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When Do We Repair the Roof? Insights from
Responses to Fiscal Crisis Early Warning Signals

Jiro Honda, René Tapsoba, and Ismael Issifou

I N T E R N A T I O N A L M O N E T A R Y F U N D

IMF Working Paper

Fiscal Affairs Department

When Do We Repair the Roof? Insights from Responses to Fiscal Crisis Early Warning Signals¹

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Abstract

Should policymakers wait for fiscal crisis early warning signals before repairing the roof? We give an answer to this question by investigating the interlinkages between early warning signals for fiscal crisis, policy responses, and policy outcomes, using a broad panel of 119 countries. We find that fiscal adjustment is a good remedy for countries that act proactively, reducing their likelihood of facing fiscal crisis by up to about 60 percent. For those waiting for wake-up calls from early-detection tools, however, fiscal adjustment may not fully prevent fiscal crisis occurrence, with the chance of fiscal crisis prevention not only smaller (about 30 percent) but also statistically not significant. These findings highlight the prominence of repairing the roof when the sun is shining, particularly in countries with weak institutions.

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I. INTRODUCTION

1. **The recent Great Recession, along with the erosion of public finances associated with its unwinding, have put at the forefront of the policy debate the need for enhanced monitoring and prevention of fiscal crises**, including through undertaking well-designed fiscal consolidations and strengthening fiscal institutions (Mauro, 2011; IMF, 2009; Budina and others, 2012; Debrun and Kinda, 2014). Indeed, fiscal crises have been found to lead to large and protracted growth and employment costs, owing to the disruptive fiscal adjustments undertaken amid their occurrence (ECB, 2014; Gerling and others, 2017).
2. **The development of reliable and timely indicators of fiscal distress signs took center stage in the quest for enhanced fiscal crisis prevention.** This follows the failure of government bond yields and sovereign spreads to signal early in advance the crisis. Building on early warning signals (EWS) analyses for banking and currency crises, a growing strand of literature developed EWS of fiscal crises to gauge ex-ante, countries' vulnerability to fiscal distress (Baldacci and others, 2011; Detragiache and Spilimbergo, 2001; Manasse and others, 2003). Fiscal distress is viewed as changes in underlying fiscal sustainability risks, even in the absence of outright debt default (Baldacci and others, 2011; Cottarelli, 2011; IMF, 2011, Manasse and others, 2003).
3. **Together with indicators of short-term refinancing needs, EWS for fiscal crises aim at capturing early on any signs of governments' extreme funding difficulties.** The underlying goal is to allow for timely policy responses and prevention of fiscal crisis occurrence. Applications of such EWS for fiscal crises include notably the so-called *S0 indicator*, an early warning indicator introduced by the European Commission for monitoring short-term risks to fiscal sustainability in the European system of fiscal surveillance (Berti and others, 2012; and European Commission, 2012). In the absence of comprehensive database on fiscal crisis worldwide, these exercises tended to focus on a limited group of countries (advanced countries or countries with high market access).
4. **More recently, Gerling and others (2017) constructed a broad database of fiscal crises, which allowed developing a worldwide database of EWS.** The database does not only cover countries of all income groups (advanced economies (AEs), emerging market economies (EMs), and low-income countries (LICs)), but also encompasses an enhanced set of criteria for capturing periods of extreme funding difficulties, including notably the accumulation of domestic payment arrears and the loss of market access. Building on this Gerling and others (2017)'s fiscal crisis database, Medas and others (forthcoming) constructed a comprehensive dataset of EWS for fiscal crises, covering AEs, EMs and LICs.
5. **A missing piece, common to all these studies above, is undoubtedly assessing whether and to which extent these EWS tools could be effective in preventing/mitigating the occurrence of fiscal crises.** Put differently, do countries respond to the signs of fiscal crisis to avoid their materialization? The main novelty of this study is thus to bridge this gap in the literature by expanding our understanding of the linkages between fiscal crisis signs (EWS), policy responses, and policy outcomes.

6. **Specifically, we examine three main empirical questions.** Do policy actions (in the forms of fiscal consolidation) prevent or mitigate the occurrence of fiscal crises, irrespective of the presence of EWS? Or is just luck (change in external environments/investors' appetite) at play in the avoidance of fiscal crises in countries that experienced fiscal crisis alarm bells? Do policymakers proactively respond to signs of fiscal distress, notably through undertaking fiscal adjustment? Do wake up calls from EWS make a difference in the effect of policy response (fiscal consolidation) on fiscal crisis occurrence?

7. **We make use of discrete choice models to address the above-mentioned questions.** We carefully account for the counterfactuals of implementing *fiscal consolidation after EWS* to isolate the effect that policy responses to EWS add to the relationship between fiscal consolidation and fiscal crisis occurrence. We also use lagged values of the variables of interest to mitigate endogeneity concerns. Estimates are based on 325 two-year ahead signs of fiscal crises (EWS) from a broad panel of 119 countries over 2007–2015, encompassing AEs, EMs, and LICs.

8. **We unveil important suggestive evidence for the interlinkages between early-detection tools of fiscal distress, policy responses, and policy outcomes.** First, countries (60 percent) tend to undertake fiscal consolidation when facing signs of fiscal distress (EWS). Second, fiscal consolidation, irrespective of the presence of EWS, seems to be a good remedy against the materialization of fiscal crises. Third, responding to EWS through fiscal consolidation may not necessarily yield successful results, as it may prove too late to effectively prevent its occurrence. Fourth, and puzzlingly, larger fiscal consolidations in response to EWS do not necessarily work better to prevent fiscal crisis. Fifth, substitutability seems to be at work between fiscal consolidation and institutional quality when it comes to fiscal crisis prevention, in that undertaking fiscal consolidation before the emergence of fiscal distress appears more critical in less resilient countries (countries with weak institutions).

9. **From a policy standpoint, these findings underscore the criticality of securing sufficient buffers to cushion against fiscal crisis.** They suggest that once fiscal vulnerabilities are laid bare, timely policy response is essential, but preparing for the signs of fiscal distress is equally important. Large fiscal consolidations may not work to fix the vulnerabilities once-and-for-all: the adjustment may help lower the severity of fiscal crisis but not fully stave it off. Countries should invest in resilience building through gradual but steady accumulation of fiscal buffers and improvement in the quality of institutions. Put simply, policymakers need to *fix the roof while the sun is shining*.

10. **The rest of the paper is structured as follows.** Section II provides a brief review of the existing literature, while section III introduces the dataset and highlights a few correlations. Section IV presents the econometric methodology and discusses the results, while section V briefly concludes and draws some policy implications.

II. RELATED LITERATURE

11. **A nascent strand of literature analyzed the determinants of fiscal crises, building on the traditional analytical framework for crisis determinants.** As well summarized in Bruns and Poghosyan (2016), the traditional literature on crisis determinants can be regrouped in two: a first group, pioneered by Krugman (1979), which views crisis as mainly driven by the deterioration of fundamentals (Kaminsky and others, 1998; Kaminsky and Reinhart, 1999; Berg and Pattillo, 1999; Detragiache and Spilimbergo, 2001; and Chakrabarti and Zeaiter, 2014); and a second group, which goes beyond the role of fundamentals to consider self-fulfilling expectations as another set of crisis drivers (Obstfeld, 1984; Calvo, 1988; Alesina et al., 1989; Cole and Kehoe, 1994; Eichengreen and others, 1995; Jeanne, 1997; and Masson, 1999).³ The nascent body of the literature on the predictors of fiscal crisis aligns well with the *fundamentals* segment of the crisis literature.

12. **The seminal contributions view fiscal distress through the lens of changes in underlying fiscal sustainability risks, even in the absence of outright debt default.** Following the framework set out by Cottarelli (2011), Baldacci and others (2011) circumscribe fiscal distress through factors encompassing public debt default/restructuring, the need to access large-scale official/IMF support, hyperinflation, and extreme funding difficulties. More recently, Gerling and others (2017) extended the concept of fiscal crisis to an enhanced set of criteria capturing periods of extreme funding difficulties, including notably the accumulation of domestic payment arrears and the loss of market access. They constructed a broad database of fiscal crises covering AEs, EMEs and LICs.

13. **The development of fiscal crisis databases gave rise to a body of literature focused on the quest for reliable tools to timely prevent fiscal crises occurrence.** The underlying goal is to develop indicators to gauge ex-ante signs of fiscal distress, the so-called early warning signals (EWS) for fiscal crises. The construction of such EWS for fiscal crises follows closely the framework underpinning the development of EWS for banking, currency and financial crises (Kaminsky and others, 1998; Hawkins and Klaw, 2000; Abiad, 2003; Berg and others, 2005; and Frankel and Saravelos, 2012). Cottarelli (2011), Baldacci and others (2011), and IMF (2011) provide an overview of fiscal crisis predictors. Real applications of EWS for fiscal crises include the so-called S0 indicator, an early warning indicator introduced by the European Commission for monitoring short-term risks to fiscal sustainability in the European system of fiscal surveillance (Berti and others, 2012; and European Commission, 2012). While most EWS for fiscal crises rely on a set of only fiscal variables predetermined by the researchers, Bruns and Poghosyan (2017) rather use an extreme bound analysis to identify robust leading indicators (fiscal and non-fiscal factors) of fiscal distress. They found that both fiscal (fiscal balance, foreign exchange debt) and non-fiscal variables (output, FX reserves, current account balance, and openness) are robust leading indicators of fiscal crises. Additional EWS studies based on EBA include Chakrabarti and Zeaiter (2014), Ho (2014), and Christofides and others (2016).

