

## Leading Indicators of Fiscal Distress: Evidence from the Extreme Bound Analysis<sup>1</sup>

Martin Bruns<sup>2</sup> and Tigran Poghosyan<sup>3</sup>

### Abstract

Early warning systems (EWS) are widely used for assessing countries' vulnerability to fiscal distress. A fiscal distress episode is identified as a period when government experiences extreme funding difficulties. Most EWS employ a specific set of only fiscal leading indicators predetermined by the researchers, which casts doubt on their robustness. We revisit this issue by using the Extreme Bound Analysis, which allows identifying robust leading indicators of fiscal distress from a large set. A robust leading indicator's effect does not strongly depend on the model specification. Consistent with the theoretical predictions of latest generation crisis models, we find that both and non-fiscal leading are robust. In addition, we find that a fiscal vulnerability indicator based on fiscal and non-fiscal leading indicators offers a 29% gain in predictive power compared to a traditional one based on fiscal leading indicators only. This suggests that both fiscal and non-fiscal leading indicators should be taken into account when assessing country's vulnerability to fiscal distress.

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Author's E-Mail Address: [MBruns@diw.de](mailto:MBruns@diw.de), [TPoghosyan@imf.org](mailto:TPoghosyan@imf.org).

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<sup>2</sup> German Institute for Economic Research (DIW), Mohrenstrasse 58, 10117 Berlin, Germany, Phone: +49 30 89789 427

<sup>3</sup> International Monetary Fund (IMF), 700 19th St NW, Washington, DC 20431, USA

## I. Introduction

The global financial crisis and the subsequent weakening of fiscal positions in advanced and emerging economies once again underscored the importance of monitoring country's vulnerability to fiscal distress. A fiscal distress episode is identified as a period when government experiences extreme funding difficulties, which can manifest through outright default or restructuring, bond yield pressure, a large IMF-supported program or excessive inflation. What variables should policymakers watch to assess fiscal risks? There is a large empirical literature by now attempting to answer this question using Early Warning Systems (EWS). International financial organizations, central banks, rating agencies and other organizations draw on these studies to develop indicators of vulnerability to fiscal distress.

Most of the existing EWS have the following characteristics (see Abiad, 2003 for a survey). First, they use a predetermined set of leading indicators to assess country's vulnerability to fiscal distress, which are typically based on economic reasoning. Second, the list of these variables varies widely across studies, in part driven by the preference of the researchers for parsimonious models with a large number of significant leading indicators. Finally, the results from the studies are mixed, with no agreement as to which leading indicators are most robustly associated with fiscal distress. A key characteristic of a robust leading indicator is that its coefficient's sign does not depend on the model specification.

The purpose of this paper is to revisit the issue of leading indicators of fiscal distress by using the Extreme Bound Analysis (EBA). The main advantage of this methodology is that it takes an agnostic approach with respect to leading indicators of fiscal distress and does not require the researcher to predetermine the set of explanatory variables. Instead, it "allows the data to speak" and ranks a set of possible leading indicators based on the "robustness" of their association with fiscal distress. This methodology was used in other fields of economics, notably, growth theory (see for example Sala-i-Martin, 1997) and only recently was applied to analyze financial crises, for example by Ho (2010). However, to our best knowledge we are the first to apply it for analyzing fiscal distress.

Our analysis leads to the following conclusions. First, both fiscal and non-fiscal leading indicators are robustly associated with fiscal distress. This is in contrast to traditional measures of fiscal stress based on fiscal leading indicators (Baldacci et al., 2011). Second, a vulnerability index based on these robust indicators has a performance comparable to the average of performance of other EWS (for fiscal, currency, banking, and other types of crises) in the literature. However, it has better predictive power than the EWS of Baldacci et al. (2011), which is based on only fiscal leading indicators. Finally, the main result on the importance of both fiscal and non-fiscal leading indicators for fiscal distress is robust to various model specifications and sample compositions. The policy implication is that policymakers should not restrict their attention to fiscal indicators only when assessing country's vulnerability to fiscal distress.

The remainder of the paper is structured as follows. Section 2 surveys the related literature. Section 3 describes the empirical methodology and data. Section 4 presents the estimation results using EBA and conducts robustness checks. Section 5 develops an indicator of fiscal distress based on most robust leading indicators identified using EBA and assesses its predictive power. The final section concludes.

## **II. Related Literature**

### **A. Theories of Crisis Determinants**

When modeling crises, it is important to draw distinction between underlying vulnerabilities and crisis risks. The presence of underlying vulnerabilities is a necessary precondition for a crisis to occur, but not sufficient. Crises tend to be triggered by external or domestic shocks, which are highly uncertain. The underlying vulnerability helps to identify countries that are prone to crisis should even a moderate shock occur.

The early theoretical literature emphasized the role of fundamentals in measuring underlying vulnerability. The classic reference is Krugman (1979), which predicts that weak fundamentals, in part driven by unsustainable fiscal and monetary policies, make countries vulnerable to a balance of payments crisis. For fiscal crises, Detragiache and Spilimbergo (2001) show that sovereign default is the only equilibrium response to a large negative shock to fundamentals.

The following generation of theoretical literature of crises emphasizes the role of self-fulfilling expectations and non-fiscal fundamentals. The self-fulfilling crisis literature (Obstfeld, 1984; Calvo, 1988; Alesina et al., 1989; Cole and Kehoe, 1994; Jeanne, 1997; and Masson, 1999) was inspired by the fact that while some crises were preceded by deterioration in fundamentals, some speculative attacks have taken place without apparent monetary and fiscal imbalances. These studies developed multiple-equilibrium models, which allow better capturing the complex interaction between underlying vulnerabilities and speculative attacks (Eichengreen et al., 1995 provide a review). In these models, countries can jump from good to bad equilibrium for a certain range of values of economic fundamentals. For example, Calvo (1988) shows that if a government is unable to commit to repay its debt, multiple equilibria, including repudiation and inflation, can arise.

The main takeaway from the review of theoretical literature is that there is no a priori reason to restrict leading indicators of fiscal distress to fiscal fundamentals.

### **B. Empirical Evidence on Early Warning Indicators of Fiscal Distress**

The empirical literature on early warning indicators of fiscal distress was developed as part of a larger literature on early warning indicators of financial crises. Comprehensive surveys of EWS for banking, currency, sovereign debt, equity, and inflation crises can be found in Kaminsky et al. (1998), Hawkins and Klaw (2000), Abiad (2003), Berg et al. (2005), and Frankel and Saravelos (2012). As discussed above, the main objective of these studies is to identify leading indicators

making countries vulnerable to a crisis, rather than prediction of the timing of the crisis. The empirical techniques used in this literature could be grouped into two main categories: non-parametric and parametric (Hemming et al., 2003; Baldacci et al., 2011; Frankel and Saravelos, 2012; and Comelli, 2013).<sup>5</sup>

The most popular non-parametric EWS is the “signals” approach popularized by Kaminsky et al. (1998) in the context of currency crises. This approach selects a number of variables as leading indicators of crises and determines threshold values beyond which a crisis signal is considered to have been given. The main drawback of this approach is that it only focuses on bivariate association between an early warning indicator and crises and does not allow controlling for other factors. Also, the statistical significance of the early warning indicators cannot be determined directly, although out-of-sample performance could be assessed. Studies using these techniques in the context of fiscal crises include Reinhart (2002), Hemming et al. (2003), Baldacci et al. (2011), Berti et al. (2012) and de Cos et al. (2014). These studies suggest that fiscal fundamentals, such as the level of public debt and its composition, fiscal deficit, fiscal financing needs, are important leading indicators of fiscal distress.

The parametric EWS models draw on limited dependent variable techniques (multivariate logit, probit). These methods allow testing the significance of various leading indicators in determining the likelihood of crisis occurring in the near future, while accounting for their correlation. However, these methods require long-time series of leading indicators and low degrees of freedom that may prevent the use of multivariate approach when the number of predictors is large. Studies that applied parametric methods to analyze fiscal crises include Marashaden (1997), Peter (2002), Manasse et al. (2003), Kraay and Nehru (2006), and Gourinchas and Obstfeld (2012). These studies confirm the importance of fiscal fundamentals, but suggest that macroeconomic developments in general, especially in the external sector, also play a role.

Both groups of studies share a common characteristic – the set of leading indicators of fiscal distress is predetermined by the researcher. This selection is typically done with the benefit of hindsight, with the significance of the leading indicator typically playing a role in the selection process.<sup>6</sup> To overcome this issue, some recent studies applied the extreme bound methodology to study leading indicators of financial crises.

### **C. Extreme Bound Methodology**

The extreme bound methodology was developed and applied to study determinants of growth by Leamer (1978), and was later on extended and popularized by Sala-i-Martin (1997). The methodology does not rely on a predetermined set of explanatory variables and “lets the data

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<sup>5</sup> Some studies have also applied relatively less standard techniques, such as binary recursive trees, artificial neural networks, and Markov switching models.

<sup>6</sup> In the meta-analysis literature, this phenomenon is often referred to as “publication bias”.

speak” by examining all possible combinations of explanatory variables. The focus is on the change in signs of explanatory variables. If a sign change is observed relatively frequently, the explanatory variable is said not robustly related to the dependent variable.

Early warning studies using the extreme bound methodology (or its Bayesian equivalent) include Chakrabarti and Zeaiter (2014), Ho (2014), and Christofides et al. (2015). However, to our best knowledge no study used this approach to analyze determinants of fiscal distress, which is the gap we would like to fill in our paper. The closest paper to ours is Chakrabarti and Zeaiter (2014), which analyzes determinants of external debt arrears using a linear regression model. The results suggest that a range of fiscal and non-fiscal indicators, including growth, inflation, trade deficit, foreign reserves, and exchange rate, are robust predictors of external debt arrears.

Alessi et al. (2015) provide an overview of alternative ways of combining the information in a large set of variables such as the Lasso, the ridge regression estimator, Bayesian Model Averaging, principal component analysis or factor models. However, the advantages of the Extreme Bound Analysis are that it does not introduce an estimation bias such as the Lasso or the ridge regression. Furthermore, its data requirements are less strict than for Bayesian Model Averaging as it can be applied to unbalanced panels and the results are more directly interpretable than the ones stemming from principal component or factor models.

### III. Empirical Methodology and Data

#### A. Empirical Methodology: Extreme Bound Analysis

As discussed above, Extreme Bound Analysis (EBA) is an agnostic approach to identify explanatory variables that are robustly associated with an outcome variable. Instead of pre-selecting a small set of explanatory variables, EBA explores a large number of combinations from a pool of variables used in the previous literature and based on theoretical considerations.

In the context of an Early Warning System (EWS) for fiscal distress events, the following logit specification is estimated:

$$\log \left( \frac{P[Y = 1 | z, x]}{P[Y = 0 | z, x]} \right) = \beta_{zj}z + \beta_{xj}x_j + \varepsilon \quad (1)$$

Where  $Y$  is a binary outcome variable indicating a fiscal distress event,  $z$  is the leading indicator whose robustness is to be assessed and  $x_j$  are other leading indicators from the pool of all leading indicators excluding  $z$ . Assume there are  $n$  elements in this pool. Then, for each leading indicator  $z$ , one has to estimate a regression with  $k$  additional controls  $x_j$ , which gives  $M = \frac{(n-1-k)!}{k!}$  combinations per leading indicator  $z$  and a total of  $nM$  regressions to be estimated.

For each leading indicator  $z$ , we follow the following procedure:

- Estimate each of the  $M$  regressions and store the estimated coefficient of  $z$ ,  $\hat{\beta}_{zj}$ .

