EARLY WARNING INDICATORS FOR FISCAL STRESS IN EUROPEAN BUDGETARY SURVEILLANCE

The euro area sovereign debt crisis has resulted in exceptionally large economic costs. One of the key lessons from it is therefore that crisis prevention should be strengthened to avoid the build-up of huge macroeconomic, fiscal and financial imbalances in the first place. In order to work effectively, crisis prevention requires reliable and timely indicators for any risks to fiscal stability that may emerge. This has created a strong interest in early warning systems. With respect to public finances, early warnings are required, especially for "fiscal stress", which can be defined as the short-term risk of facing a sovereign liquidity crisis. As such risks to fiscal sustainability can result directly from fiscal, but also indirectly from macroeconomic or financial, imbalances and their interaction, early warning indicators that have recently been developed aim to extract signals for fiscal stress from a broad range of fiscal and non-fiscal variables. This article reviews recent advances in integrating early warning indicators into the European system of budgetary surveillance, as well as proposing further improvements to these indicators.

I   INTRODUCTION

The sovereign debt crisis has demonstrated that fiscal sustainability concerns can become virulent not only in the long run, but also in the short run. In the medium to long term, the assessment of a government's solvency is crucial. Solvency requires a government's intertemporal budget constraint to be fulfilled, meaning that the net present value of its future primary balances must be at least as high as that of outstanding government debt. This can be assessed by debt sustainability analyses, for example. However, governments can encounter the risk of a liquidity crisis even if they are not experiencing any solvency problems. Such liquidity risks imply that a government is having difficulty accessing financial markets in order to service all its forthcoming obligations in the short term. Against this background, fiscal stress can be defined as the short-term risk of facing a sovereign liquidity crisis, which is characterised by severe sovereign funding difficulties.[1]

The fiscal stress episodes in the context of the sovereign debt crisis have created an interest in early warning systems, partly because government bond yields and sovereign spreads largely failed to signal the impending crisis early on.[2] The main aim of such early warning indicators is to provide reliable and timely signs of any risks to fiscal stability that may emerge. Ideally, they can be used to identify a need for policy action in order to prevent the occurrence of fiscal stress in the first place.

In reaction to the lessons of the debt crisis, the European Commission has introduced an early warning indicator for short-term risks to fiscal sustainability in the European system of fiscal surveillance (the so-called S0 indicator).[3]

This article discusses concepts of early warning indicators for fiscal stress, reviews the application of such early warning indicators in the European system of fiscal surveillance and proposes avenues for further improvements to these indicators.

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1   Aside from early warning indicators, short-term risks to fiscal sustainability can also be monitored by short-term refinancing needs. See the article entitled "Analysing government debt sustainability in the euro area", *Monthly Bulletin*, ECB, April 2012.

2   For more information on the development of sovereign bond spreads ahead of and during the crisis, see the article entitled "The determinants of euro area sovereign bond yield spreads during the crisis", *Monthly Bulletin*, ECB, May 2014.

3   Information on the S0 indicator is contained in the European Commission's "Fiscal Sustainability Report 2012", *European Economy*, No 8/2012, 2012. The indicator is described in detail in Berti, K., Salto, M. and Lequien, M., "An early-detection index of fiscal stress for EU countries", *European Economy – Economic Papers*, No 475, Brussels, 2012.

The article is structured as follows: Section 2 sets out the general approach of early warning systems based on the signalling approach, including the definition of fiscal stress and the selection of the potential determinants of fiscal stress. Section 3 discusses the design and performance of early warning indicators for fiscal stress that are applied in the European budgetary surveillance framework and proposes further enhancements. Section 4 concludes, drawing particular attention to the limitations of early warning systems for fiscal stress.

2 EARLY WARNING SYSTEMS FOR FISCAL STRESS BASED ON THE SIGNALLING APPROACH

This section starts with a short characterisation of the concept of early warning systems based on the signalling approach, before going through its main elements and their implementation, and then examining the advantages and disadvantages of the approach in more detail.

EARLY WARNING SYSTEMS BASED ON THE SIGNALLING APPROACH

The basic concepts for early warning indicators have been developed mainly for emerging countries in studies of "twin" crises affecting the currency and financial markets. In the context of these studies, a so-called signalling approach has been developed.[4] This approach has also been applied in the context of the recent fiscal crises and is the standard approach for setting up early warning systems for country surveillance.[5] The signalling approach employs historical data from crisis episodes to identify early warning indicators with leading properties to flag any impending crisis. Setting up a system of early warning indicators for fiscal stress based on the signalling approach basically consists of four steps: first, the criteria for identifying episodes of fiscal stress in the past need to be defined. In the second step, a set of variables needs to be selected as potential "leading indicators" for fiscal stress, and a "signalling window" has to be defined. This signalling window determines how far in advance the early warning system can signal fiscal stress. Most approaches choose a signalling window of one year. This means that a signal sent by an indicator in any given year indicates whether fiscal stress is to be expected in the following year.[6] In the third step, critical thresholds for each of the leading indicators are calculated on the basis of historical data for the leading indicators and on past episodes of fiscal stress. Calculating these critical thresholds is at the core of the signalling approach, as they determine whether a variable sends a crisis signal or not. In the fourth step, the different leading indicators are aggregated into composite indices for signalling fiscal stress, which can be used for policy surveillance. The implementation of these four steps for an early warning system for fiscal stress is discussed below.

