ISSN 2443-8022 (online)

A Complementary Tool to Monitor Fiscal Stress in European Economies

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DISCUSSION PAPER 049 | JUNE 2017

EUROPEAN ECONOMY

Economic and Financial Affairs

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Authorised for publication by Lucio Pench, Director for Fiscal Policy and Policy Mix.

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Luxembourg: Publications Office of the European Union, 2017

KC-BD-17-049-EN-N (online)
ISBN 978-92-79-64889-2 (online)
doi:10.2765/963362 (online)

KC-BD-17-049-EN-C (print)
ISBN 978-92-79-64890-8 (print)
doi:10.2765/774719 (print)

European Commission
Directorate-General for Economic and Financial Affairs

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Abstract

This paper presents an indicator of fiscal distress for European economies based on a multivariate regression analysis (logit modelling, the L1 indicator) and on a recently updated dataset of fiscal stress episodes. This indicator presents some interesting features: relying on a parsimonious set of variables that have been tested for their conditional statistical significance, it exhibits an overall satisfactory in-sample performance. In line with Berti et al. (2012), this indicator confirms the importance of monitoring macro-financial variables to assess countries' vulnerabilities to fiscal distress. It also provides some evidence that the change in the public debt ratio is an important predictor of fiscal distress events, while the level of public debt would particularly matter when combined with macro-competitiveness imbalances. Our analysis suggests that the L1 indicator could be used as a complementary tool to the Commission S0 indicator to monitor prospective fiscal risks, building on the respective strengths of the two approaches, while compensating for their limitations.

JEL Classification: E62, E65, F34, H62, H63.

Keywords: fiscal stress, fiscal vulnerability, debt sustainability, macroeconomic imbalances.

Acknowledgements: We would like to thank Jean-Charles Bricongne, Matteo Salto and Per Eckefeldt for their useful comments and suggestions.

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1. INTRODUCTION

For a long period, fiscal sustainability analysis in the EU focused primarily on long term challenges, in particular those related to population ageing. ([1]) This changed with the euro area sovereign debt crisis in 2010-12, when short- to medium-term concerns emerged in several countries. Consequently, the Commission substantially enhanced its fiscal surveillance framework, with on one hand, successive reforms of the Stability and Growth Pact (European Commission, 2016a), and on the other hand, the introduction of new tools to assess fiscal sustainability risks. ([2]) In particular, an early warning indicator of fiscal stress (the S0 indicator) was developed in 2011 (Berti et al., 2012; European Commission, 2011), based on a non-parametric 'signalling approach', with a view to detect first signs of distress. ([3]) This indicator, based on endogenously derived critical thresholds beyond which risks are signalled, is regularly updated and used by the European Commission to assess fiscal sustainability in the context of the European Semester. ([4]) Other institutions use similar approaches (for instance the IMF, central banks and rating agencies), and the last financial and economic crisis has more generally renewed academic and policy-makers' interest in early warning systems (EWSs).

Once the S0 indicator entered the Commission governance framework, it was decided that the thresholds used for S0 would be updated at regular intervals, notably to account for recent fiscal stress episodes, and further work on another indicator, based on a multivariate econometric approach, was envisaged (European Commission, 2011). The 'signalling approach' has gained popularity over the last few years (De Cos et al., 2014), in particular because it allows the consideration of a large set of variables with heterogeneous data availability. There is nonetheless no clear *a priori* methodological superiority of the 'signalling approach', compared to other, model-based, approaches (Baldacci et al., 2011), each method presenting its own strengths and weaknesses. Given persistent fiscal sustainability concerns in several Members States (e.g. public debt is close to or above 90% of GDP in 2016 in 8 EU countries) and the importance of monitoring short-term fiscal risks, the main purpose of this paper is to present an additional indicator of fiscal stress for European economies, based on a parsimonious set of variables that have been tested for their conditional statistical significance.

Our contributions are as follows: i) we extend the Baldacci et al. (2011) dataset to take into account recent episodes of fiscal distress; ([5]) ii) we update the thresholds used for the S0 indicator based on this extended fiscal stress series and other revised variables; ([6]) iii) we present an additional indicator of fiscal stress based on a logit model, focusing (as for the S0 indicator) on European economies (while most studies centre their analysis on emerging economies); iv) we provide some elements of comparison of the respective performance of the two indicators. Our results, like in any early warning system, are conditioned on the country sample, time span and predictors used. ([7]) Bearing in mind these caveats, the paper features a number of interesting findings: i) the complementary fiscal distress

([1]) See the first European Commission Fiscal Sustainability Report in 2006.
([2]) See the European Commission Fiscal Sustainability Report 2015 for a comprehensive presentation.
([3]) With respect to macroeconomic imbalances, a scoreboard of early warning indicators was introduced in parallel within the macroeconomic imbalance procedure, to signal the building up of macroeconomic imbalances (European Commission, 2016c).
([4]) For instance, it is used in the assessment of Member States Stability and Convergence Programmes updated every year. The S0 indicator is also included in the Fiscal Sustainability Report, published every 3 years, and in the Debt Sustainability Monitor published every year.
([5]) The IMF also recently presented a revised and extended dataset of fiscal crises, with differences in some cases with our own estimates (Gerling et al., 2017).
([6]) Results of this revision are also presented in European Commission (2017).
([7]) In our specific case, where we concentrate on advanced economies, any early warning system faces practical limitations, given the relatively low occurrence of fiscal stress events, as compared to emerging economies. In the literature, few papers actually focus their analysis on advanced economies (exceptions are De Cos et al., 2014 and Berti et al., 2012). Baldacci et al. (2011) is particularly important in this respect in that it first proposed to relax the definition of fiscal crisis to take into account episodes of sovereign bond yield pressure (hence a broader concept than the one based on sovereign defaults, more suitable for emerging economies).

indicator, the L1 indicator based on a logit model, developed in the paper shares some common features with the S0 indicator: relying on a similar (but reduced) set of (statistically significant) trigger variables, it confirms the importance of macro-financial variables to predict fiscal distress events for European economies. It additionally highlights the role of the international economic context as a supplementary factor of risk. ii) The paper also provides some insights into the debate on public debt thresholds: as found in some other papers (e.g. Bassanetti et al. (2016)), the change in the public debt ratio appears a more consistent predictor of fiscal distress events than the level itself. However, the paper also suggests that the level of public debt would matter insofar it captures structural / institutional characteristics, and in combination with macro-competitiveness imbalances. iii) In terms of in-sample overall performance, the logit approach, while performing well, does not appear superior to the S0 – signal-based approach. iv) Building on the wealth of successive vintages of the S0 indicator, the paper highlights that this indicator, which allowed identifying the main past fiscal stress events in EU countries, provided relatively consistent and stable signals across the different rounds of revisions.

The rest of the paper is organised as follows: section 2 presents the different methods and data used; section 3 provides an analysis of the past performance of the S0 indicator, featuring in particular its last revision; section 4 presents an additional indicator, the L1 indicator based on a logit model, and provides some elements of comparison with the S0 indicator. Finally, section 5 concludes.

2. EARLY WARNING SYSTEMS: ALTERNATIVE APPROACHES AND DATA USED

2.1. EARLY WARNING SYSTEMS: STRENGTHS AND WEAKNESSES OF ALTERNATIVES APPROACHES

The empirical literature on early warning indicators of fiscal distress was developed as part of a larger literature of early warning indicators for different types of crises, including currency, banking and fiscal crises. Although a variety of techniques is used in this literature, two main categories can be distinguished: non-parametric and parametric approaches.

The most popular non-parametric method is the 'signalling approach', used for example in Baldacci et al. (2011) and for the S0 indicator (Berti et al., 2012). This approach looks at the behaviour of selected individual variables around fiscal stress episodes, and endogenously determines thresholds beyond which a crisis signal is given. These thresholds are derived based on ex-post data of fiscal stress episodes so as to maximise the predictive power of the variables. The main strength of this method is that it allows for the consideration (and aggregation in a single index) of a large set of variables, including with underlying heterogeneous data availability. Hence, it permits a rather comprehensive analysis of vulnerabilities. The main drawback of the 'signalling approach' however is that it only focuses on bivariate association between an early warning variable and crises, without taking into account the correlation between variables, nor controlling for other factors. Relatedly, the 'signalling approach' does not allow testing for the (conditional) statistical significance of individual variables.

The parametric early warning systems' approach draws on standard panel regression techniques (multivariate probit or logit models) with a binary dependent variable equal to one if a crisis occurs (and zero otherwise). With this approach, the impact of a set of explanatory variables on the crisis probability is derived by estimating the model, through maximum likelihood estimation. Bassanetti et al. (2016), Catao et al. (2013) and Gourinchas and Obstfeld (2012) use this approach to predict fiscal (and other) crises. The main advantage of this method is that it allows testing for the significance of the different leading variables, while accounting for their correlation and controlling for other factors (e.g. unobservable fixed effects). However, the main limitation of the logit / probit modelling is that it requires long time-series, and in case of unbalanced panels, limits the dataset that can be effectively used (in terms of time span and / or number of predictive variables that can be included). Hence, if this approach is appealing in that it relies on a parsimonious selection of regressors that can be tested for their conditional statistical significance, a model-based indicator may have to omit certain variables solely due to data gaps. Various studies have attempted to compare the respective performance of the non-parametric and parametric methods to predict fiscal crises, but concluded that no clear winner emerged (Baldacci et al., 2011). Using complementary methods and tools would thus allow gaining on their respective advantages, while compensating for their limitations (see Table 1 for a summary of the pros and cons of both approaches. ([8])

Table 1. **Comparison of two different early warning indicators' approaches**

	Signalling approach (used for S0)	**Regression approach (probit / logit)**
Description	Composite fiscal stress indicator calculated as the weighted proportion of variables signalling fiscal stress. A variable signals fiscal stress when it reaches a value at or beyond a certain threshold. This threshold is determined endogenously (for each variable and the composite indicator) so that it minimises the number of incorrect (false negative / positive) signals. The weight used for each variable entering the composite indicator is determined by its respective signalling power.	Panel model where the probability of fiscal stress (dependent binary variable that takes value 1 if a crisis occurs) is regressed on a set of 'independent' variables. The threshold beyond which the probability is considered as signalling a crisis can also be determined *ex-post* so that it minimises false negative / positive signals.
Advantages	Non-parametric approach. Accommodates for differences in data availability in unbalanced panels. Allows incorporating a large number of variables. Permits a relatively transparent mapping from individual variables to aggregate index.	Takes into account correlations between variables and allows testing for their statistical significance. Enables including control variables. Provides an estimate of the probability of entering in crisis.
Limits	Focuses on bivariate association between a trigger variable and crises, without controlling for other factors. Hence, correlations between (explanatory) variables are ignored. Statistical significance of the early warning variable cannot be tested directly.	Relies on a pre-defined functional form (logit / probit). Requires longer time-series. Limits the number of variables to be used (to preserve degree of freedom). Threshold used to determine whether a crisis is signalled is to some extent conventional.
Selected recent papers (on fiscal crises)	De Cos et al. (2014) Berti et al. (2012) Baldacci et al. (2011)	Bassanetti et al. (2016) Catao et al. (2013) Gourinchas and Obstfeld (2012) Kraay and Nehru (2006) Manasse et al. (2003)

Source: Commission services

2.2. DATA USED: DESCRIPTIVE ANALYSIS

Any early warning system relies on several critical elements: i) the definition of the fiscal crisis variable, ii) the choice of the potential leading variables that are tested; iii) the threshold derived / used to determine whether a crisis signal is sent (even with the model-based approach); iv) the 'signalling

([8]) Some studies also applied relatively less standard techniques such as classification tree analysis (Manasse and Roubini, 2009, Manasse et al., 2003, and Joy et al., 2014 in the context of banking and currency crises), or extreme bound analysis (Bruns and Poghosyan, 2016).

window' (i.e. the horizon ahead of the (crisis) observation over which the crisis prediction is made). The first two elements are discussed in this section, while the two last ones are discussed in sections 3 and 4.

2.2.1. Fiscal distress variable

Our sample comprises 35 countries (all EU countries, but Luxembourg and Malta, and 9 other OECD countries: Norway, Switzerland, Iceland, United-States, Canada, Australia, New-Zealand, Japan and Israel) and 46 years (from 1970 – 2015). As pointed in other papers, in any EWS, the definition of the fiscal stress variable (dependent variable) is critical. In this paper, we use the same definition and data as for the S0 indicator, where a fiscal distress episode is identified if one of the following criteria is met (Berti et al., 2012; Baldacci et al., 2011):

– Sovereign default or restructuring, defined as a failure to service debt as payments come due, as well as distressed debt exchanges (Standard & Poor's definition);
– (EU /) IMF program with an access to 100% of quota or more;
– Bond yield pressures defined as a sovereign spread greater than 2 standard deviation from the country average (or 1 000 basis points on a yearly basis, or 6 months where this level is reached within a year);
– Inflation pressure (moderate implicit default event) where inflation is greater than 35% per annum.

Over the period 1970 – 2010, the data used are the ones provided by Baldacci et al. (2011) – also used more recently by Bruns and Poghosyan (2016). Over the period 2011 – 2015, we extend these series using the four criteria above. As no *new* sovereign debt default or restructuring, nor inflation episode greater than 35%, has been experienced during this period over the sample of 35 countries considered, we focus on the other two criteria (IMF programme and bond yield pressures). Moreover, we extend the notion of programme to EU programmes (for instance, to include the 2012 bank recapitalisation programme in Spain and the 2015 Greek programme). We estimate bond yield pressures by reference to German bond yields, and using more restrictive time-period averages (since 1999) given changed financial conditions since the launch of the euro. ([9]), ([10]) Compared to the original Baldacci et al. (2011) dataset, 7 additional 'distinct' fiscal distress events have been identified (hence 64 events in total over the period 1970 – 2015). ([11]), ([12])

Looking at our fiscal distress variable, ([13]) the 64 'distinct' fiscal distress events, identified since 1970 over our 35 countries (see Graph 1), correspond to 186 years of fiscal distress (see Graph 2), and are associated with a probability of entering in fiscal distress of 4% (close to 9% since 2008), and a probability of being in fiscal stress (taking into account all fiscal stress years) of close to 12% (close to 25% since 2008) over our sample (see Table 2). Moreover, looking at the distribution by country, time period and type of fiscal stress events, some interesting features emerge:

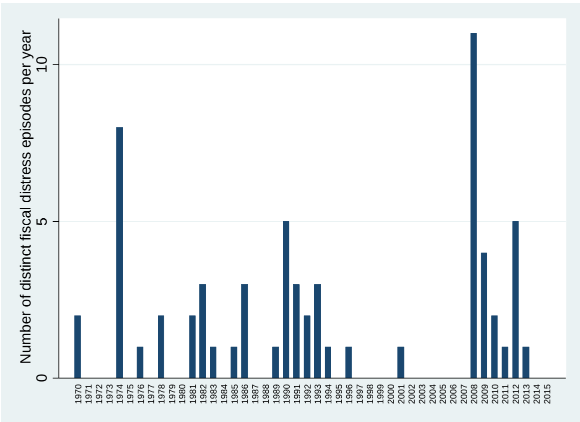
- The incidence of new fiscal stress episodes is clustered around specific time periods: around the oil boom – burst period (mid 1970's), during the recession of the early 1990's and as a result of the 2008 financial crisis. In fact, close to 40% of fiscal stress episodes are

([9]) In Baldacci et al. (2011), the reference (risk-free asset) is US government bonds, and the averages are calculated over a longer time-period.
([10]) Bond yield pressures are identified if the spread between a given country 10-year government bond yield and Germany 10-year government bond yield for a given year is greater than the average of (the country) bond yield spreads (over the period 1999-2015) + 2 standard deviations. The source used is the ECB.
([11]) This concerns in 2011, Belgium (bond yield pressures); in 2012, Austria (bond yield pressures), Spain (bond yield pressures and EU program), France, Hungary and Italy (bond yield pressures); and in 2013, Cyprus (IMF / EU program). Considering continuous bond yield pressures, and over-lapping programs, the 2015 EU Greek program is not considered as a *new* fiscal distress event according to our criteria (2 years gap minimum as required in line with Baldacci et al., 2011). The same type of considerations applies for other (ex-) programme countries (e.g. Ireland, Portugal).
([12]) Compared to the original S0 dataset, we have also included Cyprus.
([13]) Binary variable coded 1 if there is fiscal distress, 0 otherwise.

concentrated after 2008, which is non-trivial given the particular nature of the last fiscal crisis (largely driven by financial and macroeconomic imbalances, rather than fiscal slippages).

