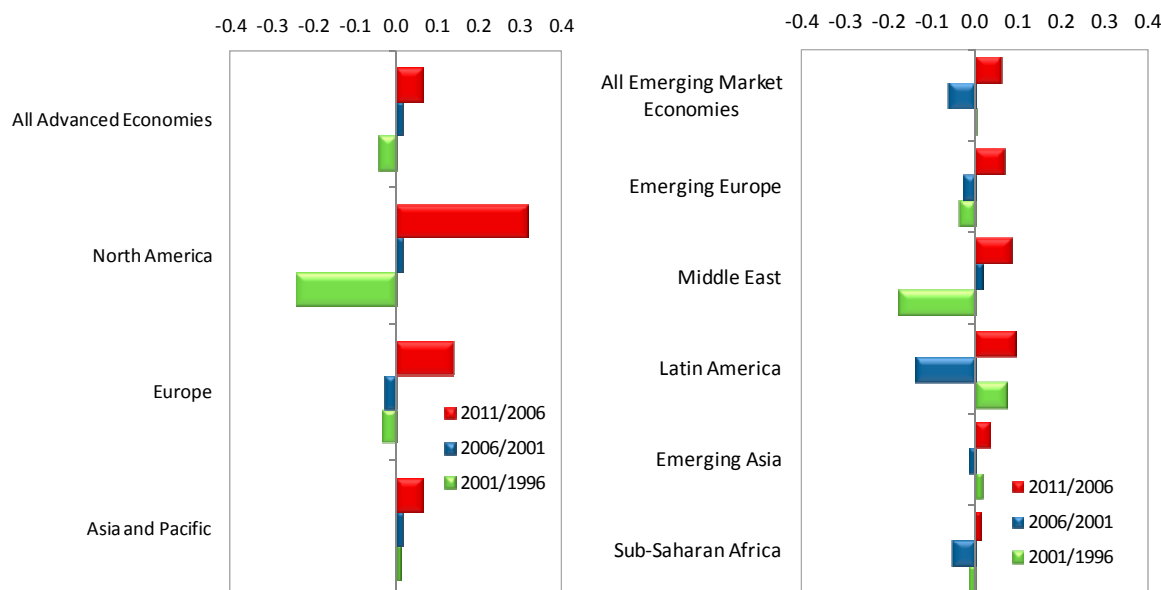
Note: Unweighted fiscal stress index.

Source: Authors' calculations.

In the last five years, the index has increased sharply in North America (Figure 10). This is mainly due to deterioration in the cyclically adjusted primary balance and a sharp increase in debt and gross financing needs. While in Asia and the Pacific the index has increased the least, it has been on an upward trend for the last 15 years. This is due to underlying demographic trends, putting pressure on the long-term fiscal component of the index, as well as rising debt and large gross financing needs.

In emerging economies, over the last five years the index has increased the most in Latin American countries, due to peaking cyclically adjusted primary deficits, in a few cases accompanied by declining debt maturity and international reserve coverage of short-term debt. In Emerging Europe, the index has remained elevated throughout 1996-2011. This is not only due to the solvency indicators, but also worsening asset and liability management risks—high ratio of foreign currency denominated debt and low reserve coverage of short-term debt—in addition to growing concerns about the long-term fiscal outlook.

Figure 10. Fiscal Stress Index Changes by Region, 1996-2011



Source: Authors' calculations.

V. CONCLUSIONS

The fiscal stress index presented in this paper provides a signaling tool to assess exposure to fiscal sustainability risks and helps identify the factors underlying changes in fiscal stress risks. However, like similar early warning tools, the stress index does not attempt to predict crises, which are typically triggered by a combination of economic, financial, or political shocks. While signaling tools like the fiscal stress index presented here are important to assess vulnerabilities, they should be complemented by judgment-based approaches.

This paper calculates thresholds that identify the likelihood of fiscal stress for a large set of fiscal variables. These thresholds are based on an EWS methodology and are used to construct a summary index of fiscal sustainability risks for advanced economies and emerging markets. In contrast with previous studies, the fiscal stress index relies on a broader definition of crisis episodes, consistent with the conceptual framework developed by Cottarelli (2011). In calculating the fiscal stress index, this paper uses a parsimonious set of fiscal indicators proposed by Baldacci, McHugh and Petrova (2011).

