EUROPEAN CENTRAL BANK

EUROSYSTEM

WORKING PAPER SERIES

NO 1712 / AUGUST 2014

# SIGNALLING FISCAL STRESS IN THE EURO AREA

## A COUNTRY-SPECIFIC EARLY WARNING SYSTEM

Pablo Hernández de Cos, Gerrit B. Koester, Enrique Moral-Benito and Christiane Nickel

In 2014 all ECB publications feature a motif taken from the €20 banknote.

**NOTE:** This Working Paper should not be reported as representing the views of the European Central Bank (ECB). The views expressed are those of the authors and do not necessarily reflect those of the ECB.

**Pablo Hernández de Cos**
Bank of Spain; e-mail: pablo.hernandez_de_cos@bde.es

**Gerrit B. Koester**
European Central Bank; e-mail: Gerrit.Koester@ecb.europa.eu

**Enrique Moral-Benito**
Bank of Spain; e-mail: enrique.moral@bde.es

**Christiane Nickel**
European Central Bank; e-mail: christiane.nickel@ecb.int

**© European Central Bank, 2014**

| | |
|---|---|
| **Address** | Kaiserstrasse 29, 60311 Frankfurt am Main, Germany |
| **Postal address** | Postfach 16 03 19, 60066 Frankfurt am Main, Germany |
| **Telephone** | +49 69 1344 0 |
| **Internet** | http://www.ecb.europa.eu |

All rights reserved. Any reproduction, publication and reprint in the form of a different publication, whether printed or produced electronically, in whole or in part, is permitted only with the explicit written authorisation of the ECB or the authors. This paper can be downloaded without charge from http://www.ecb.europa.eu or from the Social Science Research Network electronic library at http://ssrn.com/abstract_id=2471464. Information on all of the papers published in the ECB Working Paper Series can be found on the ECB's website, http://www.ecb.europa.eu/pub/scientific/wps/date/html/index.en.html

| | |
|---|---|
| **ISSN** | 1725-2806 (online) |
| **ISBN** | 978-92-899-1120-7 (online) |
| **EU Catalogue No** | QB-AR-14-086-EN-N (online) |

**Abstract:** The sovereign debt crisis in the euro area has increased the interest in early warning indicators, with the aim to indicate the build-up of fiscal stress early on and to facilitate crisis prevention by a timely counteraction of fiscal and macroeconomic policies. This paper presents possible improvements to enhance existing early warning indicators for fiscal stress, especially for the euro area. We show that a country-specific approach could strongly increase the signalling power of early warning systems. Finally we draw policy conclusions for the setting-up and application of a system of early warning indicators for fiscal stress.

JEL classification: E62 - Fiscal Policy, E65 - Studies of Particular Policy Episodes, E66 - General Outlook and Conditions, H62 - Deficit; Surplus, H63 - Debt; Debt Management; Sovereign Debt, F34 - International Lending and Debt Problems.

## Non-technical summary

The difficulties and high costs of solving the sovereign debt crisis, which has followed the severe macroeconomic and fiscal imbalances in some euro area countries, underline the importance of timely policy actions to prevent the building up of strong imbalances in the first place.

An element that might facilitate the timely implementation of such policy actions is an early warning system (EWS), which indicates the building up of fiscal stress early on and therefore leaves economic policy enough time to counteract adverse developments and to prevent the occurrence of major crises.

In the economic literature, we can find a broad variety of approaches that aim at developing and providing such early warning systems. While this literature had originally focused on currency and financial crises, recent developments have increased the interest in fiscal and economic crises.

However, early warning systems are not only discussed in the analytical literature, but have already been implemented in practice. In the European governance framework several early warning tools have recently been established. With respect to macroeconomic imbalances, a scoreboard of early warning indicators has been introduced within the so called macroeconomic imbalance procedure. This scoreboard is designed to signal the building up of macroeconomic imbalances. In the fiscal sphere, the European Commission has established a new "S0 – indicator", which is included in the fiscal sustainability report as an early detection indicator of fiscal stress.

Given this prominent role of early warning indicators, this paper aims to develop possible improvements to enhance existing early warning indicators for fiscal stress, especially for the euro area. These improvements include the identification of country-specific thresholds in a signalling approach and an expansion of the signalling window. We show that a country-specific approach could strongly increase the signalling power of an early warning system for fiscal stress based on in-sample as well as based on out-of-sample forecasts.

We conclude that an early warning system for fiscal stress should include country-specific thresholds for the signalling variables, a signalling window of more than one year and fiscal as well as macro and financial variables.

# I. Introduction

The difficulties and high costs of solving the sovereign debt crisis, which has followed the severe macroeconomic and fiscal imbalances in some euro area countries, underline the importance of timely policy actions to prevent the building up of strong imbalances in the first place.

An element that might facilitate such policy actions are reliable early warning signals, which indicate the building up of risks for public finances early on and therefore leave economic policy enough time to counteract adverse developments and to prevent the occurrence of major crises. In this paper we focus on risks in form of fiscal stress, which can be defined as the short-term risk of facing a sovereign liquidity crisis. Such a crisis is characterized by a (partial) loss of access to financial markets and the resulting difficulties to service all upcoming obligations in the short-term.

The failure of sovereign bond spreads[1] and ratings by major agencies[2] to indicate the building up of fiscal vulnerabilities in several Member States prior to the crisis has increased the interest in alternative early warning indicators for fiscal stress.

In the economic literature, we can find a broad variety of approaches, which aim at developing and providing such early warning systems. While this literature had originally focused on currency and financial crises, especially recent developments have increased the interest in fiscal and economic crises (see discussion in part II).

However, early warning systems are not only discussed in the analytical literature, but have already been implemented in practice. In the European governance framework several early warning tools have recently been established. With respect to macroeconomic imbalances, a scoreboard of early warning indicators has been introduced within the macroeconomic imbalance procedure to signal the building up of macroeconomic imbalances.[3] In the fiscal sphere, the European Commission has established a new "S0 – indicator", which is included in the fiscal sustainability report as an early detection indicator of fiscal stress.[4]

Given the prominent role of early warning indicators, this paper aims to evaluate possible improvements to enhance existing early warning indicators for fiscal stress, especially for the euro area. These improvements include the identification of country-specific thresholds in a signalling approach and an expansion of the signalling window.

1 See European Central Bank (2014).
2 See Polito and Wickens (2014).
3 For details see European Commission (2014).
4 See European Commission (2012a).

The rest of the paper is organised as follows. In Section II we shortly review the related literature. In Section III we develop a signalling approach, which takes cross-country heterogeneity into account. Part IV reviews the dataset. Analytical results – including out-of-sample forecasts - are presented in part V. Part VI concludes.

# II. Literature Review

The literature on early-warning systems originated from studies of "twin" currency and financial crises. Seminal contributions were Kaminsky, Lizondo and Reinhart (1998) and Kaminsky and Reinhart (1999), who introduced the non-parametric "signalling approach" for early warning systems.[5] The basic idea of the signalling approach is to derive thresholds, which distinguish values of variables, which do and which do not signal a crisis. These thresholds are endogenously derived based on ex post data on fiscal stress episodes so as to maximize the predictive power of the indicators. This approach has witnessed a revival in the context of recent fiscal crises – and is applied for example in recent studies by Berti et al. (2013) and Baldacci et al. (2011).