³ More recent studies include Gourinchas and Obstfeld (2012) that show that domestic credit expansion and real currency appreciation precede sovereign default, banking, and currency crises, and Catão and Milesi-Ferretti (2014) that identify net foreign liabilities as a significant predictor of external crises.

14. **Unlike most studies above, which focus predominantly on public debt crises, Medas and others (forthcoming) computed EWS relying on enhanced set of criteria for identifying fiscal crises.** The following section discusses briefly the construction of this EWS for fiscal crises and provides an overview of key correlations between this index, policy responses, and fiscal crises.

III. DATA AND CORRELATIONS

3.1. Fiscal Crisis and EWS for Fiscal Crisis

15. **The EWS for fiscal crises used throughout the paper (Medas and others, forthcoming) hinges on the fiscal crisis database recently put together by Gerling and others (2017).**⁴ The latter build on Baldacci and others (2011), though with the main novelty of relying on an enhanced set of criteria to better identify periods of extreme funding difficulties, including notably the accumulation of domestic arrears and loss of market access. Specifically, a year is considered as a *fiscal crisis* year when at least one of the following four criteria is met: (i) credit events associated with sovereign debt (including outright defaults and restructuring); (ii) recourse to large-scale IMF financial support; (iii) implicit domestic public default (e.g., via high inflation rates); and (iv) loss of market confidence in the sovereign.

16. **The EWS of fiscal distress used in this paper builds on the non-parametric approach popularized by Kaminsky and others (1998) in the context of currency crises.** As pointed out in Hemming and others (2003), Baldacci and others (2011), Frankel and Saravelos (2012), and Comelli (2013), two main approaches exist when it comes to computing EWS: the *non-parametric* EWS or “*signals*” approach and the *parametric* EWS approach. The signals approach determines for a set of selected leading indicators of crises, threshold values beyond which a crisis signal is issued.⁵ A weighted average of these individual indicators is used to produce a composite early warning indicator (with its own critical threshold), which can issue a single EWS of a crisis. The parametric approach rather use limited-dependent variable techniques (multivariate logit, probit) to assess the effect of various leading indicators on the likelihood of crisis occurrence in a near future (one or two years), while accounting for their interdependencies and interactions.⁶ Both approaches have pros and cons, but we chose to rely on the signal approach because (i) sufficient data may not have been available for precise estimation of panel logit/probit models, particularly in LICs; and (ii) the signals approach makes it easy to track which variables/indicators are causing an early warning signal to be issued.⁷

⁴ The paper is based on the preliminary results on EWS for fiscal crisis by Medas and others (forthcoming). While the methodologies to identify the EWS would stay unchanged, their final results may be different from the preliminary ones.

⁵ Kaminsky and others, 1998; Reinhart, 2002; Hemming and others, 2003; Baldacci and others, 2011; Berti and others, 2012; and de Cos and others, 2014

⁶ Eichengreen and others, 1995; Frankel and Rose, 1996; Berg and Pattillo, 1999; Bussiere and Fratzscher, 2006; Marashaden, 1997; Peter, 2002; Manasse and others, 2003; Kraay and Nehru, 2006; and Gourinchas and Obstfeld, 2012

⁷ See ECB (2014) for an overview of the strengths/weaknesses associated with each of these approaches.

17. **Our empirical investigation builds on two-year ahead EWS over the period 2008–15, which itself is based on an unbalanced panel of historical data covering the period 1970–2007.** The composite EWS results from aggregating signals generated out of individual leading variables, with greater weights assigned to variables with small prediction errors (low relative number of missed crisis and false alarms), to maximize the predictive power of the composite index (see Medas and others, forthcoming, for more details). The signals on individual variables, which predict two-year ahead fiscal crisis over the period 2008–15, are issued whenever these variables cross critical thresholds that are found to be conducive to fiscal crisis based on historical data from 119 countries over 1970–2007.^{8,9} Critical thresholds for the presence of a two-year ahead fiscal crisis are in turn derived for the composite EWS. For our empirical investigation below, the composite EWS along with its associated critical threshold are used to create a dummy equaling one if for a given country at a given year, the composite EWS detects a two-year ahead fiscal crisis, zero otherwise.

18. **The individual variables included in the EWS for fiscal crisis are differentiated across specific country groups** (Medas and others, forthcoming) to take account of idiosyncratic economic, political and institutional features in individual countries.¹⁰

- For AEs and EMEs, the individual variables used to obtain the signals from the composite EWS index include real GDP growth, terms of trade growth, overall fiscal balance, current account, expenditure, the nominal exchange rate and claims on the government.
- For Commodity-dependent LICs, the individual variables used to obtain the signals from the composite EWS index include the shares of multilateral and concessional debts in total public and publicly guaranteed external debt, reserve coverage, primary fiscal balance, current account, private credit growth, expenditure, interest on new debt, and nominal exchange rate.
- For LICs with a diversified exports base, the individual variables used to obtain the signals from the composite EWS index include the maturity of new external debt, the share of concessional debt in total public and publicly guaranteed external debt, overall fiscal balance, reserve coverage, current account, real primary expenditure growth, and interest rate on new PPG external debt.

3.2. Fiscal Consolidation

19. We capture policymakers' response to EWS through a dummy variable taking the value one if a fiscal consolidation is undertaken within two years at most following the issuance of an

⁸ The country list can be found in Annex 3. Annex 1 documents the sources and definitions of all variables used in this study. Descriptive statistics can be found in Annex 2.

⁹ Unlike most existing EWS highlighted above, which focus on crisis detection in a very near future (one year in advance at most), our analysis builds on a longer interval (two-year ahead signal), to allow for sufficient time for policy response, given the inertia in the budget process.

¹⁰ Detailed analyses on the predictive power of the calculated EWS, along with its behavior across countries and time, can be found in Medas and others (*forthcoming*).

EWS for fiscal crisis, and zero otherwise. For robustness purpose, we also create a dummy for fiscal consolidation undertaken within three years at most amid an EWS.

20. **As a measure of fiscal adjustment, changes in the cyclically-adjusted primary balance (CAPB) are used, with also some robustness checks.** Given the drawbacks of the CAPB-based approach¹¹, we conduct robustness check using the changes in unadjusted primary balances.¹² To further check the robustness, policy actions-based fiscal consolidation episodes (“the narrative approach”) would have been an alternative. The dataset based on this approach, however, is not available for most developing countries, which are predominant in our sample. Under this circumstance, we see advantageous for the use of the CAPB-based approach as our baseline analysis.¹³

21. **Heterogeneity in the underlying magnitude of fiscal adjustment is also examined.** To this end, we consider three sets of fiscal consolidation indicators: (i) “small” consolidation, which refers to episodes with a cumulative and uninterrupted improvement of at least 0.5 percent of GDP in the CAPB; (ii) “medium-size” consolidation, which refers to episodes with a cumulative and uninterrupted improvement of at least 1.5 percent of GDP in the CAPB; and (iii) “large” consolidation, which refers to episodes with a cumulative and uninterrupted improvement of at least 3 percent of GDP in the CAPB.

3.3 Pairwise Correlations

22. **Figure 1 below provides an overview of key correlations standing out from recent experiences with EWS of fiscal distress, policy responses, and their outcomes.**¹⁴

- Out of the total signals observed for countries at all income levels, countries responded with fiscal consolidations in about 60 percent of these cases, of which one-third was only

¹¹ Changes in CAPB may overestimate discretionary adjustments by imputing all changes in the CAPB to fiscal policy instruments, while other non-discretionary factors might be at work (Riera-Crichton and others, 2012; Escolano and others, 2014). Furthermore, the estimation of potential output, crucial for the cyclical adjustment, varies considerably (see Escolano and others (2014) for detailed discussion on the pros and cons of CAPB-based fiscal consolidation episodes versus policy actions-based fiscal consolidation episodes).

¹² The results using unadjusted primary balances (as a measure of fiscal adjustment) are described for each empirical result (see Section 4.2.) and presented in Annexes 8 to 11. Such robustness checks allow assessing whether any polluting effect associated with the CAPB approach—possibly arising from inaccurate estimate of potential output—affect our main results. In addition, partly to mitigate concerns for possible estimation errors for CAPB, we also consider several thresholds for defining the fiscal consolidation episodes.