4   Seminal contributions were made by Kaminsky, G.L. and Reinhart, C.M., "The twin crises: the causes of banking and balance-of-payments problems", *American Economic Review*, Vol. 89, No 3, 1999, pp. 473-500, and Kaminsky, G.L., Lizondo, S. and Reinhart, C.M., "Leading indicators of currency crises", *IMF Staff Papers*, Vol. 45, No 1, 1998. A discussion of the approach and its alternatives can be found in Berg, A. and Pattillo, C., "Predicting currency crises: the indicators approach and an alternative", *Journal of International Money and Finance*, Vol. 18, pp. 561-586, and in Candelon, B. Dumitrescu, E. I. and Hurlin, C., "How to evaluate an Early Warning System? Towards a Unified Statistical Framework for Assessing Financial Crises Forecasting Methods", *IMF Economic Review*, Vol. 60, 2012, pp. 75-113.
5   It is applied, for example, in recent studies by the European Commission (see Berti, K., Salto, M. and Lequien, M., "An early-detection index of fiscal stress for EU countries", *European Economy – Economic Papers*, No 475, Brussels, 2012) and the IMF (see Baldacci, E., Petrova, I., Belhocine, N., Dobrescu, G. and Mazraani, S., "Assessing fiscal stress", *IMF Working Paper*, No 11/100, 2011). A second important approach in the field which is not discussed in this article concerns multivariate regressions based on probit or logit models. Such models are applied, for example, in Berg, A. and Pattillo, C., "Predicting currency crises: the indicators approach and an alternative", *Journal of International Money and Finance*, Vol. 18, 1999, pp. 561-586, and in Bussiere, M. and Fratzscher, M., "Towards a New Early Warning System of Financial Crises", *Journal of International Money and Finance*, Vol. 25, 2006, pp. 953-973.
6   As annual data on fiscal and macroeconomic variables are only provided with a time lag, the time between sending a signal and the expected occurrence of fiscal stress might even be shorter than one year in this case.

DEFINING AND IDENTIFYING EPISODES OF FISCAL STRESS

Fiscal stress can be defined as short-term risks to fiscal sustainability which are characterised by a period of extreme funding difficulties.[7] A number of different criteria can be employed to firmly identify such extreme funding difficulties. In the most severe cases, episodes of fiscal stress are characterised by a public default or debt restructuring.[8] However, episodes of fiscal stress are not restricted to default events, as countries under fiscal stress can apply for official financial support. This support may, for example, be granted in the form of an IMF or, for euro area countries, a European Stability Mechanism (ESM) support programme.[9] Recourse to exceptional official financing can therefore also serve as a criterion for identifying fiscal stress. Defining fiscal stress based on these criteria alone carries the risk of missing relevant episodes in which extreme funding difficulties occur, even though market access may still be maintained. Such periods may be identified as fiscal stress by a sharp deterioration in market access, which would be reflected in extraordinarily high sovereign yield spreads.[10] These three criteria (defaults, recourse to exceptional official financing and a high level of spreads) form the standard definition of fiscal stress used in most recent contributions.

POSSIBLE DETERMINANTS OF FISCAL STRESS

Fiscal stress can be caused by a broad range of different factors. One scenario is that unsound fiscal policies are followed, resulting in high deficit and debt ratios, which pose a risk to fiscal sustainability and are thereby directly responsible for triggering fiscal stress. However, unsound fiscal policies are not necessarily a precondition for fiscal stress. Funding difficulties could also result from large adverse macroeconomic shocks, which increase fiscal deficits, for example via the working of automatic stabilisers, and push up the debt ratio directly via the denominator effect.

As demonstrated during the crisis, private sector imbalances can also exacerbate fiscal imbalances. For example, fiscal imbalances can be aggravated by large and persistent current account deficits, which often result from a loss in competitiveness.[11] The economic adjustment processes that are required, typically when growth is low, can then trigger a deterioration in the public finances in that tax revenues fall and spending needs intensify.

As well as these factors, there are important interactions between the financial, fiscal and real sectors which can also create vulnerabilities for fiscal stress.[12] In the case of a financial crisis, which could follow the bursting of a housing bubble in an economy with high private sector leverage, for example, government measures to support the financial sector may contribute to a strong deterioration in the public finances. This may lead to a fall in government bond prices, which would, in turn, weigh heavily on banks' balance sheets and may also reduce the credit supply,

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7   This definition is proposed by Baldacci E., Petrova, I., Belhocine, N., Dobrescu, G. and Mazraani, S., "Assessing fiscal stress", *IMF Working Paper 11/100*, 2011, and also applied by Berti, K., Salto, M. and Lequien, M., "An early-detection index of fiscal stress for EU countries", *European Economy – Economic Papers*, No 475, Brussels, 2012.

8   For details, see Hemming, R., Kell, M. and Schimmelpfennig, A., "Fiscal vulnerability and financial crises in emerging market economies", *IMF Occasional Paper*, No 218, 2003, and Manasse, P., Roubini, N. and Schimmelpfennig, A., "Predicting sovereign debt crises", *IMF Working Paper 03/221*, 2003. Sovereign defaults can either be outright or implicit. Implicit default could result from an exceptionally high inflation rate. According to the literature, the critical level for the inflation rate should reflect an implicit default in advanced economies at an annual inflation rate of 35%. See Sturzenegger, F. and Zettelmeyer, J., *Debt Defaults and Lessons from a Decade of Crises*, MIT Press, 2007.

9   See the article entitled "The European Stability Mechanism", *Monthly Bulletin*, ECB, July 2011.

10 Such a sharp deterioration in market access conditions is usually reflected in yield spreads two standard deviations or more above the country-specific mean. Under the assumption that the yield spreads are distributed normally, this would mean that only the highest 2.5 % of the spreads included in the sample identify a crisis event.

11 Under the reinforced European governance framework, these imbalances are also monitored under the macroeconomic imbalance procedure. See the boxes entitled "The 2013 Macroeconomic Imbalance Procedure", *Monthly Bulletin*, ECB, May 2013, and "Key challenges for the surveillance of economic and fiscal policies under the 2014 European Semester", *Monthly Bulletin*, ECB, March 2014.

12 See the article entitled "Monetary and fiscal policy interactions in a monetary union", *Monthly Bulletin*, ECB, July 2012.

thereby creating an adverse feedback loop between sovereign bond markets, the real economy and the financial sector. A similar adverse feedback loop could also be triggered if the sovereign exposure of banks is high. A collapse in government bond prices resulting from concerns about fiscal sustainability based on unsound fiscal policies may easily spark a banking crisis.

Taken together, an early warning system for fiscal stress should therefore include not only fiscal, but also macroeconomic and financial variables. Ideally, the interdependencies between the different variables should be taken into account to address the risk of adverse feedback loops.