- 32 (out of 35) countries experienced at least one episode of fiscal stress over the period considered. However (and not surprisingly), the number of fiscal distress episodes, and hence the probability of being / entering a fiscal distress episode, shows an important country variability. Romania and Hungary stand out with respectively 5 and 4 distinct fiscal stress episodes experienced since 1970, followed by Australia, France, Ireland, Iceland, Israel, Italy, Poland and Portugal (each having experienced 3 distinct episodes over the period considered). On the other hand, the Netherlands, Slovakia and the US have never experienced a fiscal stress event over the period considered. The intensity of the fiscal stress event (measured by the average length of recorded fiscal stress) differs even more substantially between countries. Indeed, if fiscal stress events are found to last close to 3 years on average, this average duration varies from 1 year in several countries to 9 years in Croatia, 7 years in Poland and 6 years in Greece and Slovenia.
- More than half of fiscal stress situations manifest themselves through bond yield pressures, while about 1/5th are detected through IMF programs, and 15% through high inflation episodes (all up until the mid-1990's). In only 5 cases, there was a formal sovereign default (this concerns Bulgaria, Croatia, Poland and Romania). ([14])

Graph 1. **Number of countries experiencing a distinct fiscal distress episode per year**



Graph 2. **Number of countries in fiscal distress per year**

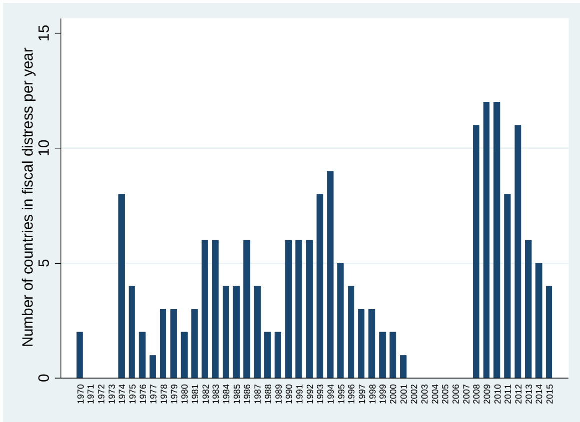


Table 2. **Key statistics of fiscal distress over the sample**

	1970-2015	2008-2015
Total number of countries x years in fiscal distress	186	69
Probability of being in fiscal distress	11.6%	24.6%
Total number of distinct fiscal distress episodes	64	24
Probability of entering in fiscal distress	4.0%	8.6%

Source: Baldacci et al. (2011), Commission services

2.2.2. Potential early warning variables

In this paper, we consider the set of 25 variables entering the S0 indicator (European Commission, 2017) as potential candidates for the logit model approach. This set comprises 12 fiscal variables (government balance, primary balance, cyclically adjusted balance, stabilising primary balance, public gross debt, change in public gross debt, short-term public debt, net public debt, public gross financing needs, interest – growth rate differential, change in government expenditures, and change in government consumption), and 13 financial-competitiveness variables (yield curve, real GDP growth,

([14]) In the case of Greece, the partial default recorded in 2012 intervened after two years of bond yield pressures, hence, it is not considered as generating a new fiscal event.

GDP per capita, net international investment position, net saving of households, private debt, private credit flow, short-term debt of non-financial corporations, short-term debt of households, value added in construction, current account balance, change in real effective exchange rate, and change in nominal unit labour costs). The data sources used for these series are presented in Berti et al. (2012) and also in Annex I.

We additionally test (for the logit model) for the inclusion of other variables (extended series of private debt / private credit flows, (15)) world GDP growth, quality of institutions variable, realisation of contingent liabilities, trade openness, GDP volatility). (16)) The data availability differs from one variable to another (we have at best 1312 observations (GDP per capita) and at the minimum 496 observations (change in short-term public debt; see Table 3)) - an important feature to be taken into account in the model-based approach presented in section 4. Another key element that needs to be considered in the model-based approach is the likely serial correlation between some of these variables. This point is also discussed in section 4.

Table 3. **Average values of main potential early warning variables over different 'regimes'**

	Tranquil period	Pre-fiscal stress period (1 year before event)	First year fiscal stress event	All fiscal stress event years	Post-fiscal stress event (up to 2 years after end event)	Post-fiscal stress event (up to 4 years after end event)	Total number observations (1970-2015)
Balance, % GDP	-2.2	-2.5	-3.8	-4.7	-3.7	-3.6	1,249
Primary balance, % GDP	1.0	0.1	-1.1	-1.4	-0.6	-0.5	1,195
Cyclically adjusted balance, % GDP	-2.6	-3.6	-4.0	-4.4	-3.1	-3.2	1,123
Stabilizing primary balance, % GDP	0.3	-0.4	1.1	1.3	-0.2	-0.3	1,112
Gross financing needs, % GDP	10.9	14.1	15.3	15.7	15.6	14.5	725
Gross public debt, % GDP	52.4	53.4	59.7	67.8	58.8	56.4	1,190
Change in gross public debt, % GDP	0.8	1.9	7.1	5.4	1.6	1.1	1,155
Net public debt, % GDP	22.1	35.0	39.4	46.8	40.5	35.6	674
Short-term public debt, % GDP	7.1	8.3	9.5	8.8	7.5	6.2	523
Change in short-term public debt, % GDP*	-0.4	1.2	2.4	-0.7	-0.4	-1.0	496
Change in public expenditure, % GDP	0.1	0.6	2.3	0.8	0.5	0.2	1,202
Change in public final consumption expenditure, % GDP	0.1	0.1	0.7	0.3	0.1	0.0	1,095
Interest rate - growth rate differential	-0.5	-3.1	0.4	0.0	-1.7	-1.6	1,109
Yield curve	0.9	0.2	0.4	2.2	1.5	1.2	932
Current account balance, 3-year backward MA, % GDP	-0.3	-4.8	-5.0	-4.1	-1.7	-1.7	1,172
Net international investment position, % GDP	-20.7	-48.6	-49.0	-56.9	-36.6	-32.8	629
Private sector debt, % GDP	126.5	161.5	165.3	155.1	121.1	100.9	535
Private sector debt, % GDP (extended series)*	115.9	131.9	132.3	132.4	112.7	105.1	1,236
Private sector credit flow, % GDP	8.8	20.8	4.9	1.4	0.6	2.1	526
Private sector credit flow, % GDP (extended series)*	2.3	6.9	3.5	1.1	-1.5	-0.6	1,201
Short-term debt, non-financial corporations, % GDP	18.8	21.6	22.1	19.8	15.7	14.2	516
Short-term debt, households, % GDP	4.3	4.1	4.1	4.3	2.3	2.1	516
Net savings of households, % GDP	4.1	1.1	1.7	-0.2	1.2	0.9	836
Change (3 years) in nominal unit labour costs, %	14.7	40.3	32.9	97.5	64.3	44.4	1,141
Change (3 years) of real eff. rxchange rate, %	2.5	4.8	3.4	1.9	6.4	6.0	594
Construction, % value added	6.6	7.4	7.0	6.5	6.3	6.3	1,196
Real GDP growth	2.8	2.1	-0.5	-0.1	2.6	3.1	1,300
GDP per capital in PPP, % of US level	73.6	62.2	61.3	54.1	60.5	59.8	1,312
World real GDP growth*	3.2	3.4	2.2	2.5	3.0	3.0	1,610
crisis_years	*0.0*	*0.0*	*1.0*	*3.1*	*0.0*	*0.0*	*1,610*
crisis (first year)	*0.0*	*0.0*	*1.0*	*0.3*	*0.0*	*0.0*	*1,610*

Note: In red, variables with highest signalling power in the S0 indicator. * Variables not included in the S0 indicator. The 'tranquil period' is defined as the period outside of fiscal stress years / pre-fiscal stress periods (up to 2 years ahead of a fiscal stress event) / post-fiscal stress periods (up to 4 years after a fiscal stress event). The 'pre-fiscal stress period' is defined as 1 year ahead of a fiscal stress event, building on the S0 definition (indicator allowing predicting fiscal stress one year into the future).

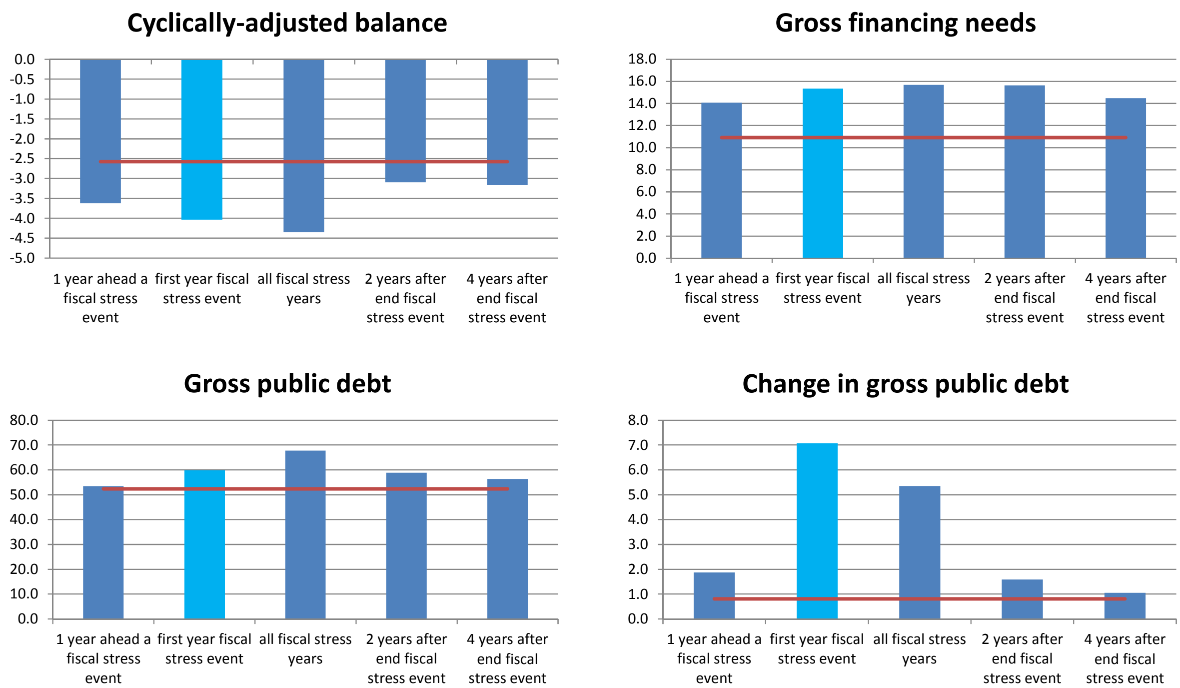
Source: Ameco, Eurostat, IMF, Commission services

(15) Based on BIS data (see Annex I).
(16) These additional variables are tested in the logit model, mainly due to the specificities of the panel regression-based approach, in particular the stronger necessity to have long time-series and the need to capture fixed effects.

A simple comparison of the average values of the different (potential) fiscal stress trigger variables over different 'regimes' (see Table 3) ([17]) allows us identifying the following elements: ([18])

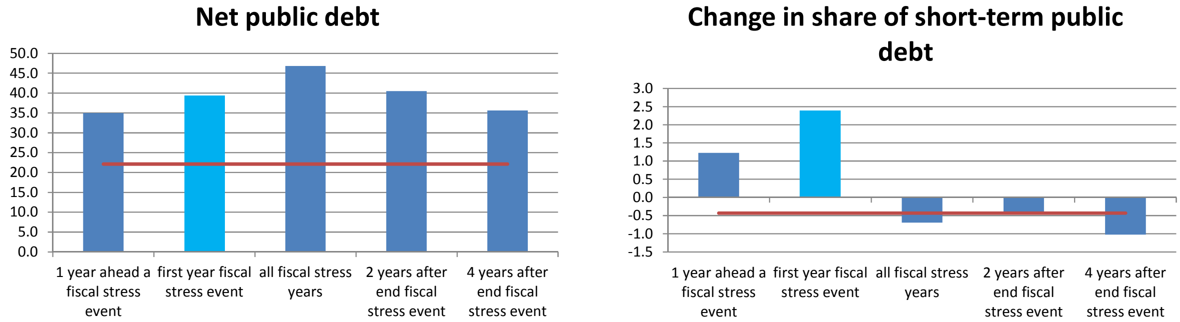
- Comparing pre-fiscal stress event values (one year ahead of a fiscal stress event) to 'tranquil periods', we can see that most selected variables behave as expected. For instance, the cyclically-adjusted balance tends to deteriorate ahead of a fiscal stress event, while gross financing needs and the share of short-term debt tend to increase. Interestingly, the level of gross public debt doesn't appear to be much higher before a fiscal distress event, compared to 'tranquil periods', while a larger gap can be seen for the level of net public debt (although the sample size is much smaller for this last variable). The change in the gross public debt ratio also seems to be more reactive (than its level) ahead of a fiscal stress event (see Graphs 3). Regarding financial-competitiveness variables, the yield curve tends to reach relatively low values prior to a fiscal stress event (although remaining slightly positive), while private credit flow tends to reach high levels. The current account balance and the net IIP are found to reach very negative values, while households' net savings tend to be much weaker than during 'tranquil periods' (see Graphs 4).
- Comparing fiscal stress period values to post-fiscal stress period values, we can see that on the whole the adjustment process appears to be relatively slow (with most variables being still unfavourably oriented from 2 to 4 years after a fiscal stress event). This confirms the need to deal with these observations to avoid estimation biases in the model-based approach (see section 4).

Graph 3. **Evolution of selected fiscal stress trigger variables in different regimes – fiscal variables**



([17]) Four 'regimes' are considered: 1) pre-fiscal stress period (1 to 2 years ahead of a fiscal stress event); 2) fiscal stress period (first year or all years); 3) post-fiscal stress period (2 to 4 years after the end of the fiscal stress event); 4) 'tranquil' period (all other periods).

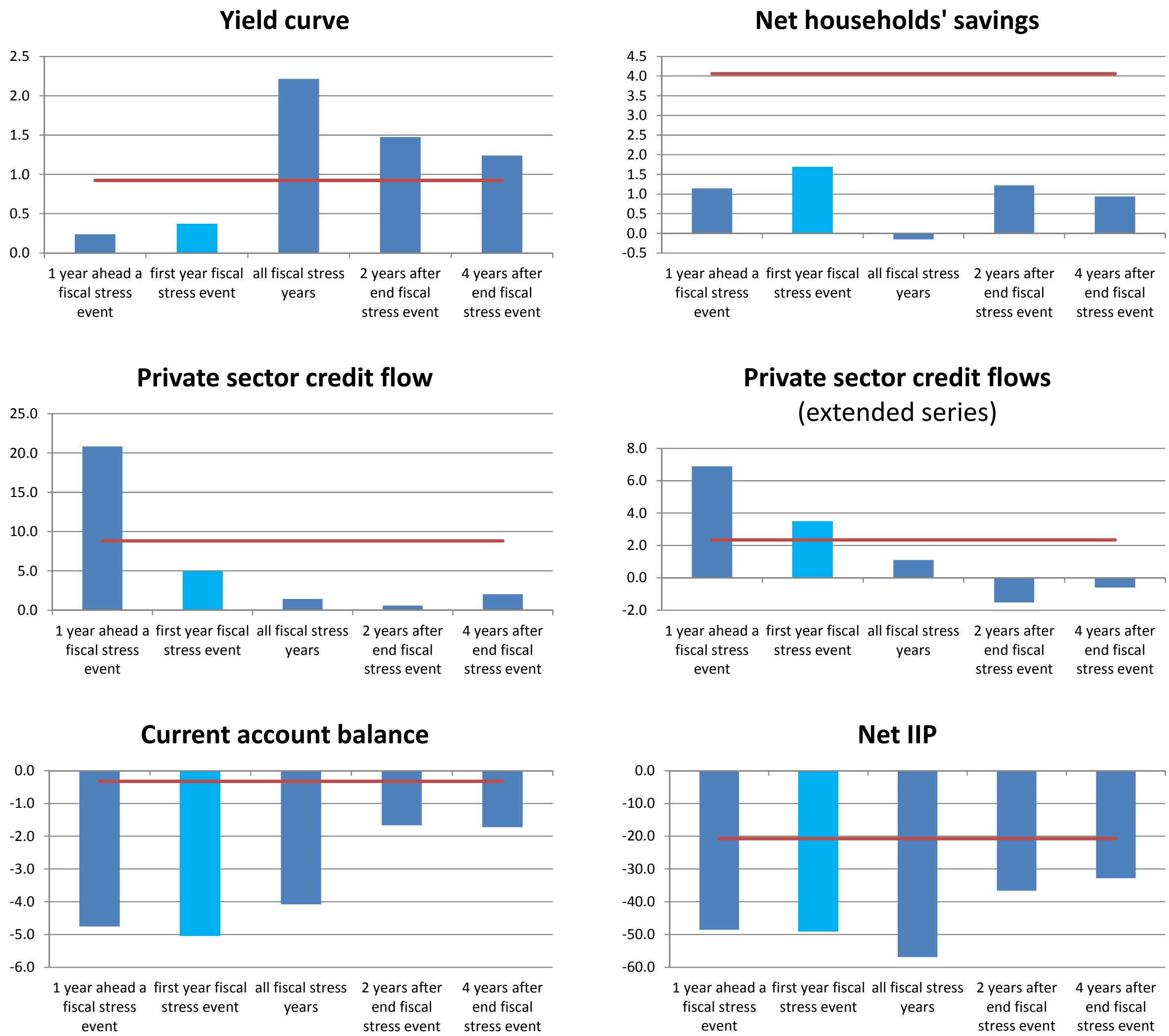
([18]) In this section, we limit ourselves to a simple descriptive analysis of the dataset rather than performing a more formal event study analysis like in Manasse et al. (2003) for example.