**Table 1: Approaches to early warning systems and crises**

| | **Signalling approach** | **Logit/probit models** | **Other approaches** |
|---|---|---|---|
| **Currency crises** | Kaminsky and Reinhart (1998)<br>Kaminsky et al. (1998)<br>Brüggermann and Linne (2002) | Berg and Pattillo (1999)<br>Kumar et al. (2002)<br>Mulder et al. (2002) | |
| **Financial crises** | | Bussieree and Fratzscher (2002)<br>Lo Duca and Peltonen (2013)<br>Hemming et al. (2013) | |
| **Fiscal crises** | Berti et al. (2013)<br>Baldacci et al. (2011)<br>Hernandez de Cos et al. (2014) | Manasse et al. (2003) | |
| **Economic crises** | Alessi and Detken (2011) | | Babecky et al. (2012) |

The second dominating approach in the field is multivariate regressions based on probit or logit models. These studies rely on panel models with a binary dependent variable (taking value 1 if a crisis occurred and 0 otherwise) and analyse the impact of different variables on the probability of a crisis. The coefficients of the different variables are estimated based on ex post data on crisis episodes. Forward-looking crisis probabilities are determined by applying the estimated coefficients from the

[5] A discussion of the approach and its alternatives can be found in Berg and Patillo (1999) and Berg, Candelon and Urbain (2008).

statistical probit/logit model to forecast data. An important advantage of this approach over the signalling approach is that correlations and interactions between the variables can be taken into account and statistical significance can be tested. Early contributions to this branch of models have been Berg and Pattilo (1998), who try to evaluate whether a probit model could have helped to predict the Asian crisis. The relatively simple models of the earlier contributions have later been refined e.g. by applying multinomial logit models (as in Bussiere and Fratzscher, 2006). Table 1 demonstrates that the logit/probit models were dominating in the earlier studies in the field, while recent studies favour the signalling approach.[6]

**Table 2: Signalling fiscal stress –overview of related studies**

| *Study* | **Manasse, Roubini and Schimmelpfennig (2003)** | **Hemming, Kell and Schimmelpfennig (2003)** | **Baldacci et al (2011)** | **Berti et. al. (2013)** | **Hernandez de Cos et al. (2014)** |
|---|---|---|---|---|---|
| *Type of crisis* | Sovereign debt crisis | Role of fiscal variables for financial crises | Fiscal stress | Fiscal stress | Fiscal Stress |
| *Statistical approach* | Logit estimation/binary recursive tree analysis | Probit model | Signalling approach | Signalling approach | Signalling approach with country-specific thresholds |
| *Variables* | Fiscal, macro and political variables | Focus on fiscal variables/control for macro/financial variables | Fiscal variables | Macro, fiscal and financial variables | Macro, fiscal, and financial variables |
| *Countries covered* | 47 (emerging) countries | 29 emerging economies | 30 advanced and 135 emerging economies | EU 27 | EMU 11 |
| *Time Span* | 1970-2002 | 1970-2000 | 1970/1995-2010 | 1970-2010 | 1970-2010 |
| *Main results* | Solvency and macro variables matter for predicting debt crises, while among fiscal variables only public debt ratio has some predictive power; heterogeneity across countries matters for the critical thresholds that signal a future crisis. | Significant influence of fiscal variables for currency crises, (especially government debt level; expenditure and revenue rigidities do also matter) | Most important predictors in advanced countries: gross financing needs and fiscal solvency risks; in emerging economies: the risks associated with public debt structure and exposure to spill-overs from financial markets | Fiscal, financial and macro variables matter; composite indicator has a far better signalling performance than fiscal/financial indicators alone | Especially country-specific thresholds improve signalling power substantially (in- and out-of-sample and also for longer signalling windows) |

With respect to fiscal stress, four studies from the last ten years are closely related to our work (see Table 2): The first two date back from 2003. Manasse, Roubini and Schimmelpfenning (2003) analyse sovereign debt crises based on logit estimation and binary recursive tree analysis. They take fiscal, macro and political variables for 47 (emerging) countries from 1970-2002 into account. Their two

[6] Abiad (2003) reviews different methodological approaches of early warning systems in detail.

most important findings are: first, solvency and macro variables matter for predicting debt crises, while among fiscal variables only public debt ratio has some predictive power; second, heterogeneity across countries matters for the critical thresholds that signal a future crisis.

In contrast, Hemming, Kell and Schimmelpfennig (2003) do not directly study fiscal stress, but analyse the role of fiscal variables for financial crises in a probit model. They focus on fiscal variables but control as well for macro and financial variables in 29 emerging economies from 1970-2000. They find a significant influence of fiscal variables for currency crises (especially the public debt level). Furthermore - according to their analyses - expenditure and revenue rigidities do also matter.

The other two closely related studies are more recent. Baldacci et al. (2011) analyse early warning indicators for fiscal stress based on the signalling approach employing fiscal variables for 30 advanced and 135 emerging economies from 1970-2010 (period to derive critical thresholds) and 1995-2010 (period for analysing the predictive power of the system) respectively. According to their results, the most important predictors for fiscal stress in advanced countries are gross financing needs and fiscal solvency risks, while in emerging economies the risks associated with public debt structure and exposure to spill-overs from financial markets matter most.

Finally, Berti et al. (2013) analyse fiscal stress based on the signalling approach taking into account a broad variety of macro, fiscal and financial variables for the EU 27 from 1970-2010. Important results from their analyses are that fiscal as well as macro and financial variables matter for predicting fiscal stress and that the composite indicator has a far better signalling performance than fiscal/financial indicators alone. Based on the work of Berti et al. the Commission has developed and implemented the early warning indicator S0.

# III. Taking heterogeneity into account – an early warning system based on a country-specific signalling approach

Recent policy-oriented research on early warning has relied especially on the signalling approach. The European Commission, for example, as well as the IMF use early warning systems based on the signalling approach for surveillance tasks.

One reason for this choice could be that the approach can integrate a large number of variables and can – far better than the panel estimation – deal with data availability problems in unbalanced panels. A further main advantage of the signalling approach is that it can be implemented relatively

easily: the critical thresholds derived for the indicator variables can directly be used for policy surveillance and analysis. This might outweigh the major disadvantage of signalling approach, namely that correlations between different variables cannot be taken into account and individual indicator variables cannot be tested for their conditional statistical significance.

Furthermore the literature suggests that early warning approaches based on the signalling approach have a higher predictive power than multivariate probit models in out-of-sample forecasts (see Berg and Patillo (1999) and Berg, Borensztein and Patillo (2005)).[7] As out-of-sample forecasts are the decisive test for the ability of early warning systems to signal fiscal stress well in advance, these findings speak in favour of relying on signalling approaches for early warning systems.

Against this background, this paper focuses as well on the signalling approach and tries to offer ways to improve the existing early warning systems based on this methodology.

Every signalling approach basically consists of four steps. First, fiscal stress needs to be defined. In a second step a set of "leading indicators" for fiscal stress is selected. In a third step, thresholds for each variable (maximising signalling power for a given signalling window with respect to past fiscal stress episodes)[8] are calculated. In the fourth step the variables are then aggregated into composite indices (e.g. an overall, a financial and a fiscal index) for signalling fiscal stress.[9]

Applying these steps we first discuss the definition of fiscal crises (Section III.1). Then we shortly review the determination of thresholds for the indicator variables together with the introduction of country-specific thresholds in an early warning system based on the signalling approach (Section III.2). The indicators for fiscal stress are discussed in Section IV of the paper – together with the dataset.

## III.1. Defining fiscal stress

In the economic literature, fiscal stress is often defined as a debt crisis. Criteria applied to identify such a debt crisis are for example a debt restructuring or the diagnosis of a default by a major rating agency.[10] Furthermore, very high inflation rates can also be classified as an implicit default event and therefore serve as an indicator for a debt crisis.[11] However, the restriction of fiscal stress to explicit or implicit government defaults might be too narrow to cover fiscal stress episodes in advanced

7 With respect to "in-sample" forecasts, the probit models seem to work better.

8 In most cases (e.g. Baldacci et al. (2011) or Berti et al. (2013)) the signalling window is set to one year, meaning that the signalling power of a variable in t-1 for a crisis in t is evaluated.

9 There are different possibilities for aggregating different variables into one stress index. These possibilities include – apart from the simplest version of just including the individual variables signalling stress - the option to take different lags for different variables or differences in the intensity of signals into account. See Kaminsky (1998).

10 See for details: Hemming, Kell, and Schimmelpfennig (2003) or Manasse, Roubini and Schimmelpfennig (2003)

11 See Sturzenegger and Zettelmeyer (2007).

economies. Baldacci et al. (2011) propose therefore a broader definition of fiscal stress, which also includes risks of liquidity crises.[12]

Based on this definition, fiscal stress is always indicated if any of the following four criteria is satisfied: i) inflation rate above 35%, ii) significant sovereign bond yield spreads (two standard deviations above their country-specific mean), iii) public debt default/restructuring/rescheduling and/or iv) a large-scale IMF-supported programme. The most important innovation is that Baldacci et al. also include significant sovereign bond spreads as a crisis indicator.