The fiscal stress index is calculated for a large sample of advanced and emerging economies during 1995-2011. Results show that in advanced countries the top predictors of fiscal stress are indicators of gross financing needs and fiscal solvency risks. In emerging economies, the best predictors of fiscal stress are risks associated with public debt structure and exposure to spillovers from financial markets. Fiscal stress risk has increased dramatically across the world as a consequence of the global financial crisis. Risks are higher in advanced economies

than in emerging economies, but remain higher than before the crisis in the latter group. North America and Europe are the regions where fiscal stress risks are highest.

There is scope for further extensions based on the analysis presented in this paper. In particular, bootstrapping methods could be used to gauge the uncertainty surrounding the point estimates. Another avenue of further research is to conduct the analysis using thresholds based on country-specific distributions (as in Hemming et al., 2003) instead of using an overall threshold, in order to control for country-specific characteristics. Using time-specific effects could also prove useful in view of the common factors that affect many countries during periods of global contagion.

REFERENCES

- Abiad, Abdul, 2003, "Early Warning Systems: A Survey and a Regime-Switching Approach," IMF Working Paper 03/32 (Washington: International Monetary Fund).
- Baldacci, Emanuele, James McHugh and Iva Petrova, 2011, "Measuring Fiscal Vulnerability and Fiscal Stress: A Proposed Set of Indicators," IMF Working Paper 11/94 (Washington: International Monetary Fund).
- Beim, David, and Charles Calomiris, 2001, "Emerging Financial Markets." Appendix to Chapter 1. New York: McGraw-Hill/Irwin Publishers.
- Berg, Andrew and Catherine Patillo, 1999, "Predicting Currency Crises: The Indicators Approach and an Alternative," *Journal of International Money and Finance*, Vol.18, pp. 561-586.
- Berg, Andrew, Eduardo Borensztein and Catherine Patillo, 2005, "Assessing Early Warning Systems: How Have They Worked in Practice?" *IMF Staff Papers*, Vol. 52, No. 3, pp. 462-502.
- Bussiere, Matthieu, and Marcel Fratzscher, 2006, "Towards a New Early Warning System of Financial Crises" *Journal of International Money and Finance*, Vol. 25, pp. 953-973.
- Candelon, Bertrand, Elena-Ivona Dumitrescu and Christophe Hurlin, 2010, "How to Evaluate an Early Warning System," IMF Working Paper (Washington: International Monetary Fund).
- Chamon, Marcos, Paolo Manasse and Alessandro Prati, 2007, "Can We Predict the Next Capital Account Crisis?" *IMF Staff Papers*, Vol. 54, No. 2, pp. 270-305.
- Čihák, Martin and Klaus Schaeck, 2010, "How Well do Aggregate Prudential Ratios Identify Banking System Problems?" *Journal of Financial Stability*, Volume 6, Issue 3, September 2010, pp. 130-144.
- Cottarelli, Carlo, 2011, "The Risk Octagon: A Comprehensive Framework for Assessing Sovereign Risks" presented in University of Rome "La Sapienza," January.
- Detragiache, Enrica, and Antonio Spilimbergo, 2001, "Crises and Liquidity: Evidence and Interpretation," IMF Working Paper No. 01/2 (Washington: International Monetary Fund).
- Edison, Hali J., 2000, "Do Indicators of Financial Crises Work? An Evaluation of an Early Warning System," International Finance Discussion Paper N°675, Board of Governors of the Federal Reserve System.