Note: The red line represents the 'tranquil period' average.

Source: Ameco, Eurostat, IMF, Commission services

Graph 4. **Evolution of selected fiscal stress trigger variables in different regimes – financial-competitiveness variables**



Note: The red line represents the 'tranquil period' average.

Source: Ameco, Eurostat, IMF, Commission services

3. THE S0 INDICATOR: REVISION AND ANALYSIS OF PERFORMANCE

3.1. THE S0 INDICATOR: DEFINITION AND REVISION

The S0 indicator has been introduced in the European Commission fiscal sustainability assessment framework in 2012 (see European Commission, 2012) and is, since then, regularly updated for the purpose of fiscal surveillance. ([19]) S0 is a composite indicator based on a set of fiscal and financial-competitiveness variables (see section 2.2) and aimed at evaluating the extent to which there might be a risk of fiscal stress in the upcoming year. The methodology lying behind this indicator (the 'signalling approach'), described in Berti et al. (2012), allows for an endogenous determination of critical thresholds (beyond which fiscal risks are identified) for the composite indicator itself, each individual variable incorporated in the composite indicator, and the two thematic sub-indexes (incorporating only fiscal and financial-competitiveness variables respectively). These thresholds are determined by looking at each variable's behaviour ahead of fiscal distress episodes in a way to minimise the share of missed stress episodes (type II error) plus the share of false positive fiscal stress signals (type I error). ([20]) The composite indicator S0 is calculated as the weighted proportion of variables having reached (or gone beyond) their critical threshold, where the weights are given by the 'signalling power' of the individual variables (i.e. the share of correctly predicted events).

Once S0 entered the Commission's fiscal sustainability assessment framework, it was decided that the thresholds used for the indicator would be updated at regular intervals. Hence, in view of the Debt Sustainability Monitor 2016, these thresholds have been updated and some methodological refinements have also been carried out. More in detail, the changes introduced in the S0 calculation concerned both the dataset and the underlying variables used as described thereafter:

- The statistical sources used for some variables have been changed (e.g. for gross financing needs the Bloomberg source has been replaced with ECB publicly available data);
- The series of fiscal stress events has been extended until 2015 (as described in section 2.2);
- Three variables have been taken out from the original S0 indicator (the two ageing variables on the fiscal side and the leverage of financial corporations on the macro-financial side) as they were deemed not sufficiently strong leading indicators of fiscal stress events (based on their estimated signalling power).

Compared to the original S0 indicator, the overall signalling power remains unchanged (at 0.55); while the signalling power of the two sub-indexes is significantly increased (from 0.23 to 0.28 on the fiscal side, and from 0.48 to 0.55 on the financial-competitiveness side; see Table 4). Moreover, the thresholds have been modified significantly in some cases (e.g. gross public debt, ([21]) private sector debt, net international investment position and short-term debt of non-financial corporations) due to the data revisions.

([19]) For instance, this indicator is considered when assessing Member States' Stability and Convergence Programs. It is also published in the Debt Sustainability Monitor (once a year) and in the Fiscal Sustainability Report (once every 3 years).

([20]) The terminology 'type I error' and 'type II error' used in the paper follow Berti et al. (2012) and Baldacci et al. (2011), but may not be the same in other papers (for example, in Bruns and Poghosyan, 2016, 'type I error' indicates missed crisis, while 'type II error' indicates false alarms).

([21]) At 68% of GDP (down from 103% of GDP), this level is now closer to the debt burden benchmarks used by the IMF (2013) for market-access countries in its Debt Sustainability Analysis framework (70% of GDP for emerging economies and 85% of GDP for advanced economies). It is also closer to the debt limit for euro area countries estimated by the OECD (2015).

Table 4. **Thresholds and signalling power before and after the last revision of the S0 indicator**

Variables	safety	threshold		signalling power		type I error		type II error	
		FSR 2015	DSM 2016	FSR 2015	DSM 2016	FSR 2015	DSM 2016	FSR 2015	DSM 2016
Balance, %GDP	>	-10.17	-9.61	0.07	0.07	0.04	0.04	0.89	0.89
Primary balance, %GDP	>	0.00	0.23	0.17	0.13	0.40	0.47	0.43	0.40
Cyclically adjusted balance, %GDP	>	-3.12	-2.50	0.25	0.23	0.45	0.52	0.30	0.25
Stabilizing primary balance, %GDP	<	2.55	2.34	0.02	0.08	0.12	0.13	0.86	0.79
Gross debt, %GDP	<	103.28	68.44	0.03	0.12	0.06	0.23	0.91	0.65
Change in gross debt, %GDP	<	6.50	8.06	0.11	0.12	0.08	0.06	0.81	0.82
Short-term debt gen. gov., %GDP	<	16.00	13.20	0.10	0.20	0.11	0.14	0.79	0.67
Net debt, %GDP	<	58.11	59.51	0.13	0.20	0.19	0.18	0.68	0.62
Gross financing need, %GDP	<	16.83	15.95	0.16	0.26	0.21	0.24	0.63	0.50
Interest rate-growth rate differential	<	5.92	4.80	0.08	0.08	0.07	0.11	0.85	0.82
Change in expenditure of gen. government, %GDP	<	2.25	1.90	0.14	0.11	0.13	0.13	0.74	0.76
Change in final consumption expend. of gen. government, %GDP	<	0.64	0.61	0.17	0.07	0.19	0.17	0.64	0.76
Fiscal index	<	0.35	0.36	0.23	0.28	0.21	0.30	0.56	0.42
L1.net international investment position, %GDP	>	-50.10	-19.80	0.31	0.29	0.13	0.47	0.56	0.24
L1.net savings of households, %GDP	>	0.96	2.61	0.34	0.33	0.26	0.42	0.40	0.25
L1.private sector debt, %GDP	<	209.20	164.70	0.25	0.18	0.04	0.22	0.71	0.60
L1.private sector credit flow, %GDP	<	10.90	11.70	0.44	0.37	0.42	0.28	0.14	0.35
L1.short-term debt, non-financial corporations, %GDP	<	27.40	15.40	0.25	0.20	0.21	0.54	0.54	0.26
L1.short-term debt, households, %GDP	<	3.50	2.90	0.27	0.21	0.34	0.52	0.38	0.26
L1.construction, %value added	<	7.25	7.46	0.27	0.22	0.36	0.27	0.38	0.51
L1.current account, 3-year backward MA, %GDP	>	-2.45	-2.50	0.38	0.34	0.37	0.35	0.25	0.31
L1.change (3 years) of real eff. exchange rate, based on exports deflator, ref 37 countries	<	9.76	9.67	0.23	0.11	0.19	0.18	0.59	0.71
L1.change (3 years) in nominal unit labour costs	<	12.70	7.00	0.27	0.18	0.48	0.64	0.25	0.18
Yield curve	>	0.59	0.59	0.48	0.37	0.39	0.34	0.14	0.29
Real GDP growth	>	-0.89	-0.67	0.10	0.10	0.07	0.09	0.83	0.81
GDP per capita in PPP, %of US level	>	73.32	72.70	0.28	0.22	0.44	0.44	0.27	0.33
Financial-competitiveness index	<	0.45	0.49	0.48	0.55	0.34	0.32	0.18	0.13
Overall index	<	0.43	0.46	0.55	0.55	0.21	0.22	0.25	0.23

Note: Type I error corresponds to the proportion of false (positive) signals: p(signal of a crisis / crisis = 0). Type II error corresponds to the proportion of missed crisis: p(no signal of a crisis / crisis = 1). The signalling power is equal to 1 – type I error – type II error. By construction (as there are less crisis events than non-crisis events), type II error (missed crisis) is given more weight than type I error (false signals) in the minimising program to derive S0's thresholds.

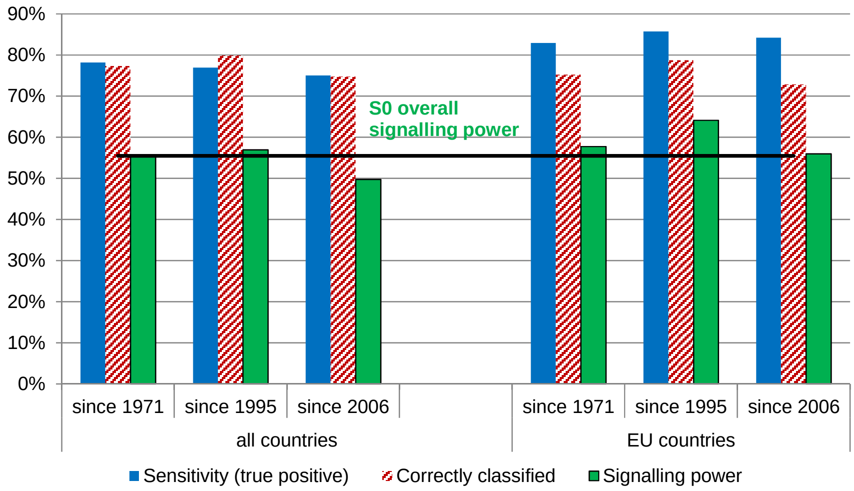
Source: European Commission (2017)

3.2. THE S0 INDICATOR: PERFORMANCE ANALYSIS

The overall performance of the S0 indicator is in line with other studies (Bruns and Poghosyan (2016); ([22]) Baldacci, et al., 2011; Hemming et al., 2003). Furthermore, it is found to be satisfactory when looking at the recent period in EU countries, with above 80% of fiscal stress episodes correctly signalled since 1995 and 2006, and an overall signalling power similar – if not above – the full sample one (see Graph 5).

([22]) In this recent study, which relies on a similar dataset of fiscal crises, the fiscal distress index has a signalling power of around 48% - based on in-sample performance analysis - level located, according to the authors, within the first and third quartile of the signalling power when compared to other studies.

Graph 5. **Performance statistics of the S0 indicator over different sub-samples (23)**



Note: The sensitivity corresponds to the percentage of crisis correctly predicted (true alarms): p(signal of a crisis / crisis = 1). It is equal by definition to 1 – type II error (proportion of missed crisis). Correctly classified events correspond to the ratio between 'true alarms + true negative signals' over all observations. The signalling power is equal to 1 – type I error (proportion of false signals) – type II error. It is a more stringent measure of performance that the correctly classified one, as it gives more weight (by construction) to type II error.

Source: Commission services

Looking into more details at the composition of past signalled versus missed events, it appears that all major fiscal stress episodes have been correctly detected in EU countries (see Table 5). ([24]) Moreover, when focusing on euro area countries that benefitted from a financial assistance programme (e.g. Ireland, Portugal, Spain, Cyprus, Latvia) or experienced some bond yield pressures (e.g. Italy), the match between the signal sent by S0 and the fiscal distress variable appears relatively satisfactory (see Graphs 6).

([23]) In this Graph, we simply compute (ex-post) these statistics over different samples; however, we do not re-estimate S0 thresholds over different samples. Furthermore, given the limited number of fiscal stress events, we choose not to perform out-of-sample simulations (as estimating S0 thresholds over a reduced period of time would yield unstable / non-comparable results).

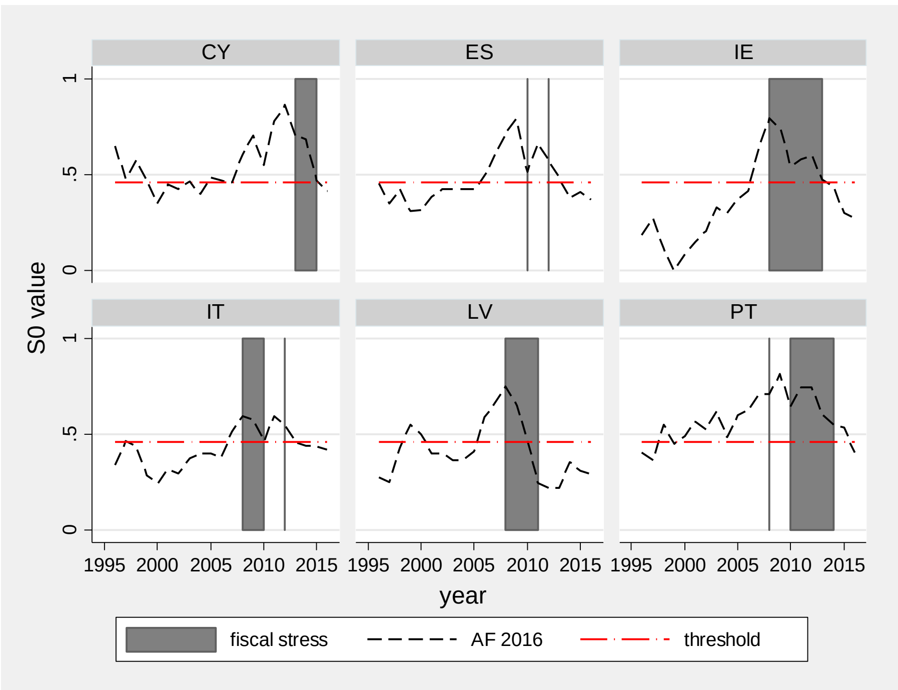
([24]) We focus on a more detailed analysis as from 1995, which corresponds to the date from which the data availability is improved for EU countries (before this date, the S0 indicator is based for some countries on a reduced number of variables).

Table 5. **Detailed in-sample signalled / missed fiscal stress events in EU countries (based on Autumn 2016 data)**

	All period
Number of distinct fiscal stress events *(in brackets, since 2008)*	***41** (19)*
Number of distinct fiscal stress events correctly signalled *(in brackets, since 2008*	34 *(16)*
o/w	1974 (IE, IT, UK)
	1976 (IE)
	1982 (DK)
	1983 (PT)
	1990 (RO)
	1991 (CZ, HU, SI)
	1992 (FI, HR)
	1993 (EL, LT, LV)
	1994 (EE)
	1996 (RO)
	2001 (PL)
	2008 (EL, HU, IE, IT, LV, PT, RO)
	2009 (BG, LT, PL)
	2010 (ES, PT)
	2012 (ES, HU, IT)
	2013 (CY)
Number of distinct fiscal stress events missed *(in brackets, since 2008)*	7 *(3)*
o/w	1974 (DE, FR)
	1990 (FI, SE)
	2011 (BE)
	2012 (AT, FR)

Source: Commission services

Graph 6. **Values of the S0 indicator since the mid 1990's (based on Autumn 2016 data) and fiscal stress years – selected countries (shaded areas and vertical lines indicate fiscal stress years)**



Note: For time-consistency reasons, the series are only shown as from the mid-1990's, corresponding to the period over which the data availability is substantially improved.