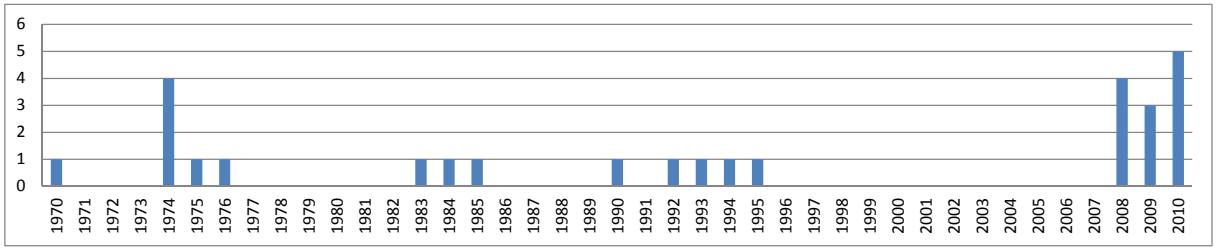
In this paper we apply this definition to identify fiscal stress episodes. The two recent studies (Baldacci et al. (2011) and Berti et al (2013)), which are especially closely related to our work, rely on the same fiscal stress definition.

**Table 3: Identified crises episodes**[13]

| | Fiscal Stress episodes |
|---|---|
| Austria | |
| Belgium | |
| Germany | 1974 |
| Spain | 2010 |
| Finland | 1990, 1992 |
| France | 1970, 1974 |
| Greece | 1993-1995, 2008-2010 |
| Ireland | 1974, 1976, 2008-2010 |
| Italy | 1974-1975, 2008-2010 |
| Netherlands | |
| Portugal | 1983-1985, 2008, 2010 |
| Total | 27 |

In Table 3, the identified crisis periods for a data-set of EMU-11[14] countries is shown – a total number of 27 crises episodes. Figure 1 reflects the distribution of the crises episodes of the EMU 11 countries over the time horizon analysed. We find that crisis were concentrated especially in the mid-seventies and at the end of the sample horizon (in the context of the sovereign debt crisis in several euro area Member States).

**Figure 1: Number of EMU countries experiencing a fiscal crisis by year**




[12] See Baldacci et al. (2011).

[13] Please note that not all crises episodes displayed here are taken into account in our estimations, as only the first year of a crisis is analysed.

[14] Luxemburg is excluded from the EMU 12 data-set due to data availability issues.

## III.2. The signalling approach – determining thresholds and taking country heterogeneity into account

The analytical core of the signalling approach is the calculation of the critical thresholds for the indicators for fiscal stress.

**Table 4: Signals and errors within the signalling approach**

| | Crisis episode | Non-crisis episode |
|---|---|---|
| Crisis signal | True positive signal | False positive signal (type I error) |
| Non-crisis signal | False negative signal (type II error) | True negative signal |

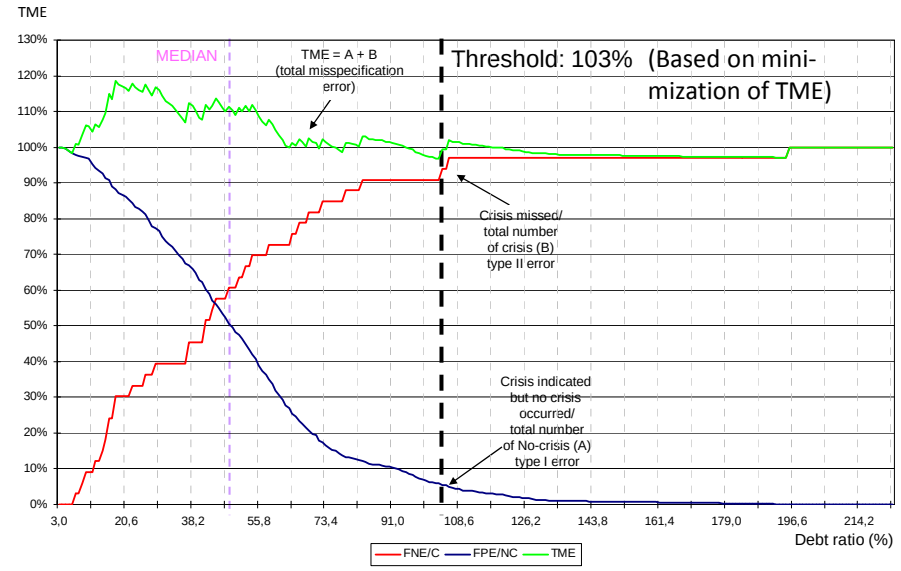
The determination of these thresholds is based on the four possible signals (see Table 4): a true positive signal, a true negative signal, a false negative signal (type II error – defined as share of no-stress signals over all stress episodes; called also "missed crises") and a false positive signal (type I error – defined as the share of crisis signals over all no-crises periods; called also "false alarms").

For variables where a value above the threshold indicates fiscal stress, the type II error increases with the threshold value (as c.p. more crises tend to missed), while the type I error decreases (because the system sends less often a crisis signal, if no crisis occurs). For variables, where a value below a threshold indicates fiscal stress, the relationship is reversed. For a graphical illustration of the development of type I and type II errors for the indicator variable public debt ratio see Figure 3.

The determination of the critical thresholds is therefore a balancing act between minimizing the number of false alarms and of missed crisis. There are different methodologies to operationalize this balancing act and determine the optimal thresholds based on the possible signals. One is the maximization of the signal-to-noise ratio, based on the sum of true over the sum of false signals. A second possibility is a minimization of the total misspecification error (TME) i.e. a maximization of the signalling power. The total misspecification error (TME) is defined as one minus type I error minus type II error. [15]

[15] Further alternatives to determine the optimal threshold include the Youden Index, a measure of total accuracy and the Matthews correlation coefficient. For a discussion and application to early warning systems see Candelon, Dumitrescu and Hurlin (2012). Demirgüc-Kunt and Detragiache (2000), pp. 294-296, propose a decision-maker loss function which allows to formally assign weights to type-I and type-II errors respectively.

**Figure 3: Illustrating signalling power based on a debt ratio variable**




Legend:

A = Crisis indicated but no crisis occurred/total number of no-crisis episodes (type I error)

B = Crises missed/total number of crises (type II error)

A+B Total Missspecification Error (TME)

The most important difference of the maximization of the signal-to-noise ratio and the minimization of the TME is that the signal-to-noise-ratio assigns the same weight to false positive and false negative signals. In contrast, the TME approach assigns a far higher weight to false negative signals, as the type II error is defined as the ratio of false negative signals over the total number of crises and the number of crises is usually a lot lower than the number of no-crisis events in a sample. Against this background, we apply the TME here, as we want to avoid especially false negative signals, which are likely to be far costlier than false positive signals.[16]

The signalling approach is usually applied to calculate common thresholds of the variables employed over all the countries included in the analysis. In this setting, all country-year pairs are treated as independent observations and the typical panel dimension of the data is ignored. Indeed, the assumption of a common threshold for all countries represents a concern; on the one hand, the critical levels for the thresholds of the variables signalling fiscal stress might vary strongly in different countries, and, on the other hand, the estimated common thresholds might be driven by outliers. As a result, the common thresholds may be misleading for some countries and lead to a relatively low predictive power of an early warning system.

In this paper, we explicitly take country heterogeneity into account by exploiting the panel dimension of the data and calculating country-specific thresholds. We conduct the signalling approach on a

[16] For a discussion of how to measure the costs of crises events see Babecky (2011).

country-by-country basis to achieve a higher robustness of the critical thresholds with respect to outliers and hope for a higher predictive power of the early warning system. An alternative to our approach would be to estimate common percentiles for all the countries and then apply these to each country separately to derive country-specific thresholds (this approach is followed in Alessi and Detken (2011)).

# IV. The data set

Fiscal stress can be caused by very different factors. One possibility is that weak fiscal fundamentals, reflected in deficits and debt levels which pose a risk to fiscal sustainability, are directly responsible for triggering fiscal stress. But private sector imbalances can – as the crisis demonstrated - also quickly turn into public debt and deficits and thereby exacerbate fiscal imbalances. Examples for such imbalances are large and persistent current account deficits or high private sector leverage – potentially combined with a housing market boom.[17] Finally there are important interactions between the financial and the fiscal sector, which can also create vulnerabilities for fiscal stress. In case of a financial crisis, measures to support the financial sector can contribute to a strong deterioration of public finances. As these measures can then lead to falling government bond prices, which weigh heavily on banks' balance sheets, this can reduce also the credit supply and create an adverse feedback loop between sovereign bond markets, the real economy and the financial sector.