CALCULATING CRITICAL THRESHOLDS FOR EARLY WARNING INDICATORS

The identification of critical thresholds for different indicator variables forms the core of the signalling approach. These thresholds determine whether the indicator variables send a crisis signal or not. Ideally, the early warning indicators only send a crisis signal if a crisis actually occurs (true positive signal), otherwise no crisis signal should be sent (true negative signal). In practice, however, such a perfect early warning indicator for fiscal stress is difficult to define, such that wrong predictions cannot be ruled out. In general, two different types of wrong prediction are possible. First, it may be that an early warning indicator does not send a crisis signal, but a crisis then occurs. This prediction error can be called a "missed crisis".[13] Alternatively, the indicator could signal a crisis, but no crisis occurs. This means the indicator sends a "false alarm".[14]

The likelihood of missing crises and sending false alarms depends on the threshold value of the leading indicators. For example, if the threshold for an indicator variable such as the government debt ratio is set very low, it is very likely that false alarms will be sent, as the indicator variable will all too often indicate fiscal stress. On the other hand, setting the threshold very high increases the probability of missing crises. Determining the critical thresholds is therefore a balancing act between minimising the number of false alarms and the number of missed crises. One prominent way of conducting this balancing act is to just minimise – on the basis of historical data – the sum of the errors resulting from missed crises and false alarms.[15] This can be done by maximising the so-called signalling power, which is the estimated ability of the variable to send correct signals. The signalling power can be calculated by subtracting the ratio of false alarms over no-crisis episodes and the ratio of missed crises over crisis episodes from unity. This signalling power therefore takes the value of 1 if no crises are missed and no false alarms are sent, and decreases with the share of wrong predictions in the form of missed crises and false alarms.

AGGREGATING INDIVIDUAL INDICATORS TO COMPOSITE EARLY WARNING INDICES

To make it easier to monitor the risks of fiscal stress, the signals of the individual variables can be aggregated to composite early warning indices. These indices can comprise all variables or just sub-groups. The starting point for this aggregation is to distinguish whether the individual indicator signals a crisis for a given year or not. To maximise the predictive power of the overall index, the aggregation of the signals should then take into account the reliability of the signal of the individual indicator and that of all the indicators signalling a crisis in a given year compared with the reliability of all variables in the system. For the aggregation, the individual value of the indicator is therefore set to 1 for the years in which it signals a crisis and to 0 for all other years. These signals (1 or 0) are then multiplied by the signalling power of the respective indicator. This multiplication

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13 In the literature, this is called a "type II error".
14 In the literature, this is called a "type I error".
15 In recent contributions, the most common way of doing this has been to minimise the total misspecification error (TME), which is defined as the sum of the ratio of false alarms to no-crisis episodes and the ratio of missed crises to crisis episodes. An alternative way is to maximise the signal-to-noise ratio, which is based on the sum of true over that of false signals. The advantage of the TME compared with the signal-to-noise ratio is that it assigns a higher weighting to "missed crisis" signals, which are likely to be far costlier than false alarms.

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ensures that variables with small prediction errors (implying a low relative number of missed crisis and false alarms) receive a higher weighting than indicators with large prediction errors. The results of the multiplication of signals by signalling power are then added together to make up the composite indicator. Finally, the result is divided by the sum of the signalling power of all variables included in the index, which accounts for the relative reliability of the indicators compared with that of all variables together. This final step also ensures that the value of the composite indicator always remains between 0 (if no variable sends a crisis signal) and 1 (if all variables indicate a crisis simultaneously). The values of the aggregate index will be higher, the larger the number of variables that are signalling a crisis and the higher the predictive power of these variables.

Once the values of the aggregate indices are calculated, critical thresholds need to be determined in order to identify whether an index value signals a crisis or not. To this end, the approach described above can be applied to the index in the same way as to the individual variables.

STRENGTHS AND WEAKNESSES OF THE SIGNALLING APPROACH FOR CALCULATING EARLY WARNING INDICES

The signalling approach for setting up an early warning system for fiscal stress has significant advantages. First, it can integrate a large number of variables. This is an important feature, as fiscal stress can result from a broad variety of factors. Second, the estimation of critical thresholds can take all available historical data into account, even when the individual data series cover very different sample periods. This is important because there are significant differences across variables in terms of data availability. Third, the economic literature suggests that early warning systems based on the signalling approach have a higher predictive power than those based on alternative approaches.[16] Finally, another major advantage is that the signalling approach allows for a relatively easy implementation of an early warning system, as the critical thresholds derived for the indicator variables can be used for policy surveillance and analysis directly.

While these strengths can help to explain the popularity of the signalling approach for setting up early warning indicators for fiscal stress, the weaknesses of the approach should not be ignored. One key disadvantage of the signalling approach is that interdependencies and interactions between the variables cannot be taken into account, although these interdependencies are likely to play an important role in the development of fiscal stress.

3   EARLY WARNING INDICATORS FOR FISCAL STRESS IN EUROPEAN BUDGETARY SURVEILLANCE

One experience of the recent crisis is that fiscal and macroeconomic risks can also materialise in the short term. This has also prompted the implementation of early warning indicators in the European fiscal and macroeconomic governance framework. The macroeconomic imbalance procedure, for example, which was introduced as part of the so-called six-pack reform[17], includes a scoreboard of early warning indicators as a means to identify any need for in-depth analyses of macroeconomic imbalances.[18] In the fiscal sphere, the European Commission has established the S0 indicator for

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16   This holds especially for out-of-sample forecasts. The predictive power of approaches based on the signalling approach and of alternative multivariate probit models is evaluated and compared in Berg, A. and Pattillo, C. "Predicting currency crises: the indicators approach and an alternative", *Journal of International Money and Finance*, No 18, 1999, pp. 561-586, and Berg, A., Borensztein, E. and Pattillo, C., "Assessing early warning systems: how have they worked in practice?", *IMF Working Paper 04/52*, 2004. With respect to in-sample forecasts, probit models seem to work better. 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 are an argument in favour of relying on signalling approaches for early warning systems.

17   See the box entitled "The stronger EU economic governance framework comes into force", *Monthly Bulletin*, ECB, December 2011.

18   For details, see "Alert Mechanism Report", European Commission, 2014.

fiscal stress[19]. This allows the analysis of risks to fiscal sustainability, which originally focused only on the medium and long-term perspective, to be expanded to include the short-term perspective as well.[20] The concept of the S0 indicator is presented in the next part. This is followed by an evaluation of its performance, including an illustration of how the S0 could have helped to signal fiscal stress before the recent sovereign debt crisis.