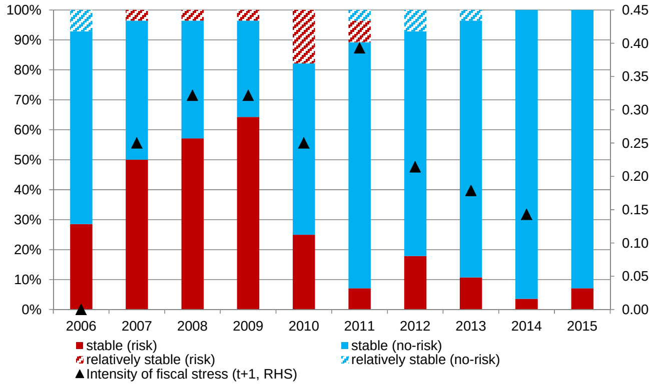
Source: Commission services

Another interesting feature that emerges from the analysis is that the S0 indicator provides relatively consistent and stable signals. Indeed, the S0 indicator is estimated twice a year based on real time data for the year considered. At each update, the past years' values of the indicator are also re-estimated based on ex-post data. Hence, looking at revisions of the S0 indicator over the different vintages (8 successive rounds since 2012) ([25]) allows gauging the consistency and stability trough time of the signal sent by this indicator.

Table 6. **Frequency of revision of the S0 indicator (from Spring 2012 to Spring 2016 data), by country**

Country	stable (no-risk)	stable (risk)	relatively stable (no-risk)	relatively stable (risk)
AT	100%	0%	0%	0%
BE	100%	0%	0%	0%
BG	50%	40%	**10%**	0%
CY	10%	70%	**10%**	**10%**
CZ	100%	0%	0%	0%
DE	100%	0%	0%	0%
DK	90%	10%	0%	0%
EE	60%	40%	0%	0%
ES	30%	40%	**30%**	0%
FI	100%	0%	0%	0%
FR	100%	0%	0%	0%
HR	40%	50%	0%	**10%**
HU	60%	40%	0%	0%
IE	50%	40%	0%	**10%**
IT	70%	0%	0%	**30%**
LT	70%	30%	0%	0%
LU	100%	0%	0%	0%
LV	50%	50%	0%	0%
MT	50%	30%	**10%**	**10%**
NL	100%	0%	0%	0%
PL	60%	30%	0%	10%
PT	20%	70%	0%	10%
RO	50%	50%	0%	0%
SE	100%	0%	0%	0%
SI	70%	20%	0%	**10%**
SK	80%	20%	0%	0%
UK	60%	40%	0%	0%
Average	**67%**	**27%**	**2%**	**4%**

Graph 7. **Frequency of revision of the S0 indicator (from Spring 2012 to Spring 2016 data), by year**



Note: These results refer to revisions of the S0 indicator at unchanged threshold (i.e. only accounting for the revision of the underlying series used in the indicator). The indicator is deemed stable (no-risk) when its value has been consistently below the critical threshold through all vintages considered; stable (risk) when its value has been consistently above the critical threshold through all vintages considered; relatively stable (no-risk) when its value has been below the critical threshold in at least 75% of the vintages considered; relatively stable (risk) when its value has been above the critical threshold in at least 75% of the vintages considered.

Source: Commission services

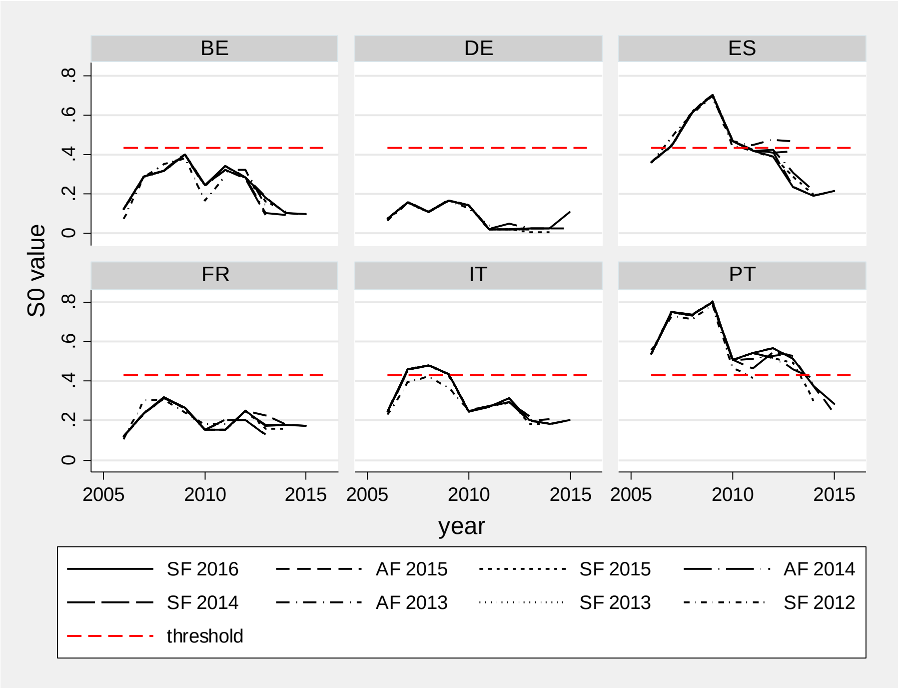
The S0 revisions appear relatively limited on the whole (at the most around +/- 0.15 for some vintages / years) ([26]) Therefore, the risk classification provided by this indicator has been largely stable through time for the majority of countries. Indeed, in more than 90% of the cases considered (over the period 2006-2015), countries have been consistently classified at risk / no-risk of fiscal stress over the vintages considered (see Table 6). Some (albeit limited) more frequent revisions have been observed for Spain, Italy, Bulgaria, Cyprus, Croatia, Ireland, Malta and Slovenia (see Graphs 8 for selected countries and Annex II for all countries). These results can be explained by the fact that the S0 indicator relies largely on outturn data (current / previous years), which are typically subject to less revisions than forecast data. An analysis of the time pattern of S0 revisions seems to suggest that some

([25]) These vintages correspond to European Commission Spring and Autumn forecast updates.
([26]) At unchanged thresholds i.e. taking into account all vintages since 2012 except for the last one (Autumn forecasts 2016).

uncertainties in the risk classification were more likely to arise as the fiscal crisis reached its peak in the EU (see Graph 7).

The last S0 revision (Autumn forecasts 2016) has logically led to more substantial changes of S0 values, given the update of the thresholds. Indeed, even if the overall threshold of the S0 indicator has only slightly changed (from 0.43 to 0.46), the thresholds for individual variables composing the indicator have substantially changed in some cases (see previous section), affecting the value of the indicator itself. (27) Even with this revision, in most cases (87% of cases over the period 2006-2016), the risk classification has been consistent across the two vintages (pointing to either no-risk / risk for a given year and country according to both estimations). However, in four cases (Spain, Italy, Malta and the UK), the risk classification appears less stable (around 40% of inconsistent classification across the two vintages over the whole period, see table in Annex 3). In the case of Malta and the UK, the values of the S0 appear nevertheless relatively close (especially in the case of Malta, the classification appears borderline over the first half of the period considered). In the case of Spain and Italy, the upward revision of S0 values appear more in line with recent stress events detected in these two countries (see shaded areas or lines in Graph 9).

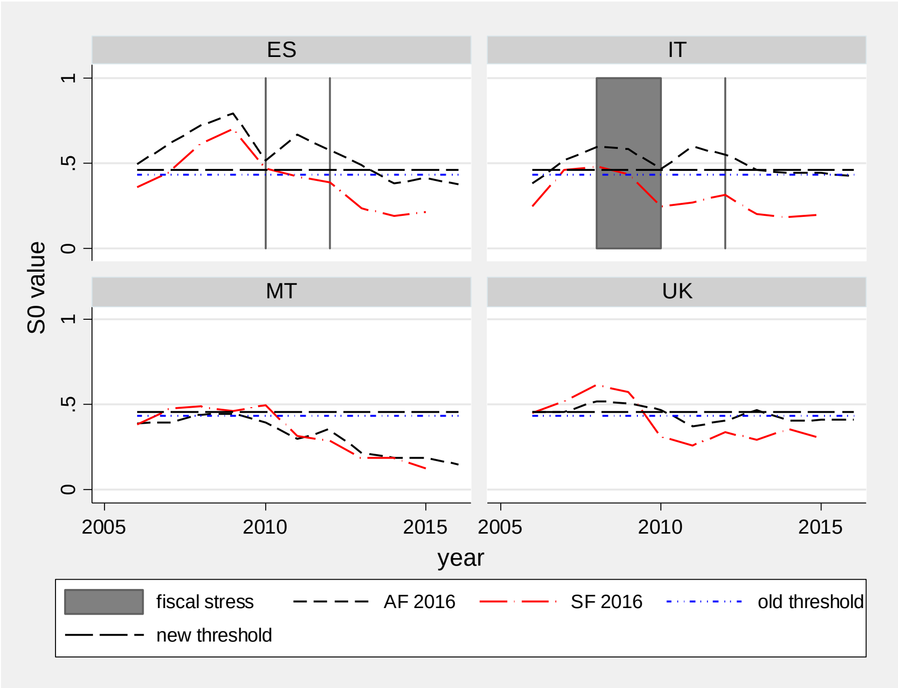
Graph 8. **Values of the S0 indicator through different vintages – selected countries**



Source: Commission services

(27) Since only variables having reached their critical threshold are taken into account in the S0 indicator.

Graph 9. **Values of the S0 indicator Spring versus Autumn 2016 vintages and fiscal stress years – selected countries (shaded areas and vertical lines indicate fiscal crisis years)**



Source: Commission services

4. A COMPLEMENTARY INDICATOR BASED ON A LOGIT MODEL

4.1. METHODOLOGY

A simple pooled logit is estimated (more formally defined by (1)), where the probability for a given country *i* to experience (new) fiscal distress in *t* is regressed as a function of the level of public debt in t-1, the change in the level of public debt between *t-2* and *t-1*, other fiscal variables in *t-1*, lagged macro-financial variables (lags between *t-3* and *t-1* are tested, see below), and world GDP in *t* as a quasi-time fixed effects. When possible (when considering a larger sample), a fixed effect model is also tested (mainly as a robustness check given caveats of such models in our case). ([28])

$$p(fiscal\ distress_{i,t}) = \varphi(debt_{i,t-1}, \Delta debt_{i,t-1}, other\ fiscal_{i,t-1}, macrofin_{i,t-j}, world\ GDP_t) \quad (1)$$

([28]) Indeed, fixed effects models are more demanding in terms of sample size and necessitate, in order to provide efficient estimates, a sufficient within variability (conditions which may prove difficult in our case with a relatively limited total number of observations for some variables and a relatively large n / t). Furthermore, in our case of a binary variable, such models imply dropping countries that never experienced fiscal distress, hence valuable information. Finally, the interpretation and use of the results in the context of a logit model are less straightforward (Pforr, 2013). Hence, most of EWS papers based on logit approach seem to use fixed-effect models as a way to test the robustness of their results rather than as their reference regression (Bassanetti *et al*, 2016; Bussière, 2013; Kraay and Nehru, 2006), while others only present pooled models (Catao *et al*, 2013; Manasse *et al*, 2003).

As pointed before, the regressions tested rely on a parsimonious choice of explanatory variables based on S0 variables showing the highest signalling power, and on the literature. Attention is also paid in choosing variables with the largest possible number of observations possible, and avoiding multicollinearity problems (see Annex I with a correlation matrix for the main variables tested). ([29]) Moreover, as usual and consistent with the literature, explanatory variables enter the logit model lagged at least one year (to mitigate endogeneity biases and provide more meaningful results). For macro-financial variables, lags of each explanatory variable up to 3 are tested (in line with Bussière, 2013 pointing that structural indicators, such as a measure of banking sector fragility for example, will have a longer-term impact on fiscal vulnerability than fiscal 'liquidity' variables). ([30])

The sample used only considers the first year of fiscal distress events (subsequent years are dropped – consistently with the S0 approach), and excludes post-crisis years up to 2 years. This methodology is similar to the one used by Bassanetti *et al* (2016) and Gourinchas and Obstfeld (2012) in order to avoid the risk of a 'post-crisis' bias. Indeed, as seen from Graphs 3, variables tend to behave differently after a crisis, during the adjustment period, compared to pure 'tranquil' periods. For instance, public debt tends to rise sharply right after fiscal crises. From this fact, one might erroneously conclude that relatively low public debt levels make crises more likely. ([31])

In order to gauge the influence of each explanatory variable, the estimated coefficients and the average marginal effects are reported (given the non-linearity of our model, the effect of a given variable is not independent from its value, nor the value taken by other variables). In order to assess the performance of each model, we report the pseudo R2, the log-likelihood, and the AUROC measure (a summary statistic to assess the overall predictive accuracy of the regression). ([32]) The percentage of events / crisis correctly classified, type 1 and type 2 errors, as well as the signalling power are also reported. These last measures are derived by choosing cut-off values or thresholds for the probability of entering in fiscal distress (5.5% and 4.5%), which correspond to the optimal cut-off value (determined in a way so that type I and type II errors are minimised, see section 3.2) and is close to the naive in-sample probability of entering in fiscal distress. ([33]) Of course, the higher the threshold, the more we risk to miss crises, while the lower it is, the more we risk sending false alarms.

([29]) Multicollinearity refers to predictors that are correlated with other predictors. Severe multicollinearity is a problem because it can increase the variance of the coefficient estimates and make the estimates very sensitive to minor changes in the model. The result is that the coefficient estimates are unstable and difficult to interpret (in terms of significance, size and sign).

([30]) For these variables, we keep the best lags (in terms of significance and predictive power of the model).

([31]) Another less crude way to deal with this bias would be to use a crisis variable with 3 outcomes, where the 'post-crisis/tranquil' period (taking value 0) would be split in two regimes: a crisis/post-crisis regime (for example, year 2 of a crisis and subsequent post-crisis years) and a pure 'tranquil' regime. This is what is done in Bussière and Fratzscher (2006) for example. However, the estimation of such a multinomial logit is more challenging (for example, involving determining the end of the post-crisis period) and requires a sufficient number of observations.

([32]) The Area under the ROC (R*eceiver Operating Characteristic*) is a measure of overall predictive accuracy of a model. The ROC curve plots the fraction of true positives that a model signals versus the fraction of false positive signals along continuous threshold settings. Formally, the fraction of true positives are also called the *sensitivity,* defined as: p(signal of a crisis / crisis = 1), which corresponds to 1 – type II error as defined before. The fraction of false positive signals correspond to type I error as defined previously; it corresponds to 1 – the *specificity*, which is to the percentage of true negative signals: p(no-signal of a crisis / crisis = 0). The best model according to AUROC is the one that delivers the highest trade-off frontier between true and false alarms.

([33]) In the literature, various cut-off values can be found (often higher than in our paper given that the samples used often comprise emerging economies, for which the probability of experiencing fiscal distress is higher): Catao et al (2013) tested 10.5% (optimal cut-off they found) and 20% (as a conventional value). Manasse et al (2003) chose 20.5% (but indicated that they could also have chosen the value 5.6%, which corresponds to their in-sample probability of entering into crisis). Bruns and Poghosyan (2016) obtain an optimal threshold of 7%.

4.2. MAIN REGRESSION RESULTS

Two main regressions are presented: the first one (model 1) intends to rely strictly on S0 variables (as many as possible, including some macro-financial variables such as private credit flows, which have a high signalling power in S0, but which are available only over a limited time-span). The second one (model 2) tries to make use of longer series (in particular fiscal distress events in the 1980's – 1990's) by excluding some variables upfront (for example, households savings), and using an alternative series for private credit flow (proxied by the variation of private debt available over a long time period from both AMECO and the BIS, see Annex I). In this latter case, we are able to increase by more than 50% the number of observations used in the regression, and to introduce fixed effects. Additional regressions have been tested and presented in the Annex III. ([34])

Both regressions include as significant variables (with the expected sign) the *change* in public debt, private credit flows, the current account balance and real GDP growth rate (country-specific and world one; see Table 7). Such a reduced model is very close to Gourinchas and Obstfeld (2012). In model 1, the *level* of public debt is also found to be significant, while it becomes non-significant in model 2, where country-fixed effects are included. These results suggest that the level of public debt would matter for predicting future fiscal distress events mainly to the extent that it captures structural / institutional (less easily observable) features of a country. ([35]) Other fiscal (liquidity) variables such as the cyclically-adjusted balance are on the other hand not found to be significant (see Annex III). ([36]) Interestingly, macro-financial variables (such as private credit flows, current account and GDP growth) appear robust predictors of fiscal crises whether we rely on a restrictive sample (as in model 1), or a longer dataset (as in model 2).