- Eichengreen, B., R. Hausmann and U. Panizza, 2002, “Original Sin: the Pain, the Mystery, and the Road to Redemption,” Mimeo (Washington: Inter-American Development Bank).
- Finger, Harald and Mauro Mecagni, 2007, *An Analysis of Recent Cross-Country Experience*, IMF Occasional Paper.
- Frankel, Jeffrey and George Saravelos, 2010, “Are Leading Indicators of Financial Crises Useful for Assessing Country Vulnerability? Evidence from the 2008-09 Global Crisis,” NBER Working Paper 16047, June.
- Hemming, Richard, Michael Kell, and Axel Schimmelpfennig, 2003, *Fiscal Vulnerability and Financial Crises in Emerging Market Economies*, IMF Occasional Paper 218.
- Hemming, Richard, and Murray Petrie, 2000, “A Framework for Assessing Fiscal Vulnerability,” IMF Working Paper 00/52.
- International Monetary Fund, 2007, “Assessing Underlying Vulnerabilities and Crisis Risks in Emerging Market Countries—A New Approach” (Washington: International Monetary Fund).
- International Monetary Fund, 2010a, Updating the VEE Methodology, unpublished paper.
- _____, 2010b, “Fiscal Exit: From Strategy to Implementation,” *Fiscal Monitor*, November 2010 (Washington: International Monetary Fund).
- _____, 2011, “Shifting Gears: Tackling Challenges of the Road to Fiscal Adjustment,” *Fiscal Monitor*, April 2011 (Washington: International Monetary Fund).
- Kaminsky, Graciela, Saul Lizondo and Carmen Reinhart, 1998, “Leading Indicators of Currency Crisis,” *IMF Staff Papers*, Vol. 45, No. 1, pp. 1-48.
- Laeven, Luc, and Fabian Valencia, 2008, “Systemic Banking Crises: A New Database,” IMF Working Paper 08/224 (Washington: International Monetary Fund).
- Manasse, Paolo, Nouriel Roubini and Axel Schimmelpfennig, 2003, “Predicting Sovereign Debt Crises,” IMF Working Paper 03/221 (Washington: International Monetary Fund).
- Kumar, Manmohan S., Uma Moorthy and W. R. M. Perraudin, 2002, “Predicting Emerging Market Currency Crashes,” Working Paper No. 02/7 (Washington: International Monetary Fund).
- Mauro, Paolo, Nathan Sussman, and Yishay Yafeh, 2002, “Emerging Market Spreads: Then vs. Now,” *Quarterly Journal of Economics*, Vol. 117 (May), pp. 695–733.

- Nag, Ashok, and Amit Mitra, 1999, "Neural Networks and Early Warning Indicators of Currency Crises," *Reserve Bank of India Occasional Papers* 20(2), pp. 183-222 (Monsoon).
- Pescatori, Andrea and Amadou Sy, 2007, "Are Debt Crises Adequately Defined?," *IMF Staff Papers*, Vol. 54(2).
- Reinhart, Carmen and Kenneth Rogoff, 2009, "The Aftermath of Financial Crises," *American Economic Review*, Vol. 99 No. 2, May 2009, 466-472.
- Reinhart, Carmen and Kenneth Rogoff, 2010, "From Financial Crash to Debt Crises," NBER Working Paper 15795, <http://www.nber.org/papers/w15795>.
- Sturzenegger, Federico and Jeromin Zettelmeyer, 2006, *Debt Defaults and Lessons from a Decade of Crises*. Table 1 in Chapter 1, Cambridge: MIT Press.
- Wong, J., E. Wong and P. Leung, 2007, *A Leading Indicator Model of Banking Distress—Developing an Early Warning System for Hong Kong and Other EMEAP Economies*, Working Paper 07_22, Hong Kong Monetary Authority.

Appendix Table 1. Pros and Cons of Early Warning Statistical Methodologies

Methodology	Studies	Pros	Cons
Signaling Approach	<ul style="list-style-type: none"> ▪ Kaminsky, Lizondo, and Reinhart, 1998 (1998) ▪ IMF (2007) ▪ Allen and Johnson (2007) ▪ Hemming, Kell and Schimmelpfennig (2003) ▪ Edison (2000) 	<ul style="list-style-type: none"> ▪ Easily accommodate differences in data availability across variables ▪ Permit a transparent mapping from indicators to aggregate indices 	<ul style="list-style-type: none"> ▪ Ignore interactions among variables ▪ Cannot use standard statistical tests to check for robustness
Logit/Probit Models	<ul style="list-style-type: none"> ▪ Berg and Patillo (1999) ▪ Berg, Borensztein and Patillo (2005) ▪ Bussiere and Fratzscher (2006) ▪ Hemming, Kell and Schimmelpfennig (2003) ▪ Kumar, Moorthy and Perraudin (IMF 2002) ▪ Cihak and Schaeck (2010) ▪ Wong, Wong and Leung (2010) 	<ul style="list-style-type: none"> ▪ Take into account correlations across variables ▪ Easily test for statistical significance of individual variables 	<ul style="list-style-type: none"> ▪ Constrain usable dataset when data availability varies across variables ▪ Number of variables that can be meaningfully considered simultaneously is limited ▪ Changes in the variables themselves and changes in their contribution to the crisis prediction not always transparent