As fiscal stress can therefore not only result from fiscal factors, an early warning system needs to take a broad range of indicators into account, which also cover private and financial sector imbalances. Hence a large dataset is used for our analyses, including 27 variables (13 fiscal and 14 financial-competitiveness variables aggregated to a fiscal and a financial index - see for an overview table 5).The dataset we rely on covers 1970-2010 and was compiled by the European Commission and employed in the early warning exercise presented in its 2011 Public Finance Report[18] (as well as later in Berti et al. (2013)) and is also underlying the calculations of the S0 indicator (the European Commission slightly modified the list of variables in subsequent updates of the S0 indicator).[19]

[17] Under the reinforced European governance framework, these imbalances are monitored under the macroeconomic imbalance procedure. See European Commission (2014) and European Central Bank (2013).

[18] The countries covered are the EU (without Cyprus, Luxemburg and Malta) and Australia, Canada, Iceland, Israel, Japan, New Zealand, Norway, Switzerland and the US. The dataset was kindly provided by the European Commission.

[19] For instance, they replaced the variables real short-term interest rate and net savings (non-financial corporations) by the yield curve and gross financing needs (see European Commission, 2012).

**Table 5: Overview of fiscal and financial variables in the dataset**

| Fiscal variables/fiscal index | Financial variables/financial index |
|---|---|
| Average yearly change in projected age-related expenditures as % of GDP over 30 years | Change (3 years) in nominal unit labour costs |
| Balance, % of GDP | Change (3 years) of real effective exchange rate, based on exports deflator |
| Change in expenditure of general government, % of GDP | Construction, % value added |
| Change in final consumption expenditure of general government, % of GDP | Current account, 3-year backward moving average, % of GDP |
| Change in gross debt, % of GDP | Debt (loans and securities other than shares), households and non-financial corporations |
| Cyclically adjusted balance, % of GDP | Gross domestic product at current market prices per capita |
| Gross debt, % of GDP | Leverage (financial liabilities) financial corporations |
| Interest rate-growth rate differential | Net international investment position, % of GDP |
| Net debt, % of GDP | Net saving: corporations |
| Old-age dependency ratio 20 years ahead | Net saving: households |
| Primary balance, % of GDP | Private sector credit flow (households and non-financial corporations), % of GDP |
| Short-term debt general government, % of GDP | Real GDP growth |
| Stabilising primary balance, % of GDP | Real short-term interest rates, GDP deflator |
| | Short-term debt, non-financial corporations, % of GDP |

The dataset is of annual frequency. Regular updates of the data are available in each spring. Based on a signalling window of one year this means that based on the data release in spring of year t, the risk of fiscal stress occurring in this same year can be evaluated. Based on a signalling window of three years, the risk for fiscal stress in year t+2 could be evaluated.

**Table 6: Descriptive Statistics 1970-2010**

| Variable | Obs | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| Stabilizing primary balance, % GDP | 425 | 0.182 | 2.555 | -7.923 | 9.607 |
| Gross debt, % GDP | 436 | 57.936 | 30.239 | 6.149 | 142.754 |
| Change in gross debt, % GDP | 425 | 1.543 | 4.543 | -10.757 | 30.556 |
| Short-term debt general gov't, ESTAT (%GDP) | 175 | 9.319 | 6.624 | 0.400 | 31.800 |
| Net debt, % GDP | 250 | 39.211 | 62.712 | -208.440 | 119.274 |
| Interest rate-growth rate differential | 404 | -1.282 | 6.336 | -25.433 | 17.334 |
| Change in expenditure of general government, % GDP | 440 | 0.515 | 2.132 | -7.012 | 18.864 |
| Change in final consumption expenditure of general government, % GDP | 440 | 0.212 | 0.737 | -2.381 | 4.255 |
| Old-age dependency ratio 20 years ahead | 450 | 27.343 | 6.279 | 15.803 | 46.225 |
| Avg yearly change in projected age-related public expenditure as %GDP over 30 ye | 198 | 0.124 | 0.068 | 0.021 | 0.349 |
| Debt (loans and securities other than shares), households and non-financial corp | 189 | 146.395 | 57.456 | 37.360 | 341.340 |
| Leverage (fin. liab.), Financial corporations, non cons + cons | 189 | 5.181 | 3.462 | 1.582 | 20.913 |
| Short-term debt, non-financ corp, non-cons (%GDP) | 180 | 28.355 | 15.993 | 6.410 | 87.160 |
| Real short-term interest rates, deflator GDP | 433 | 1.911 | 3.495 | -12.490 | 12.208 |
| Construction, % value added | 420 | 6.918 | 1.572 | 3.922 | 12.131 |
| Change (3 years) of real effective exchange rate, based on exports deflator, ref | 143 | 0.710 | 4.971 | -12.265 | 12.626 |
| Change (3 years) in nominal unit labour costs | 397 | 20.573 | 21.502 | -7.839 | 104.200 |
| Balance, % GDP | 451 | -3.487 | 4.285 | -32.423 | 7.797 |
| Primary balance, % GDP | 451 | 0.405 | 3.435 | -29.156 | 9.635 |
| Cyclically adjusted balance, % GDP | 451 | -3.499 | 4.018 | -30.310 | 8.676 |
| Net international investment position, BoP + IMF (%GDP) | 277 | -11.021 | 32.701 | -176.966 | 65.594 |
| Net saving; households | 254 | 5.874 | 4.735 | -6.359 | 22.231 |
| Net saving; corporations | 254 | 2.410 | 3.106 | -7.619 | 10.472 |
| Private sector credit flow (hh's and nfcorp), non-cons (%GDP) | 186 | 10.487 | 7.640 | -4.530 | 40.880 |
| Current account,3-year backward MA, % GDP | 341 | -0.672 | 4.103 | -13.427 | 8.200 |
| Real GDP growth | 440 | 2.675 | 2.654 | -8.204 | 11.461 |
| Gross domestic product at current market prices per capita | 451 | 70.540 | 13.312 | 36.619 | 97.748 |

The focus of the results presented in this paper lies on 11 EMU countries: the EMU 12 countries excluding Luxemburg.[20] This group seems suited best for analytical purposes as it joined (with the exception of Greece) the EMU simultaneously from the start. However, integration of the countries, which joined EMU later or even of the whole EU28 is easily possible as country heterogeneity is taken into account via the country- specific approach.

Table 6 shows descriptive statistics of the 27 variables employed for the EMU 11 dataset. A very broad range of values is the rule (rather than the exception) and the variation – as demonstrated by the standard deviation – is high for most of the variables.

# V. Analytical results

In the following we will present and discuss the analytical findings of our country-specific signalling approach. We first discuss the predictive power of our indices – also in comparison with the alternative of a "common threshold" approach – for in- and out-of-sample results. In the next step we review the importance of signals in a disaggregated analysis - variable by variable. In a further step we demonstrate how and why the influence of country heterogeneity is decisive in our early warning system. This part also discusses the reliability of forward-looking signals of the proposed early warning system.

## V.1.1. Predictive power of a country-specific early warning system

The main innovation of our approach is the introduction of country-specific thresholds in a signalling approach for fiscal stress. To evaluate the value-added of such a system, we estimate and compare the signalling power of two different early warning systems: one based on common thresholds (as a benchmark) and one based on country-specific thresholds. We first review the signalling power of individual variables under the two approaches and then discuss the signalling power of the indices. For this exercise we include also an out-of-sample estimation, in which the predictive power of the early warning system for 2000-2010 is evaluated based on the identification of the (common and country-specific) thresholds for data only from 1970-2000.

## V.1.2. Individual variables

Table 7 shows the signalling power for in- and out-of-sample results for all 27 variables in the common and the country-specific threshold approach. We find that – for the in-sample results for 1970-2010 – all variables in the country-specific as well as in the common threshold approach have a

[20] Luxemburg is not included because of data restrictions.

positive signalling power and thereby can contribute to the predictive power of the system. A second finding is that – for the in-sample results – the signalling power of all variables is higher in the country-specific than in the common threshold approach. The concrete signalling power of the different variables however differs very much – in and across approaches. In the country-specific approach, the short-term debt of non-financial corporations, the overall debt of households and changes in age-related public spending have the highest predictive power in the in-sample results. In the common threshold approach the predictive power of the current account, the net international investment position and of net savings of households and the share in value added of construction is highest in the in-sample estimations. In both approaches, the highest predictive power is assigned to non-fiscal variables.