- Weigh coefficients  $\hat{\beta}_{zj}$  by the relative likelihood of the model, which they are a part of, so that coefficients stemming from a very unlikely model receive less weight than others. The weight is:

$$\omega_{zj} = \frac{L_{zj}}{\sum_{i=1}^M L_{zi}} \quad (2)$$

- Calculate the weighted average of coefficients across regressions to obtain the coefficient of leading indicator z:

$$\hat{\beta}_z = \sum_{j=1}^M \omega_{zj} \beta_{zj} \quad (3)$$

- Calculate a likelihood-weighted average standard error in a similar fashion.
- Assess the robustness of  $\hat{\beta}_z$ . Assuming that  $\hat{\beta}_z$  is normally distributed across regressions, calculate the proportion of its distribution to one side of zero, and consider  $\hat{\beta}_z$  to be robust if this proportion exceeds a certain confidence level (e.g. 90 percent).

Following these steps for each indicator results in a set of indicators which can be ranked according to their respective robustness.

## B. Data

Our dataset covers 29 advanced and 52 emerging economies (81 countries in total) over the period 1970–2015. It builds on the original dataset of fiscal distress developed by Baldacci et al. (2011), extending the data through 2015 and expanding the set of leading indicators.

### Fiscal distress

A fiscal distress episode is identified as a period when government experiences extreme funding difficulties. Based on the literature survey, Baldacci et al. (2011) identify four types of criteria to capture fiscal distress episodes: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. We adopt the same definition of fiscal distress (see Table 1) and expand the series through 2015.

Table 2 presents the distribution of fiscal distress episodes across their types and country groups. Several observations emerge. First, comparison across country groups suggests that advanced economies have experienced fewer fiscal distress episodes compared to emerging economies. The low unconditional likelihood of fiscal distress for advanced economies will have implications for the conditional analysis conducted below. Second, the comparison across types of distress events suggests that advanced economies experienced almost no outright default episodes and most fiscal distress episodes were manifested in the form of bond yield pressures. By contrast, emerging economies experienced a large number of fiscal distress episodes and were frequent

recipients of large IMF-supported bailouts. Finally, the total number of distress episodes is lower than the sum of individual episodes. This is due to the fact that some countries have experienced several types of fiscal distress events simultaneously.

Figure 1 shows the share of fiscal distress episodes that coincided with currency and banking crises using Reinhart and Rogoff's dataset.<sup>8</sup> We find that currency crises overlap with 26 percent of fiscal distress episodes, while banking crises overlap with 24 percent of fiscal distress episodes for the sample spanning through 2010 (the last year of Reinhart and Rogoff's dataset). The high share of overlaps suggest that some of the fiscal distress events may have originated outside of the fiscal sector, which is consistent with the "twin crises" narrative proposed by Kaminsky and Reinhart (1999).

### **Leading indicators**

We identify 37 variables that were used as leading indicators for fiscal distress in the literature. Table 3 lists these variables as well as their sources. The indicators cover not only the fiscal sector, but also macro, monetary, and external sectors. Some of the indicators reflect the impact of contagion effects and global factors, which is consistent with predictions of the theoretical literature. All variables are measured in percentage points. The panel is unbalanced as some indicators are not available for all countries and differ in time coverage.

Table 4 presents descriptive statistics, while Table 5 presents bivariate correlations based on the pooled series. As shown in the latter table, most of the variables are not highly correlated with the exception of some debt-related indicators. This should limit the issue of multicollinearity.

## **IV. Estimation Results**

In this section, we present estimation results for the baseline specification covering the whole sample and based on the pooled logit specification. We also check whether results are sensitive to changes in the sample and estimation methods. Leading indicators are assessed to be robust if the probability of not switching the sign exceeds 90 percent, as approximated by the normal distribution. We use a forecasting horizon of 1 year throughout the estimation.<sup>9</sup>

### **A. Baseline Extreme Bound Analysis Model**

Table 6 presents baseline EBA estimation results. Estimations are performed using the pooled logit model. We use various combinations of 2 additional controls per regression, which leads to 630 regressions per leading indicator (23,410 regressions in total). The main reason for using two additional controls as a baseline is computational efficiency and a higher number of

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<sup>8</sup> The dataset is available at: <http://www.reinhartandrogoff.com/data/>.

<sup>9</sup> The results do not change qualitatively when using a forecasting horizon of two years.

observations per regression. The variables are ranked according to their robustness, with most robust indicators placed on top.

The estimation results suggest that both fiscal and non-fiscal variables are robust leading indicators of fiscal distress. We find that fiscal distress tends to follow a period of overheating in the real sector (widening of output gap). This is consistent with Alberola et al. (2013) finding that growth, if it is not driven by sound economic fundamentals, can be detrimental to systemic stability. A related explanation could be that a large positive output gap, even if it is non-inflationary, can be associated with a buildup of financial imbalances, which in turn can indirectly lead to fiscal distress (see Borio et al. 2013).

In addition, adverse developments in the external sector (high current account deficit, low level of FX reserves/GDP ratio, slowdown in FX reserves growth, and higher openness) tend to precede fiscal distress episodes. These results are consistent with Chakrabarti and Zeaiter (2014)'s analysis for external debt arrears and also Gourinchas and Obstfeld's (2011) analysis of the causes of sovereign default. A negative effect of openness is also found in Manasse et al. (2003).

Among fiscal leading indicators, we found that foreign exchange debt to GDP ratio, primary fiscal balance gap, as well as primary and overall fiscal balance to GDP ratios, are robust indicators, which is in line with most fiscal EWS such as Baldacci et al. (2011).

One potential reason for the robustness of non-fiscal indicators could be a high correlation with fiscal indicators. Table 5 shows that this is not the case: for example, the correlation between FX reserves (% of GDP) and various robust fiscal indicators, such as primary balance, overall balance or primary balance gap does not exceed 0.35 in absolute terms. The same is true for the output gap. This indicates that non-fiscal indicators do not only pick up the effects of fiscal indicators but matter on their own.

An illustration for why external factors perform better than fiscal factors as leading indicators can be observed in Figure 2. It shows an application of the Event Study Methodology proposed by Gourinchas and Obstfeld (2012) where a fixed effects model is employed to regress the leading indicator of interest on dummies indicating the distance from a fiscal distress event. The graphs plot the estimated coefficients of these dummies, which are a measure of the percent deviation of the respective leading indicator from its "tranquil" time average. This "tranquil" time average is defined as the average level of the respective variable outside the Event Study horizon. Figure 2 shows that debt to GDP ratio before the crisis is not significantly different from the levels observed in tranquil times, but increases rapidly after the crisis incident. This indicates that debt to GDP ratio – one of the key fiscal indicators used in previous studies (see, e.g., Kraay and Nehru, 2006) – is more of an "ex post" indicator of fiscal distress rather than a leading indicator. The current account balance, on the other hand, is significantly lower relative to tranquil times before the crisis, suggesting that it can be used as a leading indicator. This result supports the hypothesis that fiscal vulnerabilities can be built up outside the public sector.



Overall, the baseline results suggest that limiting leading indicators to fiscal variables, like in Baldacci et al. (2011), may result in a loss of important information regarding vulnerability to fiscal distress.<sup>10</sup> Consistent with predictions of most recent theories of crises, information from other sectors should also be monitored.

## **B. Robustness Checks**

We run several additional EBA regressions to check the results for sensitivity to changes in the sample and estimation methods.

### **“Narrow” definition of fiscal distress**

The robustness of non-fiscal leading indicators, especially those pertaining to the external sector, may be driven by the fact that some of the large scale IMF programs (third definition of fiscal distress) are triggered by balance of payment or other crises not purely linked to fiscal distress. Also, high inflationary pressures (fourth definition of fiscal distress) may be caused by large devaluations following currency crises. To check whether robustness of non-fiscal variables still holds for “narrow” fiscal distress episodes, we re-estimate the model using a more restrictive sample of fiscal distress episodes that did not overlap with banking and currency crises.

Table 7 presents estimation results from a specification that restricts the dependent variable to “narrow” fiscal distress episodes. The set of robust determinants still includes non-fiscal leading indicators, confirming the baseline results. Gross financing needs and interest costs also turn robust in this specification, suggesting that borrowing cost pressures are important leading indicators for “narrow” fiscal distress episodes. The main drawback of this specification is that the sample has to be restricted through 2010, which is the last year for which banking and currency crisis variables are available in Reinhart and Rogoff’s database.

### **Emerging economies**

As indicated in the previous section, most fiscal crisis events took place in emerging economies, which could explain the relatively high proportion of external leading indicators that are mostly relevant for emerging economies. For example, difficulties to finance a persistent current account deficit and the associated decline in FX reserves have historically been associated with fiscal distress in emerging markets. Advanced economies on the other hand, face fewer financing problems of this sort as they are often able to borrow in their own currency and generally rely less on external financing (IMF, 2010). To assess whether our baseline results are mostly driven by emerging economies, we redo the analysis by restricting the sample to emerging economies.<sup>11</sup>

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<sup>10</sup> Our results remain qualitatively unchanged when the sample is restricted to the period 1970–2010 as in Baldacci et al. (2011).

<sup>11</sup> Unfortunately, we could not replicate the analysis for advanced economies only due to the limited number of fiscal distress events.

Table 8 presents estimation results from the sample of emerging economies. The set of robust indicators is very similar to the one for the total sample, confirming the influence of emerging economies in driving the main results. Out of 10 robust leading indicators found in the total sample, 8 remain significant in emerging economies. One additional variable that becomes significant for emerging economies is the unemployment rate. The latter is consistent with the robust result on the output gap, given that unemployment is its mirror image.

### **Number of control variables**

We also check the robustness of results to the larger number of control variables. Table 9 presents estimation results from a specification that increases the number of control variables from two to three. This results in substantially higher time for estimating the model, as the number of regressions per leading indicator increases to 7140 (264,180 regressions in total). Nevertheless, the main results remain unchanged, with 8 out of 10 robust indicators from baseline regression remaining robust. As before, the set of robust leading indicators includes both fiscal and non-fiscal variables.

### **Random effects logit and pooled probit models**

We also check robustness of main results to types of discrete choice models.

First, we control for unobserved country-specific heterogeneity by using a random effects logit model.<sup>12</sup> Table 10 presents estimation results, showing that the set of robust indicators remains qualitatively unchanged, with 8 out of 10 robust indicators from baseline regression remaining robust.

Second, given that logit model has fatter tails than probit model, we also check sensitivity to tail risks by using a pooled probit model. Table 11 presents estimation results, showing that the set of robust indicators remains practically unchanged and suggesting that fat tails are not affecting the results.

### **Using alternative filtering technique for output gap**

Throughout the analysis, we find a persistent evidence of robustness of the output gap variable, which comes on top of the list in all tables. This could be due to the fact that the two-sided HP filter used to estimate the output gap could potentially bias the results prior to fiscal crises as one uses future values of output, already affected by the crisis, to smooth past series. To check the sensitivity of results to the smoothing technique, we use one-sided filter of Christiano and Fitzgerald (2003). Table 11 presents estimation results using this filter. The results remain

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<sup>12</sup> We have also tried a fixed effects logit specification and the results remain similar. The main drawback of the fixed effect model is that it drops countries that never experienced a fiscal distress (see Bussière, 2013 for a discussion).

unchanged suggesting that measurement of the output gap does not constitute a problem and reinforcing the importance of output cycles as leading indicators of fiscal crises.

## V. Fiscal Distress Index and Its Performance

In this section, we present an alternative fiscal distress index based on the most robust leading indicators identified using the EBA methodology (Table 13).<sup>13</sup> We then measure its performance for in-sample and out-of-sample and make a comparison with other EWS in the literature.