([34]) For example, in order to capture quasi country fixed effects, we tested the inclusion of GDP per capita and a measure of past fiscal stress events (taking values 0, 1 and 2). However, GDP per capita is not significant, while the inclusion of a measure of past fiscal stress event deteriorate the overall results. Alternative specifications have also been tested including a quality of institutions indicator (based on World Bank data), a contagion effect variable (based on fiscal stress experienced in other countries), and a realisation of contingent liabilities one (based on Bova et al. (2016) data). Nevertheless, these variables did not yield satisfactory results, at the exception of the contagion variable (see Annex III).

([35]) The fact that the *level* of debt becomes non-significant when introducing country fixed-effects suggests that a higher level of debt across countries can be associated with a higher probability of fiscal distress, while we could not establish a similar relationship within countries. The debt *dynamics* is found to be associated with increasing values of the probability of fiscal distress both across and within countries.

([36]) This is not surprising given the correlation between the fiscal balance variables and the change in the public debt ratio (for instance, an alternative estimation to model 1 that considers the cyclically adjusted balance rather than the change in the public debt ratio identifies this first variable as significant – the overall performance of such a regression is however slightly lower).

Table 7. **Logit regression results: two main models selected (dependent variable: probability of fiscal distress)**

VARIABLES	Model 1		Model 2	
	Coefficients	Average marginal effects	Coefficients	Average marginal effects
L1.gross public debt (% GDP)	**0.0339*** **	**0.00109*** **		
	(0.0114)	(0.000372)		
L1.change in gross public debt (% GDP)	**0.111***	**0.00358***	**0.0944***	**0.0137***
	(0.0576)	(0.00189)	(0.0511)	(0.00817)
L1.private sector credit flow (% GDP)	**0.00955***	**0.000308***		
	(0.00532)	(0.000170)		
L3. private sector credit flow (% GDP, extended series)			**0.132*** **	**0.0192*** **
			(0.0356)	(0.00666)
L1. current account balance (3-year backward MA, % GDP)	**-0.353*** **	**-0.0114*** **	**-0.148** **	**-0.0215** **
	(0.0619)	(0.00239)	(0.0685)	(0.0102)
L3.real GDP growth (%)	**-0.231*** **	**-0.00744*** **	**-0.131** **	**-0.0190** **
	(0.0615)	(0.00228)	(0.0654)	(0.00794)
World GDP growth	**-0.578*** **	**-0.0186*** **	**-0.473*** **	**-0.0686*** **
	(0.150)	(0.00511)	(0.135)	(0.00928)
Constant	**-4.819*** **			
	(0.910)			
Observations	416		680	
Number of id	28		26	
Pseudo R2	0.393		0.291	
Log likelihood	-48.70		-74.38	
AUROC	0.927		0.849	
Fixed effects	no		yes	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

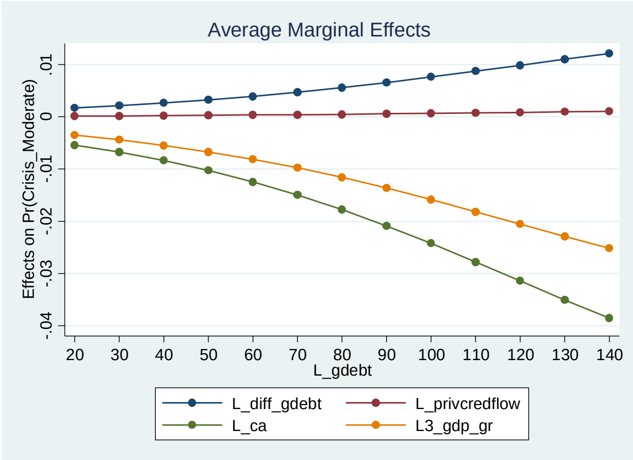
Note: 1) The AUROC is a measure of overall predictive accuracy of the model. An uninformative model would have a value of 0.5; a perfect predictor would have a value of 1. 2) Marginal effects of a given regressor measure the change in probability for one unit change in the regressor. Given the non-linearity of logit models, these marginal effects are not constant (i.e. they change with different values of the explanatory variables). Hence, as commonly done in the literature, these effects are calculated for each value of the regressor and then averaged. For example, looking at model 2, a decrease of public debt between t-2 and t-1 by 10 pps. with respect to initial GDP translates into a decrease of the probability of fiscal distress of 0.14 pps.

Source: Commission services

Given the non-linearity of our model, the marginal effect of each explanatory variable depends on this variable's value, as well as other variables' values. For instance, according to Model 1, the (marginal) effects of macro-competitiveness variables (e.g. GDP growth rate, current account balance) on the probability of being in fiscal distress increase with the level of public debt (see Graph 10). This result illustrates the interactions between macroeconomic and fiscal imbalances. Not surprisingly, the effect of public debt dynamics on the probability of experiencing a fiscal stress event also depends on the level of public debt. ([37])

([37]) On the other hand, the effect of private credit flows seems less sensitive to the level of public debt based on these estimations.

Graph 10. **Average marginal effects on fiscal distress probability of different explanatory variables depending on the public debt level (based on Model 1)**

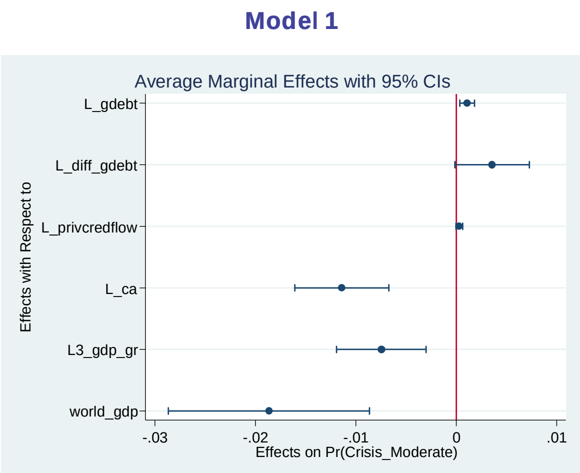


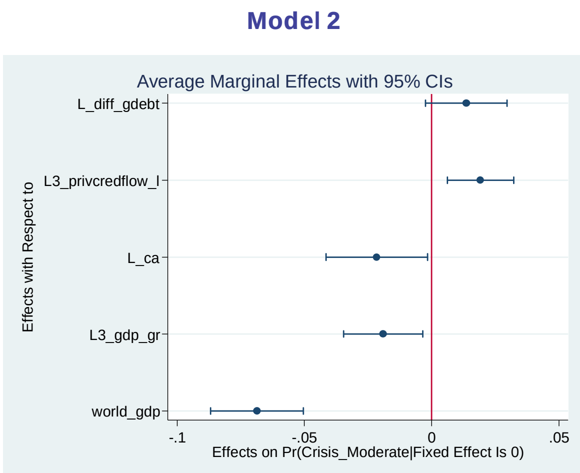
Note: *gdebt* stands for gross public debt; *diff_gdebt* stands for the change in gross public debt; *privcredflow* stands for private sector credit flows; *ca* stands for current account balance (as defined before) and *gdp_gr* stands for real GDP growth.

Source: Commission services

Average marginal effects appear nevertheless overall quite low (see Graph 11), as fiscal stress events are particularly rare events, especially in our set of advanced economies (as seen before). For instance, a reduction of public debt by 10 pps. is found to decrease the probability of fiscal distress by a maximum of 0.3 – 0.4 pps. according to model 2, ([38]) which is non-negligible but still limited (it represents a 6-7% decline when relating this value to the average probability of fiscal stress over the estimation sample).

Graph 11. **Average marginal effects: two main models**





Note: The charts represent the point estimate of the average marginal effects for the main variables, and the associated 95 percent confidence interval.

Source: Commission services

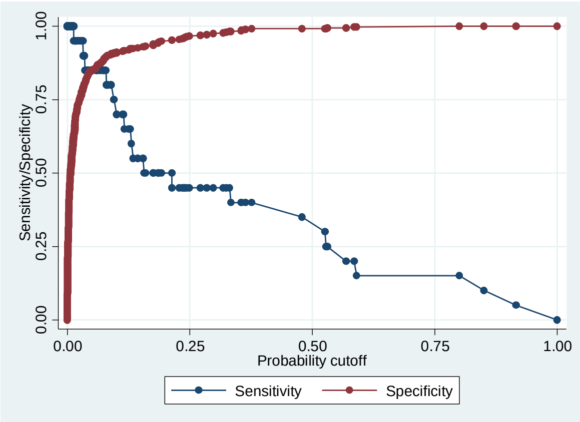
([38]) This value is based on the maximum impact obtained with a 95% confidence interval (this value is obtained by considering the average marginal effect of around 0.014 obtained plus 2 standard deviations – of around 0.008, see Table 7).

The AUROC value, measuring the overall predictive accuracy of the models, appears relatively high in both models (close to 1) – although higher for model 1, and in line with results obtained in the literature. Moreover, the in-sample overall predictive performance of model 1 is (logically) satisfactory when choosing a threshold corresponding to the optimal probability cut-off value (around 5%, see Graph 12) and the unconditional probability of a fiscal stress event over the estimation sample (at 4.8%, see Table 8), and close to S0 performance. For instance, this regression allows predicting 85% of fiscal stress events (*sensitivity*), and has a signalling power of around 70% (the signalling power is a preferred statistic to the proportion of correction classified events as it gives more weight to type II error than to type I error). Model 2 has a similar signalling power to S0 when choosing a low cut-off value (at 4.5%), however, with an associated higher type II error.

Table 8. **In-sample predictive performance compared**

	(1) Restricted sample, no FE	(2) Larger sample, FE
AUROC	**0.927**	**0.849**
Cut-off value = 5.5%		
Correctly classified	86	88
Sensitivity	85	58
type I error	14	10
type II error	15	42
Signalling power	**71**	**48**
Cut-off value = 4.5%		
Correctly classified	84	85
Sensitivity	85	69
type I error	16	15
type II error	15	31
Signalling power	**69**	**55**
Unconditional probability of crisis (over estimation sample)	*4.8%*	*5.3%*
S0 (threshold = 0.46)		
Correctly classified	77	
Sensitivity	78	
type I error	22	
type II error	23	
Signalling power	**55**	

Graph 12. **Optimal cut-off value depending on sensitivity and specificity**



Note: 1) FE stands for fixed effects; 2) the optimal probability cut-off value is the one that achieves the best trade-off between type I and type II errors.

Source: Commission services

Looking at the composition of the fiscal stress events correctly predicted / missed (see Table 9), one observes that, despite better overall performance statistics, the performance of model 1 is similar to the one of model 2 for EU countries since 2008 (3 fiscal events missed out of 19 in both cases). In both cases, one important fiscal stress event is missed (Ireland in 2008 in the first case, and Spain in 2012 in the second case). ([39])

([39]) The out-of-sample predictive power of these regressions cannot easily be tested given the lack of observations: for instance, if we re-estimate model 2 excluding years after 2007, some variables are not significant anymore (the exclusion of the years 2008-2015 leaving a sample with a limited number of fiscal stress events – given missing observations for explanatory variables at the beginning of the sample period).

Table 9. **Detailed in-sample predicted / missed fiscal stress events in EU countries (based on cut-off value of 4.5%)**

	Model 1	Model 2
Number of distinct fiscal stress events *(in brackets, since 2008)*	**19** ***(19)***	**29** ***(19)***
Number of distinct fiscal stress events correctly signalled *(in brackets, since 2008)*	16 *(16)*	21 *(16)*
o/w		1974 (IT)
		1982 (DK)
		1983 (PT)
		1992 (FI)
		2001 (PL)
	2008 (EL, HU, IT, LV, PT, RO)	2008 (EL, HU, IE, IT, LV, PT, RO)
	2009 (BG, LT, PL)	2009 (BG, LT, PL)
	2010 (ES, PT)	2010 (PT)
		2011 (BE)
	2012 (ES, FR, HU, IT)	2012 (FR, HU, IT)
	2013 (CY)	2013 (CY)
Number of distinct fiscal stress events missed *(in brackets, since 2008)*	3 *(3)*	8 *(3)*
o/w		1974 (UK)
		1976 (IE)
		1990 (FI, SE)
		1993 (EL)
	2008 (IE)	
		2010 (ES)
	2011 (BE)	
	2012 (AT)	2012 (AT, ES)

Note: 1) The sensitivity and type II error obtained here are slightly different compared to Table 8 as we concentrate on EU countries (respectively 84% and 16% in Model 1, and in model 2 as from 2008). 2) As can be seen, with Model 1, only fiscal stress events, as from 2008 can be used (due to data limitation – on the other hand, non-crisis events as from the mid-1990's can be used), while with Model 2, episodes as early as in the mid-1970's can be used. However, observations on countries that never experienced fiscal stress events over the estimation sample (e.g. DE, DK, NL) are dropped in Model 2 (due to country fixed effects).

Source: Commission services

4.3. OUT-OF-SAMPLE PREDICTIONS (FOR 2017) AND COMPARISON WITH S0 RESULTS

In this section, given that there is no obvious statistical superiority of model 2 compared to model 1, and given limitations of fixed-effects models in the case of a model with a binary variable already pointed, especially when performing projections, we choose to make projections based on model 1 only, and compare them with the signal sent by the S0 indicator in 2017.

In 2017, no country is identified to be at-risk of experiencing fiscal stress according to S0 (see Table 10), although Cyprus is flagged according to the S0 financial-competitiveness sub-index, and four additional countries exhibit borderline values (Belgium, Italy, Portugal and the UK). According to the logit model, five countries would be at risk of experiencing fiscal stress (Cyprus, Portugal, the UK, Italy and to a lower extent Belgium). Hence, even though the magnitude of the 'signal' sent by the two approaches (S0 and logit model) is slightly different, the group of countries identified as being at risk / borderline is identical. ([40])

([40]) As pointed in the European Commission Fiscal Sustainability Report 2015, the reading and interpretation of S0 results on a country by country basis are supported by the two fiscal and financial-competitiveness sub-indexes, the most relevant variables included in S0 and the heat maps on risks (or mitigating factors) related to the structure of public debt financing and government contingent liabilities.

Table 10. **'Signal' of fiscal distress in 2017: S0 versus logit model (based on data available at last Autumn forecasts 2016)**

	2017		
	S0	**So financial compet.**	**Logit model 1**
BE	0.42	0.35	4.8%
BG	0.28	0.39	1%
CZ	0.19	0.28	0%
DK	0.19	0.29	0%
DE	0.08	0.12	0%
EE	0.25	0.37	0%
IE	0.28	0.32	0%
ES	0.37	0.27	2%
FR	0.31	0.25	4%
HR	0.18	0.23	1%
IT	0.42	0.40	8%
CY	0.41	0.57	25%
LV	0.29	0.45	1%
LT	0.21	0.33	0%
HU	0.31	0.27	0%
NL	0.20	0.31	0%
AT	0.15	0.19	1%
PL	0.29	0.41	1%
PT	0.41	0.46	10%
RO	0.26	0.26	1%
SI	0.14	0.16	0%
SK	0.34	0.46	1%
FI	0.22	0.29	3%
SE	0.12	0.19	0%
UK	0.41	0.35	10%
S0			
threshold	*0.46*		
lower threshold	*0.37*		
S0 financial-competitiveness			
threshold	*0.49*		
Logit Model 1			
upper threshold	*5.5%*		
lower threshold	*4.5%*		

Note: 1) The lower threshold for S0 is conventionally set at 80% of S0 (endogenous) critical threshold. We also consider the signal sent by the S0 financial-competitiveness sub-index as its signalling power is similar to S0. The upper and lower thresholds for the logit model are the ones considered previously. 2) As seen before, the S0 indicator measures the weighted proportion of variables signalling risks of fiscal stress, while the logit L1 indicator measures the predicted probability of entering in fiscal distress.