**Table 7: Disaggregated signalling power by variable – common and country-specific approach**

| | In-sample | | | | | | Out-of-Sample | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Common threshold | | | Country-specific | | | Common threshold | | | Country-specific | | |
| | Sig. Power | Type I | Type II | Sig. Power | Type I | Type II | Sig. Power | Type I | Type II | Sig. Power | Type I | Type II |
| Stabilizing primary balance | 0.09 | 0.12 | 0.79 | 0.53 | 0.33 | 0.14 | 0.13 | 0.87 | 0.00 | 0.28 | 0.30 | 0.43 |
| Gross debt | 0.09 | 0.06 | 0.85 | 0.50 | 0.38 | 0.12 | 0.00 | 0.77 | 0.24 | 0.07 | 0.34 | 0.59 |
| Change in gross debt | 0.11 | 0.08 | 0.81 | 0.56 | 0.35 | 0.09 | 0.09 | 0.08 | 0.82 | 0.24 | 0.23 | 0.53 |
| Short-term debt general gov't | 0.27 | 0.09 | 0.64 | 0.69 | 0.31 | 0.00 | 0.00 | 0.00 | 1.00 | 0.01 | 0.16 | 0.83 |
| Net debt | 0.14 | 0.18 | 0.68 | 0.57 | 0.34 | 0.09 | 0.13 | 0.87 | 0.00 | 0.30 | 0.27 | 0.44 |
| Interest rate-growth rate differential | 0.11 | 0.07 | 0.82 | 0.57 | 0.28 | 0.14 | 0.07 | 0.86 | 0.07 | 0.26 | 0.24 | 0.50 |
| Change in expenditure of general gov't | 0.10 | 0.90 | 0.00 | 0.60 | 0.31 | 0.09 | 0.02 | 0.51 | 0.47 | 0.26 | 0.21 | 0.53 |
| Change in final consumption exp. of general gov't | 0.17 | 0.22 | 0.61 | 0.61 | 0.30 | 0.09 | 0.02 | 0.65 | 0.33 | 0.18 | 0.22 | 0.60 |
| Old-age dependency ratio 20 years ahead | 0.12 | 0.14 | 0.74 | 0.55 | 0.38 | 0.07 | 0.13 | 0.88 | 0.00 | 0.13 | 0.88 | 0.00 |
| Avg yearly change in age-related public expenditure | 0.19 | 0.12 | 0.69 | 0.86 | 0.14 | 0.00 | 0.06 | 0.02 | 0.92 | 0.33 | 0.34 | 0.33 |
| Debt, households and non-financial corp | 0.25 | 0.05 | 0.69 | 0.89 | 0.03 | 0.08 | 0.19 | 0.56 | 0.25 | 0.40 | 0.60 | 0.00 |
| Leverage, Financial corporations, non cons + cons | 0.23 | 0.56 | 0.21 | 0.76 | 0.17 | 0.07 | 0.00 | 0.00 | 1.00 | 0.27 | 0.15 | 0.58 |
| Short-term debt, non-financ corp, non-cons | 0.26 | 0.21 | 0.54 | 0.91 | 0.09 | 0.00 | 0.14 | 0.45 | 0.42 | 0.62 | 0.30 | 0.08 |
| Real short-term interest rates, deflator GDP | 0.18 | 0.06 | 0.76 | 0.52 | 0.33 | 0.15 | 0.04 | 0.02 | 0.93 | 0.30 | 0.10 | 0.60 |
| Construction, % value added | 0.36 | 0.21 | 0.43 | 0.66 | 0.25 | 0.10 | 0.37 | 0.10 | 0.53 | 0.31 | 0.23 | 0.47 |
| Change (3 years) of REER, based on exports deflator | 0.25 | 0.28 | 0.47 | 0.77 | 0.23 | 0.00 | 0.04 | 0.59 | 0.38 | 0.00 | 0.56 | 0.44 |
| Change (3 years) in nominal unit labour costs | 0.32 | 0.54 | 0.14 | 0.62 | 0.22 | 0.16 | 0.05 | 0.01 | 0.94 | 0.05 | 0.06 | 0.88 |
| Balance | 0.17 | 0.03 | 0.80 | 0.48 | 0.38 | 0.15 | 0.08 | 0.16 | 0.77 | 0.00 | 0.18 | 0.82 |
| Primary balance | 0.20 | 0.26 | 0.54 | 0.54 | 0.36 | 0.10 | 0.07 | 0.06 | 0.88 | 0.15 | 0.35 | 0.50 |
| Cyclically adjusted balance | 0.29 | 0.41 | 0.30 | 0.59 | 0.32 | 0.09 | 0.15 | 0.05 | 0.80 | 0.08 | 0.32 | 0.60 |
| Net international investment position, BoP + IMF | 0.39 | 0.45 | 0.16 | 0.74 | 0.22 | 0.04 | 0.37 | 0.50 | 0.13 | 0.34 | 0.59 | 0.07 |
| Net saving; households | 0.36 | 0.19 | 0.45 | 0.74 | 0.11 | 0.15 | 0.13 | 0.20 | 0.67 | 0.24 | 0.59 | 0.17 |
| Net saving; corporations | 0.23 | 0.07 | 0.70 | 0.64 | 0.26 | 0.10 | 0.00 | 0.00 | 1.00 | 0.25 | 0.25 | 0.50 |
| Private sector credit flow | 0.07 | 0.93 | 0.00 | 0.68 | 0.25 | 0.08 | 0.00 | 0.25 | 0.75 | 0.12 | 0.30 | 0.58 |
| Current account | 0.47 | 0.21 | 0.32 | 0.71 | 0.17 | 0.12 | 0.42 | 0.41 | 0.18 | 0.46 | 0.37 | 0.18 |
| Real GDP growth | 0.11 | 0.07 | 0.83 | 0.50 | 0.41 | 0.10 | 0.00 | 0.00 | 1.00 | 0.14 | 0.51 | 0.35 |
| GDP per capita at current market prices | 0.30 | 0.40 | 0.30 | 0.41 | 0.40 | 0.20 | 0.32 | 0.44 | 0.24 | 0.00 | 0.18 | 0.82 |
| Vars. Average | 0.22 | 0.26 | 0.53 | 0.64 | 0.27 | 0.09 | 0.11 | 0.34 | 0.54 | 0.21 | 0.33 | 0.46 |
| Index | 0.56 | 0.24 | 0.20 | 0.96 | 0.04 | 0.00 | 0.42 | 0.40 | 0.18 | 0.77 | 0.18 | 0.06 |

Notes: Type I error is the ratio of false positives to number of no-crisis observations. Type II error is the ratio of false negatives to number of crisis observations. Signaling power is defined as 1 - Type I - Type II. The percentage of true positives can be recovered as 1 - Type II; the percentage of true negatives is 1 - Type I.

For the out-of-sample results the picture changes. Here several variables lose all their predictive power (signalling power of 0). In the country-specific threshold approach these are the fiscal balance, the changes in the real effective exchange rate and GDP. In the common threshold approach these are gross debt, short-term debt of the general government, leverage of financial corporations, net savings of corporations, private sector credit flow and real GDP growth. Furthermore it should be noted that – under the out-of-sample results - six variables have a higher predictive power now under the common than under the country-specific approach (the fiscal balance, the cyclically adjusted balance, value-added in construction, the net international investment position, the real exchange rate and GDP). The signalling power is highest under the country-specific approach for the

out-of-sample results for short-term debt, the current account and household debt, while under the common threshold approach the current account, construction value-added and the net international investment position have the highest signalling power.

Taken together these findings indicate that the importance of the variables considered differs strongly. As all variables have a positive signalling power – at least under the in-sample identification – there are no "obvious candidates" which could be deleted from the sample. On the other hand, there is no small group of variables which seem to drive the results (in- and out-of-sample) and would allow for a parsimonious EWS. Especially under the country-specific approach the importance of different variables for signalling fiscal stress differs strongly across countries. Furthermore it should be noted that under the signalling approach interactions between the variables are not modelled. Therefore it is impossible that the signalling power of one variable is distorted by another included variable. Against this background there seems to be no reason to strip down the number of included variables. Furthermore, in concrete cases detailed analyses of the driving forces of an indication of fiscal stress are possible based on such a comprehensive EWS.