A natural question which arises is which indicators have the largest contribution to the fiscal distress index. In order to assess this, Figure 8 shows the impact of changes in robust leading indicators between the 75<sup>th</sup> and the 25<sup>th</sup> percentile on the logarithm of the odds ratio of the fiscal crisis. It is computed as  $\hat{\beta}_i x_i^{(0.75)} - \hat{\beta}_i x_i^{(0.25)}$ , where  $x_i^q$  is the  $q^{\text{th}}$  quantile of leading indicator  $i$ . The figure shows that non-fiscal indicators have a larger relative impact on the fiscal distress index than fiscal indicators reflecting their importance in assessing underlying vulnerabilities.

### A. Fiscal Distress Index

Figure 3 presents the evolution of the fiscal distress index based on most robust leading indicators for advanced and emerging economies and the fiscal distress incidents. This index is obtained by computing the predicted values from the logit model, which includes the most robust leading indicators obtained in the first step. Two observations are worth noting. First, the level of fiscal stress tends to be lower in advanced economies compared to emerging economies, which is consistent with the fact that advanced economies have a lower propensity to distress on average. Second, there are spikes in the level of fiscal distress around periods of notable financial crises (late 1990s, the global financial crisis). This is consistent with the empirical regularity of clustering across different types of crises due to contagion effects.

### B. Measure of Performance

As pointed out by Ho (2015), it is not obvious that the most robust leading indicators are also those that yield the best predictive performance of an EWS. This is why, following Baldacci et al. (2011), we assess the performance of our model using the total misclassification error:

$$TME(t) = Type1(t) + Type2(t) \quad (4)$$

where *Type1* indicates missed crises as a share of all crises, *Type2* indicates false alarms as a share of all non-crisis periods, and  $t$  is the threshold level. The choice of the threshold level is made by the policymaker who faces a trade-off. If  $t$  is set too high, the index will cross it in very few cases and many crises will be missed resulting in a large Type 1 error. Alternatively, if  $t$  is set too low,

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<sup>13</sup> The index does not include primary balance gap variable (because of low numbers of observations), the foreign exchange debt ratio (because the series end in 2012), and the FX reserves to GDP ratio (because we already control for the FX reserves growth variable).

the index will cross the threshold very often so that many alarms will be falsely issued resulting in a large Type 2 error. We assume that the utility of the policy maker can be represented by using TME as a loss function, which is minimized over  $t$ .

Figure 4 presents in-sample performance for different threshold values for both the EBA-based indicator and the Baldacci et al (2011) fiscal distress index. Neither model is dominated by the other as the performance depends on the choice of the threshold. Figure 4 shows that the TME of the EBA-based indicator is minimized at 0.52 when the level of threshold is 0.7. The Baldacci et al. (2011) fiscal distress index obtains a minimum of 0.73 when the level of the threshold is 0.38. The TME is thus reduced by 29 percent for the optimal choice of the threshold, suggesting that our model has a better fit.

Figure 5 presents in-sample and out-of-sample performance for different threshold values of the EBA-based fiscal distress indicator. We use the years 1970 through 2007 to fit the model, compute the coefficients and obtain the threshold. The model is then applied to the years 2008 through 2015 computing the fiscal distress index by combining these estimated coefficients from the model-fitting sample with the data in the prediction sample. As expected, the in-sample performance outperforms out-of-sample performance. Nevertheless, the minimum TME for the out-of-sample is not much higher than in-sample TME suggesting that our model would have done well predicting the post-2007 sample using information up to 2007.

Figure 6 presents classification table for out-of-sample predictions made by the EBA-based fiscal distress indicator. It is an illustration for the two types of errors that every EWS makes and which were explained above. Out of the 32 crises which were identified between 2008 and 2015, the model predicts 25 correctly (78 percent). A false alarm is issued for 118 out of 344 non-crisis years (34 percent).

Figure 7 presents comparison with other studies. It plots the minimum, 25<sup>th</sup> percentile, mean, 75<sup>th</sup> percentile and maximum of the 3 relevant quality measures of an EWS: The TME, type 1 error and type 2 error. It shows that our model is within the 1<sup>st</sup> and 3<sup>rd</sup> quartile of the TME when compared to other studies on EWS. It performs slightly worse than average regarding the type 2 errors and slightly better regarding the type 1 errors. As mentioned in Berg and Pattillo (2005), a different trade-off between the two error types could be achieved using an asymmetrically weighed loss function. Our model is conservative, issuing false alarms relatively more often than an average EWS study, which seems reasonable from a policymaker's perspective as a missed crisis is likely to be more costly than a false alarm.

## **VI. Conclusions**

Reviewing the large literature on EWS for fiscal distress, we have assessed the robustness of the leading indicators employed in these studies using the Extreme Bound Analysis. We find both fiscal and non-fiscal leading indicators to be robust, consistent with the prediction of recent

theoretical studies emphasizing the role of multiple equilibria and spillovers across different sectors of the economy.

In a second step, we build a vulnerability index using the most robust leading indicators and find that its predictive properties are close to the average found in other EWS (for fiscal, currency, banking, and other types of crises) in the literature. However, the use of robust fiscal and non-fiscal leading indicators helps us to improve performance relative to Baldacci et al. (2011) EWS based on fiscal indicators only. From a policy perspective, these results suggest that some non-fiscal leading indicators should be monitored as closely as fiscal leading indicators to assess a country's vulnerability to fiscal distress.

Designing a EWS based on robust leading indicators poses several problems, which could be addressed in the future. First, the estimation sample using a logit model is constrained by the shortest time series, which can significantly reduce the sample size and thus precision. Second, while using a pooled sample of both advanced and emerging economies does increase the sample size, it constrains the leading indicators and their relative effects to be the same across the two subsamples. However, separate analysis for advanced economies only is complicated given that most fiscal crises have occurred in emerging economies. Lastly, identifying "narrow" fiscal distress events is challenging due to the frequent occurrence of twin or multiple crises and the spillovers among them.

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**Table 1. Definition of Fiscal Distress**

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
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
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

Source: Baldacci et al. (2011).

**Table 2. Fiscal Distress Episodes**

	Sovereign Default or Restructuring	Bond Yield Pressures	Inflation Pressures	IMF program	Total
Advanced Economies	1 (0)	30 (29)	5 (5)	8 (6)	41 (39)
Emerging Economies	54 (52)	17 (15)	6 (6)	103 (79)	160 (135)

Source: Baldacci et al. (2011) and authors' calculations for 2011–2015.

Note: The numbers in brackets represent fiscal distress episodes in the original Baldacci et al. (2011) dataset running through 2010.

**Table 3. List of Leading Indicators of Fiscal Distress**

Leading Indicator	Source	Grouping	Method	Description
Average Maturity	Baldacci et al. (2011)	Public Sector: Liquidity Pressure Indicators	Signals	Average Maturity of remaining debt (in years)
Gross Financing Need	Baldacci et al. (2011)	Public Sector: Debt Burden	Signals	Gross financing needs (short-term debt plus the overall balance), percent of GDP
Interest-Growth Differential	Baldacci et al. (2011)	Public Sector: Debt Tolerance Indicators	Signals	Difference between average effective interest rate and GDP growth in percent
Primary Balance (% of GDP)	Baldacci et al. (2011)	Public Sector: Liquidity Pressure Indicators	Signals	Revenue-Expenditure+Interest Expenditure, percent of GDP
Short Term Debt (% of FX Reserves)	Baldacci et al. (2011)	Public Sector: Debt Burden	Signals	Short Term Debt, percent of FX Reserves
Short Term Debt (% of total)	Baldacci et al. (2011)	Public Sector: Debt Burden	Signals	Short Term Debt, percent of total Debt
GDP per Capita	Chakrabarti and Zeaiter (2014)	Public Sector: Debt Tolerance Indicators	EBA and OLS	Gross domestic product per capita, current prices in U.S. dollars
Concessional Debt (% of total)	Detragiache and Spilimbergo (2001)	Public Sector: Debt Burden	OLS, Probit, Logit (FE)	Concessional Debt, percent of total Debt
Debt owed to Commercial Banks (% of total)	Detragiache and Spilimbergo (2001)	Public Sector: Debt Burden	OLS, Probit, Logit (FE)	Debt owed to Commercial Banks, percent of total Debt
Debt owed to Multilateral Creditors (% of total)	Detragiache and Spilimbergo (2001)	Public Sector: Debt Burden	OLS, Probit, Logit (FE)	Debt owed to Multilateral Creditors, percent of total Debt
Debt Service due (% of GDP)	Detragiache and Spilimbergo (2001)	Public Sector: Liquidity Pressure Indicators	OLS, Probit, Logit (FE)	Debt Service due, percent of GDP
Current Account Balance (% of GDP)	Gourinchas and Obstfeld (2012)	Public Sector: Liquidity Pressure Indicators	Logit	Balance on current account, percent of GDP
Domestic Credit Gap	Gourinchas and Obstfeld (2012)	Public Sector: Macroeconomic Factors	Logit	Domestic Credit percent deviation from HP-filter trend
FX Reserves (% of GDP)	Gourinchas and Obstfeld (2012)	Public Sector: Macroeconomic Factors	Logit	Foreign Exchange Reserves, percent of GDP
Real Exchange Rate Undervaluation	Gourinchas and Obstfeld (2012)	Public Sector: Macroeconomic Factors	Logit	Percent deviation of real effective exchange rate from HP filter trend
Real Interest Rate	Gourinchas and Obstfeld (2012)	Public Sector: Macroeconomic Factors	Logit	6 months Treasury Bill Rate - CPI Inflation (end of period percentage change)
Short Term External Debt (% of GDP)	Gourinchas and Obstfeld (2012)	Public Sector: Debt Burden	Logit	Short Term External Debt, percent of GDP
Change in Net Claims on Central Government	Hemming et al. (2003)	Public Sector: Liquidity Pressure Indicators	Probit, Signals	Change in Net Claims on Central Government, in percent
CPI Inflation	Manasse et al. (2003)	Public Sector: Macroeconomic Factors	Logit, Binary Tree	Consumer Prices, end-of-period, percent change
Debt (% of GDP)	Manasse et al. (2003)	Public Sector: Debt Burden	Logit, Binary Tree	Public Debt, percent of GDP
External Debt (% of GDP)	Manasse et al. (2003)	Public Sector: Debt Burden	Logit, Binary Tree	Total external debt, gross, including arrears and other short-term debt, percent of GDP
FDI (% of GDP)	Manasse et al. (2003)	Public Sector: Macroeconomic Factors	Logit, Binary Tree	Foreign direct investment, net inflows in reporting economy, percent of GDP
FX Reserves Growth	Manasse et al. (2003)	Public Sector: Debt Tolerance Indicators	Logit, Binary Tree	Annual percentage change in Foreign Exchange Reserves
Interest Expenditure (% of total Expenditure)	Manasse et al. (2003)	Public Sector: Liquidity Pressure Indicators	Logit, Binary Tree	Interest Expenditure, percent of total Expenditure
LIBOR	Manasse et al. (2003)	Contagion Effects and Global Factors	Logit, Binary Tree	London Interbank Offered Rate
Nominal GDP Growth	Manasse et al. (2003)	Public Sector: Macroeconomic Factors	Logit, Binary Tree	Nominal GDP, annual percentage change
Openness: (M+X)/ GDP	Manasse et al. (2003)	Public Sector: Macroeconomic Factors	Logit, Binary Tree	Exports+Imports, percent of GDP
Overall Fiscal Balance (% of GDP)	Manasse et al. (2003)	Public Sector: Liquidity Pressure Indicators	Logit, Binary Tree	Revenue-Expenditure, percent of GDP
Real GDP Growth	Manasse et al. (2003)	Public Sector: Macroeconomic Factors	Logit, Binary Tree	Gross domestic product, constant prices, annual percentage change
Unemployment Rate	Manasse et al. (2003)	Public Sector: Macroeconomic Factors	Logit, Binary Tree	Unemployment Rate
US TBill Rate	Manasse et al. (2003)	Contagion Effects and Global Factors	Logit, Binary Tree	6 months US Treasury Bill Rate
Output Gap	Ostry et al. (2010)	Public Sector: Macroeconomic Factors	OLS	Percent deviation of real GDP from Baxter-King filter
Average Effective Interest Rate	VEE 2014	Public Sector: Liquidity Pressure Indicators	Signals	Interest payments(t)/General Government Debt(t-1)
Foreign Exchange Debt (% of GDP)	VEE 2014	Public Sector: Debt Burden	Signals	General government gross debt in foreign currency, percent of GDP
FX Reserve Coverage	VEE 2014	External Sector	Signals	Reserves, percent of (Short Term debt at remaining maturity+Current Account deficit)
Primary Balance Gap (% of GDP)	VEE 2014	Public Sector: Liquidity Pressure Indicators	Signals	Primary Balance Gap, percent of GDP
Amortisation of Total Public Debt (% of GDP )	VEE 2015	External Sector	Signals	Amortization paid, (principal only), percent of GDP

Source: Survey of the literature by the authors.