THE S0 INDICATOR

The S0 indicator is based on the signalling approach discussed in Section 2 and employs the standard definition of fiscal stress. Accordingly, fiscal stress is identified on the basis of defaults or debt restructuring, recourse to exceptional official financing and strong deteriorations in the financing conditions of governments.[21] The signalling window of the S0 is set to one year. As fiscal stress can be triggered by a broad variety of factors, the indicator is based on 28 fiscal, macroeconomic, financial and competitiveness variables. In particular, many of the variables of the scoreboard for the surveillance of macroeconomic imbalances are included. Critical thresholds are provided for all 28 indicator variables and for an overall index (the S0 indicator), as well as a fiscal and a non-fiscal (financial/competitiveness) sub-index. Overall risks for fiscal stress can therefore be assessed by looking at the S0 indicator, while the sub-indices indicate whether risks are emanating from the fiscal side or the financial/competitiveness side. The sources of risks for fiscal stress can be identified even more precisely by analysing the individual variables and the values they take relative to their critical thresholds.

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19 The S0 indicator is part of the European Commission's fiscal sustainability analysis framework, which was explained in the "Fiscal Sustainability Report 2012", *European Economy*, No. 8/2012, European Commission (see also Berti, Salto and Lequien, 2012, for further details on S0). Values of the S0 indicator by country are regularly reported (together with the medium and long-term fiscal sustainability gap indicators S1 and S2) in the European Commission's staff working documents accompanying the recommendations for country-specific recommendations in the context of the European Semester (the EU's integrated cycle of economic policy coordination).

20 The S0 indicator complements the existing fiscal sustainability indicators of the European Commission, S1 and S2, which analyse medium and long-term fiscal risks by defining fiscal gaps, taking consolidation needs and the projected costs of ageing into account. The methodology for the S0 indicator is fundamentally different from that for the S1 and S2 indicators, as it does not assess "fiscal gaps", but risks of "fiscal stress" in the short term. For details, see "Fiscal Sustainability Report 2012", *European Economy*, No. 8/2012.

21 Only the first year of a crisis episode is used when calculating the critical thresholds of the indicator variables, as the early warning indicator should focus on signalling the start of a crisis.

Box 1

PREDICTIVE POWER OF THE S0 INDICATOR AND ITS COMPONENTS

The predictions of the S0 indicator and its individual variables are based on critical thresholds that determine whether a crisis signal is sent. Calculation of the critical thresholds for all 28 variables and the composite early warning indices is therefore at the core of the S0 indicator.

Table 1 (based on calculations by the European Commission in spring 2014) maps the critical threshold values for all the individual variables and indicates whether the values above or below the threshold are critical. It also reports the signalling power for each indicator, which is calculated by subtracting from unity the ratio of false alarms over no-crisis periods and the ratio of missed crises over crisis episodes. In addition to the results for individual variables, the table also shows the respective values for the fiscal sub-index (consisting of 14 fiscal variables), the financial/competitiveness sub-index (derived from 14 macroeconomic, competitiveness and financial variables) and the overall S0 indicator for fiscal stress (derived from all 28 variables).

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Signalling power of the S0 indicator and its components

Variables	Threshold	Values that are uncritical (>/< means above/ below threshold)	Signalling power	Ratio of false alarms over no-crisis episodes (type I error)	Ratio of missed crises over crisis episodes (type II error)
Budget balance, % GDP	-10.2	>	0.07	0.04	0.89
Primary balance, % GDP	0.0	>	0.17	0.40	0.43
Cyclically adjusted balance, % GDP	-3.1	>	0.25	0.45	0.30
Debt stabilising primary balance, % GDP	2.5	<	0.02	0.12	0.86
Gross debt, % GDP	103.3	<	0.03	0.06	0.91
Change in gross debt, % GDP	6.5	<	0.11	0.08	0.81
Short-term government debt % GDP	16.0	<	0.10	0.11	0.79
Net government debt, % GDP	58.1	<	0.13	0.19	0.68
Gross financing needs, % GDP	16.8	<	0.16	0.21	0.63
Interest rate-growth rate differential	5.9	<	0.08	0.07	0.85
Change in expenditure of general government, % GDP	2.3	<	0.14	0.13	0.74
Change in final consumption expenditure of general government, % GDP	0.6	<	0.17	0.19	0.64
Old-age dependency ratio 20 years ahead	33.9	<	0.10	0.11	0.79
Average yearly change in projected age-related public expenditure as % of GDP over next 5 years	0.3	<	0.09	0.14	0.77
Fiscal sub-index	**0.35**	**<**	**0.23**	**0.21**	**0.56**
Net international investment position, % GDP	-50.1	>	0.31	0.13	0.56
Net savings of households, % GDP	1.0	>	0.34	0.26	0.40
Private sector debt, % GDP	209.2	<	0.25	0.04	0.71
Private sector credit flow (amount of private liabilities incurred along the year), % GDP	10.9	<	0.44	0.42	0.14
Leverage, financial corporations	2.2	<	0.03	0.97	0.00
Short-term debt, non-financial corporations, % GDP	27.4	<	0.25	0.21	0.54
Short-term debt, households, % GDP	3.5	<	0.27	0.34	0.38
Construction value added, %	7.3	<	0.27	0.36	0.38
Current account, three-year backward moving average, % GDP	-2.5	>	0.38	0.37	0.25
Change (three years) of real effective exchange rate (based on exports deflator)	9.8	<	0.23	0.19	0.59
Change (three years) in nominal unit labour costs	12.7	<	0.27	0.48	0.25
Yield curve (nominal long-term minus nominal short-term interest rates)	0.6	>	0.48	0.39	0.14
Real GDP growth	-0.9	>	0.10	0.07	0.83
GDP per capita in purchasing power parities, % of US level	73.3	>	0.28	0.44	0.27
Financial/competitiveness sub-index	**0.45**	**<**	**0.48**	**0.34**	**0.18**
Overall index (S0 indicator)	**0.43**	**<**	**0.55**	**0.21**	**0.25**

Source: European Commission; spring 2014.