Source: Commission services

5. CONCLUSION

In a context where fiscal sustainability challenges remain important in a number of European economies, we have proposed several extensions of the early-detection index of fiscal stress developed in Berti al. (2012): i) we extended the Baldacci et al. (2011) dataset to take into account recent episodes of fiscal distress; ii) we updated the thresholds used for the S0 indicator, based on this extended fiscal stress series, and other revised variables; iii) we presented another indicator of fiscal stress (the L1 indicator), based on a logit model, focusing (as for the S0 indicator) on European economies (while most studies centre their analysis on emerging economies); iv) we provided some elements of comparison of the respective performance of the two indicators.

The indicator of fiscal distress presented in this paper based on a multivariate regression analysis (logit modelling, the L1 indicator) and on a recently updated dataset of fiscal stress episodes presents some interesting features: relying on a parsimonious set of variables that have been tested for their conditional statistical significance, it exhibits an overall satisfactory in-sample performance. In line with Berti et al. (2012), this indicator confirms the importance of monitoring macro-financial variables to assess countries' vulnerabilities to fiscal distress. It also provides some evidence that the change in the public debt ratio is an important predictor of fiscal distress events, while the level of public debt would particularly matter when combined with macro-competitiveness imbalances. Our analysis suggests that the L1 indicator could be used as a complementary tool to the S0 indicator to monitor prospective fiscal risks, building on the respective strengths of the two approaches, while compensating for their limitations.

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ANNEX I

Dataset sources and correlation matrix

Main data sources used

Main variables tested	**Sources**
Fiscal stress variable	IMF (Baldacci et al., 2011), Commission services based on IMF (MONA), ECB (10 year bond yields)
Fiscal trigger variables	
Cyclically-adjusted balance, primary balance, fiscal balance	AMECO, IMF (WEO)
Gross public debt ratio (level and change)	AMECO, IMF (WEO)
Realisation of contingent liabilities	IMF (Bova et al., 2016)
Macro-financial trigger variables	
Private credit flows and private debt	Estat, AMECO (short time series) Estat, AMECO and BIS (longer time series, linked private debt series, variation of private debt used as a proxy for private credit flows)
Current account balance and net IIP	Estat, Commission, IMF (WEO)
Net household savings	AMECO
GDP growth rate	AMECO World Bank (World Development Indicators) for World GDP growth
Institutional variable	World Bank (World Governance Indicators)

Correlation matrix: main potential trigger variables

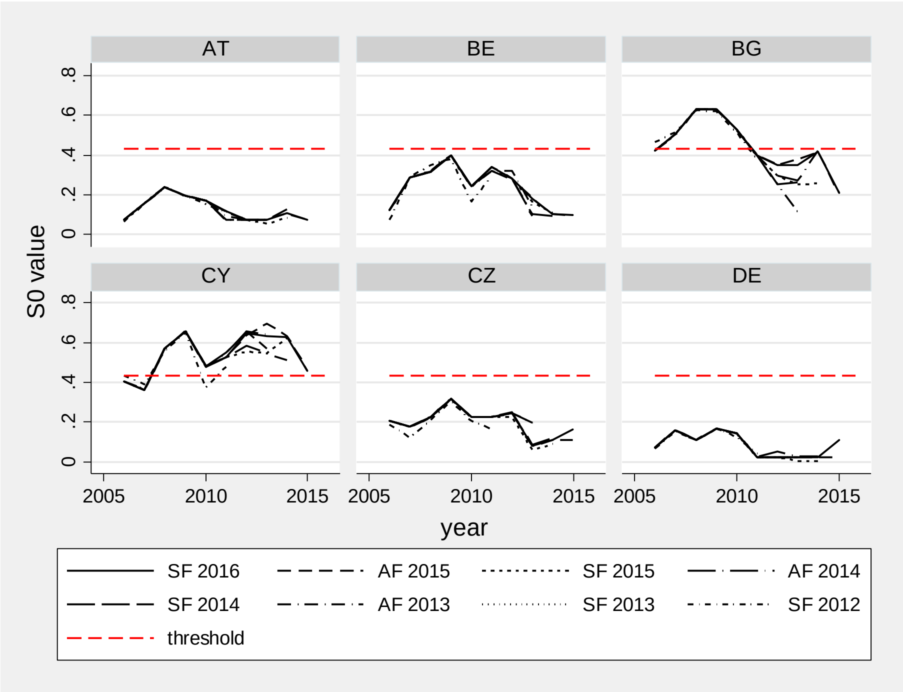
	bal	pb	cab	stab_pb	diff_exp	diff_cons	gfn	gdebt	diff_gdebt	ndebt	stdebt	iff_stdebt	int_gr	ycurve	privdebt	rivcredflo	ns_hh	debt_nfco	stdebt_hh	ca	iip	gdp_gr	gdp_pc	constr	ulc	reer
bal	1.000																									
pb	0.842	1.000																								
cab	0.764	0.575	1.000																							
stab_pb	-0.239	-0.071	-0.099	1.000																						
diff_exp	-0.194	-0.270	-0.211	0.149	1.000																					
diff_cons	0.011	-0.069	0.001	0.104	0.512	1.000																				
gfn	-0.679	-0.438	-0.561	0.423	0.123	0.037	1.000																			
gdebt	-0.423	-0.133	-0.385	0.408	-0.081	-0.085	0.750	1.000																		
diff_gdebt	-0.527	-0.551	-0.443	0.474	0.356	0.173	0.382	0.214	1.000																	
ndebt	-0.653	-0.471	-0.252	0.345	-0.064	-0.095	0.673	0.656	0.139	1.000																
stdebt	-0.239	0.013	-0.203	0.236	-0.043	0.031	0.555	0.560	0.175	0.487	1.000															
diff_stdebt	0.094	0.073	0.049	-0.054	-0.095	0.044	-0.116	-0.052	0.019	-0.049	0.046	1.000														
int_gr	-0.197	-0.033	-0.068	0.768	0.147	0.161	0.283	0.344	0.380	0.205	0.243	-0.064	1.000													
ycurve	-0.160	-0.210	0.002	0.347	-0.085	-0.129	0.181	0.225	0.164	0.304	0.110	-0.062	0.250	1.000												
privdebt	0.017	0.002	0.049	0.193	0.114	0.077	-0.147	0.193	0.251	0.010	0.360	-0.019	0.251	0.032	1.000											
privcredflow	0.339	0.298	0.205	-0.304	-0.051	-0.055	-0.336	-0.253	-0.257	-0.159	-0.058	0.143	-0.330	-0.346	0.242	1.000										
ns_hh	-0.193	-0.020	-0.222	0.073	0.039	0.012	0.189	0.172	0.077	0.109	0.275	0.030	0.227	-0.144	-0.099	-0.167	1.000									
stdebt_nfcorp	-0.172	-0.084	0.006	0.224	0.043	0.051	0.249	0.379	0.087	0.424	0.377	0.079	0.256	0.045	0.438	0.090	0.236	1.000								
stdebt_hh	-0.071	-0.051	0.022	0.226	0.068	0.038	-0.103	0.221	0.108	0.129	0.196	0.037	0.235	0.085	0.523	0.093	0.085	0.596	1.000							
ca	0.339	0.368	0.228	-0.004	-0.115	0.010	-0.121	0.150	-0.179	-0.226	0.183	0.014	0.110	0.037	0.035	-0.218	0.385	0.048	0.056	1.000						
iip	0.253	0.277	0.240	-0.179	-0.021	0.093	-0.166	-0.078	-0.237	-0.079	0.011	0.012	-0.061	-0.292	0.036	0.066	0.365	0.266	0.088	0.477	1.000					
gdp_gr	0.210	0.209	0.139	-0.538	-0.367	-0.416	-0.259	-0.264	-0.504	-0.153	-0.170	0.037	-0.583	-0.213	-0.235	0.400	-0.104	-0.229	-0.195	-0.060	0.079	1.000				
gdp_pc	0.211	0.271	0.128	0.153	0.035	0.015	-0.157	0.144	0.001	-0.176	0.340	0.046	0.273	-0.017	0.532	0.063	0.386	0.368	0.410	0.479	0.418	-0.018	1.000			
constr	0.086	-0.090	0.089	-0.334	0.158	0.123	-0.144	-0.376	-0.008	-0.149	-0.284	0.046	-0.359	-0.253	-0.009	0.397	-0.129	-0.179	-0.055	-0.410	-0.034	0.227	-0.123	1.000		
ulc	0.025	0.012	0.023	-0.272	0.039	0.251	0.006	-0.096	-0.113	-0.175	-0.097	0.020	-0.255	-0.307	-0.210	0.024	-0.138	-0.169	-0.186	0.015	0.050	-0.017	-0.205	0.080	1.000	
reer	0.254	0.190	0.068	-0.177	0.010	0.048	-0.327	-0.317	-0.122	-0.273	-0.276	-0.008	-0.250	-0.155	-0.231	0.257	-0.264	-0.247	-0.233	-0.155	-0.093	0.141	-0.197	0.197	0.139	1.000

Note: cells are highlighted when the correlation coefficient is greater (lower) than 0.4 (-0.4).

Source: Commission services

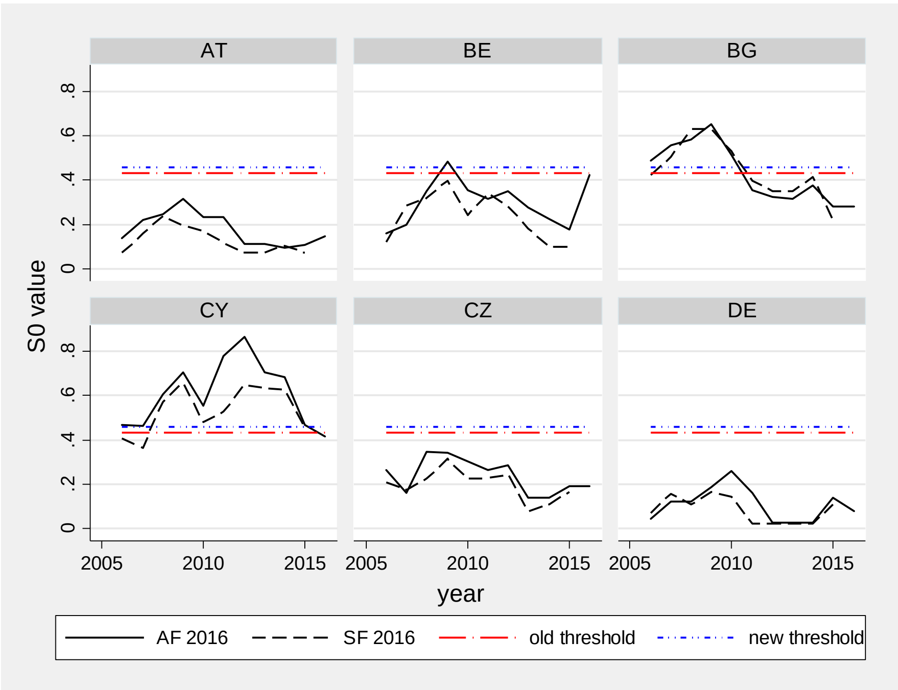
ANNEX II
S0 values through different vintages

Spring forecast 2012 to Spring forecast 2016



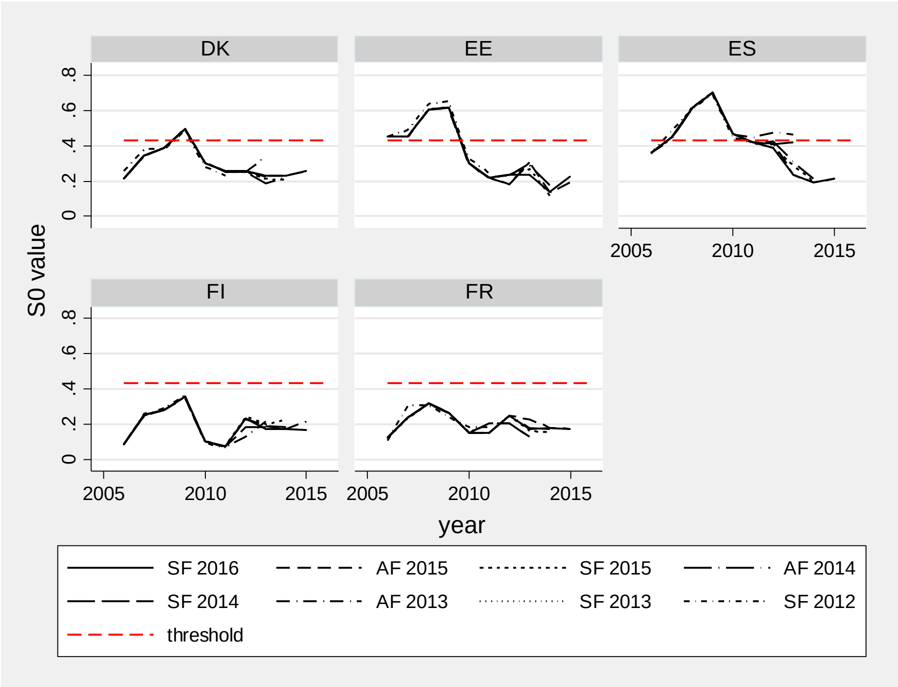
Source: Commission services

Spring forecast 2016 and Autumn forecast 2016 (thresholds' revision)



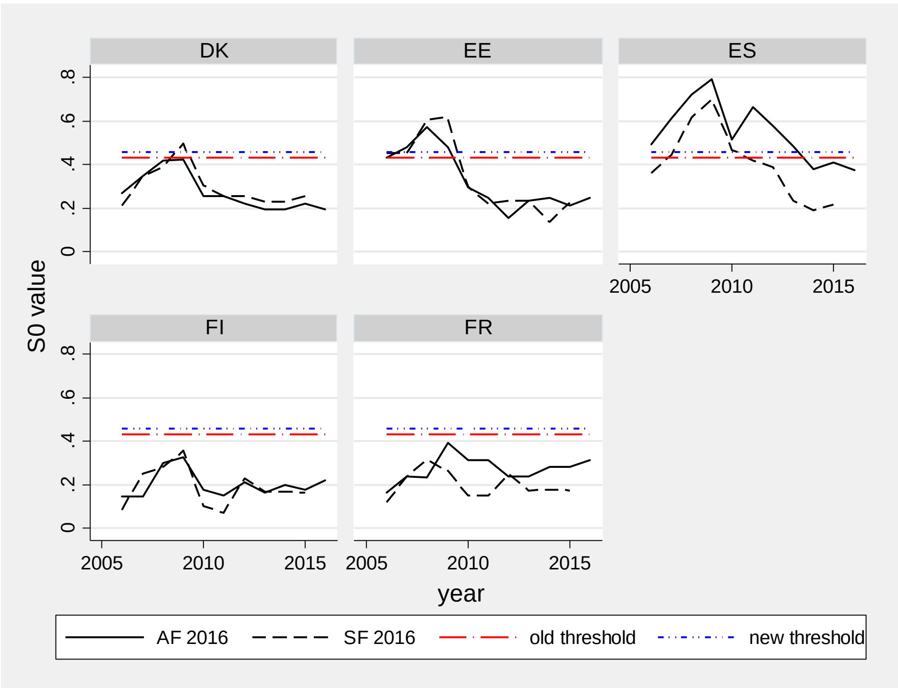
Source: Commission services

Spring forecast 2012 to Spring forecast 2016



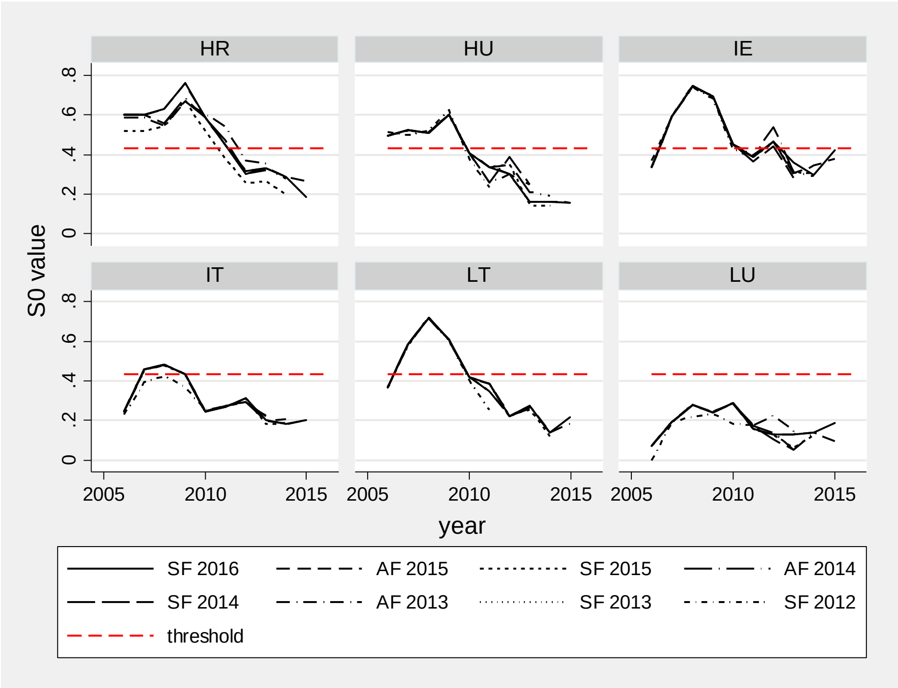
Source: Commission services

Spring forecast 2016 and Autumn forecast 2016 (thresholds' revision)