**Table 4. Descriptive Statistics**

	Obs.	Mean	Median	St. Dev.	10th percentile	90th percentile
Debt (% of GDP)	3,073	52.5	45.3	34.1	16.6	95.2
Output Gap	3,188	-0.1	-0.1	2.0	-1.5	1.3
Openness: (M+X)/ GDP	3,254	71.2	60.0	53.2	26.1	123.0
CPI Inflation	2,804	28.3	6.2	224.0	1.4	26.1
FX Reserve Coverage	1,581	1.7	0.7	11.2	0.1	2.9
Amortisation of Total Public Debt (% of GDP )	2,030	10.0	4.2	19.9	0.6	19.4
Real Interest Rate	1,387	-1.2	1.4	52.9	-4.9	6.9
Domestic Credit Gap	2,588	-48.1	-1.4	1754.8	-94.0	26.3
Current Account Balance (% of GDP)	3,275	-2.1	-1.9	7.6	-8.4	4.7
Real Exchange Rate Undervaluation	2,877	-3.6	-1.5	38.0	-24.6	20.3
FX Reserves (% of GDP)	3,103	12.3	7.5	15.0	1.9	25.9
Short Term External Debt (% of GDP)	2,142	14.4	4.8	37.8	0.0	27.6
Interest-Growth Differential	2,154	-15.7	-4.1	108.6	-24.7	3.0
Primary Balance (% of GDP)	1,874	0.7	0.3	3.9	-3.4	5.3
Short Term Debt (% of total)	2,107	17.9	13.8	17.5	0.0	41.3
Short Term Debt (% of FX Reserves)	1,984	654.0	51.6	5328.2	0.0	438.5
Debt owed to Commercial Banks (% of total)	1,423	11.3	5.8	14.0	0.1	30.6
Concessional Debt (% of total)	1,632	22.8	15.6	22.1	1.3	58.9
Debt owed to Multilateral Creditors (% of total)	1,632	17.4	14.1	13.1	3.7	35.3
Debt Service due (% of GDP)	1,602	5.8	4.3	6.4	1.4	10.9
FX Reserves Growth	3,051	18.3	9.4	52.4	-19.8	58.6
LIBOR	3,670	2.5	2.6	2.5	-1.1	5.4
US TBill Rate	3,592	5.1	5.0	3.3	0.1	9.6
Unemployment Rate	2,546	8.5	7.2	6.0	2.6	15.7
Nominal GDP Growth	3,046	40.4	11.2	297.2	2.8	34.9
Real GDP Growth	3,269	3.5	3.7	4.9	-0.9	8.3
External Debt (% of GDP)	2,475	68.2	44.4	90.0	14.5	141.1
FDI (% of GDP)	2,972	-1.4	-0.7	3.4	-5.1	1.0
Overall Fiscal Balance (% of GDP)	2,035	-2.5	-2.5	4.3	-7.4	2.1
Interest Expenditure (% of total Expenditure)	1,908	9.9	7.8	8.9	2.3	20.2
Change in Net Claims on Central Government	2,415	47.4	10.8	795.9	-48.3	116.4
GDP per Capita	3,291	9.3	9.7	4.2	6.0	13.3
Average Effective Interest Rate	1,951	17.5	0.2	75.1	0.0	14.4
Gross Financing Need	735	11.4	8.8	11.3	1.3	26.6
Average Maturity	733	7.2	6.2	4.2	3.0	13.3
Primary Balance Gap (% of GDP)	688	0.9	0.8	8.3	-4.7	7.6
Foreign Exchange Debt (% of GDP)	1,124	15.4	4.4	22.6	0.0	41.5

Source: IMF WEO, World Development Indicators, International Finance Statistics, Government Finance Statistics.

Table 5. Correlation Matrix

	Debt (% of GDP)	Output Gap	Openness: (M+X)/ GDP	CPI Inflation	FX Reserve Coverage	Amortisation of Total Public Debt (% of GDP)	Real Interest Rate	Domestic Credit Gap	Current Account Balance (% of GDP)	Real Exchange Rate Undervaluation	FX Reserves (% of GDP)	Short Term External Debt (% of GDP)	Interest-Growth Differential	Primary Balance (% of GDP)	Short Term Debt (% of total)	Short Term Debt (% of FX Reserves)	Debt owed to Commercial Banks (% of total)	Concessional Debt (% of total)	Debt owed to Multilateral Creditors (% of total)	
Debt (% of GDP)	1.000																			
Output Gap	-0.173	1.000																		
Openness: (M+X)/ GDP	-0.160	-0.007	1.000																	
CPI Inflation	0.249	-0.070	-0.034	1.000																
FX Reserve Coverage	-0.272	-0.057	0.291	-0.199	1.000															
Amortisation of Total Public Debt (% of GDI)	-0.421	0.063	0.106	0.017	-0.260	1.000														
Real Interest Rate	0.353	-0.054	-0.650	0.064	-0.326	-0.108	1.000													
Domestic Credit Gap	0.059	0.299	-0.143	0.002	-0.551	0.108	0.063	1.000												
Current Account Balance (% of GDP)	-0.451	-0.087	-0.238	-0.323	0.378	0.403	0.160	-0.156	1.000											
Real Exchange Rate Undervaluation	0.202	0.012	0.290	0.096	-0.017	0.195	-0.247	0.062	-0.083	1.000										
FX Reserves (% of GDP)	-0.223	0.114	0.715	-0.151	0.282	0.397	-0.562	-0.156	0.096	0.150	1.000									
Short Term External Debt (% of GDP)	-0.595	0.110	0.026	-0.162	-0.224	0.906	-0.138	0.223	0.462	0.064	0.302	1.000								
Interest-Growth Differential	0.556	0.108	-0.414	-0.384	-0.238	-0.149	0.346	0.062	-0.044	0.026	-0.168	-0.154	1.000							
Primary Balance (% of GDP)	0.652	0.042	-0.374	0.106	-0.232	-0.281	0.491	-0.152	-0.218	-0.177	-0.269	-0.385	0.673	1.000						
Short Term Debt (% of total)	-0.665	0.295	0.039	-0.184	-0.184	0.703	-0.173	0.252	0.364	-0.117	0.299	0.868	-0.131	-0.285	1.000					
Short Term Debt (% of FX Reserves)	-0.546	0.085	-0.323	-0.003	-0.361	0.642	0.087	0.245	0.297	-0.047	-0.226	0.804	-0.160	-0.249	0.733	1.000				
Debt owed to Commercial Banks (% of total)	-0.059	-0.011	-0.092	0.563	-0.417	0.357	0.343	0.011	-0.114	-0.295	-0.095	0.295	-0.297	0.206	0.359	0.427	1.000			
Concessional Debt (% of total)	-0.215	-0.222	0.604	-0.028	0.498	-0.325	-0.489	-0.173	-0.102	0.158	0.215	-0.332	-0.615	-0.593	-0.399	-0.429	-0.417	1.000		
Debt owed to Multilateral Creditors (% of total)	0.265	-0.276	0.307	0.012	0.306	-0.672	-0.139	-0.067	-0.300	0.098	-0.068	-0.712	-0.241	-0.156	-0.741	-0.689	-0.470	0.818	1.000	
Debt Service due (% of GDP)	0.444	-0.200	-0.226	0.093	-0.329	0.485	0.326	-0.047	0.148	0.267	0.043	0.271	0.444	0.370	-0.066	0.108	0.153	-0.493	-0.378	
FX Reserves Growth	-0.075	-0.027	-0.163	0.004	0.347	-0.205	0.013	-0.325	0.252	-0.361	0.159	-0.124	0.078	0.146	-0.007	-0.128	0.009	-0.077	-0.040	
LIBOR	-0.194	0.190	0.024	-0.261	0.193	-0.186	-0.033	-0.132	-0.011	-0.321	0.087	-0.060	0.149	0.003	0.041	-0.147	-0.162	0.044	0.056	
US TBill Rate	-0.190	0.022	-0.090	-0.339	0.271	-0.151	0.026	-0.347	0.123	-0.358	0.055	-0.045	0.221	0.151	0.014	-0.098	-0.135	-0.060	-0.039	
Unemployment Rate	0.219	0.035	-0.456	-0.003	-0.371	-0.177	0.311	0.083	-0.216	0.092	-0.578	-0.057	0.494	0.392	0.015	0.350	0.037	-0.418	-0.170	
Nominal GDP Growth	-0.020	-0.132	-0.047	0.872	-0.075	0.037	0.129	-0.094	-0.129	-0.030	-0.185	-0.094	-0.617	-0.056	-0.121	0.121	0.590	0.101	0.033	
Real GDP Growth	-0.680	0.010	-0.070	-0.031	0.267	0.233	-0.055	-0.118	0.437	-0.262	-0.047	0.327	-0.645	-0.476	0.281	0.441	0.195	0.229	-0.121	
External Debt (% of GDP)	0.355	-0.256	-0.007	0.084	-0.216	0.358	0.053	0.045	-0.017	0.493	0.005	0.202	0.194	0.012	-0.259	0.121	-0.117	-0.052	-0.028	
FDI (% of GDP)	-0.265	-0.105	-0.629	-0.164	0.069	0.329	0.324	-0.047	0.710	-0.158	-0.273	0.455	0.167	-0.035	0.358	0.553	0.066	-0.442	-0.511	
Overall Fiscal Balance (% of GDP)	-0.596	0.283	0.281	-0.664	0.306	0.168	-0.440	-0.156	0.268	-0.168	0.349	0.326	0.053	-0.115	0.491	0.163	-0.268	0.054	-0.210	
Interest Expenditure (% of total Expenditure)	0.878	-0.183	-0.390	0.316	-0.337	-0.294	0.547	0.006	-0.293	0.064	-0.354	-0.461	0.571	0.790	-0.568	-0.325	0.113	-0.385	0.115	
Change in Net Claims on Central Government	0.159	0.047	0.178	0.133	0.102	-0.059	-0.018	0.078	-0.030	0.083	0.148	-0.145	-0.162	-0.139	-0.256	-0.299	-0.173	0.300	0.316	
GDP per Capita	-0.088	-0.096	0.849	-0.037	0.416	-0.314	-0.601	-0.129	-0.320	0.250	0.382	-0.339	-0.462	-0.423	-0.292	-0.478	-0.335	0.841	0.655	
Average Effective Interest Rate	-0.307	-0.141	0.642	0.098	0.333	-0.237	-0.461	-0.080	-0.194	0.081	0.194	-0.236	-0.715	-0.592	-0.204	-0.231	-0.144	0.825	0.567	
Gross Financing Need	0.585	-0.341	-0.617	0.421	-0.313	-0.014	0.693	-0.053	0.095	0.061	-0.450	-0.190	0.276	0.442	-0.417	-0.019	0.245	-0.384	-0.041	
Average Maturity	0.254	0.089	-0.061	-0.260	0.218	-0.332	-0.185	-0.026	-0.172	0.321	-0.084	-0.324	0.289	-0.045	-0.439	-0.331	-0.682	0.131	0.200	
Primary Balance Gap (% of GDP)	-0.138	-0.093	-0.108	0.262	0.242	-0.021	-0.182	-0.258	0.194	-0.251	0.028	-0.048	-0.198	0.200	0.011	0.057	0.164	-0.080	-0.155	
Foreign Exchange Debt (% of GDP)	0.842	-0.207	0.162	0.311	-0.148	-0.351	0.086	-0.008	-0.575	0.343	-0.075	-0.552	0.286	0.439	-0.717	-0.530	-0.098	0.109	0.447	