### V.1.3. Predictive power of the composite indices

We now turn to the aggregate indices combining the information in all the individual variables. When calculating the composite indices for fiscal stress, the influence of the different variables is weighted with the signalling power. To be more concrete, we combine the individual signals from each variable into a single indicator using as weights the signalling power of each variable. Since the signalling power of all the variables is re-scaled to sum up to one, the resulting composite index can be interpreted as a weighted average of the variable-specific signals with weights given by the signalling power. In a second step, the threshold for the composite indices is then determined analogously to the approach taken for every single variable - by minimizing the TME. [21]

The ability of the composite indices to predict episodes of fiscal stress is summarized in Table 8. These results show a high overall predictive power of the country-specific signalling approach. The in-sample results of the overall index derive a signalling power of 95% for our dataset of EMU 12 countries (without Luxemburg) from 1970-2010. It should be noted that especially the type II error can be completely eliminated while it is as high as 0.20 using the common threshold approach considered for instance in Baldacci et al. (2011) or Berti et al. (2013).

[21] It should be noted that this calculation of signalling power cannot account for the possible existence of interactions among a set of individual indicators.

**Table 8: Predictive power of the composite indices based on common and country-specific thresholds**

| | In-sample | | | | | | Out-of-sample | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Common threshold | | | Country-specific | | | Common threshold | | | Country-specific | | |
| | Sig. Power | Type I | Type II | Sig. Power | Type I | Type II | Sig. Power | Type I | Type II | Sig. Power | Type I | Type II |
| **PANEL A: OVERALL INDEX** | | | | | | | | | | | | |
| Vars. Average | 0.22 | 0.26 | 0.53 | 0.58 | 0.32 | 0.09 | 0.11 | 0.34 | 0.54 | 0.21 | 0.33 | 0.46 |
| Index | 0.56 | 0.24 | 0.20 | 0.95 | 0.05 | 0.00 | 0.42 | 0.40 | 0.18 | 0.77 | 0.18 | 0.06 |
| **PANEL B: FISCAL INDEX** | | | | | | | | | | | | |
| Vars. Average | 0.16 | 0.21 | 0.64 | 0.59 | 0.32 | 0.09 | 0.07 | 0.44 | 0.48 | 0.17 | 0.31 | 0.52 |
| Index | 0.22 | 0.15 | 0.64 | 0.88 | 0.09 | 0.04 | 0.13 | 0.05 | 0.82 | 0.58 | 0.24 | 0.18 |
| **PANEL C: FINANCIAL INDEX** | | | | | | | | | | | | |
| Vars. Average | 0.27 | 0.30 | 0.43 | 0.68 | 0.22 | 0.10 | 0.15 | 0.25 | 0.60 | 0.25 | 0.34 | 0.41 |
| Index | 0.50 | 0.26 | 0.24 | 0.87 | 0.06 | 0.07 | 0.47 | 0.36 | 0.18 | 0.79 | 0.16 | 0.06 |

Notes: Type I error is the ratio of false positives to number of no-crisis observations. Type II error is the ratio of false negatives to number of crisis observations. Signaling power is defined as 1 - Type I - Type II. The percentage of true positives can be recovered as 1 - Type II; the percentage of true negatives is 1 - Type I.

The signalling power for both the fiscal and the financial index are also high and relatively close to the performance of the overall index. A comparison with the signalling power of the indices based on common thresholds demonstrates the importance of taking country heterogeneity into account. The in-sample signalling power of the overall index based on common thresholds is with 56% substantially lower than the signalling power of the country-specific approach. With respect to the fiscal sub-index, the difference is even more striking: Here the common threshold approach derives only a signalling power of 22% (compared to 88% in the country-specific model). This demonstrates that country heterogeneity plays an especially crucial role with respect to fiscal variables – a results which might help to explain why some other (especially non-country-specific) studies fail to find an important role for fiscal variables as a signal for upcoming fiscal stress. With respect to the financial sub-index the difference between the two approaches is substantial as well – but somewhat less pronounced. Here the overall signalling power of the common threshold approach is with 50% still substantially lower than the 87% of the country-specific approach.

However, even more important for the practical application and the ability of a EWS to help prevent crisis is the predictive power of a EWS in out-of-sample estimation. As expected, the predictive power of our indices is in the out-of-sample estimation lower than for the in-sample analyses – but the results are nonetheless by comparison quite good. The signalling power for the overall index is reduced to 77% - but still only 6% of the crises are missed. The reduction of the overall signalling performance results especially from an increased number of false alarms – in 18% of the cases where a crisis signal was sent, actually no crisis followed. With respect to the sub-indices, the predictive power of the financial sub-index is with 79% only somewhat reduced, while the fiscal index has only a signalling power of 58% for out-of-sample predictions.

Also for the out-of-sample results the country-specific approach fairs far better than the common threshold approach. The signalling power of the common threshold approach is in all dimensions - of the overall index (42%), the fiscal index (13%) and the financial index (47%) - substantially lower than the signalling power of the country-specific approach. Notably, especially the fiscal sub index has a low signalling power under the common threshold approach pointing – as discussed above – to an especially important role of country heterogeneity for fiscal variables.

### V.1.4. The influence of country-heterogeneity on the predictive power of early warning systems

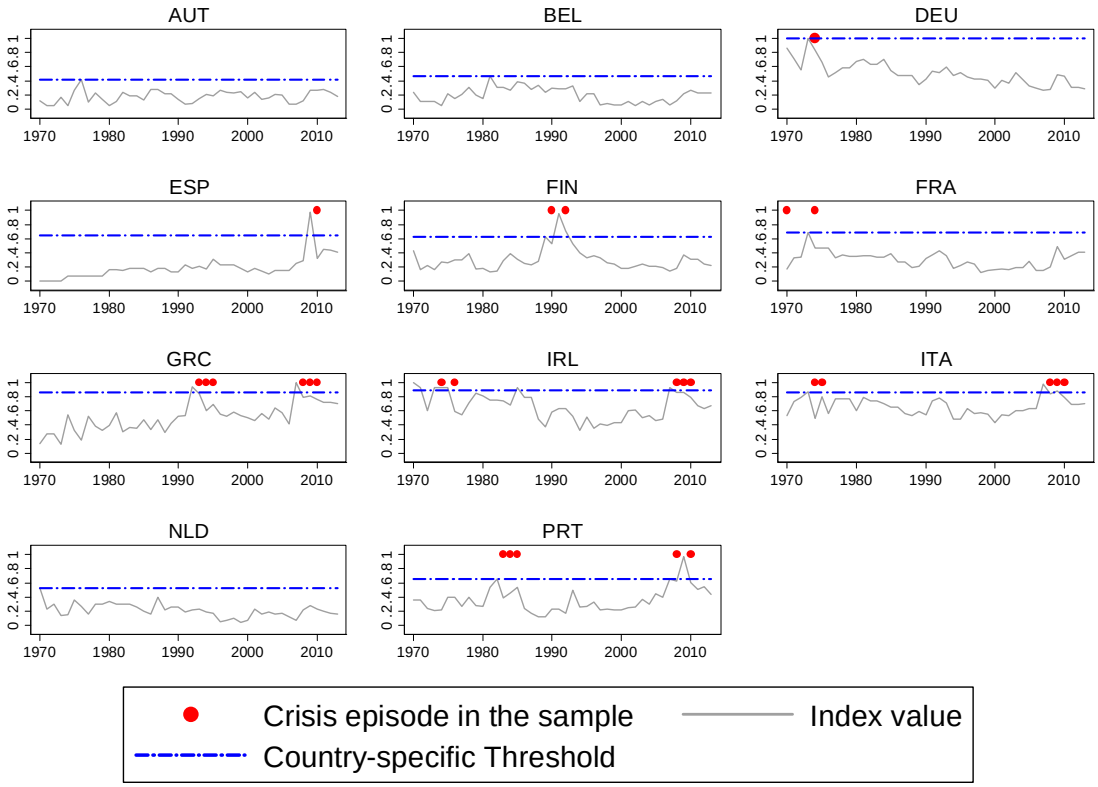
An early warning system based on the signalling approach tries to extract information about critical thresholds for signalling indicators based on past experiences. One decisive question is whether these thresholds are country-specific or universal. Both approaches have advantages and disadvantages. A common threshold approach allows pooling the data across countries and increases the number of crises observations for the threshold identification, which should increase the robustness of the results. On the other hand, the common threshold approach disregards heterogeneity between the countries in a sample. In contrast, a country-specific threshold approach can fully take country heterogeneity into account. On the other hand, it has necessarily to rely on a lower number of crisis observations, which might affect the reliability of the results negatively. Which approach is preferable depends largely on the country heterogeneity of the data sample. One test for this heterogeneity is the comparison of concrete results for country-specific and common thresholds for a given sample.