Appendix Table 2. Comparison of Statistical Methodologies

Study	Comparison Criteria	Evaluation Criteria	Findings
Berg and Patillo (1999)	<ul style="list-style-type: none"> ▪ In-sample ▪ Out-of-sample ▪ Cross-country 	<ul style="list-style-type: none"> ▪ Percent of pre-crisis periods correctly called ▪ Percent of tranquil periods correctly called ▪ False alarms as percent of total alarms ▪ QPS and LPS 	<ul style="list-style-type: none"> ▪ Signaling methodologies outperform probit out-of-sample ▪ Probit outperform signaling methodologies in cross-country studies
Berg, Borensztein and Patillo (2005)	<ul style="list-style-type: none"> ▪ In-sample ▪ Out-of-sample 	<ul style="list-style-type: none"> ▪ Same as above ▪ Probability of crisis given signal ▪ Probability of crisis given no signal ▪ Loss function = weighted sum of false alarms (as a % of total non-crisis) and missed crises (as a % of total crisis) 	<ul style="list-style-type: none"> ▪ Signaling methodologies perform better out-of-sample than in-sample
Davis and Karim (2008)	<ul style="list-style-type: none"> ▪ In-sample ▪ Cross-country 	<ul style="list-style-type: none"> ▪ Correctly classified relative to incorrectly classified events 	<ul style="list-style-type: none"> ▪ Probit's performance deteriorates substantially over the sample ▪ Logit most appropriate for global EWS; signaling approach for country-specific EWS.

Appendix Table 3a. Advanced Economies: Fiscal Stress Events

Country	Start of Crisis	Sovereign Default or Restructuring	First Year of IMF-Supported Program	Inflation Pressures (35 percent)	Bond Yield Pressure	Duration of Fiscal Crisis
Australia	1986				<input type="checkbox"/>	2
	1989				<input type="checkbox"/>	1
	2008				<input type="checkbox"/>	3
Canada	1990				<input type="checkbox"/>	1
Czech Republic	1991		<input type="checkbox"/>			1
Denmark	1982				<input type="checkbox"/>	1
Finland	1990				<input type="checkbox"/>	1
	1992				<input type="checkbox"/>	1
France	1970					1
	1974				<input type="checkbox"/>	1
Germany	1974				<input type="checkbox"/>	1
Greece	1993				<input type="checkbox"/>	3
	2008				<input type="checkbox"/>	6
Iceland	1974			<input type="checkbox"/>		2
	1978			<input type="checkbox"/>		6
	2008		<input type="checkbox"/>		<input type="checkbox"/>	4
Ireland	1974				<input type="checkbox"/>	1
	1976				<input type="checkbox"/>	1
	2008				<input type="checkbox"/>	6
Israel	1974			<input type="checkbox"/>		2
	1978			<input type="checkbox"/>		3
	1982			<input type="checkbox"/>		5
Italy	1974		<input type="checkbox"/>			2
	2008				<input type="checkbox"/>	3
Japan	1974				<input type="checkbox"/>	1
	2009				<input type="checkbox"/>	2
Korea, Republic of	1974				<input type="checkbox"/>	8
	1983		<input type="checkbox"/>			2
	1997		<input type="checkbox"/>			4
New Zealand	1985				<input type="checkbox"/>	3
	2008				<input type="checkbox"/>	1
Norway	1986				<input type="checkbox"/>	3
Portugal	1983		<input type="checkbox"/>			3
	2008				<input type="checkbox"/>	1
	2010				<input type="checkbox"/>	1
Slovenia	1991				<input type="checkbox"/>	6
Spain	2010				<input type="checkbox"/>	1
Sweden	1990				<input type="checkbox"/>	1
Switzerland	2008				<input type="checkbox"/>	1
United Kingdom	1970					1
	1974				<input type="checkbox"/>	6

Sources: IMF International Financial Statistics; Standard and Poor's; and authors' calculations.