**Table 5. Correlation Matrix (continued)**

	Debt Service due (% of GDP)	FX Reserves Growth	LIBOR	US TBill Rate	Unemployment Rate	Nominal GDP Growth	Real GDP Growth	External Debt (% of GDP)	FDI (% of GDP)	Overall Fiscal Balance (% of GDP)	Interest Expenditure (% of total Expenditure)	Change in Net Claims on Central Government	GDP per Capita	Average Effective Interest Rate	Gross Financing Need	Average Maturity	Primary Balance Gap (% of GDP)	Foreign Exchange Debt (% of GDP)
Debt Service due (% of GDP)	1.000																	
FX Reserves Growth	-0.149	1.000																
LIBOR	-0.248	0.342	1.000															
US TBill Rate	-0.092	0.462	0.876	1.000														
Unemployment Rate	0.035	-0.006	0.085	0.081	1.000													
Nominal GDP Growth	-0.061	0.054	-0.304	-0.317	-0.102	1.000												
Real GDP Growth	-0.268	0.126	-0.172	-0.023	-0.316	0.377	1.000											
External Debt (% of GDP)	0.742	-0.284	-0.226	-0.162	0.117	-0.023	-0.182	1.000										
FDI (% of GDP)	0.249	0.169	-0.104	0.060	0.225	-0.050	0.344	0.102	1.000									
Overall Fiscal Balance (% of GDP)	-0.327	0.148	0.348	0.414	-0.073	-0.538	0.211	-0.384	0.031	1.000								
Interest Expenditure (% of total Expenditure)	0.561	-0.019	-0.142	-0.068	0.379	0.094	-0.559	0.421	-0.049	-0.609	1.000							
Change in Net Claims on Central Government	0.037	-0.073	-0.152	-0.291	-0.404	0.068	-0.063	0.110	-0.354	-0.235	0.046	1.000						
GDP per Capita	-0.508	-0.143	0.012	-0.126	-0.341	0.006	-0.013	-0.109	-0.673	0.162	-0.358	0.237	1.000					
Average Effective Interest Rate	-0.606	-0.097	-0.088	-0.233	-0.392	0.276	0.321	-0.221	-0.513	0.074	-0.523	0.247	0.866	1.000				
Gross Financing Need	0.629	0.041	-0.252	-0.138	0.219	0.340	-0.170	0.460	0.319	-0.757	0.761	0.116	-0.579	-0.478	1.000			
Average Maturity	0.038	-0.082	0.101	0.106	-0.024	-0.284	-0.180	0.276	-0.105	-0.025	0.055	0.070	0.141	0.018	-0.048	1.000		
Primary Balance Gap (% of GDP)	-0.051	0.333	-0.317	-0.107	-0.169	0.390	0.363	-0.172	0.141	0.105	0.006	-0.024	-0.065	0.066	0.046	-0.158	1.000	
Foreign Exchange Debt (% of GDP)	0.382	-0.213	-0.168	-0.173	0.164	0.077	-0.566	0.561	-0.457	-0.560	0.771	0.185	0.232	-0.048	0.410	0.243	-0.132	1.000

**Table 6. EBA Results: Baseline Specification**

	<b>Coeff.</b>	<b>SE</b>	<b>C(0)</b>	<b>Obs.</b>
Output Gap	0.296	0.069	1.000	3188
Current Account Balance (% of GDP)	-0.046	0.014	1.000	3275
FX Reserves Growth	-0.010	0.003	0.998	3051
FX Reserves (% of GDP)	-0.034	0.012	0.998	3103
Openness: (M+X)/ GDP	-0.006	0.003	0.970	3254
Primary Balance Gap (% of GDP)	-0.029	0.017	0.958	688
Real GDP Growth	-0.039	0.023	0.957	3269
Overall Fiscal Balance (% of GDP)	-0.052	0.031	0.953	2035
Primary Balance (% of GDP)	-0.048	0.037	0.907	1874
Foreign Exchange Debt (% of GDP)	0.008	0.006	0.903	1124
Gross Financing Need	0.016	0.013	0.885	735
Change in Net Claims on Central Government	0.000	0.000	0.861	2415
Short Term Debt (% of total)	-0.008	0.007	0.854	2107
Unemployment Rate	-0.020	0.021	0.826	2546
LIBOR	0.042	0.049	0.801	3670
FX Reserve Coverage	-0.012	0.015	0.788	1581
CPI Inflation	0.004	0.005	0.786	2804
Concessional Debt (% of total)	-0.004	0.006	0.766	1632
Interest Expenditure (% of total Expenditure)	0.010	0.014	0.763	1908
Domestic Credit Gap	0.001	0.002	0.755	2588
Real Interest Rate	0.010	0.015	0.752	1387
Short Term External Debt (% of GDP)	-0.005	0.008	0.746	2142
Debt (% of GDP)	-0.002	0.004	0.744	3073
Real Exchange Rate Undervaluation	-0.002	0.004	0.741	2877
External Debt (% of GDP)	-0.002	0.003	0.722	2475
Average Maturity	-0.020	0.039	0.698	733
FDI (% of GDP)	0.010	0.033	0.625	2972
Amortisation of Total Public Debt (% of GDP )	-0.003	0.008	0.622	2030
Debt owed to Commercial Banks (% of total)	-0.005	0.016	0.618	1423
US TBill Rate	0.010	0.042	0.594	3592
GDP per Capita	-0.006	0.033	0.575	3291
Short Term Debt (% of FX Reserves)	0.000	0.001	0.568	1984
Nominal GDP Growth	0.001	0.005	0.567	3046
Debt Service due (% of GDP)	-0.003	0.020	0.551	1602
Debt owed to Multilateral Creditors (% of total)	0.001	0.009	0.545	1632
Interest-Growth Differential	-0.001	0.008	0.527	2154
Average Effective Interest Rate	0.000	0.002	0.523	1951

Note: Reported are estimation results from the EBA regression. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. Estimations are performed using the pooled logit model, with 2 additional controls per specification. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 29 advanced and 52 emerging economies for the period 1970–2015.

**Table 7. Robustness Check 1: “Narrow” Fiscal Distress Episodes****Table 7. Robustness check 1: “Purely” fiscal distress episodes**

	Coeff.	SE	C(0)	Obs.
Output Gap	0.194	0.076	0.995	2955
FX Reserves Growth	-0.011	0.006	0.979	2736
CPI Inflation	0.025	0.012	0.978	2576
FX Reserves (% of GDP)	-0.049	0.024	0.977	2788
Primary Balance Gap (% of GDP)	-0.105	0.057	0.968	453
Gross Financing Need	0.032	0.017	0.965	502
Real Interest Rate	0.064	0.037	0.959	1263
Openness: (M+X)/ GDP	-0.010	0.006	0.951	2859
Current Account Balance (% of GDP)	-0.037	0.024	0.940	2882
Change in Net Claims on Central Government	0.000	0.000	0.939	2415
Overall Fiscal Balance (% of GDP)	-0.083	0.054	0.939	1640
Interest Expenditure (% of total Expenditure)	0.042	0.030	0.920	1513
FX Reserve Coverage	-0.023	0.021	0.870	1385
Average Maturity	-0.064	0.062	0.850	514
Nominal GDP Growth	0.012	0.012	0.832	2812
External Debt (% of GDP)	-0.005	0.006	0.831	2081
Debt owed to Multilateral Creditors (% of total)	-0.012	0.015	0.783	1509
Foreign Exchange Debt (% of GDP)	0.009	0.011	0.782	994
Concessional Debt (% of total)	-0.006	0.010	0.730	1509
Debt Service due (% of GDP)	-0.030	0.055	0.708	1479
Short Term External Debt (% of GDP)	-0.011	0.020	0.702	1834
Real Exchange Rate Undervaluation	-0.003	0.008	0.671	2646
Average Effective Interest Rate	0.003	0.008	0.651	1556
Interest-Growth Differential	-0.006	0.017	0.649	1920
Short Term Debt (% of total)	-0.005	0.013	0.645	1797
GDP per Capita	0.018	0.057	0.627	2896
Debt owed to Commercial Banks (% of total)	0.006	0.018	0.620	1423
Domestic Credit Gap	0.001	0.002	0.609	2588
US TBill Rate	0.015	0.060	0.600	3280
Debt (% of GDP)	-0.001	0.006	0.558	2678
Short Term Debt (% of FX Reserves)	0.000	0.001	0.551	1736
LIBOR	0.009	0.073	0.547	3280
Unemployment Rate	-0.004	0.039	0.544	2175
Amortisation of Total Public Debt (% of GDP )	0.002	0.021	0.541	1767
Real GDP Growth	-0.004	0.045	0.533	2874
Primary Balance (% of GDP)	-0.004	0.061	0.528	1479
FDI (% of GDP)	0.003	0.067	0.516	2579

Note: Reported are estimation results from the EBA regression. The dependent variable is the narrower fiscal stress definition, which excludes Currency and Banking crises as identifies in Reinhart and Rogoff (2009). Estimations are performed using the pooled logit model, with 2 additional controls per specification. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 29 advanced and 52 emerging economies for the period 1970–2010.

**Table 8. Robustness Check 2: Emerging Economies**

	Coeff.	SE	C(0)	Obs.
Output Gap	0.259	0.070	1.000	3188
FX Reserves Growth	-0.012	0.004	0.999	3051
FX Reserves (% of GDP)	-0.040	0.013	0.999	3103
Current Account Balance (% of GDP)	-0.033	0.014	0.989	3275
Real GDP Growth	-0.050	0.023	0.987	3269
Overall Fiscal Balance (% of GDP)	-0.066	0.035	0.972	2035
Primary Balance Gap (% of GDP)	-0.029	0.017	0.958	688
Unemployment Rate	-0.035	0.023	0.937	2546
Primary Balance (% of GDP)	-0.056	0.042	0.911	1874
Openness: (M+X)/ GDP	-0.004	0.003	0.896	3254
Gross Financing Need	0.016	0.013	0.885	735
Change in Net Claims on Central Government	0.000	0.000	0.865	2415
FDI (% of GDP)	0.037	0.041	0.816	2972
FX Reserve Coverage	-0.012	0.015	0.784	1581
Short Term Debt (% of total)	-0.006	0.008	0.770	2107
Concessional Debt (% of total)	-0.004	0.006	0.766	1632
LIBOR	0.039	0.054	0.766	3670
CPI Inflation	0.004	0.006	0.750	2804
Short Term External Debt (% of GDP)	-0.007	0.010	0.749	2142
Domestic Credit Gap	0.001	0.002	0.748	2588
External Debt (% of GDP)	-0.002	0.004	0.719	2475
Average Maturity	-0.020	0.039	0.698	733
Real Interest Rate	0.008	0.015	0.696	1387
Real Exchange Rate Undervaluation	-0.002	0.005	0.658	2877
Interest-Growth Differential	0.003	0.009	0.638	2154
Foreign Exchange Debt (% of GDP)	0.002	0.007	0.629	1124
Short Term Debt (% of FX Reserves)	0.000	0.001	0.622	1984
Debt (% of GDP)	-0.001	0.004	0.621	3073
Debt owed to Commercial Banks (% of total)	-0.005	0.016	0.618	1423
Average Effective Interest Rate	-0.001	0.003	0.607	1951
US TBill Rate	0.006	0.047	0.552	3592
GDP per Capita	0.004	0.035	0.551	3291
Debt Service due (% of GDP)	-0.003	0.020	0.551	1602
Nominal GDP Growth	-0.001	0.006	0.547	3046
Debt owed to Multilateral Creditors (% of total)	0.001	0.009	0.545	1632
Amortisation of Total Public Debt (% of GDP )	-0.001	0.009	0.542	2030
Interest Expenditure (% of total Expenditure)	0.001	0.014	0.531	1908

Note: Reported are estimation results from the EBA regression. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. Estimations are performed using the pooled logit model, with two additional controls per specification. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 52 emerging economies for the period 1970–2015.