The underlying dataset used to determine the critical thresholds and the signalling power for each variable consists of ex-post data and covers 33 advanced economies[1] from 1970-2013 on the basis of annual frequency.

The table shows that the signalling power of the different variables varies substantially. In the case of the cyclically adjusted balance, for example, the threshold value shows that a cyclically adjusted balance below -3.1% of GDP indicates fiscal stress. Around two-thirds of the crisis included in the sample for which data on the cyclically adjusted balance are available would have been indicated correctly by the cyclically adjusted balance. However, it would also have sent a false alarm in 45% of the no-crisis episodes. Taken together, this leads to a signalling power of 0.25.

1 All EU Member States except Cyprus, Luxembourg and Malta, plus Australia, Canada, Iceland, Israel Japan, New Zealand, Norway, Switzerland and the United States.
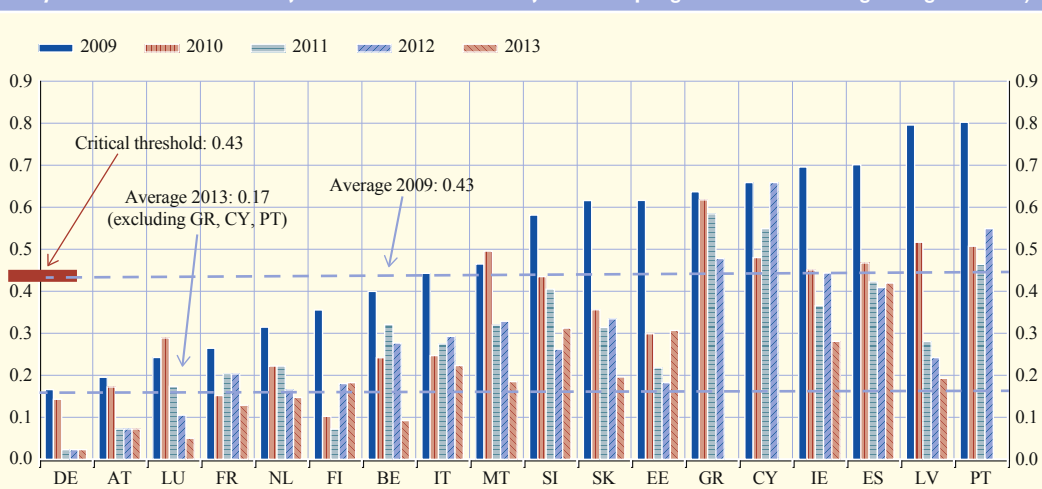
For the financial/competitiveness sub-index, a critical threshold of 0.45 is derived. As the index values represent an aggregation of all the 14 financial/competitiveness variables included, their level has no further economic interpretation – in contrast to the thresholds of the single variables – except that all values in this sub-index above 0.45 signal fiscal stress. As the table shows, the financial/competitiveness index would have missed only 18% of the crises. Overall, the financial/competitiveness variables perform significantly better in predicting fiscal stress than the fiscal variables,[2] and the reliability of the signals of the financial/competitiveness sub-index is therefore higher than that of the fiscal sub-index.

The highest signalling power among the financial/competitiveness variables is found for the yield curve, followed by the private sector credit flow and the current account. Among fiscal variables, the cyclically adjusted balance sends the most reliable signals, followed by the primary balance and the change in government consumption.

2   This is also highlighted in Berti, K., Salto, M. and Lequien, M., "An early-detection index of fiscal stress for EU countries", *European Economy – Economic Papers*, No 475, European Commission, Brussels, 2012.

Chart 1 reflects an application of the S0 indicator for the years 2009-13 for the euro area countries which were not under an adjustment programme at the beginning of 2014. [22] In 2009 the unweighted average of the indicator equalled 0.43 – exactly at the critical threshold. The 2009 values of the indicator signalled a risk of fiscal stress in 11 euro area countries (Italy, Malta, Slovenia, Slovakia, Estonia, Greece, Cyprus, Ireland, Spain, Latvia and Portugal) in 2010, with the risks being highest in Portugal. By 2013 the unweighted average value of the index in the euro area (excluding Greece, Cyprus and Portugal) had fallen to 0.17, indicating that fiscal vulnerability in the euro area was much lower. The overall reduction in the average vulnerability is also reflected in most countries individually. Based on data for 2013, the S0 sees Germany as having the lowest risk of fiscal stress

Chart 1 S0 indicator for fiscal stress in euro area countries 2009-2013 (2013 values included only for countries not subject to an economic adjustment programme at the beginning of 2014)

Source: European Commission; spring 2014.

22   Values of the S0 indicator by country are also reported (for non-programme countries) in the European Commission's staff working documents, which are available online at http://ec.europa.eu/europe2020/making-it-happen/country-specific-recommendations/index_ en.htm.

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in 2014. Of the euro area countries for which the 2013 values of the S0 indicator are reported in Chart 1, none appear to be at risk of fiscal stress in 2014.

EARLY INDICATION OF FISCAL STRESS BY THE S0
The goal of an early warning indicator for fiscal stress is to correctly signal the build-up of short-term risks to fiscal sustainability. The overall reliability of its crisis signals is therefore crucial for the performance of the S0 as an early warning indicator (for a detailed analysis of the predictive power of the S0 indicator and its components, see Box 1). As the last line of Table 1 in Box 1 indicates, the S0 would have accurately predicted 75% of the crisis episodes and 79% of the no-crisis episodes. This implies that it would have missed 25% of the crisis episodes and sent false alarms in 21% of the no-crisis episodes included in the dataset. Comparing the overall S0 indicator with the fiscal sub-index based only on fiscal variables shows that, on the basis of the fiscal index alone, a lot more crisis episodes would have been missed (56% instead of 25%). The fiscal sub-index alone would have signalled only 44% of the crisis episodes correctly.

However, all these results need to be interpreted cautiously. First, the critical thresholds that are applied to evaluate the predictive power of the individual variables and the overall index were derived from data from 1970-2013. This means that the prediction of fiscal stress that was made in 2009 relied on information for calculating the critical thresholds that also included the years 2009-13. Consequently, the results presented reflect an "in-sample" early warning exercise, which could be interpreted as an upper bound on the forecasting ability of the S0 indicator. In this respect, further detailed analyses on the predictive capabilities of the indicator, including beyond the time period used to calculate the critical thresholds (so-called out-of-sample forecasts), seem to be warranted in order to better evaluate the predictive power of the indicator (see also the discussion in Box 2). Second, the results are derived from ex-post data, whereas, in practice, an early warning system needs to rely on real-time data, which may be subject to substantial ex-post revisions. Assessed in real time, the reliability of the crisis signals might therefore have been somewhat lower than indicated.