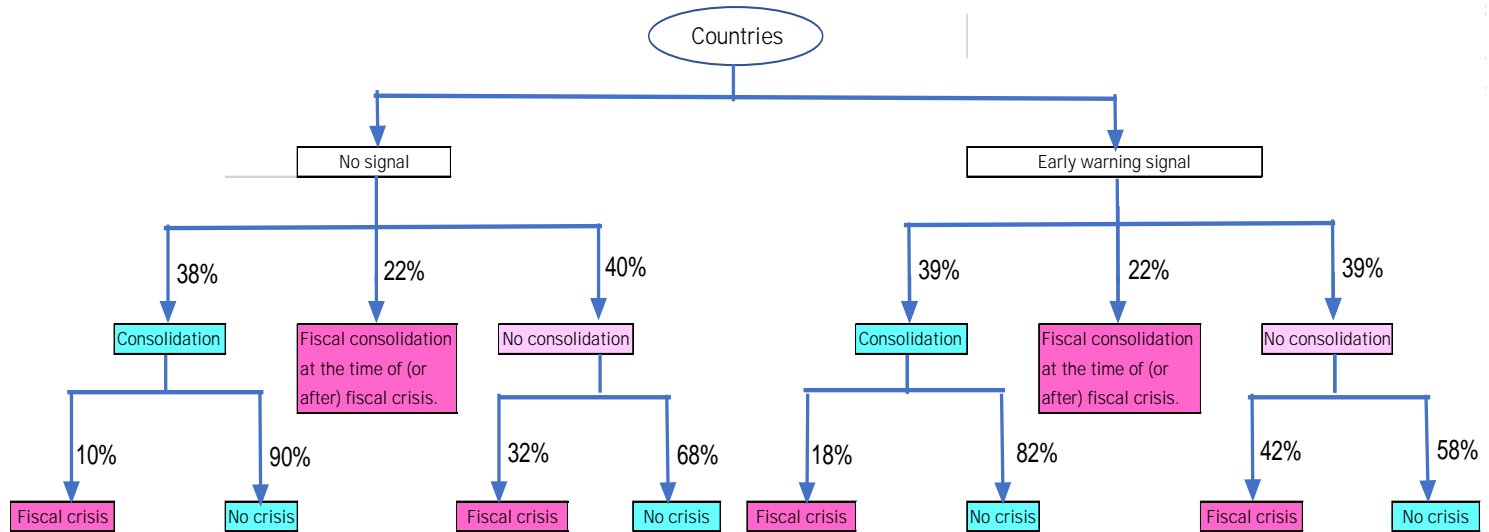
¹³ As discussed in Escolano and others (2014), the advantageous of the CAPB-based approach are that: (i) it provides a uniform methodology across countries; (ii) it captures the fiscal adjustment that was actually implemented, and (iii) it provides broad coverage across countries and time in a consistent manner.

¹⁴ Episodes of cumulative and uninterrupted improvements of at least 1.5 percent of GDP in the CAPB are used as the benchmark for fiscal consolidation throughout the paper, unless otherwise indicated.

undertaken after/at the time of fiscal crisis (untimely fiscal consolidation). Among countries that undertook fiscal consolidation in a timely fashion (before fiscal crisis hit) following an EWS, most (about 82 percent) managed to avoid fiscal crisis occurrence, though 18 percent of the cases experienced fiscal crisis. This implies that, even if countries respond to an EWS with fiscal consolidation, 7 percent of the total EWS signals end up with fiscal crisis.

- By contrast, in about 40 percent of the cases, countries did not undertake fiscal consolidation within three years after an EWS. Among these cases, roughly 42 percent ended up with fiscal crisis, while the rest (58 percent) did not. The findings show that, following the signs of fiscal distress, 38 percent of the countries (including the untimely fiscal consolidations) ended up with fiscal crisis without timely policy response. This implies that, even without fiscal consolidation, 23 percent of the cases with EWS signals did not experience fiscal crisis (typical false alarms).
- In cases with no EWS, countries still experienced fiscal crisis (missing crisis). When countries undertake consolidation, only a few (10 percent) experienced fiscal crisis. Without consolidation, they ended up with fiscal crisis in about 32 percent of the cases.

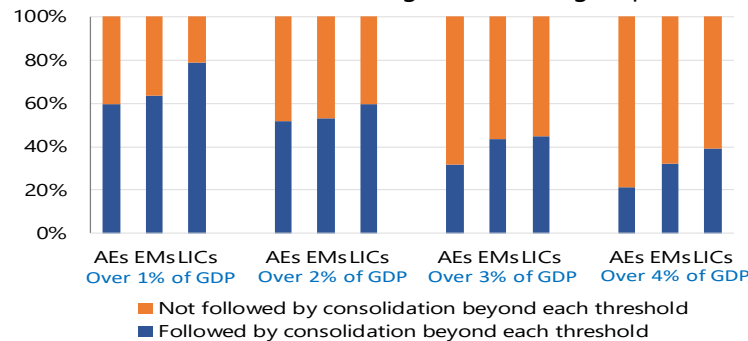
Figure 1. Post-Signal Developments (1999–2015) *



*Developments following three years. Fiscal consolidation episodes refer to the benchmark of cumulative and uninterrupted improvements of at least 1.5 percent of GDP in the CAPB.

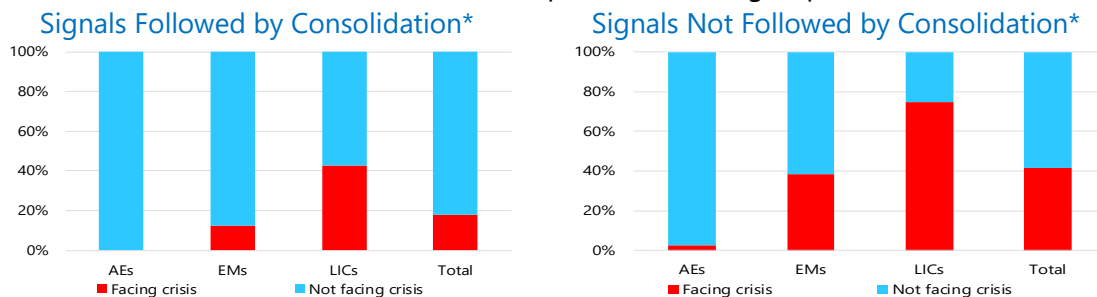
23. **When facing fiscal distress, policymakers tend to undertake fiscal consolidation, especially in LICs (Figure 2).** Most countries facing EWS undertook fiscal consolidation within three years after the signal. When defining fiscal consolidation as a cumulative improvement in the CAPB of at least 1 percent of GDP, 68 percent of the countries are found to have undertaken fiscal consolidation. The ratio falls to 32 percent when we rather consider a cumulative improvement of at least 4 percent of GDP in the CAPB as the criteria for defining a consolidation episode. Among income groups, LICs tend to undertake fiscal consolidation more.

Figure 2. Early Warning Signals Followed by Fiscal Consolidation by Size
(Percent of the total signals of each group)



24. **There is a strong correlation between fiscal consolidation and the prevention of fiscal crisis occurrence (Figure 3).** Countries having implemented a fiscal consolidation amid an EWS are less likely to face fiscal crisis, though resilience to fiscal crisis seems to increase with the level of economic development. For instance, among LICs that implemented fiscal consolidations (excluding those undertaken after fiscal crisis), only 43 percent ended up with fiscal crisis, against 75 percent among those that did not undertake fiscal consolidation after EWS. Most advanced economies having experienced an EWS—irrespective of undertaking fiscal consolidation or not—did not end up with fiscal crisis.¹⁵

Figure 3. Early Warning Signals Followed by Fiscal Crisis
(Percent, share of the episodes of each group)



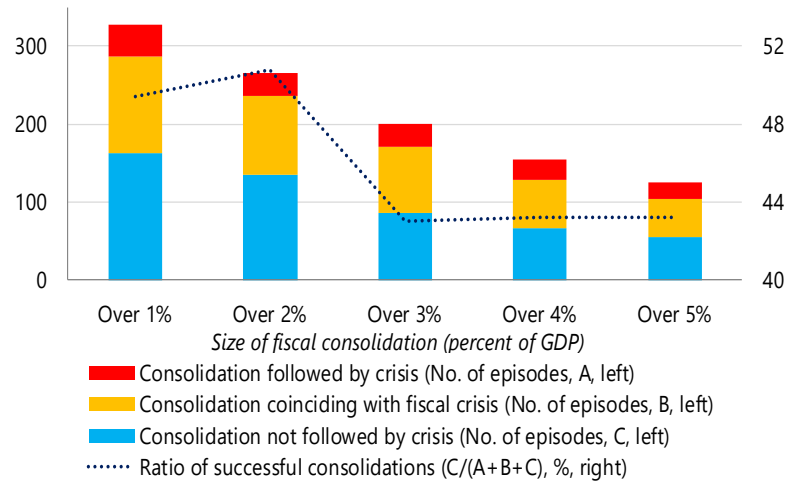
*Fiscal consolidation episodes refer to the benchmark of cumulative and uninterrupted improvements of at least 1.5 percent of GDP in the CAPB.

¹⁵ Excluding cases where countries undertook fiscal consolidation after fiscal crisis. The 11 fiscal crisis episodes observed in AEs occurred when fiscal consolidations started too late, that is after the occurrence of fiscal crisis.

25. **There is no strong and systematic correlation between the size of fiscal consolidation and the prevention of fiscal crisis once fiscal vulnerabilities emerge (EWS).**

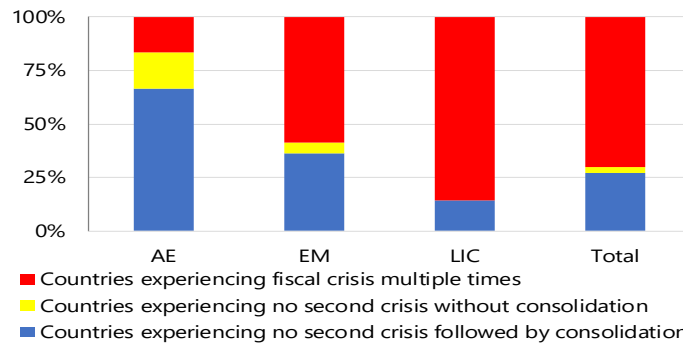
Figure 4 tracks the outcomes of fiscal consolidation by consolidation size within three years after an EWS. Consolidation cases are regrouped into three; (i) fiscal consolidations followed by fiscal crisis (unsuccessful consolidation); (ii) fiscal consolidations undertaken after fiscal crisis (untimely consolidation); and (iii) fiscal consolidations not followed by fiscal crisis (successful consolidation). The ratio of successful consolidation does not increase with the size of consolidation. For countries that achieved cumulative improvements in the CAPB by at least 2 percentage point of GDP following the issuance of an EWS, about 50 percent successfully prevented fiscal crisis. This ratio of “successful” fiscal consolidations, however, drops to 45 percent once we focus on larger consolidation size (cumulative improvements by at least 3, 4 or 5 percentage points of GDP). This somewhat counterintuitive correlation would be further explored through econometrically.