Appendix Table 3b. Emerging Market Economies: Fiscal Stress Events

Country	Start of Crisis	Sovereign Default or Restructuring	First Year of IMF-Supported Program	Inflation Pressures (500 percent)	Bond Yield Pressure	Duration of Fiscal Crisis
Albania	1991	<input type="checkbox"/>				5
	1998		<input type="checkbox"/>			1
Algeria	1991	<input type="checkbox"/>				6
Argentina	1982	<input type="checkbox"/>				12
	1998		<input type="checkbox"/>			1
	2000		<input type="checkbox"/>			6
Armenia	1993			<input type="checkbox"/>		2
	1996		<input type="checkbox"/>			1
	2000				<input type="checkbox"/>	4
	2009		<input type="checkbox"/>			2
Bosnia and Herzegovina	1992	<input type="checkbox"/>				6
	2009		<input type="checkbox"/>			1
Brazil	1983	<input type="checkbox"/>	<input type="checkbox"/>			12
	1998		<input type="checkbox"/>			1
	2001		<input type="checkbox"/>			2
Bulgaria	1990	<input type="checkbox"/>				6
	1997			<input type="checkbox"/>		2
	2009				<input type="checkbox"/>	1
Chile	1972	<input type="checkbox"/>				1
	1974	<input type="checkbox"/>		<input type="checkbox"/>		2
	1983	<input type="checkbox"/>	<input type="checkbox"/>			8
Colombia	1999		<input type="checkbox"/>			1
	2003		<input type="checkbox"/>			1
	2009		<input type="checkbox"/>			1
Costa Rica	1980		<input type="checkbox"/>			11
	2009		<input type="checkbox"/>			1
Croatia	1992	<input type="checkbox"/>				6
Dominican Republic	1975	<input type="checkbox"/>				20
	2003		<input type="checkbox"/>			1
	2005	<input type="checkbox"/>	<input type="checkbox"/>			1
	2009		<input type="checkbox"/>			1
Ecuador	1982	<input type="checkbox"/>				14
	1999	<input type="checkbox"/>				2
	2005	<input type="checkbox"/>				1
Egypt	1978		<input type="checkbox"/>			1
El Salvador	1981	<input type="checkbox"/>				16
	2009		<input type="checkbox"/>			2
Georgia	1996		<input type="checkbox"/>			1
	2008		<input type="checkbox"/>			1
Guatemala	1983		<input type="checkbox"/>			1
	1986	<input type="checkbox"/>				1
	1989	<input type="checkbox"/>				1
	2009		<input type="checkbox"/>			1
Hungary	1982		<input type="checkbox"/>			1
	1991		<input type="checkbox"/>			1
	2008		<input type="checkbox"/>		<input type="checkbox"/>	3
India	1972	<input type="checkbox"/>				5
	1981		<input type="checkbox"/>			1
	1989	<input type="checkbox"/>				2
Indonesia	1997		<input type="checkbox"/>			4
	2002	<input type="checkbox"/>				1

Country	Start of Crisis	Sovereign Default or Restructuring	First Year of IMF-Supported Program	Inflation Pressures (500 percent)	Bond Yield Pressure	Duration of Fiscal Crisis
Jamaica	1977		☐			3
	1981	☐	☐			17
	2010		☐			1
Jordan	1989	☐				6
	1996		☐			1
Kazakhstan	1993			☐		2
	1996		☐			1
Kenya	1975		☐			1
	1979		☐			2
	1982		☐			2
	1988		☐			2
	1994	☐				5
	2000	☐				1
Latvia	2008		☐			3
Lithuania	1994		☐			1
	2009				☐	1
Macedonia	1992	☐		☐		6
Malaysia	1998				☐	1
	2009				☐	2
Mexico	1977		☐			1
	1982	☐				9
	1995		☐		☐	3
	1999		☐		☐	1
	2009		☐			2
Morocco	1980		☐			4
	1986	☐				5
Nigeria	1982	☐				11
	2001	☐				1
	2004	☐				2
Pakistan	1980		☐			2
	1988		☐			1
	1994		☐			1
	1997		☐			3
	2001		☐			1
	2008		☐			3
Panama	1980		☐			1
	1983	☐	☐			14
Peru	1976	☐				1
	1978	☐	☐			3
	1982		☐			16
Philippines	1976		☐			1
	1980		☐			1
	1983	☐	☐			10
	1998		☐		☐	1
Poland	1981	☐				14
	2001				☐	1
	2009		☐			2
Romania	1981	☐	☐			3
	1986	☐				1
	2008				☐	3
Russian Federation	1991	☐				10
	2009				☐	1
Serbia	1983	☐				22
South Africa	1985	☐				3
	1989	☐				1
	1993	☐				1