Taken together, the overall results nonetheless demonstrate that the S0 indicator provides important information for impending fiscal stress. The fact that the S0 index performed significantly better than the fiscal sub-index in itself supports the approach of not relying solely on fiscal variables in an early warning system for fiscal stress. There is therefore a strong case for including the S0 in country surveillance. Considering the fact that the number of missed crises and false alarms is still high, however, the results of the S0 also need to be interpreted carefully. In any case, as with any other mechanical analysis, the broader country-specific contexts need to be taken into account when interpreting the results of the S0 indicator. [23]
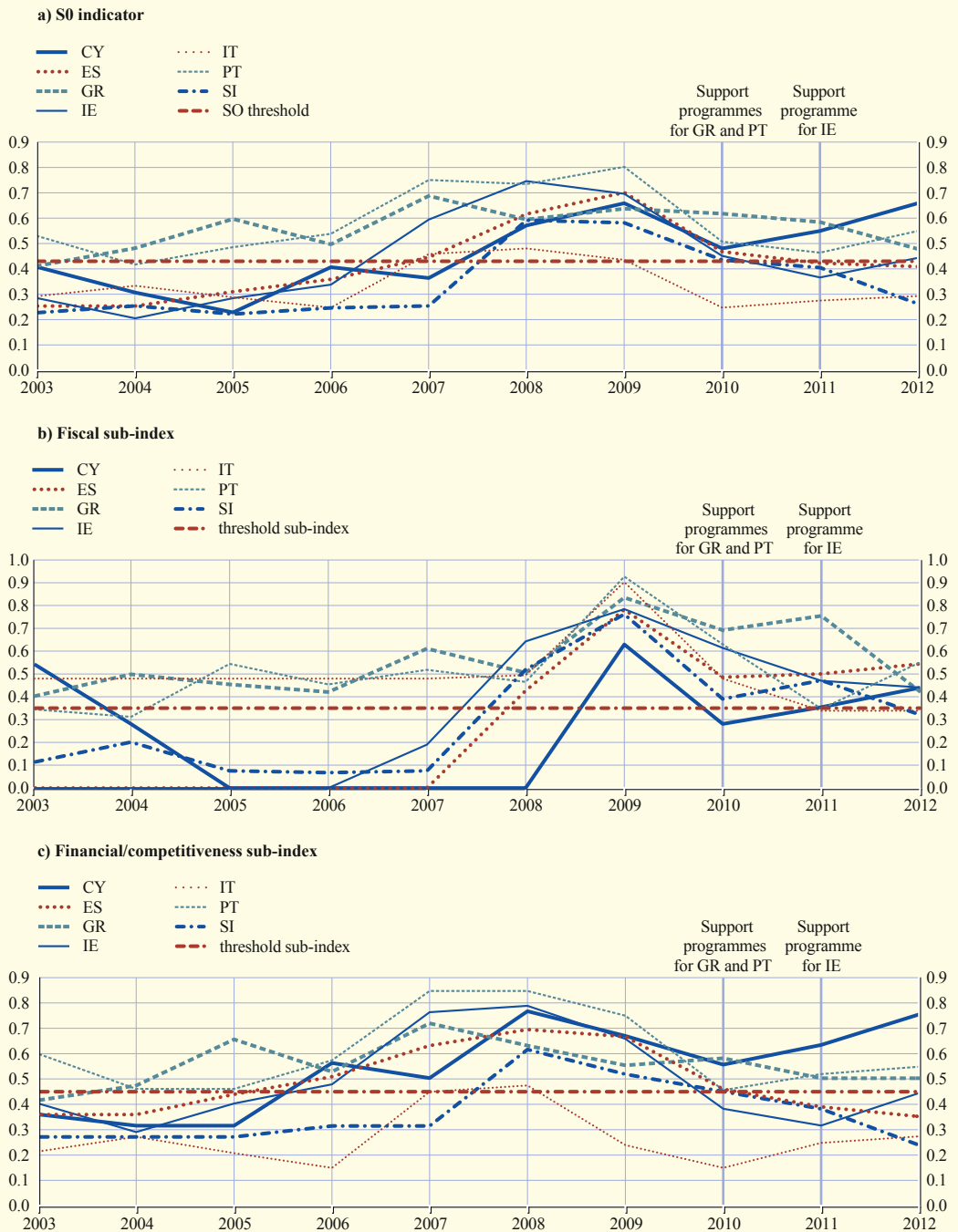
THE S0 INDICATOR AND THE BUILD-UP OF FISCAL STRESS BEFORE THE SOVEREIGN DEBT CRISIS
The introduction of the S0 in European budgetary surveillance has, in particular, been prompted by experiences in the recent crisis. This raises the question as to how well the S0 indicator would have predicted impending fiscal stress in crisis countries in the past. Would the build-up of fiscal stress – which culminated in the application of Greece, Ireland, Portugal and Cyprus for international financial support in 2010-2012 – have been indicated by the S0 well in advance?

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23 This is explicitly acknowledged by the European Commission in its "Fiscal Sustainability Report 2012", *European Economy*, No 8/2012, 2012, p. 24.

Chart 2 Signalling imbalances ahead of the crisis

(y-axis: index value)

a) S0 indicator

Legend:
- CY
- ES
- GR
- IE
- IT
- PT
- SI
- SO threshold

Support programmes for GR and PT

Support programme for IE

b) Fiscal sub-index

Legend:
- CY
- ES
- GR
- IE
- IT
- PT
- SI
- threshold sub-index

Support programmes for GR and PT

Support programme for IE

c) Financial/competitiveness sub-index

Legend:
- CY
- ES
- GR
- IE
- IT
- PT
- SI
- threshold sub-index

Support programmes for GR and PT

Support programme for IE

Source: European Commission; spring 2014.