Figure 4. Early Warning Signals Followed by Fiscal Consolidation by Size
(Number of signals)



26. **No clear pattern emerges in terms of learning from past experiences for fiscal crisis prevention (Figure 5).** Among the crisis cases, 70 percent experienced the crisis multiple times (more than two crises with interruption in-between), while the remaining 30 percent experienced fiscal crisis once during the sample period. Among these countries, some countries undertook consolidation rather intensively (possibly to avoid the next crisis), based on the lessons learned from the first crisis. From an income country group perspective, more AEs avoided a second crisis, while LICs experienced multiple crisis more often.

Figure 5. Countries Experiencing Fiscal Crisis Multiple Times*
(Share of counties in each group, 1999-2015)



*Fiscal consolidation episodes refer to the benchmark of cumulative and uninterrupted improvements of at least 1.5 percent of GDP in the CAPB.

IV. ECONOMETRIC ANALYSIS

4.1. Methodology

27. **We adopt a three-pronged approach to econometrically examine the linkages between signals of fiscal distress, policy responses, and policy outcomes** –prevention of fiscal crisis occurrence. Specifically, we examine the following three questions, using discrete-choice models, assuming a normal distribution (a *probit* model) of the error term:¹⁶

- (1) Do policy actions matter for fiscal crisis prevention, irrespective of EWS?
- (2) Do policymakers respond to signs of fiscal distress?
- (3) Does EWS make a difference in the relationship between policy response –with a focus on fiscal consolidation – and fiscal crisis occurrence?

28. **Regarding the first question, we run the following probit model, with a dummy for fiscal crisis as the dependent variable.** Policy actions are captured through (i) a binary variable for fiscal consolidation; (ii) resilience building, in the form of either upgrading institutional quality or enhancing fiscal discipline through the introduction of binding numerical fiscal rules. In the absence of good instrumental variables, we somewhat mitigate endogeneity concerns by using the lagged (one up to three years) values of the variable of interest, which also allows accounting for delays in the transmission of policy actions.¹⁷ Although we control to the extent possible for explanatory variables that are likely to affect both the variable of interest (fiscal consolidation) and the outcome variable (fiscal crisis occurrence), our empirical strategy, like most empirical

¹⁶ The results remain qualitatively unchanged when assuming a logistic distribution (a *logit* model). They are available upon request.

¹⁷ Note that using the lagged values of covariates would remain vulnerable to endogeneity arising from a rational expectation reasoning.

investigations, remains vulnerable to omitted variables bias, notably from unobservable heterogeneity. In principle, accounting for individual country effects could go a long way in dealing with unobservable heterogeneity. However, the Conditional Logit Estimator (CLE), which is the only feasible fixed-effects estimator for discrete-choice panel data, restricts estimation to countries whose choice (values for the dependent binary variable) varies over time, as it eliminates the country fixed effects (Andersen, 1970; and Chamberlain, 1980). As such, the CLE reduces the sample size by discarding all countries whose choice does not vary over the sample period time, which is predominantly the case in our sample, given its limited period time (2007–15). This therefore makes the CLE unattractive to our empirical investigation.¹⁸

$$\Pr(\text{Crisis}_{it} = 1) = F(\text{Consolidation}_{it-k}, X_{it-1}); \quad k = [1, 2, 3] \quad (1)$$

Where X is a vector of explanatory variables, including indicators of government quality, fiscal rules strength, planned adjustment size, inflation, changes in Real Effective Exchange Rates (REER), trade openness, political stability, and dummies for non-fiscal crises and the presence of an election.

29. **For the second question, a probit model is also used, with a binary variable for fiscal consolidation as the dependent variable this time.** A dummy for the issuance of EWS is also included as explanatory variable, along with a vector of additional control variables. Lagged values of the variable of interest are used here as well, which to some extent, helps mitigate endogeneity concerns.

$$\Pr(\text{Consolidation}_{it} = 1) = F(\text{EWS}_{it-k}, X_{it-1}); \quad k = [1, 2, 3] \quad (2)$$

30. **The third question, which focuses on the influence of EWS on the linkage between policy actions and the occurrence of fiscal crisis is dealt with Equation (3) below.** This is a replication of Equation (1), with the following key difference: the fiscal consolidation dummy is replaced by a dummy for a fiscal consolidation undertaken *after* an EWS issuance (*Conso_EWS*). Of particular importance, we control for the counterfactuals of *undertaking a consolidation after an EWS issuance*, to isolate the effect of responding to EWS through a consolidation, namely: (i) a binary variable (*Conso_noEWS*) equaling one if a consolidation is undertaken without EWS, and zero otherwise; (ii) a binary variable (*noConso_EWS*) equaling one if no consolidation is undertaken despite the issuance of an EWS, and zero otherwise; and (iii) a binary variable (*noConso_noEWS*) equaling one if no EWS is issued and no consolidation is undertaken. The latter is used as the benchmark, and thus dropped from the regression to avoid multicollinearity. Controlling for the counterfactuals of *undertaking a consolidation after an EWS alarm* somehow

¹⁸ This can be deemed a limitation of our methodology, but at least it allows for more successful estimations (less regression failures, as it preserves at least our already-limited sample size). We also account somewhat for individual effects by considering more homogenous country groups subsequently (e.g., by income group). While the random effects estimator (RE) could be an alternative discrete choice model for accounting for individual country effects without removing them, it presents the key weakness of being restricted by any assumption on the joint distribution of individual effects and explanatory variables (Gouriéroux and Monfort, 2002). Put simply, RE yields less robust estimates.

mimics a matching exercise, whereby observations from episodes of *consolidation after an EWS* are matched with comparable consolidation observations except they occur without *an EWS alarm*. As such, any difference in the probability of fiscal crisis occurrence across the estimated coefficients associated with each of these dummies is attributable to the influence that the issuance or not of an EWS along with its timing add to the underlying relationship between fiscal consolidation and fiscal crisis occurrence. Undoubtedly, as in Equation (1), accounting for individual country effects could go a long way in dealing with unobservable heterogeneity. However, in line with the reasons highlighted above, the limited period time of our sample, prevents from doing so. Here again, in the absence of good instrumental variables, endogeneity concerns are somewhat mitigated, by using the lagged (one up to 3 years) values of the variables of interest.¹⁹

$$\Pr(\text{Crisis}_{it} = 1) = (\text{Conso_EWS}_{it-k}, \text{Conso_noEWS}_{it-k}, \text{noConso_EWS}_{it-k} X_{it-1}); \quad k = [1, 2, 3] \quad (3)$$

4.2. Results

31. **There is suggestive evidence supportive of a positive role of fiscal consolidation for fiscal crisis prevention (Table 1).** The coefficient associated with the consolidation dummy (defined as the cumulative improvement of 1.5 percent of GDP in the CAPB) is significant and bears the expected negative signs (columns 1 to 3). This finding suggests that fiscal consolidation—irrespective of the presence of EWS—generally helps reduce the likelihood of fiscal crisis occurrence by about 35 percent.²⁰ The finding also holds across income groups.²¹ Using PB-based fiscal consolidation episodes does not also alter qualitatively the result (Annex 9).

32. **Some control variables also exhibit the expected signs and are statistically significant.** On the macroeconomic front, inflation and the presence of non-fiscal crises enhances the likelihood of fiscal crisis occurrence. Regarding politico-institutional factors, the results show that enhanced quality of government and political stability go hand-in-hand with less probability of fiscal crisis occurrence.

¹⁹ Note that using the lagged values of covariates would remain vulnerable to endogeneity arising from a rational expectation reasoning.

²⁰ The odds ratio is 0.65. Note that the probit regression coefficients reported throughout the paper do not directly refer to marginal effects as in a linear regression. Results on marginal effects as well as on odds ratio are available upon request.

²¹ A natural split would have been to obtain separate estimates for AEs vs EMEs vs LICs. However, the limited time coverage of the sample constrained us to resort to broader grouping, that is AEs-EMEs vs EMEs-LICs.

Table 1. Fiscal consolidation (1.5 percent of GDP) and fiscal crises, 2007–15

| Dependent variable: | (1) | (2) | (3) |
|-----------------------------|----------------------|----------------------|----------------------|
| Fiscal Crisis | Full | AEs-EMEs | EMEs-LICs |
| Fiscal consolidation (1.5%) | -0.234* (0.131) | -0.294* (0.161) | -0.293** (0.144) |
| Inflation | 0.375** (0.185) | 0.663* (0.349) | 0.034 (0.236) |
| Change in REER | -0.008 (0.008) | -0.002 (0.012) | -0.002 (0.009) |
| Planned adjustment size | 0.018 (0.015) | 0.042 (0.029) | 0.016 (0.014) |
| Fiscal rule strength | -0.095 (0.058) | -0.074 (0.062) | 0.038 (0.067) |
| Financial openness | -0.455** (0.181) | -0.252 (0.242) | -0.410** (0.193) |
| Non-fiscal crises | 0.746*** (0.247) | 0.845*** (0.253) | 1.074*** (0.395) |
| Quality of government | -2.056*** (0.453) | -1.862*** (0.537) | -3.067*** (0.641) |
| Election | 0.036 (0.124) | 0.045 (0.151) | 0.033 (0.138) |
| Government Stability | -0.122*** (0.038) | -0.154*** (0.046) | -0.106*** (0.041) |
| Observations | 650 | 496 | 468 |
| Pseudo R-squared | 0.134 | 0.142 | 0.091 |

Probit model. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as Inflation/(1+ Inflation) reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

33. **The results associated with Equation (2) confirm that policymakers respond to EWS with fiscal consolidation (Table 2).** Using dummy variables for medium size consolidations (cumulative improvements of at least 1.5 percent of GDP in the CAPB), the coefficient associated with EWS bears the expected positive sign and is statistically significant. This suggests that policymakers tend to react to signs of fiscal distress (EWS) through undertaking fiscal consolidations. The effect is, however, insignificant in less developed countries (column 3), which may reflect donor financing-induced weak incentives for policymakers to react to solvency concerns through fiscal consolidation. Indeed, some studies find evidence supportive of moral hazard in domestic revenue mobilization in contexts of dependency to public aid, especially unconditional grants (Thornton, 2014). Using the PB-based fiscal consolidation episodes does not also alter qualitatively these results (Annex 10).