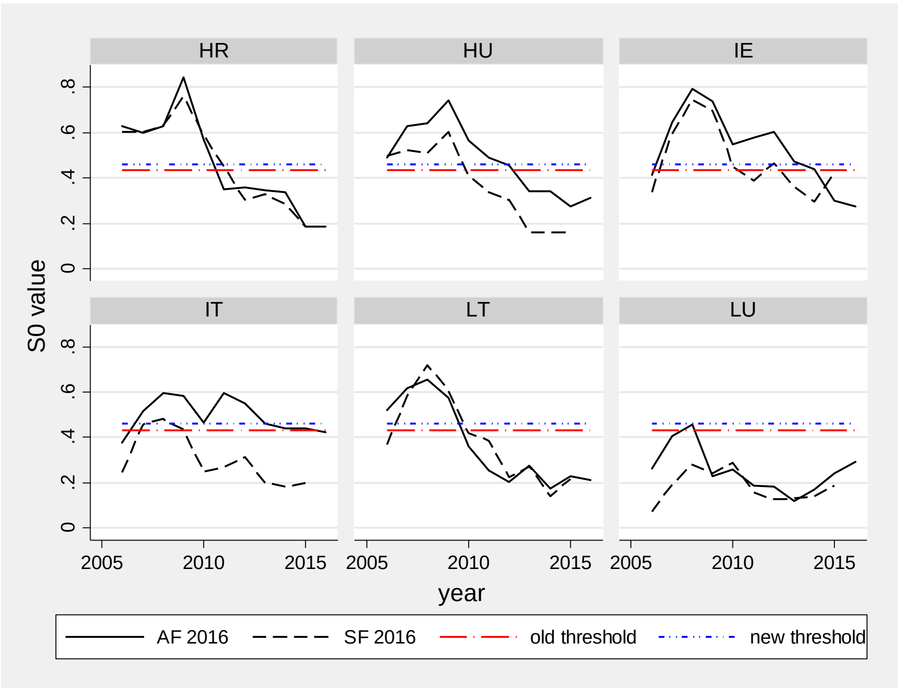
Source: Commission services

Spring forecast 2012 to Spring forecast 2016



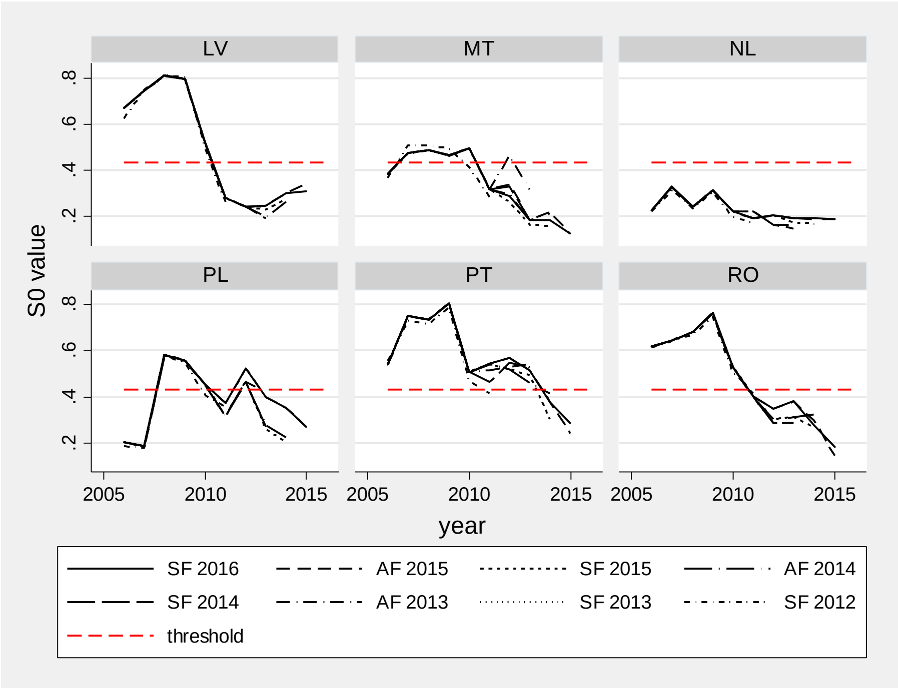
Source: Commission services

Spring forecast 2016 and Autumn forecast 2016 (thresholds' revision)



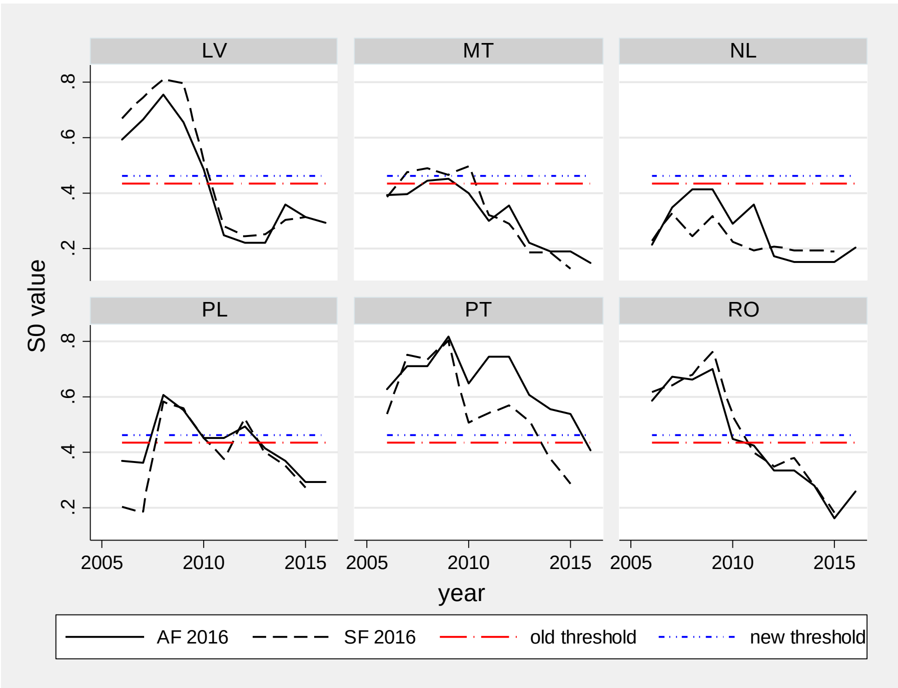
Source: Commission services

Spring forecast 2012 to Spring forecast 2016



Source: Commission services

Spring forecast 2016 and Autumn forecast 2016 (thresholds' revision)

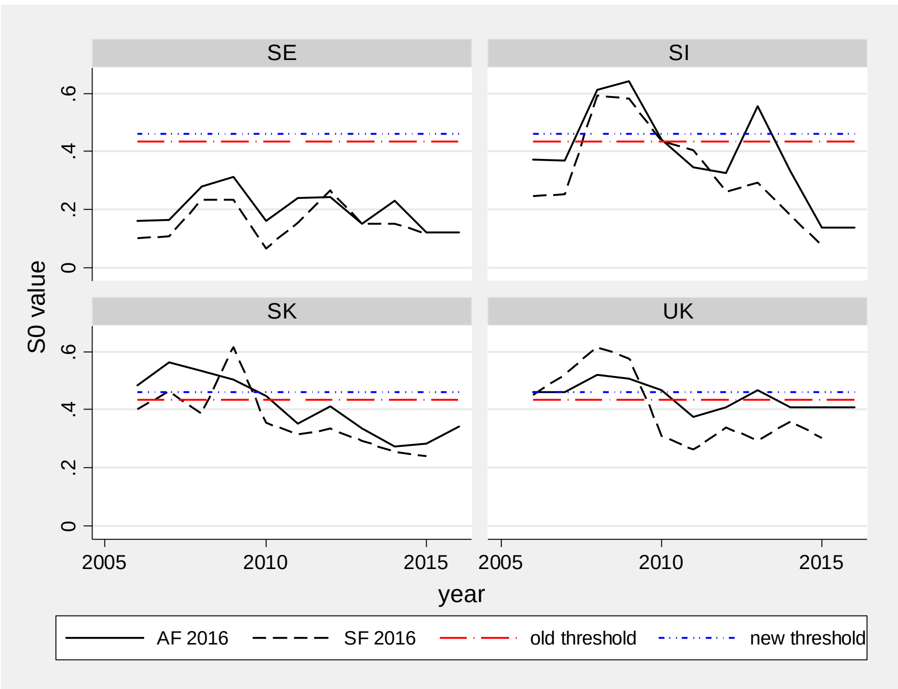


Source: Commission services

Spring forecast 2012 to Spring forecast 2016

Source: Commission services

Spring forecast 2016 and Autumn forecast 2016 (thresholds' revision)



Source: Commission services

Frequency of revision of the S0 indicator by country (over the period 2006-2016): comparing the Spring forecast 2016 to Autumn forecast 2016

	stable (no-risk)	stable (risk)	not stable
AT	100%	0%	0%
BE	90%	0%	10%
BG	50%	40%	10%
CY	0%	80%	20%
CZ	100%	0%	0%
DE	100%	0%	0%
DK	90%	0%	10%
EE	60%	30%	10%
ES	20%	40%	40%
FI	100%	0%	0%
FR	100%	0%	0%
HR	40%	50%	10%
HU	40%	40%	20%
IE	30%	50%	20%
IT	30%	30%	40%
LT	60%	30%	10%
LU	100%	0%	0%
LV	50%	50%	0%
MT	60%	0%	40%
NL	100%	0%	0%
PL	60%	30%	10%
PT	0%	80%	20%
RO	50%	40%	10%
SE	100%	0%	0%
SI	60%	20%	20%
SK	60%	20%	20%
UK	40%	20%	40%
Average	**61%**	**26%**	**13%**

Note: the S0 indicator is deemed stable (no-risk) when its value has been consistently below the critical threshold through the two vintages considered; stable (risk) when its value has been consistently above the critical threshold through the two vintages considered; not stable when the risk classification differed in the two vintages considered.

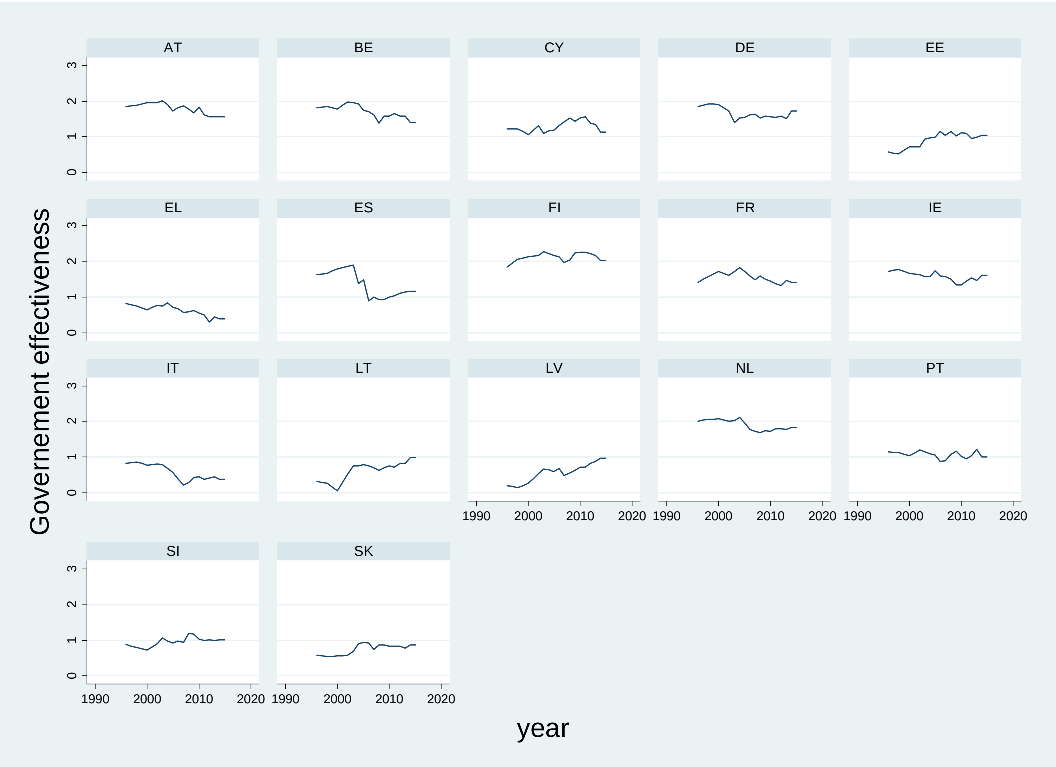
Source: Commission services

ANNEX III
Alternative logit estimations

Including a quality of institutions variable

Several studies consider that the quality of institutions has an impact on the incidence of fiscal distress (starting from the seminal work of Reinhart and Rogoff, 2003; Bassanetti et al, 2016; Kraay and Nehru, 2006). In this section, we test for the introduction of such a variable, in particular, we test several governance indicators provided by the World Bank (World Governance Indicators - control of corruption, political stability and absence of violence, governess effectiveness). ([41]) Given the relative inertia of such indicators, the introduction of such a variable also plays the role of a quasi-country fixed-effect (see Graphs below). However, the main drawback of these indicators is that data are only available as from 1996.

Government effectiveness, by selected country

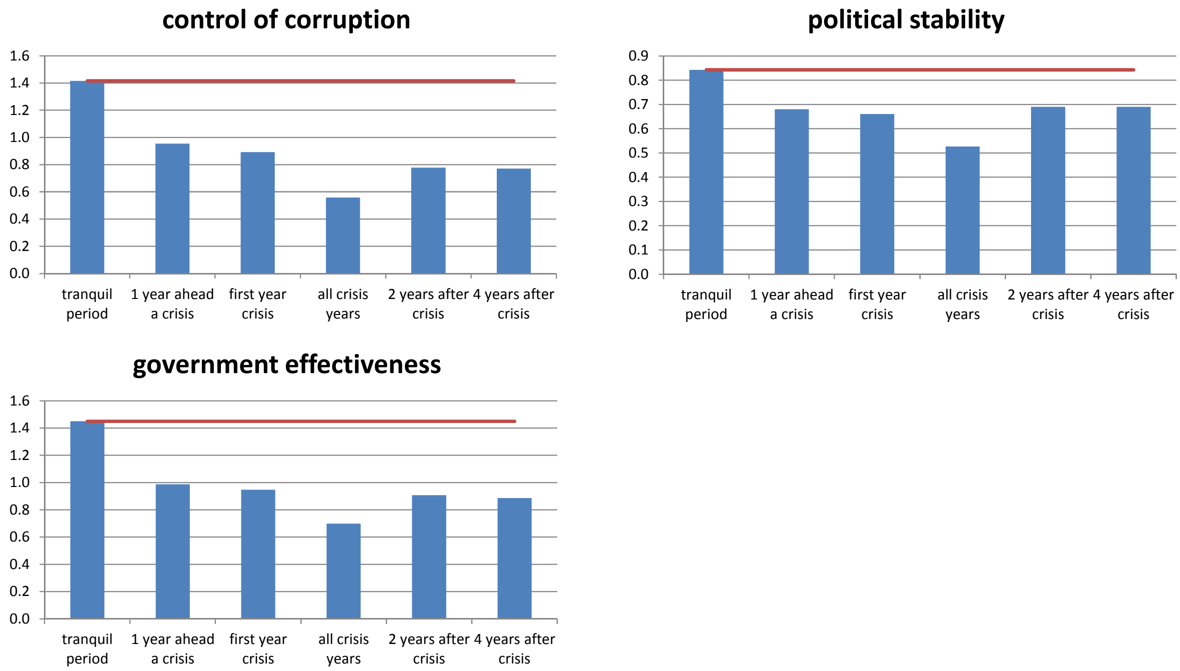


Note: these indicators range from -2.5 (worse performance) to 2.5 (best performance). See http://info.worldbank.org/governance/wgi/index.aspx#doc for the methodology

Source: World Bank (WGI)

([41]) This source is used by the ECB in its DSA framework (see Bouabdallah et al., 2017). Other sources were considered but not used for different reasons: short time span and insufficient geographical coverage (World Bank, CPIA); lack of differentiation for European countries (Polity IV, index of democracy); break in methodology through time (Transparency international, corruption perceptions index); non-publicly available data (PRS, International Country Risk Guide over the period 1984 - 1995).