Country	Start of Crisis	Sovereign Default or Restructuring	First Year of IMF-Supported Program	Inflation Pressures (500 percent)	Bond Yield Pressure	Duration of Fiscal Crisis
Sri Lanka	1979		☐			1
	1991		☐			1
	1993				☐	1
	2003		☐			1
	2009		☐			1
Thailand	1981		☐			2
	1985		☐			1
	1997		☐			2
Tunisia	1988		☐			1
Turkey	1978	☐	☐			3
	1982	☐				1
	1999		☐			1
	2002		☐			1
	2005		☐			1
Ukraine	1992			☐		4
	1998	☐	☐			3
	2008		☐			1
	2010		☐			1
Uruguay	1983	☐	☐			3
	1987	☐				1
	1990	☐				2
	2002		☐			2
	2005		☐			1
Venezuela	1983	☐				23
	2008				☐	1
	2010				☐	1
Vietnam	1975	☐				1
	1985	☐				14

Sources: IMF International Financial Statistics; Standard and Poor's; and authors' calculations.

Appendix Table 4a. Advanced Economies: Event Comparison Across Studies

Country	Start of Crisis	IMF (2007)	Reinhart and Rogoff	Hemming et al.	Manasse et al.	Laeven and Valencia
Australia	1986 1989 2008	n.a.	1989	n.a.	n.a.	n.a.
Austria	No crisis	n.a.	n.a.	n.a.	n.a.	n.a.
Belgium	No crisis	n.a.	n.a.	n.a.	n.a.	n.a.
Canada	1990	n.a.		n.a.	n.a.	n.a.
Czech Republic	1991					
Denmark	1982	n.a.		n.a.	n.a.	n.a.
Finland	1990 1992	n.a.	1991	n.a.	n.a.	1991
France	1970 1974	n.a.		n.a.	n.a.	n.a.
Germany	1974	n.a.		n.a.	n.a.	n.a.
Greece	1993 2008	n.a.	1991	n.a.	n.a.	n.a.
Hong Kong	No crisis					
Iceland	1974 1978 2008	n.a.	n.a.	n.a.	n.a.	n.a.
Ireland	1974 1976 2008	n.a.	n.a.	n.a.	n.a.	n.a.
Israel	1974 1978 1982	n.a.	1977		n.a.	1977
Italy	1974 2008	n.a.		n.a.	n.a.	n.a.
Japan	1974 2009	n.a.	n.a.	n.a.	n.a.	n.a.
Korea	1974 1983 1997	n.a.	1983 1997		1980 1997	1997
Netherlands	No crisis					
New Zealand	1985 2008	n.a.	1987	n.a.	n.a.	n.a.
Norway	1986	n.a.	1987	n.a.	n.a.	1991
Portugal	1983 2008 2010	n.a.		n.a.	n.a.	n.a.
Singapore	No crisis					n.a.
Slovak Republic	No crisis					
Slovenia	1991	n.a.	1994	n.a.	n.a.	1992
Spain	2010	n.a.	n.a.	n.a.	n.a.	n.a.
Sweden	1990	n.a.	1991	n.a.	n.a.	1991
Switzerland	2008	n.a.	n.a.	n.a.	n.a.	n.a.
United Kingdom	1970 1974	n.a.	1974	n.a.	n.a.	
United States	No crisis					

¹ "n.a." indicates that either the country or the year were not covered in the respective study. Empty cells indicate no crisis. The dating of the crises follows exactly the respective studies - i.e. we include events from other studies where two consecutive crises are separated by only one year.