Table 2. EWS and fiscal Policy Response, 2007–15

| Dependent variable: | (1) | (2) | (3) |
|-----------------------------|---------------------|---------------------|--------------------|
| | Full | AEs-EMEs | EMEs-LICs |
| Fiscal Consolidation (1.5%) | | | |
| Early Warning Signal (EWS) | 0.483*** (0.132) | 0.499*** (0.152) | 0.223 (0.177) |
| Inflation | 0.003 (0.013) | -0.008 (0.019) | -0.010 (0.016) |
| Change in REER | -0.013 (0.011) | -0.029** (0.013) | -0.001 (0.013) |
| Planned adjustment size | 0.053** (0.021) | 0.077*** (0.029) | 0.036** (0.018) |
| IMF support | 0.339** (0.168) | 0.625*** (0.216) | 0.279 (0.184) |
| Fiscal rule strength | -0.138** (0.061) | -0.140** (0.063) | -0.138 (0.088) |
| Non-fiscal crises | -0.126 (0.322) | -0.095 (0.347) | 0.998* (0.591) |
| Quality of government | 0.859** (0.417) | 0.769 (0.493) | 1.660** (0.833) |
| Government Stability | -0.045 (0.041) | -0.048 (0.047) | -0.039 (0.049) |
| Election | -0.227* (0.138) | -0.250 (0.154) | -0.306* (0.179) |
| Observations | 484 | 398 | 324 |
| Pseudo R-squared | 0.072 | 0.103 | 0.048 |

Probit model. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as $\text{Inflation} / (1 + \text{Inflation})$ reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

34. The results associated with Equation (3) are somewhat counterintuitive, failing to find statistically significant effects of fiscal consolidation in response to EWS (Table 3).

Assessing whether policymakers' reactivity to signs of fiscal distress could alter the influence of fiscal consolidation on fiscal crisis prevention, there is suggestive evidence that fiscal consolidations are effective in mitigating the likelihood of fiscal crisis occurrence only when undertaken despite the absence of EWS. Indeed, only the coefficient associated with "consolidation without signal" is significantly negative, suggesting that countries that proactively undertake fiscal consolidation reduces their likelihood of facing fiscal crisis by about 50 percent.²² The coefficient associated with "consolidation after signal" is not significant, suggesting that reacting to signs of fiscal distress through fiscal consolidation may not necessarily prevent its occurrence.²³ Alternatively, waiting for wake-up calls from EWS before addressing fiscal vulnerabilities may not allow for timely response to prevent fiscal crisis. Or in some cases, detecting the signs of fiscal distress based on two-year ahead EWS may not have allowed

²² The odds ratio is 0.50.

²³ While it is possible that reacting to signs of fiscal distress through fiscal consolidation may help to lower the severity of fiscal crisis, the binary nature of the fiscal crisis variable (used in our analysis) prevents from assessing the effect on crisis severity.

effective policy response early enough. These results remain unchanged when using PB-based (instead of CAPB-based) fiscal consolidation episodes (Annex 11).

Table 3. EWS, Fiscal Policy Response (1.5 percent of GDP) and Fiscal Crises, 2007–15

| Dependent variable: | (1) | (2) |
|---|----------------------|----------------------|
| Fiscal Crisis | 2-year window | 3-year window |
| Consolidation (1.5% of GDP) after signal | 0.037 (0.221) | 0.038 (0.211) |
| Consolidation (1.5% of GDP) without signal | -0.378* (0.229) | -0.487* (0.274) |
| No-consolidation (1.5% of GDP) after signal | 0.041 (0.170) | 0.111 (0.173) |
| Inflation | 0.466* (0.249) | 0.476* (0.255) |
| Change in REER | -0.012 (0.012) | -0.011 (0.012) |
| Planned adjustment size | 0.026 (0.019) | 0.027 (0.019) |
| Fiscal rule strength | -0.081 (0.076) | -0.075 (0.077) |
| Financial openness | -0.269 (0.232) | -0.281 (0.231) |
| Non-fiscal crises | 0.512* (0.279) | 0.505* (0.288) |
| Quality of government | -1.827*** (0.494) | -1.853*** (0.484) |
| Election | 0.130 (0.156) | 0.109 (0.156) |
| Observations | 410 | 410 |
| Pseudo R-squared | 0.123 | 0.126 |

Probit model. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as $\text{Inflation} / (1 + \text{Inflation})$ reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

35. **Another noticeable finding is the statistically significant and negative coefficient associated with the quality of government.** This result indicates that higher institutional quality seems to provide stronger resilience, thus making it easier to prevent fiscal crisis occurrence. We will tweak further this finding by exploring whether the influence of EWS on the relationship between fiscal consolidation and fiscal crisis occurrence is non-linear with respect to the quality of institutions.

36. **Further analysis indicates the presence of institutional quality-driven non-linearity in the relationship between fiscal consolidation and the likelihood of fiscal crisis occurrence** (Table 4). Indeed, when regressing Equation (3) on countries with less developed institutions (countries ranking at the bottom quartiles for the quality of government, namely Q1-Q3), the coefficient associated with *consolidation without signal* remains significant, but with a larger magnitude compared to the baseline results in Table 3, indicating a reduction in the

likelihood of facing fiscal crisis by about 57 percent.²⁴ Some substitutability seems to be at play between fiscal consolidation and institutional quality, in that the need to undertake fiscal consolidation before the emergence of fiscal vulnerabilities is more critical in less resilient countries, that is countries with weak institutions. This non-linearity also holds when considering an alternative strategy, namely keeping the full sample but using a model in which the consolidation dummies are interacted with a dummy for country's membership to the "club" of low (bottom quartiles, i.e., Q1-Q3) institutional quality (Annex VII).²⁵ Besides, the coefficient associated with non-fiscal crises now turns statistically significant, which may suggest that non-fiscal crises are more likely to spill over to fiscal crises in countries with weaker institutions. Additionally, the coefficient associated with fiscal rule strength is now positive and statistically significant. This may also point out that in countries with weaker institutions, *de jure* stronger fiscal rules do not necessarily translate into *de facto* stronger fiscal rules, because of enforcement capacity weaknesses, thereby allowing risks to build up unseen.

37. **Additional heterogeneity is at play in the results.** First, the crisis-mitigating effect of *fiscal consolidation without signal* is stronger when the time lag for the effect of fiscal consolidation to play out is longer, that is three-year window versus two-year window (Annex VI). Second, unlike the benchmark results for consolidations (based on cumulative improvements of at least 1.5 percent of GDP in the CAPB), annexes IV to VI consider cases where fiscal consolidations are defined with alternative thresholds, namely 0.5 percent of GDP and 3 percent of GDP.

- The coefficient associated with the consolidation dummy (irrespective of EWS) is not significant when focusing on large consolidations, i.e., episodes of cumulative improvement in the CAPB of at least 3 percent of GDP (Annex IV, columns 4 and 5). This counterintuitive result may reflect that unlike small and medium-size consolidations, which are more often front-loaded (Akitoby and others, forthcoming), large consolidations tend to be delivered gradually over time, such that they may not be completed on time to prevent the occurrence of fiscal crisis. Indeed, large fiscal adjustment needs are best delivered through sustained revenue-enhancing reforms over time (Tsibouris and others, 2006), because otherwise they may prove self-defeating (Attinasi and Metelli, 2017).²⁶ It is worth noting that this result is also not driven by a "hidden" size of country's adjustment needs, as the latter is controlled for in the regression. Relatedly, the results using three-year window (Annex VI) provide suggestive evidence supportive of the longer time needed for successfully implementing large consolidations. Indeed, while the coefficient associated with large consolidation is

²⁴ The odds ratio is 0.43. The coefficient associated with "consolidation after signal" not only points to a rather limited likelihood of preventing fiscal crisis (by about 27 percent, i.e. odds ratio of 0.73).

²⁵The low institutional quality (IQ) dummy is included in the regression not only in isolation but also in interaction with the consolidation dummies. The magnitude of the total crisis-reducing effect of fiscal consolidation (the sum of the coefficient associated with the consolidation dummy and of the coefficient associated with its product with the low IQ dummy) is the largest when considering the "consolidation without signal" dummy (Annex 7).

²⁶ The relatively smaller number of large consolidation observations (about 22 percent of total observations over the 2007–15) may also be accountable for the lack of significance of the coefficient associated with large consolidations.

insignificant when allowing for a two-year window for the transmission of the policy response (column 2), it turns out statistically significant when allowing for a three-year window for the policy response to play out (column 4).