**Table 9. Robustness Check 3: Number of Control Variables**

	Coeff.	SE	C(0)	Obs.
Output Gap	0.333	0.083	1.000	3188
Current Account Balance (% of GDP)	-0.054	0.017	0.999	3275
FX Reserves (% of GDP)	-0.038	0.014	0.996	3103
FX Reserves Growth	-0.011	0.004	0.993	3051
Real GDP Growth	-0.045	0.028	0.947	3269
Openness: (M+X)/ GDP	-0.006	0.004	0.941	3254
Primary Balance Gap (% of GDP)	-0.028	0.019	0.935	688
Overall Fiscal Balance (% of GDP)	-0.050	0.038	0.907	2035
Unemployment Rate	-0.030	0.025	0.891	2546
CPI Inflation	0.009	0.008	0.858	2804
Primary Balance (% of GDP)	-0.045	0.043	0.853	1874
Short Term Debt (% of total)	-0.009	0.009	0.849	2107
Gross Financing Need	0.014	0.014	0.842	735
Domestic Credit Gap	0.003	0.003	0.834	2588
Change in Net Claims on Central Government	0.000	0.000	0.786	2415
LIBOR	0.054	0.069	0.785	3670
Concessional Debt (% of total)	-0.005	0.007	0.766	1632
FX Reserve Coverage	-0.011	0.016	0.761	1581
Debt (% of GDP)	-0.003	0.005	0.755	3073
Short Term External Debt (% of GDP)	-0.008	0.011	0.754	2142
Real Interest Rate	0.015	0.022	0.753	1387
External Debt (% of GDP)	-0.003	0.004	0.746	2475
Foreign Exchange Debt (% of GDP)	0.005	0.007	0.745	1124
Average Maturity	-0.024	0.041	0.719	733
Real Exchange Rate Undervaluation	-0.003	0.005	0.689	2877
Interest Expenditure (% of total Expenditure)	0.007	0.016	0.660	1908
Interest-Growth Differential	-0.004	0.011	0.646	2154
FDI (% of GDP)	0.014	0.038	0.645	2972
Debt owed to Commercial Banks (% of total)	-0.008	0.021	0.638	1423
US TBill Rate	-0.021	0.062	0.630	3592
Nominal GDP Growth	0.002	0.008	0.600	3046
Debt Service due (% of GDP)	-0.006	0.024	0.599	1602
GDP per Capita	0.008	0.043	0.576	3291
Amortisation of Total Public Debt (% of GDP )	-0.002	0.011	0.570	2030
Average Effective Interest Rate	0.000	0.003	0.529	1951
Debt owed to Multilateral Creditors (% of total)	-0.001	0.011	0.526	1632
Short Term Debt (% of FX Reserves)	0.000	0.001	0.518	1984

Note: Reported are estimation results from the EBA regression. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. Estimations are performed using the pooled logit model, with 3 additional controls per specification. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 29 advanced and 52 emerging economies for the period 1970-2015.

**Table 10. Robustness Check 4: Random Effects Logit Model**

	Coeff.	SE	C(0)	Obs.
Output Gap	0.302	0.071	1.000	3188
Current Account Balance (% of GDP)	-0.054	0.016	1.000	3275
FX Reserves Growth	-0.010	0.003	0.998	3051
FX Reserves (% of GDP)	-0.035	0.013	0.997	3103
Real GDP Growth	-0.041	0.024	0.960	3269
Primary Balance Gap (% of GDP)	-0.029	0.018	0.950	688
Openness: (M+X)/ GDP	-0.005	0.003	0.948	3254
Overall Fiscal Balance (% of GDP)	-0.055	0.035	0.941	2035
Gross Financing Need	0.019	0.015	0.891	735
Primary Balance (% of GDP)	-0.048	0.041	0.879	1874
Change in Net Claims on Central Government	0.000	0.000	0.861	2415
Unemployment Rate	-0.025	0.024	0.851	2546
Foreign Exchange Debt (% of GDP)	0.007	0.007	0.833	1124
Short Term Debt (% of total)	-0.007	0.008	0.823	2107
LIBOR	0.045	0.050	0.814	3670
FX Reserve Coverage	-0.012	0.015	0.779	1581
Concessional Debt (% of total)	-0.005	0.006	0.775	1632
CPI Inflation	0.004	0.006	0.771	2804
Real Exchange Rate Undervaluation	-0.003	0.004	0.766	2877
Domestic Credit Gap	0.001	0.002	0.757	2588
Real Interest Rate	0.010	0.016	0.735	1387
Short Term External Debt (% of GDP)	-0.005	0.008	0.721	2142
Debt (% of GDP)	-0.002	0.004	0.702	3073
External Debt (% of GDP)	-0.001	0.003	0.682	2475
Average Maturity	-0.017	0.043	0.657	733
FDI (% of GDP)	0.012	0.035	0.636	2972
Interest Expenditure (% of total Expenditure)	0.005	0.017	0.617	1908
Debt owed to Commercial Banks (% of total)	-0.005	0.016	0.614	1423
US TBill Rate	0.012	0.043	0.612	3592
Amortisation of Total Public Debt (% of GDP )	-0.002	0.009	0.595	2030
Short Term Debt (% of FX Reserves)	0.000	0.001	0.585	1984
Average Effective Interest Rate	0.000	0.003	0.554	1951
Debt Service due (% of GDP)	-0.003	0.021	0.551	1602
GDP per Capita	-0.003	0.040	0.526	3291
Nominal GDP Growth	0.000	0.006	0.525	3046
Debt owed to Multilateral Creditors (% of total)	0.000	0.010	0.504	1632
Interest-Growth Differential	0.000	0.008	0.503	2154

Note: Reported are estimation results from the EBA regression. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring, (ii) sovereign bond yield pressure, (iii) large IMF-supported program, and (iv) excessive inflation. Estimations are performed using the random effects logit model, with 2 additional controls per specification. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 29 advanced and 52 emerging economies for the period 1970–2015.

**Table 11. Robustness Check 5: Pooled Probit Model**

	Coeff.	SE	C(0)	Obs.
Output Gap	0.138	0.034	1.000	3188
Current Account Balance (% of GDP)	-0.025	0.007	1.000	3275
FX Reserves (% of GDP)	-0.016	0.005	0.998	3103
FX Reserves Growth	-0.003	0.001	0.995	3051
Primary Balance Gap (% of GDP)	-0.018	0.009	0.973	688
Openness: (M+X)/ GDP	-0.003	0.001	0.969	3254
Real GDP Growth	-0.020	0.011	0.959	3269
Overall Fiscal Balance (% of GDP)	-0.026	0.016	0.954	2035
Foreign Exchange Debt (% of GDP)	0.004	0.003	0.909	1124
Primary Balance (% of GDP)	-0.023	0.018	0.905	1874
Gross Financing Need	0.008	0.007	0.872	735
Short Term Debt (% of total)	-0.004	0.004	0.861	2107
Change in Net Claims on Central Government	0.000	0.000	0.844	2415
Unemployment Rate	-0.010	0.010	0.832	2546
LIBOR	0.020	0.024	0.798	3670
CPI Inflation	0.002	0.003	0.798	2804
FX Reserve Coverage	-0.007	0.008	0.796	1581
Domestic Credit Gap	0.001	0.001	0.781	2588
Concessional Debt (% of total)	-0.002	0.003	0.764	1632
Interest Expenditure (% of total Expenditure)	0.005	0.007	0.764	1908
Short Term External Debt (% of GDP)	-0.003	0.004	0.753	2142
Real Interest Rate	0.005	0.008	0.742	1387
Real Exchange Rate Undervaluation	-0.001	0.002	0.741	2877
Debt (% of GDP)	-0.001	0.002	0.735	3073
External Debt (% of GDP)	-0.001	0.001	0.717	2475
Average Maturity	-0.010	0.020	0.700	733
FDI (% of GDP)	0.005	0.016	0.633	2972
Amortisation of Total Public Debt (% of GDP )	-0.001	0.004	0.626	2030
Debt owed to Commercial Banks (% of total)	-0.002	0.008	0.618	1423
US TBill Rate	0.004	0.020	0.585	3592
Nominal GDP Growth	0.001	0.003	0.581	3046
Short Term Debt (% of FX Reserves)	0.000	0.000	0.576	1984
GDP per Capita	-0.003	0.017	0.570	3291
Debt Service due (% of GDP)	-0.001	0.010	0.555	1602
Debt owed to Multilateral Creditors (% of total)	0.001	0.005	0.544	1632
Interest-Growth Differential	0.000	0.004	0.542	2154
Average Effective Interest Rate	0.000	0.001	0.520	1951

Note: Reported are estimation results from the EBA regression. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. Estimations are performed using the pooled probit model, with 2 additional controls per specification. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 29 advanced and 52 emerging economies for the period 1970–2015.