Appendix Table 4b. Emerging Market Economies: Event Comparison Across Studies

Country	Start of Crisis	IMF (2007)	Reinhart and Rogoff	Hemming et al.	Manasse et al.	Laeven and Valencia
Albania	1991 1998	n.a. n.a.	1992	n.a. n.a.	n.a. n.a.	1994
Algeria	1991	1994	1990	n.a.	1991	1990
Argentina	1982 1998 2000	n.a. 1995 2001	1980, 1985, 1995 2001	1983	1982 1995 2001	1980, 1989 1995 2001
Armenia	1993 1996 2000 2009	n.a.	1994	n.a.	n.a.	1994
Bosnia and Herzegovina	1992 2009					
Brazil	1983 1998 2001	n.a. 1998 2002	1985, 1990,	1983	1983 1998	1990, 1994
Bulgaria	1990 1997 2009	1994	1994	n.a.	n.a.	1996
Chile	1972 1974 1983	n.a. n.a.	1976 1980	1973 1983	1983	1981
China	No crisis					
Colombia	1999 2003 2009	1999 2002	1998	1985 n.a.	n.a.	1998
Costa Rica	1980 2009	n.a.	1987	n.a.	1981	1987
Croatia	1992		1996	n.a.	n.a.	1998
Dominican	1975 2003 2005 2009	2003	2003	n.a.	1981	2003
Ecuador	1982 1999 2005	n.a. 1999	1996, 1998	n.a. n.a.	1982 1999	1982 1999
Egypt	1978					
El Salvador	1981 2009	n.a.	n.a.	n.a.	n.a.	n.a.
Estonia	No crisis					
Georgia	1996 2008	n.a.	n.a.	n.a.	n.a.	n.a.
Guatemala	1983 1986 1989 2009		2001		n.a.	n.a.
Hungary	1982 1991 2008	1994	1991	n.a.	n.a.	1991
India	1972 1981 1989	n.a.				
Indonesia	1997 2002	1997	1997	1998	1997	1997

Country	Start of Crisis	IMF (2007)	Reinhart and Rogoff	Hemming et al.	Manasse et al.	Laeven and Valencia
Jamaica	1977 1981 2010	n.a.		n.a.	1978 1981, 1987	
Jordan	1989 1996	n.a.	n.a.	1989	1989	1989
Kazakhstan	1993 1996	n.a.	n.a.	n.a.	n.a.	n.a.
Kenya	1975 1979 1982 1988 1994 2000	n.a.		n.a.	n.a.	1985 1992
Latvia	2008	n.a.		n.a.	n.a.	n.a.
Lebanon	No crisis	2001		n.a.	n.a.	
Lithuania	1994 2009	n.a.	1995	n.a.	n.a.	1995
Macedonia	1992	n.a.	1994	n.a.	n.a.	1993
Malaysia	1998 2009					
Mexico	1977 1982 1995 1999 2009		1981 1994	1982	1982 1995	1981 1994
Morocco	1980 1986	n.a.	1983	n.a.	1983 1986	1980
Nigeria	1982 2001 2004	n.a. n.a.		n.a.	n.a.	1983 1991
Pakistan	1980 1988 1994 1997 2001 2008		n.a.			n.a.
		1998		1999	1998	
Panama	1980 1983	n.a.	1988	n.a.	1983	
Peru	1976 1978 1982	n.a.			1976 1978 1983	1983
Philippines	1976 1980 1983 1998		1981		1986	1983 1997
Poland	1981 2001 2009	n.a.	1991	n.a.	n.a.	1992
Romania	1981 1986 2009	n.a. n.a. n.a.	1990	n.a.	n.a.	1990 n.a.
Russia	1991 2009	1998	1995, 1998	n.a.	1998	1998
Saudi Arabia	No crisis					
Serbia	1983	n.a.	n.a.	n.a.	n.a.	n.a.
South Africa	1985	n.a.			1985	n.a.

Country	Start of Crisis	IMF (2007)	Reinhart and Rogoff	Hemming et al.	Manasse et al.	Laeven and Valencia
Sri Lanka	1989		1989			
	1993				1993	
	1979	n.a.			n.a.	
	1991		1989			1989
	1993			1996		
Thailand	2003					
	2009					
Thailand	1981		1983		1981	1983
	1985					
Tunisia	1997	1997	1996	1998	1997	1997
	1988	n.a.		n.a.	1991	1991
Turkey	1978			n.a.	1978	
	1982		1982			1982
	1999				2000	2000
	2002	2001				
Ukraine	2005					
	1992			n.a.		
	1998	1998	1997		1998	1998
Uruguay	2008					
	2010					
	1983		1981	1983	1983	1981
	1987					
	1990					
Venezuela	2002	2002	2002	n.a.		2002
	2005					
	1983	1994, 2001	n.a.	1985	1983, 1995	1994
Vietnam	2008					
	2010					
	1975	n.a.	n.a.	n.a.	n.a.	n.a.
	1985					

¹ "n.a." indicates that either the country or the year were not covered in the respective study. Empty cells indicate no crisis. The dating of the crises follows exactly the respective studies - i.e. we include events from other studies where two consecutive crises are separated by only one year.