- The crisis-mitigating effect of large consolidation is not voided in less developed countries (Annex IV, column 6), which might suggest that large consolidations are particularly helpful in mitigating fiscal crisis occurrence in less resilient countries.
- When considering small consolidation (irrespective of EWS), that is episodes of cumulative improvement of at least 0.5 percent of GDP in the CAPB (Annex IV, columns 1 to 3), the mitigating effect of fiscal consolidation on the likelihood of fiscal crisis occurrence turns out stronger in richer countries. Indeed, the magnitude of the coefficient is larger in the AEs-EMEs group compared to the EMEs-LICs (column 2 vs. 3).
- The results are broadly similar for control variables, except that the crisis-reducing effect of stronger fiscal rules becomes statistically significant when considering small consolidations (Annex IV, column 1).

**Table 4. EWS, Fiscal Policy Response (1.5 percent of GDP) and Fiscal Crises
(Low Institutional Quality Countries: Bottom Quartiles), 2007–15**

| Dependent Variable: | (1) | (2) |
|---|----------------------|----------------------|
| Fiscal Crisis | 2-year window | 3-year window |
| Consolidation (1.5% of GDP) after signal | -0.195 (0.255) | -0.177 (0.242) |
| Consolidation (1.5% of GDP) without signal | -0.492* (0.254) | -0.504* (0.297) |
| No-consolidation (1.5% of GDP) after signal | -0.155 (0.196) | -0.010 (0.197) |
| Inflation | 0.181 (0.287) | 0.186 (0.295) |
| Change in REER | -0.002 (0.012) | -0.001 (0.012) |
| Planned adjustment size | 0.010 (0.016) | 0.011 (0.017) |
| Fiscal rule strength | 0.168* (0.092) | 0.165* (0.092) |
| Financial openness | -0.319 (0.256) | -0.315 (0.252) |
| Non-fiscal crises | 1.252** (0.505) | 1.241** (0.532) |
| Quality of government | -2.426*** (0.823) | -2.375*** (0.824) |
| Election | 0.109 (0.182) | 0.085 (0.181) |
| Observations | 269 | 269 |
| Pseudo R-squared | 0.069 | 0.068 |

Probit model. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as $\text{Inflation} / (1 + \text{Inflation})$ reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

V. CONCLUSION

38. **This paper analyzed the usefulness of early-detection tools of fiscal crisis for shaping timely responses to prevent fiscal crisis occurrence, using discrete choice models on a broad panel of 119 countries over the period 2007–15.** To the best of our knowledge, this is the first paper to put together early-detection tools of fiscal crisis, policy responses and policy outcomes. Specifically, the paper examined how policymakers react to signs of fiscal distress and to what extent such policy responses (if any) affect the likelihood of fiscal crisis.

39. **From broader perspectives, this paper helps to deepen the understanding as to how crisis preventive measures work.** This is by no means an easy task since there is a wide variance of EWSs, policy responses, and even fiscal crises. The exercises, however, would help deepen our understanding as to how those measures work to achieve intended results, through examining the whole process for crisis prevention (which involves the three-stage process; recognizing risks, controlling risks (adopting policies), and evaluating the outcomes).

40. **The main suggestive evidences of the paper are as follows.** First, most countries (60 percent) tend to undertake fiscal consolidation when facing signs of fiscal distress (EWS). Second, fiscal consolidation, irrespective of the presence of EWS, seems to be a good remedy against the materialization of fiscal crises. Third, responding to EWS through fiscal consolidation may not yield timely successful results, as it may prove too late to prevent its occurrence. Fourth, larger fiscal consolidations in response to EWS are not necessarily the most effective in terms of fiscal crisis prevention. Fifth, substitutability seems to be at work between fiscal consolidation and institutional quality when it comes to fiscal crisis prevention, reflecting that undertaking fiscal consolidation before the emergence of fiscal distress is more critical in less resilient countries (countries with weak institutions).

41. **Important policy implications can be drawn from these findings:**

- **Responding to EWS alarms with fiscal consolidation may not always work to prevent fiscal crisis.** Fiscal consolidation may prove too late to fully stave off fiscal crisis. Timely policy response is critical. Policymakers might *need EWS for the EWS*, otherwise it might be too late to prevent the materialization of fiscal crisis. More broadly, these suggestive evidences call for striking a good balance between calibrating the EWS such that they sound the alarms bells early enough to allow for timely responses, and avoiding that the bars be set so low that the EWS end up issuing many false alarms, a key avenue for future research. This would certainly involve significant challenges in practice.
- **To avoid fiscal crisis, securing sufficient buffers is essential.** The findings suggest that, even if countries respond to fiscal crisis alarms bell with fiscal consolidation, they may still not be able to fully eliminate the likelihood of fiscal crisis. In addition, even if the EWS were to allow detecting fiscal vulnerabilities early enough, unexpected shocks may make it harder to prevent the materialization of fiscal crisis. This underscores the importance of securing appropriate fiscal buffers to cushion against fiscal crisis. Countries should thus invest in resilience building through gradual but steady accumulation of fiscal buffers. Put simply, policymakers need to *fix the roof while the sun is shining*.

- **Repeated experiences of fiscal crisis by some countries may point to a scope for better learning lessons from the past.** Among the crisis cases, 70 percent of the countries experienced the crisis multiple times (more than two crises with interruption in-between). From an income country group perspective, more AEs avoided a second crisis, while LICs experienced multiple crisis more often. Learning lessons from the previous experiences is thus critical for LICs, most likely reflecting institutional weaknesses (that prevent from saving during good times) as well as wrong incentives for tackling much-needed domestic revenue reforms owing to dependency to public aid. Bold steps to allow for building fiscal buffers before the emergence of fiscal distress appears more critical in such less resilient countries (countries with weak institutions), while building capacity.
- **Substitutability between fiscal consolidation and institutional quality (for fiscal crisis prevention) points to the importance of capacity (resilience) building.** While the importance of institutional quality is widely recognized from many aspects, the paper confirms this from the perspective of fiscal crisis prevention. Particularly for the countries with weak institutions, constant (or even enhanced) efforts for building resilience are important not just to improve capacity in specific areas (e.g., enhancing domestic revenues, improving the efficiency of fiscal spending), but also to ultimately mitigate the likelihood for fiscal crisis. As capacity can often take time to be built, constant efforts—well before facing the signs of fiscal distress—would be called for.

42. **The results of this paper should not be viewed as if early-detection tools were useless, but rather call for refining their designs towards greater predictive power while allowing for timely policy responses.** Though policy responses following EWS alarms do not always work to avoid crisis, such responses would contribute to lowering the likelihood for fiscal crisis. Furthermore, even if fiscal crisis may not be avoided, detecting the signs of fiscal distress at an early stage would allow the countries to prepare for the crisis and mitigate the severity of its impact. With ongoing and future studies in this area, more reliable tools could be explored, which would be better able to identify early-detection signs of fiscal distress and allow more timely policy responses. Another caveat of the findings in this study is that EWS conditioned on historical data may not fully capture the drivers of fiscal crises during the recent Global Recession and the Euro area debt crisis, when bank-sovereign linkages were important factors, especially for fiscal crises among advanced economies. Also, the results of this study would benefit from being further refined in future research when comprehensive and homogenous data for more accurate discretionary fiscal adjustments, including on developing countries, are available.

43. **Our study, however, confirms that EWS tools—being an effective supplemental tool for policy analysis—could hardly be a substitute for fiscal policy buffer.** This is largely owing to practical difficulty in identifying credible early-detection signs of fiscal distress. The EWS tools used in the paper are accompanied by significant forecast errors, both in terms of type I errors (missing crisis) and type II errors (false alarms). The latter is reflected in the fact that 23 percent of the cases with EWS alarms did not experience fiscal crisis without fiscal consolidation. While minimizing these errors is subject to future research, the difficulty in identifying an optimal EWS with high predictability would likely persist. In light of these challenges, EWS tools—no matter how they should be improved—could not be seen as a substitute for fiscal policy buffer, while they would work as an effective complement to ensure sound fiscal policy management.

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Annex I. Sources and Definition of Variables

- Fiscal crises variable is a binary variable from the newly developed database (Gerling and others, 2017). More details in the text.
- Early warning Signal is a binary variable for two-year ahead detection of fiscal distress, calculated by Medas and others (*forthcoming*), using the newly developed *fiscal crisis database* (Gerling and others, 2017). More details in the text.
- Fiscal Consolidation is a dummy variable capturing episodes of substantial cumulative improvement in the cyclically-adjusted primary balance. Cumulative improvements of 0.5 percent of GDP, 1.5 percent of GDP and 3 percent of GDP over five years are considered in the paper. Authors' calculations.
- IMF Program is a binary variable for the presence of an IMF-supported program.
- Planned adjustment size captures three-years ahead fiscal adjustment forecasts by IMF's desk economists. Data are from the WEO.
- Election is a binary variable for the presence of an executive or legislative election. Data are from Database of Political Institutions.
- Non-Fiscal Crisis consists of a dummy variable for the occurrence of at least one of the following crises: banking, currency, and/or sovereign debt crisis. Authors' calculations based on Laeven and Valencia (2012).
- Fiscal Rules consist of a dummy variable for the presence of a numerical limit on any fiscal aggregates, while fiscal rules strength is a continuous index with a higher value indicating a "stronger" rule—that is with a set of features more likely to make it bind when it should. Both variables are calculated using the IMF's Fiscal Rules Database.
- Quality of government stands is an index capturing the government effectiveness in delivering public services, and is calculated as an arithmetic mean of the rule of law, the quality of bureaucracy, and the control of corruption, using the ICRG database.
- Government stability is an index ranging from 0 to 12 and measuring the ability of government to stay in office and to carry out its declared program(s). The higher the index, the more stable the government. Data are from the ICRG database.
- Financial openness refers to Chinn and Ito's index of the degree of openness in external account transactions, along four dimensions: i) presence of multiple exchange rates; ii) restrictions on current account transactions; iii) restrictions on capital account transactions; and iv) requirement of the surrender of export proceeds. The higher the index, the more open the external accounts.
- Inflation rate measures the annual change in the CPI. Both variables are from the WEO.
- Real effective exchange rate data are from the IFS.