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Chart 2 shows the application of the S0 indicator, as well as the fiscal and financial/competitiveness sub-indices from 2003-12 for seven countries that experienced a high level of sovereign spreads in the recent crisis (Cyprus, Spain, Greece, Ireland, Italy, Portugal and Slovenia). The graphs show that the S0 would have had indicated a build-up of fiscal stress (based on ex-post data and critical thresholds that were derived from data from 1970-2013) in all seven countries by 2008. With respect to the programme countries, fiscal stress would have been signalled for Greece as early as 2004, Portugal in 2005, Ireland in 2007 and Cyprus in 2008 – well ahead of the funding difficulties that arose in 2010-11.[24]

Turning to the sub-indices, the signals first indicated fiscal stress resulting from fiscal policies in Greece as early as 2003. In Ireland, financial/competitiveness developments were signalling risks of fiscal stress as early as 2006, while fiscal policies did not give such signals until 2008. In Spain, the fiscal sub-index signalled stress only from 2008, while the non-fiscal sub-index indicated vulnerabilities as early as 2006.

The results of the S0 are promising with respect to budgetary surveillance. However, they need to be interpreted with caution, especially because they reflect only an in-sample early warning exercise and were derived from ex-post data realisations which had been revised substantially over time, especially in programme countries.[25]

POSSIBLE FURTHER IMPROVEMENTS TO EARLY WARNING INDICATORS FOR FISCAL STRESS

The usefulness of early warning indicators in fiscal surveillance depends on their ability to signal the development of fiscal stress correctly early on. How could the usefulness of indicators like the S0 be improved further in order to reduce incorrect signals and increase the signalling power? [26]

Most early warning systems that are based on the signalling approach rely on common threshold values for the indicator variables. These are derived uniformly for a large sample of countries. In the case of the S0, for example, the critical thresholds are calculated on the basis of data covering 33 advanced economies (see Box 1). Such an approach relies on the assumption that countries' vulnerability to fiscal stress is homogenous, as the critical levels beyond which the variables send a crisis signal are the same for all countries.

However, there are important arguments that these critical levels for the thresholds of the variables signalling fiscal stress may vary greatly across different countries, and that vulnerability to fiscal stress is country-specific. First, there is also strong country heterogeneity with respect to fiscal sustainability: the debt-to-GDP ratio as a leading indicator for fiscal sustainability in euro area countries in 2013 ranged from 10% of GDP in Estonia to 175% of GDP in Greece. Second, this heterogeneity matters for the thresholds of signalling variables. This can be illustrated with respect to budget balances, for example. While a high budget balance might affect the funding conditions

24 For more information on the development of sovereign bond spreads, which can be seen as an indicator for funding difficulties ahead of and during the crisis, see the article entitled "The determinants of euro area sovereign bond yield spreads during the crisis", *Monthly Bulletin*, ECB, May 2014.

25 Out-of-sample and real-time estimates are not available for the S0 indicator. Hernández des Cos et al. (2014) present evidence that a substantially lower signalling power of the indicator has to be expected in out-of-sample forecasts – see also Box 2 of this article.

26 Recent improvements for early warning indicators have been proposed, especially in research on financial stress. Holló et al. (2012), for example, propose a continuous composite indicator of systemic stress (CISS) for the euro area, which applies portfolio theory to the aggregation of individual stress indicators (covering both financial markets and intermediaries) in the composite index. See Holló, D., Kremer, M. and Lo Duca, M., "CISS – a composite indicator of systemic stress in the financial system", *Working Paper Series*, No 1426, ECB, 2012. Alessi and Detken (2011) have developed an approach that allows policy-makers' preferences to be integrated into an early warning system for asset price cycles. See Alessi, L. and Detken, C., "Quasi real time early warning indicators for costly asset price boom/ bust cycles. A role for global liquidity", *European Journal of Political Economy*, Vol. 27, No 3, 2011, pp. 520-533.

for a low-debt country only marginally, the critical level that could trigger fiscal stress for a high-debt country is likely to be far lower, as the remaining fiscal space is more limited. In addition, there is also a risk that common thresholds might heavily depend on the group of countries included, as the results can be driven by outliers.

As the critical thresholds of many of the signalling variables included are likely to depend on the country, early warning indicators for fiscal stress may be improved by calculating country-specific critical thresholds in order to account for cross-country differences.

There are advantages and disadvantages of both the common and country-specific approaches. A common threshold approach allows the data to be pooled across countries and increases the number of crisis observations when identifying thresholds, which should increase the reliability of the results. On the other hand, the common threshold approach does not take account of heterogeneity across countries in a sample. In contrast, a country-specific threshold approach can take full account of country heterogeneity, but has to rely on a lower number of crisis observations, which might have a negative effect on the reliability of the results. The choice of approach depends largely on the country heterogeneity of the data sample.

In a recent study, Hernández de Cos et al. (2014)[27] introduce country-specific thresholds in a signalling approach for fiscal stress. The analyses included in the study show that country-specific thresholds can indeed help to further reduce the likelihood of prediction errors (for details, see Box 2). This holds for in-sample and out-of-sample predictions. By introducing country-specific thresholds, the number of "missed crises" in particular is strongly reduced, which increases the possibility of signalling effectively and may prevent a fiscal crisis occurring at an early stage. The positive impact of introducing country-specific thresholds is most important for the predictive power of the fiscal variables, while the effect on the financial/competitiveness variables is more limited. This may be seen as an indication that country-specific thresholds play a particularly important role in the fiscal sphere.

27 Hernández de Cos, P., Koester, G. B., Moral-Benito, E. and Nickel, C., "Signalling fiscal stress in the euro area a country-specific early warning system", *Working Paper Series*, ECB, 2014.

COMMON VERSUS COUNTRY-SPECIFIC THRESHOLDS IN EARLY WARNING SYSTEMS FOR FISCAL STRESS

Most early warning systems that are based on the signalling approach ignore country heterogeneity and rely on common threshold values for the indicator variables, which are derived uniformly for a large sample of countries. However, as critical thresholds for the indicator variables might differ greatly across countries, Hernández de Cos et al. (2014)[1] suggested in a recent study that country-specific thresholds be integrated in a signalling approach.