Appendix Table 5. List of Indicators and Data Sources

Indicator	Additional Data Clarification	Data Availability	Data Source
Fiscal Stress Variables			
Debt default	Period of domestic or foreign bonded and bank debt default.	1970-2010	Standard and Poor's
IMF-Supported programs	Period of IMF-supported program exceeding 100 percent of IMF member's quota.	1970-2010	IMF
Inflation rate	In percent: period during which inflation exceeds 35 percent per annum for AE, or 500 percent per annum for EMs.	1970-2010	IMF/IFS
Bond yield pressure	Government bond spreads (relative to 10-year US Treasury bond) exceeding 2 standard deviations above the historical annual mean of the country, or 1000 basis points on annual basis; or at least 6 months in a year based on monthly data.	1970-2010	IMF/IFS
Basic Fiscal Variables			
r-g (5-year average)	Imputed interest rate on general government debt, deflated by the GDP deflator, minus real GDP growth rate. Five year forward moving average.	1971-2010 (AE) 1985-2010 (EM)	WEO
Cyclical adjusted primary balances	Expressed as a percentage of potential GDP.	1979-2010 (AE) 1984-2010 (EM)	WEO
General government gross/net debt	Expressed in percent of GDP. Net debt used for Japan and Canada, gross debt for all other countries.	1970-2010 (AE) 1982-2010 (EM)	WEO
Long-Term Fiscal Trend			
Total fertility rate	The average number of children per woman.	1970-2010	UN
Old age dependency ratio	20 years ahead projections of the ratio of population over 65, divided by the number of adults.	1970-2010	UN
Long-term projections of the change in public pension expenditure	Expressed in percent of GDP, the change in projected expenditures 30 year ahead relative to the base year.	1980-2010	IMF staff estimates
Long-term projections of the change in public health expenditure	Expressed in percent of GDP, the change in projected expenditures 30 year ahead relative to the base year.	1979-2010 (AE) 1995-2010 (EM)	IMF staff estimates
Asset and Liability Management			
Current gross financing need	Projected general government overall balance plus general government debt with a maturity of one year or less. Expressed in percent of GDP.	1990-2010 (AE) 1993-2010 (EM)	WEO, VEE
Share of short-term debt as a ratio of total debt	Short-term debt is defined as general government debt with	1989-2010	BIS

Indicator	Additional Data Clarification	Data Availability	Data Source
Debt denominated in foreign currencies	remaining maturity of one year or less. Total debt is general government gross debt. General government debt, expressed in terms of total debt	1990-2010 (EM)	WEO, VEE
Debt held by non-residents as a proportion of total debt	Includes both domestic and foreign currency debt issued. Expressed as a proportion of total debt.	1998-2010 (AE)	JEDH, WEO
Weighted average maturity of general government debt	Historical data calculated by staff; current data available in Bloomberg	1980-2010	Bloomberg; Dealogic
Short-term external debt to international reserves	Short-term debt is defined as general government debt with remaining maturity of one year or less.	1990-2010 (AE) 1970-2010 (EM)	WEO, IFS

Appendix Table 6. Summary Statistics of Fiscal Indicators

1995-2010 Sample Indicator	Advanced Economies			Emerging Market Economies		
	Obs.	Mean	St. Dev	Obs.	Mean	St. Dev
Basic Fiscal Variables						
r-g (5-year average)	435	0.20	2.50	591	-4.69	6.11
General government gross debt	443	60.38	34.13	629	48.81	31.10
Cyclical adjusted primary balances	446	0.34	3.42	654	0.43	9.07
Asset and Liability Management						
Current gross financing need	450	11.28	10.74	595	10.85	10.54
Share of short-term debt as a ratio of total debt	450	24.35	16.11	492	22.05	20.83
Debt denominated in foreign currencies				712	54.88	27.67
Debt held by non-residents as a proportion of total debt	228	42.10	23.92			
Weighted average maturity of general government debt	444	7.08	3.37	668	6.38	4.45
Short-term external debt (percent of international reserves)				705	73.22	87.49
Long-Term Fiscal Trend						
Total fertility rate	441	0.52	0.28	822	0.78	0.76
Old age dependency ratio	448	31.53	6.65	832	17.33	8.06
Long-term projections of the change in public pension expenditure	385	2.22	2.00	89	2.07	2.45
Long-term projections of the change in public health expenditure	396	3.69	1.30	336	1.74	1.14

Sources: IMF WEO and IFS; BIS; Bloomberg; Dealogic; and authors' calculations.