**Table 12. Robustness Check 6: Using New Measure of Output Gap**

	Coeff.	SE	C(0)	Obs.
Output Gap	0.074	0.018	1.000	3188
Current Account Balance (% of GDP)	-0.025	0.007	1.000	3275
FX Reserves (% of GDP)	-0.016	0.005	0.998	3103
FX Reserves Growth	-0.003	0.001	0.995	3051
Primary Balance Gap (% of GDP)	-0.018	0.009	0.971	688
Openness: (M+X)/ GDP	-0.003	0.001	0.967	3254
Real GDP Growth	-0.019	0.011	0.954	3269
Overall Fiscal Balance (% of GDP)	-0.026	0.016	0.953	2035
Foreign Exchange Debt (% of GDP)	0.004	0.003	0.907	1124
Primary Balance (% of GDP)	-0.023	0.018	0.904	1874
Gross Financing Need	0.008	0.007	0.873	735
Short Term Debt (% of total)	-0.004	0.004	0.859	2107
Change in Net Claims on Central Government	0.000	0.000	0.843	2415
Unemployment Rate	-0.010	0.010	0.835	2546
LIBOR	0.020	0.024	0.800	3670
FX Reserve Coverage	-0.007	0.008	0.797	1581
CPI Inflation	0.002	0.003	0.797	2804
Domestic Credit Gap	0.001	0.001	0.781	2588
Interest Expenditure (% of total Expenditure)	0.005	0.007	0.767	1908
Concessional Debt (% of total)	-0.002	0.003	0.766	1632
Short Term External Debt (% of GDP)	-0.003	0.004	0.753	2142
Real Exchange Rate Undervaluation	-0.001	0.002	0.744	2877
Real Interest Rate	0.005	0.008	0.738	1387
Debt (% of GDP)	-0.001	0.002	0.732	3073
External Debt (% of GDP)	-0.001	0.001	0.716	2475
Average Maturity	-0.010	0.020	0.695	733
FDI (% of GDP)	0.006	0.016	0.639	2972
Amortisation of Total Public Debt (% of GDP )	-0.001	0.004	0.628	2030
Debt owed to Commercial Banks (% of total)	-0.002	0.008	0.613	1423
US TBill Rate	0.005	0.020	0.589	3592
Nominal GDP Growth	0.001	0.003	0.581	3046
Short Term Debt (% of FX Reserves)	0.000	0.000	0.575	1984
GDP per Capita	-0.003	0.017	0.569	3291
Debt Service due (% of GDP)	-0.001	0.010	0.556	1602
Debt owed to Multilateral Creditors (% of total)	0.001	0.005	0.543	1632
Interest-Growth Differential	0.000	0.004	0.539	2154
Average Effective Interest Rate	0.000	0.001	0.522	1951

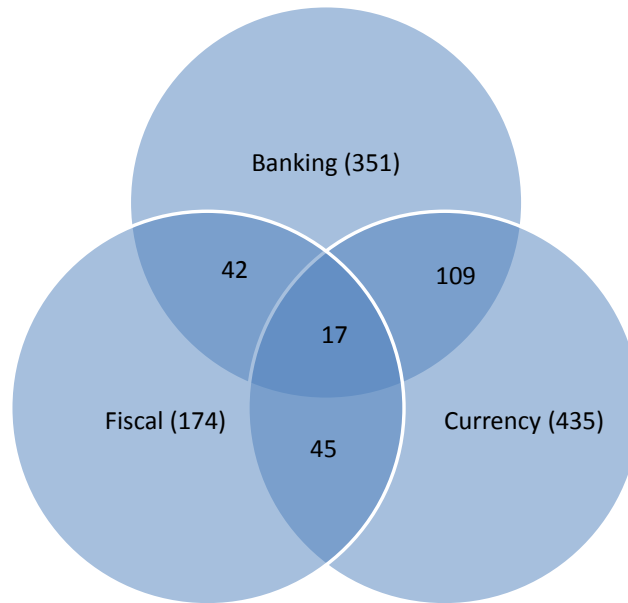
Note: Reported are estimation results from the EBA regression. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. Estimations are performed using the pooled Logit model, with 2 additional controls per specification. The output gap is generated using a one-sided Christiano-Fitzgerald filter. The variables are ranked according to their robustness, with most robust indicators placed on top. The sample covers 29 advanced and 52 emerging economies for the period 1970-2015.

**Table 13. Early Warning System Based on Most Robust Leading Indicators**

	<b>Pooled logit</b>
Output Gap	0.4377*** [0.0860]
Current Account Balance (% of GDP)	-0.0943*** [0.0196]
FX Reserves Growth	0.0002 [0.0029]
Openness: (M+X)/ GDP	-0.0097*** [0.0035]
Real GDP Growth	-0.1312*** [0.0349]
Overall Fiscal Balance (% of GDP)	-0.0030 [0.0407]
Primary Balance (% of GDP)	-0.0078 [0.0439]
Intercept	-1.9855*** [0.3069]
Number of observations	1765
Pseudo R <sup>2</sup>	0.537
AUROC	0.815
Type 1 error	0.218
Type 2 error	0.312
TME	0.530

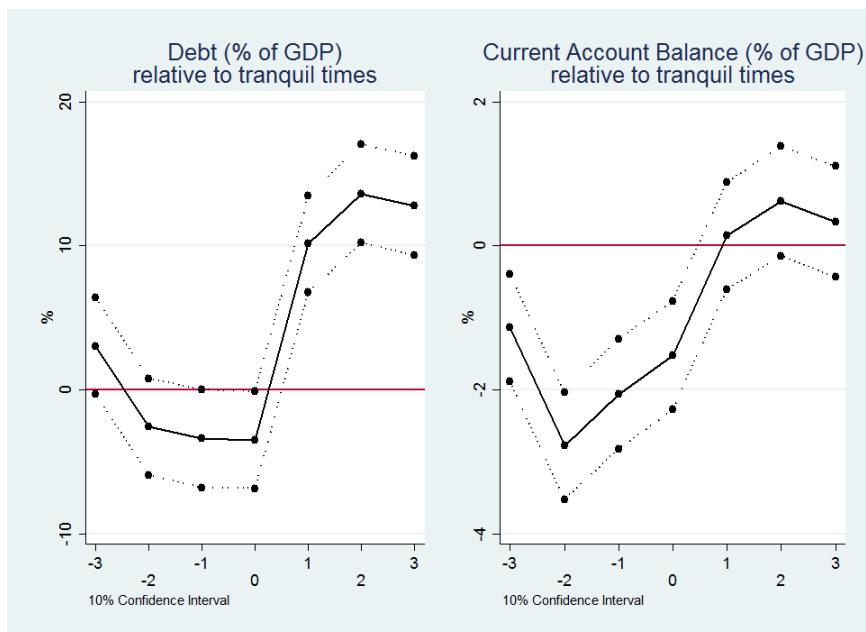
Note: Reported are estimation results from the pooled logit model using most robust leading indicators of fiscal distress. The dependent variable is Baldacci et al. (2011) definition of fiscal distress: (i) debt default or restructuring; (ii) sovereign bond yield pressure; (iii) large IMF-supported program; and (iv) excessive inflation. The sample covers 29 advanced and 52 emerging economies for the period 1970–2015. AUROC is the area under the receiver operating curve. \*\*\*, \*\*, and \* denote significance at 1, 5, and 10 percent levels, respectively.

**Figure 1. Banking, Currency and Fiscal Crises**



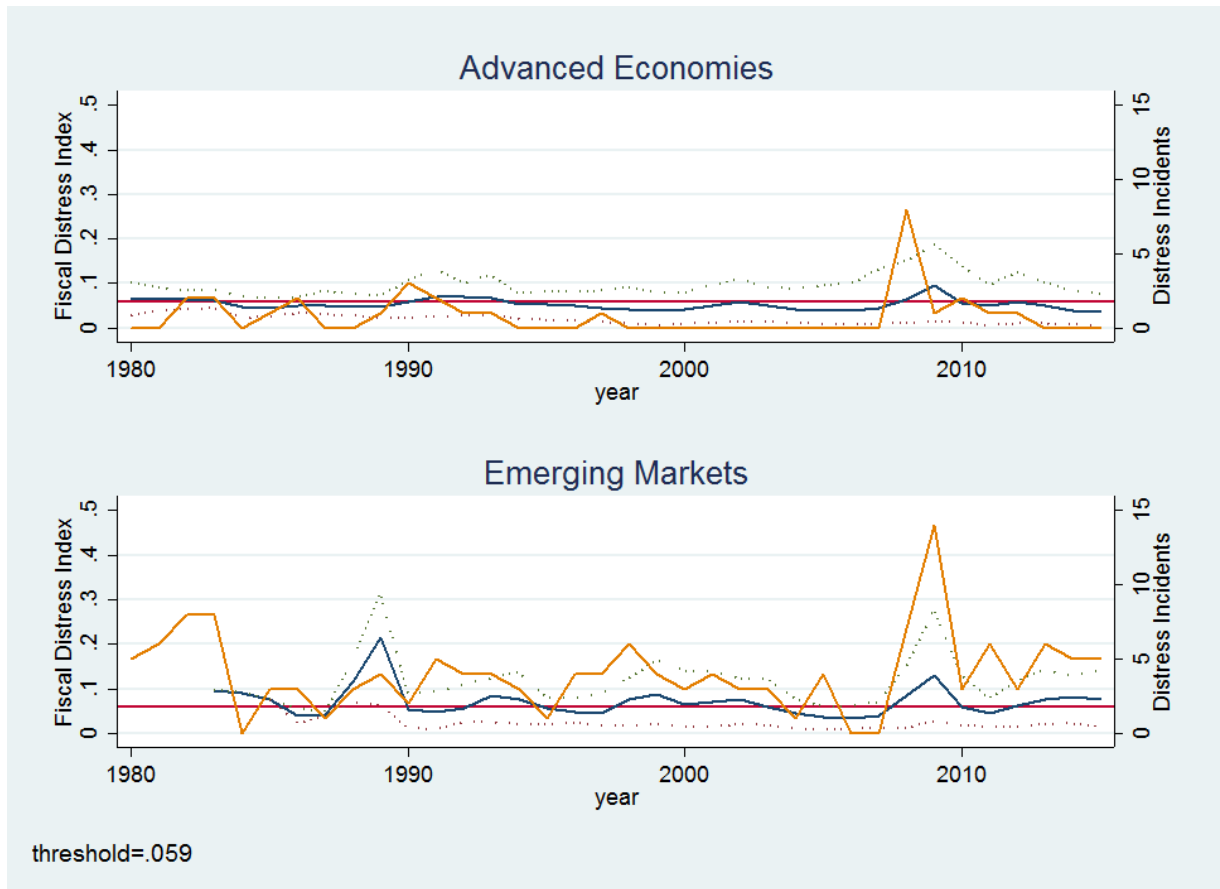
Note: Reported is the overlap between fiscal, banking and currency crises for the period 1970–2010. Data on banking and currency crisis episodes are taken from Reinhart and Rogoff (2009). Data on the first year of a fiscal crisis are from Baldacci et al. (2011).

**Figure 2. Event Study Analysis**



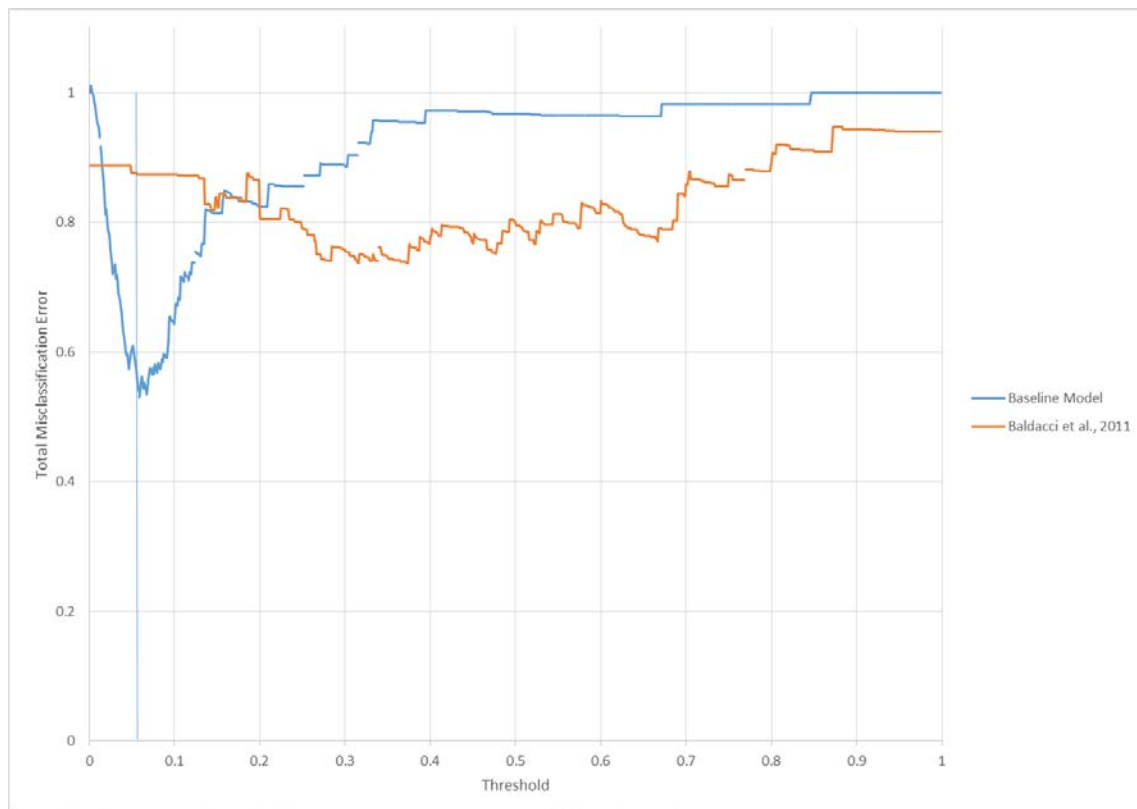
Note: Both graphs as generated using the Gourinchas and Obstfeld (2012) event study methodology. It shows the percent deviation of the debt to GDP ratio and the current account balance to GDP ratio from their respective "tranquil" averages. This is defined as the average level of the respective variable outside the 3-year window around the crisis incident. Dotted lines denote the 10% confidence intervals.