This study applies the same definition of fiscal stress as the S0 indicator and uses a similar dataset, but was restricted to 11 euro area countries (Luxemburg had to be excluded from the dataset owing to data restrictions). To evaluate possible improvements in such an approach, the

1 Hernández de Cos, P., Koester, G. B., Moral-Benito, E. and Nickel, C., "Signalling fiscal stress in the euro area a country-specific early warning system", *Working Paper Series*, No 1712, ECB, 2014.

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Predictive power of the composite indices based on common and country-specific thresholds

| | In-sample | | | | | | Out-of-sample | | | | | |
| | Common threshold | | | Country-specific threshold | | | Common threshold | | | Country-specific threshold | | |
	Signalling power	Ratio of false alarms over no-crisis episodes (type I error)	Ratio of missed crises over crisis episodes (type II error)	Signalling power	Ratio of false alarms over no-crisis episodes (type I error)	Ratio of missed crises over crisis episodes (type II error)	Signalling power	Ratio of false alarms over no-crisis episodes (type I error)	Ratio of missed crises over crisis episodes (type II error)	Signalling power	Ratio of false alarms over no-crisis episodes (type I error)	Ratio of missed crises over crisis episodes (type II error)
	OVERALL INDEX						**OVERALL INDEX**					
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
	FISCAL INDEX						**FISCAL INDEX**					
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
	FINANCIAL/COMPETITIVENESS INDEX						**FINANCIAL/COMPETITIVENESS INDEX**					
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

Source: Hernández de Cos et al. (2014).

study estimates and compares the signalling power of two different early warning systems, one based on common thresholds and the other based on country-specific thresholds. The results are summarised in Table 2.

For the in-sample analysis, which evaluates the predictive power of the indices based on critical thresholds that take data up to 2010 into account, the table shows that the predictive power of the country-specific signalling approach is considerably higher than that of the common threshold approach – both for the overall index and the fiscal and financial/competitiveness sub-indices. At 0.56, the overall country-specific index has a signalling power of 95%, significantly higher than that of the common threshold approach. The number of missed crises, in particular, can be completely eliminated (meaning that no crises are missed), while it is as high as 0.20 using the common threshold approach applied by the S0 indicator, for example (meaning that 20% of crises are missed).[2]

The signalling power for both the fiscal and financial/competitiveness sub-indices is also high under the country-specific approach and relatively close to the performance of the overall index. Compared with the common threshold approach, the improvement of the signalling power is most striking with respect to the fiscal sub-index: here, the country-specific approach derives a signalling power of 0.88, compared with only 0.22 under the common threshold approach.[3] This could indicate that country heterogeneity plays an especially crucial role with respect to fiscal variables. With regard to the financial/competitiveness sub-index, the difference between the two approaches is also substantial, albeit somewhat less pronounced.

Out-of-sample estimates, which are derived in the study of Hernández de Cos et al. (2014) for the years 2000-10 from thresholds that are estimated using data from 1970-2000, find the

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2 The slight differences between the common threshold approach presented in this box and the European Commission results for the S0 indicator reported in Table 1 stem especially from the fact that the Commission employs a dataset from 1970-2013, while the study by Hernández de Cos et al. uses a dataset that only covers the years 1970-2010.
3 This result might help to explain why some studies (especially non-country-specific) in the literature fail to find an important role for fiscal variables as a signal for impending fiscal stress.

country-specific approach likewise has a major advantage over the common threshold approach. Here, the overall signalling power of the country-specific approach is 0.77, compared with a value of 0.42 for the common threshold approach.

These analyses therefore show that country-specific thresholds can indeed help to further reduce the likelihood of prediction errors in an early warning system based on the signalling approach. This can be achieved in particular by reducing the number of "missed crises".

4 CONCLUSION

Early warning indicators for fiscal stress can be important tools for budgetary surveillance in order to allow economic policy time to counteract adverse developments and to help prevent the occurrence of major crises in the first place.

In the European system of budgetary surveillance, such an early warning indicator for fiscal stress has recently been established in the form of the S0, which aims to predict the risk of fiscal stress with a forecast horizon of one year on the basis of fiscal, macroeconomic and financial variables. The S0 indicator closes a gap in the European fiscal sustainability analysis framework by capturing fiscal vulnerability in the short run, whereas the framework previously focused exclusively on the medium and long-term dimensions of fiscal sustainability.

It is of paramount importance for the usefulness of any early warning indicator in budgetary surveillance that it predicts the risk of fiscal stress correctly. The overall results discussed in this article demonstrate that the S0 indicator provides important information on impending fiscal stress, as evidenced by its ability to correctly signal a large majority of fiscal crises in the past – on the basis of in-sample analyses, at least. There is therefore a strong case for including the S0 in country surveillance. However, given the fact that there are still a large number of the missed crises and false alarms that typically characterise applications of the signals' approach relying on common thresholds over a pool of countries, the results of the S0 need to be interpreted carefully. In this respect, further detailed analyses on the predictive capabilities of the indicator, including beyond the time period used to calculate the critical thresholds (so-called out-of-sample forecasts) and based on real-time data, would be useful. In any case, a broad background of country-specific contexts should be taken into account when interpreting the results of the S0 indicator in fiscal surveillance.

While the introduction of the S0 has improved the "toolbox" of budgetary surveillance, there might still be room for further improvement. One avenue for such improvement could be a country-specific approach, which could help to take into account the fact that the critical levels for the thresholds of the variables signalling fiscal stress may vary strongly across countries. Such country-specific thresholds could especially help to reduce the number of missed crises.

While there is a strong case for the usefulness of such early warning indicators in general, several caveats need to be borne in mind. First, all predictions of early warning indicators are based on observations of historical crises, but future crisis events and their triggers might differ fundamentally from past crises. Second, the ex-post data employed in a system of early warning indicators are usually only available with a time lag and may be subject to revision. Data availability and quality can therefore greatly affect the signalling power of early warning indicators. Third, it should

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be noted that, even if impending fiscal crises are signalled correctly, there might not be enough time left to counteract the critical developments. Finally, it needs to be noted that an early warning system based on the signalling approach can only serve as an additional cross-check within a broader budgetary surveillance system. An early warning indicator is not, and cannot be, a substitute for strict and well-observed fiscal rules under the European governance framework.