Annex II. Descriptive Statistics

| Variables | Obs. | Mean | Sdt. Dev. | Min | Max |
|--|------|-------|-----------|----------|---------|
| Fiscal Crisis | 1880 | 0.251 | 0.433 | 0 | 1 |
| Early Warning Signals | 1102 | 0.295 | 0.456 | 0 | 1 |
| Fiscal Consolidation (0.5% GDP) | 1880 | 0.370 | 0.483 | 0 | 1 |
| Fiscal Consolidation (1.5% GDP) | 1880 | 0.295 | 0.456 | 0 | 1 |
| Fiscal Consolidation (3% GDP) | 1880 | 0.219 | 0.414 | 0 | 1 |
| IMF Program | 1880 | 0.262 | 0.440 | 0 | 1 |
| Fiscal Rules | 792 | 0.768 | 0.423 | 0 | 1 |
| Election dummy | 1184 | 0.294 | 0.456 | 0 | 1 |
| Non-Fiscal Crisis dummy | 1256 | 0.029 | 0.169 | 0 | 1 |
| Normalized inflation rate | 1857 | 0.590 | 9.136 | -380.948 | 55.794 |
| Change in real effective exchange rate | 1819 | 1.719 | 13.448 | -87.911 | 472.174 |
| Planned adjustment size | 1405 | 0.757 | 4.428 | -46.681 | 43.568 |
| Fiscal rule strength | 1629 | 0.543 | 1.081 | 0 | 5.474 |
| Financial openness | 1553 | 0.541 | 0.379 | 0 | 1 |
| Quality of government | 1215 | 0.531 | 0.206 | 0.083 | 1 |
| Government Stability | 1350 | 7.938 | 1.608 | 4 | 11.5 |

Annex III. Country List

| Advanced Economies (AEs) | Emerging Market Economies (EMEs) | | Low income countries (LICs) |
|--------------------------|----------------------------------|--------------------|-----------------------------|
| Australia | Albania | Libya | Bangladesh |
| Austria | Algeria | Malaysia | Burkina Faso |
| Belgium | Angola | Mexico | Cameroon |
| Canada | Argentina | Mongolia | Congo, Republic of |
| Czech Republic | Armenia | Morocco | Cote D'Ivoire |
| Denmark | Azerbaijan | Namibia | Ethiopia |
| Estonia | Belarus | Nigeria | Gambia, The |
| Finland | Bolivia | Pakistan | Ghana |
| France | Botswana | Panama | Guinea |
| Germany | Brazil | Paraguay | Guinea-Bissau |
| Greece | Bulgaria | Peru | Guyana |
| Iceland | Chile | Philippines | Haiti |
| Ireland | China, Mainland | Poland | Honduras |
| Israel | Colombia | Russian Federation | Kenya |
| Italy | Costa Rica | South Africa | Liberia |
| Japan | Croatia | Sri Lanka | Madagascar |
| Korea, Republic of | Dominican Republic | Suriname | Malawi |
| Latvia | Ecuador | Syria | Mali |
| Lithuania | Egypt | Thailand | Moldova |
| Netherlands | El Salvador | Trinidad & Tobago | Myanmar |
| New Zealand | Gabon | Tunisia | Nicaragua |
| Norway | Guatemala | Turkey | Niger |
| Portugal | Hungary | Ukraine | Papua New Guinea |
| Singapore | India | Uruguay | Senegal |
| Slovak Republic | Indonesia | Venezuela | Sierra Leone |
| Slovenia | Iran, I. Rep. Of | Vietnam | Sudan |
| Spain | Jamaica | | Tanzania |
| Sweden | Jordan | | Togo |
| Switzerland | Kazakhstan | | Uganda |
| United Kingdom | Kuwait | | Yemen |
| United States | Lebanon | | Zambia |

Annex IV. Fiscal Consolidation (0.5 percent and 3 percent of GDP) and Fiscal Crises, 2007–15

| Dependent variable: | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| Fiscal Crisis | Full | AEs-EMEs | EMEs- LICs | Full | AEs-EMEs | EMEs- LICs |
| Fiscal consolidation (0.5%) | -0.304** (0.124) | -0.406*** (0.154) | -0.348*** (0.134) | | | |
| Fiscal consolidation (3%) | | | | -0.125 (0.146) | -0.123 (0.175) | -0.289* (0.158) |
| Inflation | 0.376** (0.183) | 0.659* (0.346) | 0.042 (0.235) | 0.378** (0.187) | 0.677* (0.359) | 0.028 (0.239) |
| Change in REER | -0.008 (0.008) | -0.003 (0.012) | -0.002 (0.009) | -0.007 (0.0086) | -0.001 (0.012) | -0.001 (0.009) |
| Planned adjustment size | 0.018 (0.015) | 0.042 (0.030) | 0.015 (0.013) | 0.018 (0.014) | 0.037 (0.029) | 0.016 (0.014) |
| Fiscal rule strength | -0.099* (0.058) | -0.082 (0.061) | 0.031 (0.067) | -0.093 (0.059) | -0.074 (0.062) | 0.037 (0.067) |
| Financial openness | -0.462** (0.181) | -0.254 (0.242) | -0.413** (0.193) | -0.457** (0.181) | -0.248 (0.240) | -0.420** (0.193) |
| Non-fiscal crises | 0.740*** (0.246) | 0.824*** (0.254) | 1.075*** (0.395) | 0.736*** (0.246) | 0.823*** (0.252) | 1.080*** (0.392) |
| Quality of government | -2.089*** (0.458) | -1.906*** (0.547) | -3.120*** (0.645) | -2.055*** (0.450) | -1.861*** (0.529) | -3.104*** (0.642) |
| Election | 0.027 (0.125) | 0.037 (0.152) | 0.021 (0.139) | 0.044 (0.123) | 0.057 (0.149) | 0.045 (0.137) |
| Government Stability | -0.123*** (0.038) | -0.162*** (0.047) | -0.107*** (0.041) | -0.118*** (0.037) | -0.150*** (0.045) | -0.103*** (0.040) |
| Observations | 650 | 496 | 468 | 650 | 496 | 468 |
| Pseudo R-squared | 0.139 | 0.150 | 0.095 | 0.131 | 0.136 | 0.089 |

Probit model. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as Inflation/(1+ Inflation) reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

Annex V. EWS and Fiscal Policy Response (0.5 percent and 3 percent of GDP), 2007–15

| Dependent variable | Fiscal consolidation (0.5% of GDP) | | | Fiscal consolidation (3% of GDP) | | |
|----------------------------|------------------------------------|----------------------|---------------------|----------------------------------|---------------------|---------------------|
| | Full | AEs-EMEs | EMEs-LICs | Full | AEs-EMEs | EMEs-LICs |
| Early Warning Signal (EWS) | 0.320** (0.157) | 0.478*** (0.178) | -0.029 (0.226) | 0.347** (0.142) | 0.363** (0.163) | 0.203 (0.192) |
| Inflation | 0.009 (0.014) | 0.013 (0.021) | -0.017 (0.017) | 0.005 (0.013) | 0.013 (0.018) | -0.020 (0.015) |
| Change in REER | 0.005 (0.013) | -0.012 (0.014) | 0.019 (0.014) | -0.002 (0.012) | -0.021 (0.013) | 0.013 (0.013) |
| Planned adjustment size | 0.061** (0.028) | 0.068** (0.028) | 0.051* (0.030) | 0.062** (0.025) | 0.073*** (0.027) | 0.050* (0.027) |
| IMF support | 0.053 (0.214) | 0.242 (0.252) | -0.411 (0.258) | 0.266 (0.179) | 0.583*** (0.217) | 0.042 (0.197) |
| Fiscal rule strength | -0.245*** (0.077) | -0.252*** (0.079) | -0.247** (0.099) | -0.158** (0.066) | -0.173** (0.067) | -0.175* (0.101) |
| Non-fiscal crises | 0.199 (0.371) | 0.170 (0.412) | 1.272** (0.597) | 0.297 (0.315) | 0.185 (0.345) | 1.578*** (0.579) |
| Quality of government | 0.756 (0.547) | 0.902 (0.644) | 0.382 (1.106) | 0.757* (0.458) | 0.955* (0.532) | 0.888 (0.929) |
| Government Stability | 0.048 (0.051) | 0.054 (0.058) | 0.086 (0.061) | -0.029 (0.045) | -0.006 (0.051) | -0.059 (0.054) |
| Election | 0.108 (0.164) | 0.082 (0.183) | 0.036 (0.214) | 0.021 (0.145) | 0.007 (0.160) | -0.125 (0.190) |
| Observations | 484 | 398 | 324 | 484 | 398 | 324 |
| Pseudo R-squared | 0.073 | 0.103 | 0.086 | 0.063 | 0.090 | 0.060 |

Probit model. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as $\text{Inflation} / (1 + \text{Inflation})$ reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