**Table 9: Values for selected country-specific thresholds of fiscal variables**

| | Gross debt, % GDP (+) | Change in gross debt, % GDP (+) | Change in public expenditure, % GDP (+) | Primary balance, % GDP (-) | Overall index (+) |
|---|---|---|---|---|---|
| AUT | 72.26 | 6.02 | 4.36 | -1.99 | 0.21 |
| BEL | 134.24 | 12.44 | 6.66 | -7.39 | 0.42 |
| DEU | 17.69 | -0.43 | 0.59 | 2.23 | 0.99 |
| ESP | 53.26 | 13.41 | 4.51 | -8.34 | 0.99 |
| FIN | 14.49 | 6.41 | 8.92 | 0.91 | 0.57 |
| FRA | 81.70 | 10.60 | -0.06 | -4.80 | 0.55 |
| GRC | 78.37 | -0.69 | 1.49 | -0.65 | 0.89 |
| IRL | 25.01 | -2.85 | -0.14 | 1.12 | 0.85 |
| ITA | 50.26 | -3.03 | -1.19 | -4.06 | 0.80 |
| NLD | 78.48 | 12.92 | 5.31 | -3.58 | 0.15 |
| PRT | 68.27 | 3.51 | 5.13 | -0.21 | 0.58 |
| Common | 103.62 | 6.59 | -2.39 | -0.65 | 0.37 |

Table 9 shows the country specific and common thresholds for four central fiscal variables for an EMU 12 dataset (without Luxemburg) from 1970-2010.[22] As we can see from the table, the thresholds differ tremendously across countries. The common threshold for the debt ratio for example equals 103% of GDP, while for example Belgium has a country-specific threshold of 134% and Germany of 18%.[23] This indicates that country heterogeneity plays – with respect to fiscal variables – an important role which should not be neglected.

**Figure 4: Value and threshold of composite fiscal stress index**




A second dimension, through which country-heterogeneity is integrated in our approach is the identification of a threshold for the composite indices. The threshold for the overall index differs as well very strongly across countries. Figure 4 displays the threshold values as well as the development of the index for each of the 11 included EMU countries from 1970-2013. The threshold of the index varies between 0.41 in Austria and 1 in Germany. This variation in the overall index threshold does further support the importance of country heterogeneity for the signalling approach. The figures show also how the index signals fiscal stress ahead of all 27 crises episodes included in the EMU 11

[22] It should be noted that the variable-specific thresholds need to be interpreted with caution. A specific variable above its corresponding threshold does not necessarily imply a signal of fiscal stress of the overall early warning system - as the composite index might remain below the critical threshold. Second, the variable-specific thresholds might change over time as they should be continuously re-estimated as new data becomes available.

[23] The threshold of Belgium results from the fact that Belgium never experienced fiscal stress (based on the definition of fiscal stress applied here), while Germany experienced a fiscal stress episode in 1974, when the debt ratio equalled 18% of GDP.

sample (red dots). In general, the figures demonstrate also important differences in country-specific developments. While the development of the index shows for example for Spain a long phase of stability and only a rapid building up of fiscal stress in recent years, the index development for Italy points more at a general vulnerability for fiscal stress throughout the sample.

## V.2. How "early" is the warning – the signalling window

So far our analyses have been restricted to a signalling window of one year – meaning that we evaluate how well fiscal stress in t is predicted based on data for t-1. However, this might not be "early enough" to prevent fiscal stress from occurring especially for two reasons. First, data is often only available with a considerable time-lag. This time-lag might transform an early warning system with only one lag into a real-time monitoring exercise – instead of the explicit goal to signal fiscal stress well ahead of a crisis materialising. Second, policy actions to prevent the materialisation of fiscal stress often need time to be passed and implemented. Against this background, a longer signalling window – to detect the building up of fiscal stress ex ante and have still enough time to react – would often be desirable.

**Table 10: Signalling power of the composite indices for in- and out-of-sample** analyses

| | | In-sample | | | Out-of-sample | | |
|---|---|---|---|---|---|---|---|
| | | Overall Index | Fiscal Index | Financial Index | Overall Index | Fiscal Index | Financial Index |
| 1 year ahead | Sig. Power | 0.98 | 0.94 | 0.94 | 0.91 | 0.49 | 0.90 |
| | Type I | 0.02 | 0.06 | 0.06 | 0.09 | 0.17 | 0.10 |
| | Type II | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.00 |
| 2 years ahead | Sig. Power | 0.82 | 0.81 | 0.85 | 0.67 | 0.09 | 0.70 |
| | Type I | 0.04 | 0.06 | 0.08 | 0.33 | 0.51 | 0.30 |
| | Type II | 0.13 | 0.13 | 0.07 | 0.00 | 0.40 | 0.00 |
| 3 years ahead | Sig. Power | 0.34 | 0.34 | 0.30 | 0.52 | 0.37 | 0.12 |
| | Type I | 0.02 | 0.02 | 0.06 | 0.24 | 0.64 | 0.13 |
| | Type II | 0.64 | 0.64 | 0.64 | 0.25 | 0.00 | 0.75 |

Notes: This table summarizes the forecasting ability of the country-specific EWS discussed in the paper. We evaluate both in-sample (using data from 1970 to 2010 for estimation and prediction) and out of-sample performance (estimating the thresholds with data from 1970 to 1999 and forecasting for the period 2000-2010). We also consider three different signalling windows for one, two, and three years ahead. Three different indices are considered, an overall index encompassing all the 27 variables in our dataset, a fiscal index considering the 13 fiscal-related variables, and a financial-competitiveness index with 14 financial and macro variables. Our measure of forecasting performance reported in the table is the signalling power given by 1 minus Type I (ratio of false positive signals to number of no crisis years) and Type II (ratio of false negative signals to number of crises) errors. Sample restricted to EMU countries.

How well would the country-specific early warning system we propose be able to signal fiscal stress earlier than one year ahead? Table 10 shows the signalling power of the overall and the fiscal and financial index for in- and out-of-sample results.[24]

We find that a prolongation of the signalling window (from 1 year ahead to 2 and 3 years ahead) decreases continuously the signalling power of the overall index. The in-sample signalling power

[24] Robustness of the out-of-sample numbers is limited as they are based on only very few crisis episodes (in some cases at best four crisis episodes).

equals – in the 3 year signalling window – only 0.34. Here already up to 2/3 of the crises episodes are not predicted by the overall index. With respect to the out of-sample forecast performance, the decrease in signalling power is a bit less pronounced.

These findings have some important implications: They underline that the longer the signalling window, the less reliable are the results. In practice this means that the signals for a longer signalling window should be interpreted especially carefully.

## V.3. Would the EWS have helped to predict the fiscal stress in euro area countries in 2008-2010?

In the years 2008-2010 the sovereign debt crisis developed in several euro area Member States – without being indicated by sovereign spreads or country ratings well ahead. One crucial question is whether the EWS proposed in this paper would also have failed to send crisis signals ahead of the fiscal stress materialising. To analyse this question, we derive the critical thresholds based on data till just before the turmoil period started in 2008 and then evaluate, how well the EWS would have predicted these crises. Based on such an exercise, Table 11 shows how the indices would have performed in predicting the fiscal stress in several euro area countries in 2008, 2009 and 2010 ex ante (i.e. based on data until 2007). The results show that all crises would have been predicted one year ahead (e.g. all crises for 2008 predicted based on 2007 data). For 2009 (2 years ahead) and even more for 2010 (3 years ahead) the signalling power would have been substantially lower. Considering all the three exercises simultaneously, half the crises would have been missed over the whole period 2008-2010. Nonetheless the indices still had a signalling power of 0.45 – comparable to the signalling power of common threshold approaches for only one year ahead and in-sample forecasts.