**Figure 3. Fiscal Distress Index Based on Robust Leading Indicators**



Note: The fiscal distress index is generated by using predicted values from the logit model that includes most robust leading indicators. The most robust leading indicators are defined as those with at least 90 percent probability of not switching signs using the EBA results. Robust leading indicators include (i) Output Gap; (ii) Current Account Balance (% of GDP); (iii) FX Reserves Growth; (iv) Openness:  $(M+X)/GDP$ ; (v) Real GDP Growth, (vi) Overall Fiscal Balance (% of GDP); (vii) Primary Balance (% of GDP). Blue line indicates the Fiscal Distress Index (left axis). Dotted lines indicate 90 percent confidence bands around predicted values. Orange line represents the absolute number of distress events in a given year (right axis). Data are missing for the pre-1980 period so that no predictive values can be generated.

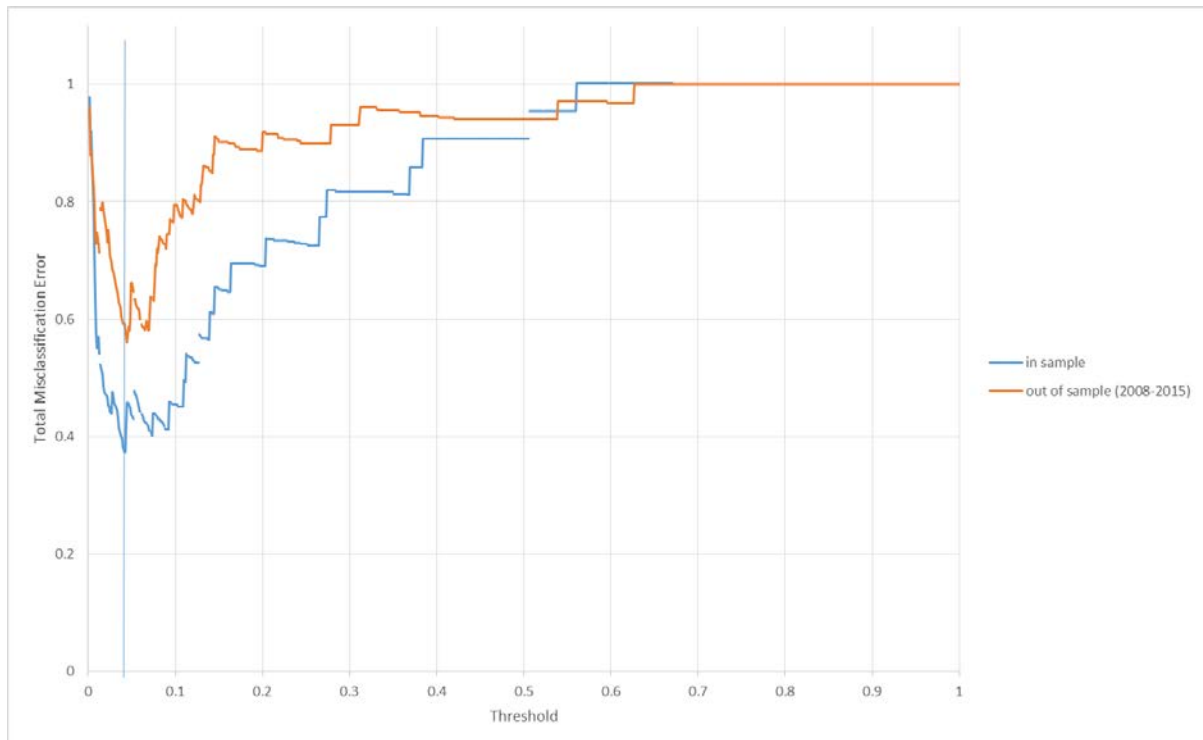
**Figure 4. In-sample Performance: EBA-based Fiscal Distress Index versus Baldacci et al. (2011) Index**



Note: Reported is the Total Misclassification Error (TME) for different threshold levels. The blue line represents the baseline model based on robust leading indicators: (i) output gap; (ii) current account balance (% of GDP); (iii) FX reserves growth; (iv) openness:  $(M+X)/GDP$ ; (v) real GDP growth; (vi) overall fiscal balance (% of GDP); (vii) primary balance (% of GDP). The vertical line marks the threshold level (0.07) that minimizes the TME. The orange line represents TME from the model based on variables used by Baldacci et al. (2011).



**Figure 5. In-sample Versus Out-of-sample Performance of the EBA-based Fiscal Distress Index**



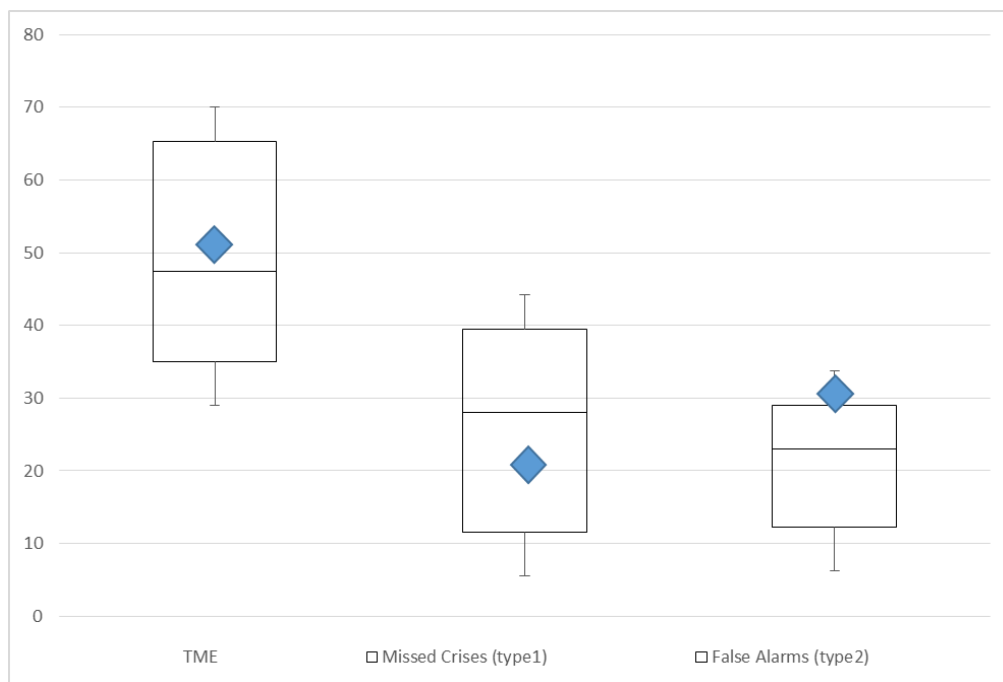
Note: Reported is The Total Misclassification Error (TME) for different levels of the threshold. The fiscal vulnerability index is based on robust leading indicators: (i) output gap; (ii) current account balance (% of GDP), (iii) FX reserves growth; (iv) openness:  $(M+X)/GDP$ ; (v) real GDP growth; (vi) overall fiscal balance (% of GDP); (vii) primary balance (% of GDP). The blue line represents the in-sample TME based on the years 1970–2007. The orange line represents the out-of-sample TME for the years 2008–2015. The vertical line marks the threshold level (0.04) that minimizes the in-sample TME.

**Figure 6. Classification Table for Out-of-sample Predictions of the EBA-based Fiscal Distress Indicator**

		Crisis		Total
		Yes	No	
Signal	Yes	25	118	<b>143</b>
	No	7	226	<b>233</b>
	Total	<b>32</b>	<b>344</b>	<b>376</b>

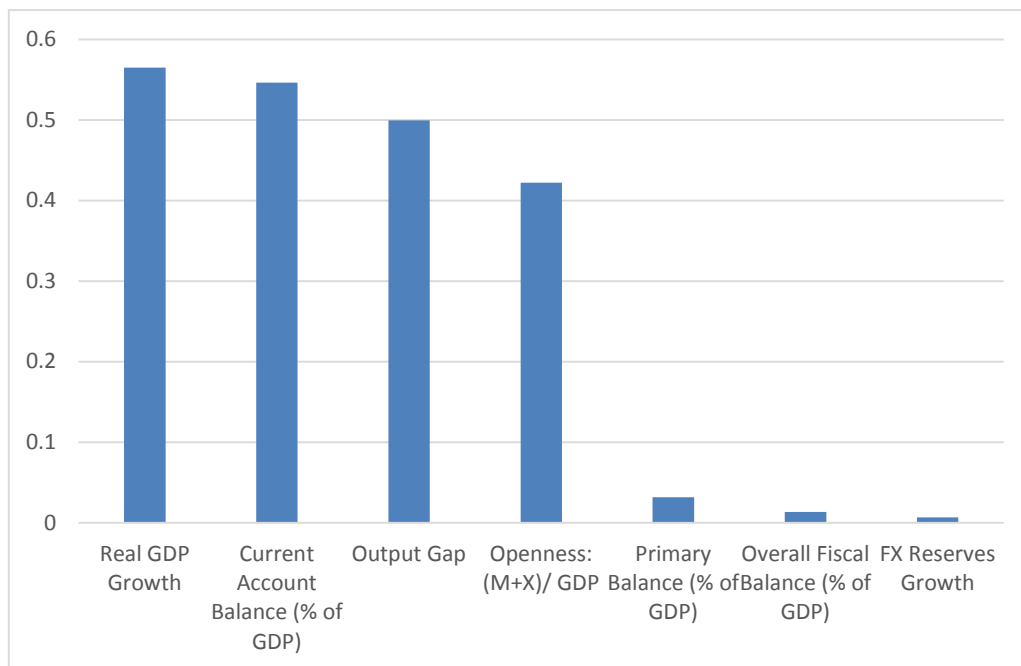
Note: Reported is the model classification for the years 2008–2015. A signal is issued if fiscal distress index exceeds the threshold derived from the in-sample minimization of the TME.

**Figure 7. Comparison with Other Studies**



Note: Reported is the in-sample total misclassification error (TME), Type1 and Type2 errors of 8 Early Warning Systems for currency, banking and sovereign crises reported in the literature. The values represent the minimum, the 25th percentile, the mean, the 75th percentile and the maximum.

**Figure 8. Economic Significance of Robust Leading Indicators**



Note: Reported is the difference in the logarithm of the odds ratio calculated for 75th and 25th percentile of each leading indicator (components of the fiscal distress index). A larger absolute value indicates a larger economic impact of a change in that indicator on the log odds ratio of a fiscal distress.