Annex VI. EWS, Policy Response (0.5 percent and 3 percent of GDP) and Fiscal Crises, 2007–15

| Dependent variable: | (1) | (2) | (3) | (4) |
|---|----------------------|----------------------|----------------------|----------------------|
| Fiscal Crisis | 2-year window | | 3-year window | |
| Consolidation (0.5% of GDP) after signal | -0.063 (0.210) | | -0.075 (0.207) | |
| Consolidation (0.5% of GDP) without signal | -0.544** (0.217) | | -0.575** (0.252) | |
| No-consolidation (0.5% of GDP) after signal | -0.045 (0.181) | | 0.078 (0.183) | |
| Consolidation (3% of GDP) after signal | | 0.251 (0.259) | | 0.288 (0.241) |
| Consolidation (3% of GDP) without signal | | -0.262 (0.262) | | -0.686** (0.319) |
| No-consolidation (3% of GDP) after signal | | 0.057 (0.159) | | 0.047 (0.163) |
| Inflation | 0.464* (0.247) | 0.479* (0.252) | 0.470* (0.251) | 0.507* (0.262) |
| Change in REER | -0.013 (0.011) | -0.011 (0.012) | -0.012 (0.011) | -0.012 (0.012) |
| Planned adjustment size | 0.025 (0.019) | 0.024 (0.018) | 0.027 (0.019) | 0.023 (0.019) |
| Fiscal rule strength | -0.085 (0.076) | -0.075 (0.077) | -0.080 (0.076) | -0.065 (0.077) |
| Financial openness | -0.268 (0.233) | -0.240 (0.231) | -0.277 (0.232) | -0.252 (0.230) |
| Non-fiscal crises | 0.475* (0.278) | 0.494* (0.283) | 0.478* (0.287) | 0.461 (0.296) |
| Quality of government | -1.850*** (0.498) | -1.890*** (0.496) | -1.875*** (0.487) | -1.981*** (0.486) |
| Election | 0.130 (0.159) | 0.149 (0.155) | 0.104 (0.158) | 0.155 (0.156) |
| Observations | 410 | 410 | 410 | 410 |
| Pseudo R-squared | 0.131 | 0.120 | 0.131 | 0.130 |

Probit model. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as $\text{Inflation} / (1 + \text{Inflation})$ reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

Annex VII. Institutional Quality-driven non-Linearity in the Relationship between EWS, Policy Responses, and Fiscal Crises, 2007-15: Robustness using Interactive Terms

| Dependent variable: Fiscal Crisis | Definition of Fiscal Consolidations | | |
|--|-------------------------------------|----------------------|----------------------|
| | (1) | (2) | (3) |
| | 0.5% of | 1.5% of | 3% of GDP |
| Consolidation after signal | 0.889** (0.402) | 0.915** (0.398) | 1.324*** (0.425) |
| (Consolidation after signal) * (Low-IQ dummy) | -1.396*** (0.464) | -1.382*** (0.468) | -1.638*** (0.491) |
| Consolidation without signal | 0.566 (0.564) | 0.636 (0.578) | 1.169* (0.631) |
| (Consolidation without signal) * (Low-IQ dummy) | -1.269** (0.606) | -1.201* (0.619) | -1.559** (0.670) |
| No consolidation after signal | 0.884** (0.375) | 0.891** (0.369) | 0.909** (0.377) |
| (No consolidation after signal) * (Low-IQ dummy) | -1.184*** (0.425) | -1.094*** (0.413) | -1.083*** (0.416) |
| Low Institutional Quality (IQ) dummy | 1.492*** (0.361) | 1.408*** (0.354) | 1.436*** (0.365) |
| Inflation | 0.473** (0.232) | 0.465** (0.235) | 0.463* (0.238) |
| Change in REER | -0.005 (0.012) | -0.004 (0.012) | -0.003 (0.012) |
| Planned adjustment size | 0.002 (0.017) | 0.003 (0.017) | 0.002 (0.017) |
| Fiscal rule strength | -0.168** (0.081) | -0.159* (0.081) | -0.157* (0.083) |
| Financial openness | -0.282 (0.228) | -0.290 (0.227) | -0.285 (0.227) |
| Non-fiscal crises | 0.670** (0.284) | 0.683** (0.287) | 0.750** (0.311) |
| Election | -0.001 (0.155) | 0.003 (0.152) | 0.022 (0.150) |
| Observations | 496 | 496 | 496 |
| Pseudo R-squared | 0.275 | 0.268 | 0.263 |

Probit model. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as Inflation/ (1+ Inflation) reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

Annex VIII. Number of fiscal consolidation episodes by size, over 2007-15
CAPB-based versus PB-based

| | 0.5% of GDP | 1.5% of GDP | 3% of GDP |
|--|-------------|-------------|-----------|
| Primary balance(PB)-based episodes | 742 | 590 | 413 |
| CAPB-based episodes | 695 | 555 | 412 |
| Overlap between PB-based and CAPB-based episodes | 626 | 491 | 355 |

Annex IX. PB-based Fiscal consolidation (1.5 percent of GDP) and fiscal crises, 2007–15

| Dependent variable: | (1) | (2) | (3) |
|-----------------------------|----------------------|----------------------|----------------------|
| Fiscal Crisis | Full | AEs-EMEs | EMEs-LICs |
| Fiscal consolidation (1.5%) | -0.303** (0.126) | -0.422*** (0.153) | -0.271* (0.141) |
| Inflation | 0.373** (0.182) | 0.651* (0.356) | 0.062 (0.232) |
| Change in REER | -0.008 (0.008) | -0.003 (0.012) | -0.001 (0.009) |
| Planned adjustment size | 0.017 (0.015) | 0.040 (0.030) | 0.015 (0.013) |
| Fiscal rule strength | -0.100* (0.059) | -0.087 (0.062) | 0.036 (0.067) |
| Financial openness | -0.463** (0.182) | -0.238 (0.241) | -0.425** (0.193) |
| Non-fiscal crises | 0.719*** (0.245) | 0.803*** (0.252) | 1.041*** (0.393) |
| Quality of government | -1.978*** (0.451) | -1.824*** (0.538) | -2.986*** (0.646) |
| Election | 0.018 (0.124) | 0.021 (0.153) | 0.022 (0.138) |
| Government Stability | -0.122*** (0.038) | -0.157*** (0.047) | -0.102** (0.041) |
| Observations | 650 | 496 | 468 |
| Pseudo R-squared | 0.138 | 0.151 | 0.090 |

Probit model. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as Inflation/ (1+ Inflation) reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

Annex X. EWS and (PB-based) Fiscal Policy Response (1.5 percent of GDP), 2007-15

| Dependent variable: | (1) | (2) | (3) |
|-----------------------------|---------------------|----------------------|--------------------|
| Fiscal Consolidation (1.5%) | Full | AEs-EMEs | EMEs-LICs |
| Early Warning Signal (EWS) | 0.407*** (0.131) | 0.401*** (0.150) | 0.211 (0.174) |
| Inflation | -0.025 (0.016) | -0.062*** (0.019) | -0.033* (0.020) |
| Change in REER | -0.003 (0.012) | -0.023* (0.013) | 0.009 (0.013) |
| Planned adjustment size | 0.052*** (0.019) | 0.070*** (0.027) | 0.036** (0.017) |
| IMF support | 0.192 (0.166) | 0.551** (0.218) | 0.167 (0.180) |
| Fiscal rule strength | -0.102* (0.059) | -0.101 (0.061) | -0.129 (0.086) |
| Non-fiscal crises | -0.576 (0.380) | -0.527 (0.396) | 0.551 (0.622) |
| Quality of government | 0.675 (0.418) | 0.188 (0.475) | 1.463* (0.806) |
| Government Stability | -0.023 (0.040) | -0.026 (0.046) | -0.047 (0.049) |
| Election | -0.070 (0.133) | -0.070 (0.148) | -0.223 (0.172) |
| Observations | 484 | 398 | 324 |
| Pseudo R-squared | 0.067 | 0.105 | 0.046 |

Probit model. Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$ show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as $\text{Inflation} / (1 + \text{Inflation})$ reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).

**Annex XI. EWS, (PB-based) Fiscal Policy Response (1.5 percent of GDP) and Fiscal Crises,
2007–15**

| Dependent variable: | (1) | (2) |
|---|----------------------|----------------------|
| Fiscal Crisis | 2-year window | 3-year window |
| Consolidation (1.5% of GDP) after signal | -0.0615 (0.228) | -0.0485 (0.216) |
| Consolidation (1.5% of GDP) without signal | -0.406* (0.214) | -0.493* (0.252) |
| No-consolidation (1.5% of GDP) after signal | 0.0278 (0.174) | 0.0987 (0.179) |
| Inflation | 0.464* (0.247) | 0.477* (0.250) |
| Change in REER | -0.0124 (0.0115) | -0.0120 (0.0115) |
| Planned adjustment size | 0.0257 (0.0188) | 0.0263 (0.0191) |
| Fiscal rule strength | -0.0873 (0.0766) | -0.0823 (0.0766) |
| Financial openness | -0.257 (0.233) | -0.265 (0.231) |
| Non-fiscal crises | 0.493* (0.280) | 0.486* (0.286) |
| Quality of government | -1.804*** (0.492) | -1.819*** (0.482) |
| Election | 0.116 (0.156) | 0.101 (0.156) |
| Observations | 410 | 410 |
| Pseudo R-squared | 0.125 | 0.128 |

Probit model. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1 show the significance level at 10%, 5%, and 1% respectively. Inflation normalized as Inflation/ (1+ Inflation) reduces the influence of outliers due to hyperinflation episodes. Constant include (but not reported).