**Table 11: Out-of-sample prediction of fiscal stress in 2008, 2009 and 2010**

| | 2008 (1 year ahead) | 2009 (2 years ahead) | 2010 (3 years ahead) | 2008-2010 (overall) |
|---|---|---|---|---|
| False Positive | 0 | 1 | 0 | 1 |
| False Negative | 0 | 3 | 3 | 6 |
| Crises | 4 | 3 | 5 | 12 |
| Non-crises | 7 | 8 | 6 | 21 |
| Type I error | 0 | 0.13 | 0 | 0.05 |
| Type II error | 0 | 1 | 0.60 | 0.50 |
| Signalling power | 1 | -0.13 | 0.40 | 0.45 |

Notes: Type I error is the ratio of false positives to number of non-crisis observations. Type II error is the ratio of false negatives to number of crisis observations. Signaling power is defined as 1 - Type I - Type II. The years refer to the early warning estimated in 2007 for 2008, 2009, and 2010, respectively (i.e. 1, 2, and 3 years ahead).

# VI. Conclusions and outlook

The previous results indicate that a system of early warning indicators based on a country-specific signalling approach can generally help to detect fiscal stress early on. However, the predictive power of an early warning system should not be overestimated. Below, the most important points with respect to the outcome of the analysis, general caveats and policy recommendations are summarised.

The main result of our analysis is that using a country-specific threshold increases the predictive power of early warning indicators in a signalling approach. Especially four elements seem worth mentioning. First, our findings also support the view that an early warning system for fiscal stress should include fiscal as well as financial variables. Second, by introducing country-specific thresholds the number of "missed crises" is - compared with the common threshold approach - strongly reduced. This increases the possibility to effectively prevent the occurrence of fiscal crisis. Third, the introduction of country-specific thresholds also helps to improve the reliability of the indicators for estimations for years, which are not included in the dataset employed to determine the critical thresholds (out-of-sample estimations). Finally, the positive impact of introducing country-specific thresholds is most important for the predictive power of the fiscal variables. This can be seen as an indication of an especially important role for country-specific factors in the fiscal sphere.

However, we also acknowledge that five general caveats apply to fiscal early warning indicators:

First, all predictions of early warning indicators are based on historical crises observations, but future crises events and their triggers might differ fundamentally from past crises and therefore they might not be indicated in the same way as past crises by early warning indicators.

Second, the data employed in a system of early warning indicators are ex post data, which are usually only available with a time lag and can be subject to revisions. Therefore data availability and quality can strongly reduce the signalling power of early warning indicators.

Third, it should be noted that even if upcoming fiscal crises are correctly signalled, there might not be enough time left to counteract the critical developments.

Fourth, the existence of feedback effects from fiscal stress episodes to the variables combined in the EWS are not taken into account. For instance, if policy actions are taken in response to an upcoming crisis and they are successful in avoiding the crisis, this would be labelled as a false positive signal within the early warning system based on ex-post data.

Finally, if an early warning system is implemented to support fiscal policy analyses, the following policy recommendations are crucial:

An early warning system for fiscal stress should include country specific thresholds for the signalling variables, a signalling window of more than one year and fiscal as well as financial variables.

Efforts to improve the timely availability and reliability of fiscal statistics would help to improve the effectiveness of early warning indicators.

Even if the previous two conditions are fulfilled, an early warning system based on the signalling approach can only serve as an additional cross-check within a broader fiscal surveillance system. An early warning indicator is not and cannot be a substitute for strict and well adhered to fiscal rules.

# VII. Bibliography


**Abiad A. (2003)** "Early-warning systems: a survey and a regime-switching approach", *IMF Working Paper* 03/32.

**Alessi, L. and C. Detken** (2011) "Quasi real time early warning indicators for costly asset price boom/bust cycles: A role for global liquidity", European Journal of Political Economy, 27, 520–533.

**Babecký, J., T. Havránek, J. Matějů, M. Rusnák, K. Šmídková and B. Vašíček (2012)** "Banking, debt and currency crises: early warning indicators for developed countries", ECB Working Paper No. 1485.

**Baldacci E., I. Petrova, N. Belhocine, G. Dobrescu, and S. Mazraani (2011a)** "Assessing fiscal stress", *IMF Working Paper* 11/100.

**Berg A. and C. Pattillo (1999)** "Predicting currency crises: the indicators approach and an alternative" *Journal of International Money and Finance,* 18, 561-86.

**Berg A., E. Borensztein, and C. Pattillo (2004)** "Assessing early warning systems: how have they worked in practice?" *IMF Working Paper* 04/52.

**Berg, J.B., Candelon, B. and J.P. Urbain (2008)** "A Cautious Note on the Use of Panel Models to Predict Financial Crises", Economics Letters, 101, 80-83.

**Berti, K., M. Salto, M. Lequien (2013)** "An early-detection index of fiscal stress for EU countries", European Economy. Economic Papers. **475**. Brussels.

**Brüggermann A. and T. Linne (2002)** "Are the Central and Eastern European transition countries still vulnerable to a financial crisis? Results from the signals approach", *BOFIT Discussion Paper* No. 5, Bank of Finland Institute for Economies in Transition (BOFIT).

**Bussiere, M. and M. Fratzscher (2006) "**Towards a New Early Warning System of Financial Crises", Journal of International Money and Finance, 25, 953-973.

**Candelon, B. Dumitrescu, E. I. and C. Hurlin (2012):** "How to evaluate an Early Warning System? Towards a Unified Statistical Framework for Assessing Financial Crises Forecasting Methods", IMF Economic Review, 60, 75–113

**Demirgüc-Kunt, A. and E. Detragiache (2000)** "Monitoring Banking Sector Fragility: A Multivariate Logit Approach", World Bank Economic Review, 14, 287-307.

**European Central Bank (2013)** "The 2013 Macroeconomic Imbalance Procedure", Monthly Bulletin, May 2013

**European Central Bank (2014)** "The determinants of euro area sovereign bond yield spreads during the crisis", Monthly Bulletin, May.

**European Commission (2011) "**Public Finances in EMU 2011" *European Economy* 3/2011.

**European Commission (2012a)** "Fiscal Sustainability Report 2012" *European Economy,* No. 8/2012.

**European Commission (2012b)** "Scoreboard for the surveillance of macroeconomic imbalances" *European Economy Occasional Paper* No. 92.

**European Commission (2014)** "Alert Mechanism Report".

**Fratzscher, M., A. Mehl and I. Vansteenkiste (2011)** "130 Years of Fiscal Vulnerabilities and Currency Crashes in Advanced Economies", IMF Economic Review, 59(4), 683-716.

**Hemming R., M. Kell, and A. Schimmelpfennig (2003) "**Fiscal vulnerability and financial crises in emerging market economies" *IMF Occational Paper* 218.

**Kaminsky, G.L. and C.M. Reinhart (1999)** "The twin crises: the causes of banking and balance-of-payments problems", *American Economic Review,* 89(3), 473-500.

**Kaminsky, G.L., S. Lizondo and C.M. Reinhart (1998)** "Leading indicators of currency crises", *IMF Staff Papers*45, No. 1.

**Kumar, M. U. Moorthy and W. Perraudin (2003)** "Predicting Emerging Market Currency Crashes", Journal of Empirical Finance, 10, 427-454.

**Lo Duca, M. and T. Peltonen** (2013) "Assessing systemic risks and predicting systemic events", Journal of Banking & Finance, 37, 2183–2195.

**Manasse, P., N. Roubini, and A. Schimmelpfennig (2003)** "Predicting sovereign debt crises", *IMF Working Paper* 03/221.

**Mulder, C., R. Perrelli and M. Rocha (2002)** "The role of corporate, legal and macroeconomic balance sheet indicators in crisis detection and prevention", *IMF Working Paper* 02/59.
**Polito, V. and M. Wickens (2014**): "Sovereign credit ratings in the European Union: a model-based fiscal analysis", mimeo.
**Reinhart, C. M. (2010)** "This Time is Different Chartbook: Country Histories on Debt, Default, and Financial Crises", NBER Working Paper No. 1581**.**
**Sturzenegger, F. and J. Zettelmeyer (2007)** "Debt Defaults and Lessons from a Decade of Crises", MIT Press.