Evolution of key governance indicators tested in different regimes



Note: The red line represents the tranquil period average.

Source: World Bank (WGI), Commission services

In the table below, alternative specifications to model 1 are considered including the government effectiveness and the political stability indicators of the World Bank WGI dataset. However, none of these variables appear significant.

Introducing quality of institutions variable

VARIABLES	Model 1		wtih effectiveness		with stability	
	Coefficients	Average marginal effects	Coefficients	Average marginal effects	Coefficients	Average marginal effects
L_gdebt	**0.0339*** **	**0.00109*** **	**0.0339*** **	**0.00110*** **	**0.0333*** **	**0.00109*** **
	(0.0114)	(0.000372)	(0.0112)	(0.000370)	(0.0111)	(0.000379)
L_diff_gdebt	**0.111***	**0.00358***	**0.137****	**0.00445****	**0.105***	**0.00343***
	(0.0576)	(0.00189)	(0.0678)	(0.00219)	(0.0542)	(0.00177)
L_effectiveness			**-1.007**	**-0.0326**		
			(0.794)	(0.0253)		
L_stability					**-0.513**	**-0.0168**
					(0.672)	(0.0217)
L_privcredflow	**0.00955***	**0.000308***	**0.0189****	**0.000613****	**0.0129****	**0.000423****
	(0.00532)	(0.000170)	(0.00799)	(0.000261)	(0.00550)	(0.000176)
L_ca	**-0.353*** **	**-0.0114*** **	**-0.306*** **	**-0.00991*** **	**-0.336*** **	**-0.0110*** **
	(0.0619)	(0.00239)	(0.0628)	(0.00213)	(0.0568)	(0.00224)
L3_gdp_gr	**-0.231*** **	**-0.00744*** **	**-0.214*** **	**-0.00695*** **	**-0.225*** **	**-0.00739*** **
	(0.0615)	(0.00228)	(0.0593)	(0.00218)	(0.0597)	(0.00225)
world_gdp	**-0.578*** **	**-0.0186*** **	**-0.582*** **	**-0.0189*** **	**-0.550*** **	**-0.0180*** **
	(0.150)	(0.00511)	(0.155)	(0.00483)	(0.158)	(0.00566)
Constant	**-4.819*** **		**-3.767*** **		**-4.418*** **	
	(0.910)		(1.103)		(0.877)	
Observations	416	416	406	406	406	406
Number of id	28		28		28	
Pseudo R2	0.393		0.408		0.395	
Log likelihood	-48.70		-47.22		-48.26	
AUROC	0.927		0.926		0.925	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: given that the governance indicators are only available over a short time period, they are only tested in Model 1.

Source: Commission services

Including contagion effects and realisation of contingent liabilities variable

In the table below, an alternative specification to model 1 is considered including a dummy variable to capture contagion effects (taking value 1 in a euro area country when at least one other euro area country experiences a fiscal stress event). The contemporaneous contagion variable appears significant. ([42]) However, the overall performance of such a regression is little improved compared to the reference regression, and would prove challenging to use for projections.

Including contagion effects in euro area countries

VARIABLES	Model 1		(2) with CAB		(3) with CAB only (& w/o diff. debt)		(2) with contagion effects		(3) with contagion effects	
	Coefficients	Average marginal effects	Coefficients	Average marginal effects	Coefficients	Average marginal effects	Coefficients	Average marginal effects	Coefficients	Average marginal effects
L_cab			-0.0958	-0.00312	-0.148*	-0.00489	-0.146**	-0.00435**	-0.176**	-0.00528**
			(0.0593)	(0.00218)	(0.0794)	(0.00306)	(0.0589)	(0.00216)	(0.0717)	(0.00260)
L_gdebt	0.0339***	0.00109***	0.0320**	0.00104**	0.0319**	0.00106**	0.0318***	0.000947***	0.0318***	0.000954***
	(0.0114)	(0.000372)	(0.0125)	(0.000416)	(0.0130)	(0.000441)	(0.0115)	(0.000320)	(0.0116)	(0.000325)
L_diff_gdebt	0.111*	0.00358*	0.0952*	0.00310*			0.0515	0.00153		
	(0.0576)	(0.00189)	(0.0569)	(0.00182)			(0.0569)	(0.00167)		
L_privcredflow	0.00955*	0.000308*	0.0165***	0.000539**	0.0179***	0.000594**	0.0243***	0.000723***	0.0252***	0.000756***
	(0.00532)	(0.000170)	(0.00572)	(0.000220)	(0.00647)	(0.000246)	(0.00544)	(0.000202)	(0.00556)	(0.000207)
L_ca	-0.353***	-0.0114***	-0.332***	-0.0108***	-0.320***	-0.0106***	-0.315***	-0.00938***	-0.311***	-0.00934***
	(0.0619)	(0.00239)	(0.0622)	(0.00221)	(0.0654)	(0.00242)	(0.0718)	(0.00216)	(0.0736)	(0.00217)
L3_gdp_gr	-0.231***	-0.00744***	-0.238***	-0.00775***	-0.252***	-0.00835***	-0.200***	-0.00596**	-0.205***	-0.00615**
	(0.0615)	(0.00228)	(0.0641)	(0.00240)	(0.0651)	(0.00245)	(0.0667)	(0.00240)	(0.0684)	(0.00243)
world_gdp	-0.578***	-0.0186***	-0.584***	-0.0190***	-0.569***	-0.0189***	-0.442**	-0.0132**	-0.416**	-0.0125*
	(0.150)	(0.00511)	(0.150)	(0.00516)	(0.162)	(0.00533)	(0.183)	(0.00612)	(0.193)	(0.00645)
contagion							1.851**	0.0551**	1.981**	0.0595***
							(0.896)	(0.0235)	(0.852)	(0.0215)
Constant	-4.819***		-5.037***		-5.040***		-6.495***		-6.634***	
	(0.910)		(1.009)		(1.087)		(1.406)		(1.414)	
Observations	416	416	411	411	411	411	411	411	411	411
Number of id	28		28		28		28		28	
Pseudo R2	0.393		0.395		0.380		0.450		0.446	
Log likelihood	-48.70		-48.36		-49.56		-44.01		-44.31	
AUROC	0.927		0.926		0.925		0.945		0.945	
FE	no		no		no		no		no	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

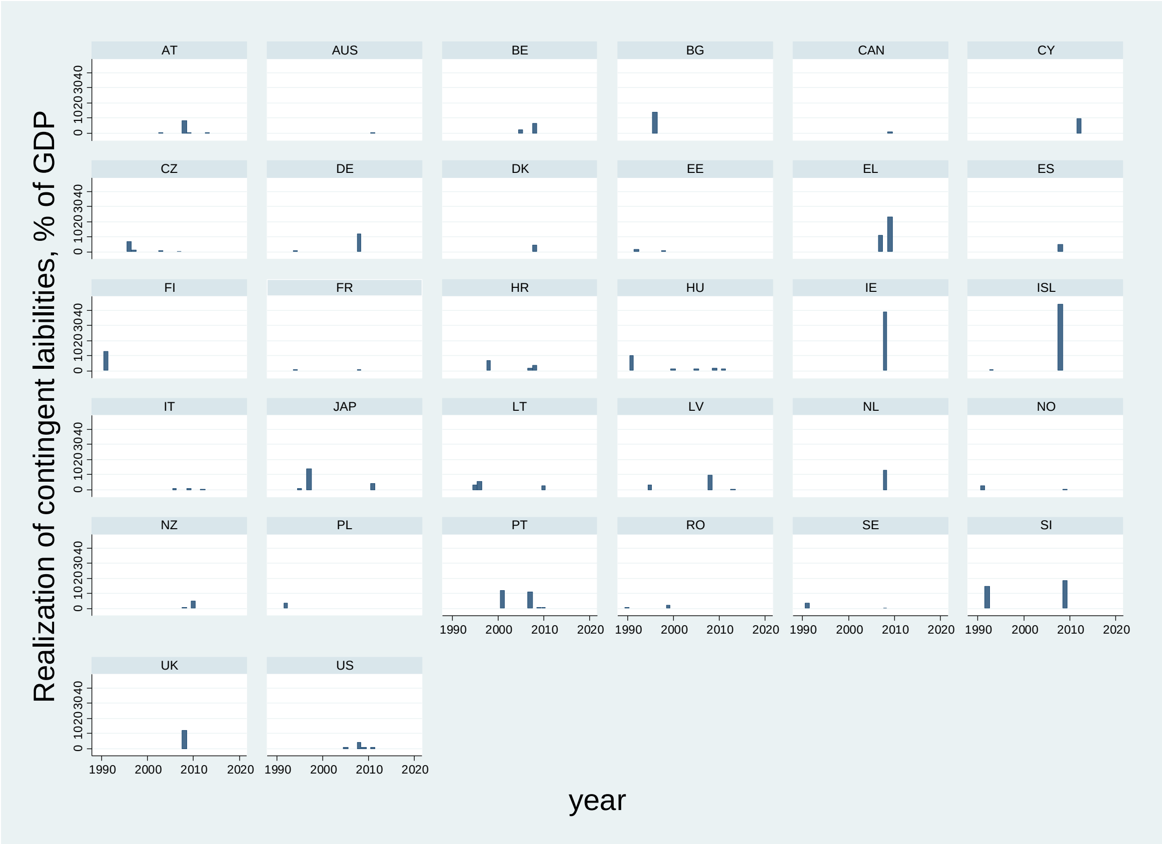
Note: we introduce the contagion variable in regressions that also include the cyclically-adjusted balance.

Source: Commission services

Building on a recent dataset on realisation of contingent liabilities (Bova et al., 2016, see Graph below), we also estimate alternative specifications to our reference regressions that include this variable. Given that each event is recorded in this dataset with a starting and an ending year for the realisation of the contingent liabilities (for example, for Ireland, the support to the financial sector, amounting to around 39% of GDP, is recorded as having being realised from 2008 to 2011), we create a dummy variable that takes value 1 for the years concerned. However, this variable does not appear significant (see Tables below).

([42]) Lagged value is not significant however, suggesting that contagion effects materialise quickly.

Realisation of contingent liabilities, by country (% of GDP, in countries with at least one event)



Note: year recorded corresponds to the start year.

Source: Bova et al. (2016)

Including realisation of contingent liabilities (Model 1)

VARIABLES	Model 1 Coefficients	Model 1 Average marginal effects	with liabilities Coefficients	with liabilities Average marginal effects	& without CAB Coefficients	& without CAB Average marginal effects
L_cab			-0.105	-0.00341		
			(0.0816)	(0.00299)		
L_gdebt	0.0339***	0.00109***	0.0353***	0.00115***	0.0373***	0.00120***
	(0.0114)	(0.000372)	(0.0134)	(0.000417)	(0.0119)	(0.000357)
L_diff_gdebt	0.111*	0.00358*				
	(0.0576)	(0.00189)				
L_liabilities			0.888	0.0289	0.984	0.0316
			(0.715)	(0.0220)	(0.691)	(0.0213)
L_privcredflow	0.00955*	0.000308*	0.0183***	0.000596***	0.0113*	0.000364*
	(0.00532)	(0.000170)	(0.00553)	(0.000219)	(0.00630)	(0.000187)
L_ca	-0.353***	-0.0114***	-0.320***	-0.0104***	-0.339***	-0.0109***
	(0.0619)	(0.00239)	(0.0577)	(0.00219)	(0.0577)	(0.00240)
L3_gdp_gr	-0.231***	-0.00744***	-0.225***	-0.00730***	-0.215***	-0.00693***
	(0.0615)	(0.00228)	(0.0661)	(0.00253)	(0.0615)	(0.00227)
world_gdp	-0.578***	-0.0186***	-0.527***	-0.0171***	-0.515***	-0.0166***
	(0.150)	(0.00511)	(0.179)	(0.00597)	(0.182)	(0.00584)
Constant	-4.819***		-5.563***		-5.354***	
	(0.910)		(1.218)		(1.167)	
Observations	416	416	411	411	419	419
Number of id	28		28		28	
Pseudo R2	0.393		0.394		0.386	
Log likelihood	-48.70		-48.50		-49.33	
AUROC	0.927		0.926		0.925	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: in the regressions, the variable on realisation of contingent liabilities is tested without public debt dynamics (to avoid multicollinearity) but with the cyclical adjusted balance.

Source: Commission services

Including realisation of contingent liabilities (Model 2)

VARIABLES	Model 2 Coefficients	Model 2 Average marginal effects	With liabilities Coefficients	With liabilities Average marginal effects	& without CAB Coefficients	& without CAB Average marginal effects	& without debt level Coefficients	& without debt level Average marginal effects
L_cab			0.0213	0.00341				
			(0.0813)	(0.0129)				
L_gdebt			0.00619	0.000991	0.00903	0.00153		
			(0.0110)	(0.00193)	(0.0102)	(0.00194)		
L_diff_gdebt	0.0944*	0.0137*						
	(0.0511)	(0.00817)						
L_liabilities			0.625	0.1000	0.615	0.104	0.646	0.103
			(0.543)	(0.0888)	(0.536)	(0.0922)	(0.500)	(0.0847)
L3_privcredflow_l	0.132***	0.0192***	0.115***	0.0184**	0.117***	0.0198***	0.117***	0.0188***
	(0.0356)	(0.00666)	(0.0353)	(0.00780)	(0.0343)	(0.00737)	(0.0323)	(0.00606)
L_ca	-0.148**	-0.0215**	-0.175**	-0.0280**	-0.165**	-0.0279**	-0.168**	-0.0269**
	(0.0685)	(0.0102)	(0.0750)	(0.0122)	(0.0684)	(0.0115)	(0.0661)	(0.0108)
L3_gdp_gr	-0.131**	-0.0190**	-0.128*	-0.0205**	-0.121*	-0.0205**	-0.119*	-0.0191**
	(0.0654)	(0.00794)	(0.0726)	(0.00932)	(0.0720)	(0.0101)	(0.0649)	(0.00896)
world_gdp	-0.473***	-0.0686***	-0.462***	-0.0740***	-0.469***	-0.0794***	-0.398***	-0.0637***
	(0.135)	(0.00928)	(0.134)	(0.0191)	(0.135)	(0.0181)	(0.129)	(0.0125)
Observations	680	680	668	668	685	685	702	702
Number of cntry	26		26		26		26	
Number of groups	26		26		26		26	
Pseudo R2	0.291		0.286		0.288		0.248	
Log likelihood	-74.38		-74.34		-74.93		-87.30	
AUROC	0.849		0.834		0.837		0.823	
FE	yes		yes		yes		yes	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: in the regressions, the variable on realisation of contingent liabilities is tested without public debt dynamics (to avoid multicollinearity) but with the cyclical adjusted balance.

Source: Commission services

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KC-BD-17-049-EN-N

Publications Office

ISBN 978-92-79-64889-2