SAFETY MARGINS IN EU BUDGETARY SURVEILLANCE: AN ASSESSMENT

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This paper deals with alternative approaches for deriving adequate budgetary safety margins. We highlight some critical features of the existing EU Commission's methodology and propose an alternative method for assessing the minimal benchmark, i.e. *the value of the deficit-to-GDP ratio that ensures compliance with the required safety margins. A number of empirical arguments lend support to this measurement approach, although our estimates of minimal benchmarks do not diverge extensively from those derived through the current methodology. We also provide estimates of safety margins by using a complementary approach based on stochastic simulations of a macroeconomic model. The findings are qualitatively very similar to those obtained with the other method. Moreover, we lend empirical support to the view that a fiscal structure with lower budget sensitivity to cyclical fluctuations is conducive to less ambitious safety margins.*

1 Introduction

As a result of the reform of the Stability and Growth Pact (SGP), which was agreed upon at the European Council of March 2005, the notion of safety margins has become crucial in the process of EU budgetary surveillance. Under the previous SGP each Member States had to pursue the attainment of a budgetary position close to balance or in surplus in the medium term. A key provision of the revised SGP is that medium-term budgetary objectives (MTO) may diverge from close to balance or in surplus and can differ across countries depending on country-specific economic conditions and risks to public finance sustainability. According to the new SGP, the MTOs are laid down with the primary aim of ensuring a safety margin with respect to the 3 per cent deficit limit in case of adverse cyclical developments. The size of this margin must take into account the country's past output volatility and the budgetary sensitivity to output. The minimal (or minimum) benchmark (MB) is the value of the deficit-to-GDP ratio that ensure compliance with such adequate safety margin (see European Commission, 2002 and 2006).

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Measures of MBs were first derived by the Commission in 2001, although even before estimates were made available in other works (see, e.g., IMF, 1998 and Buti *et al.*, 1998). Calculation of MBs requires preliminary estimation of budgetary sensitivities to output and representative negative output gaps. The latter are estimates of output gap levels which are likely to be observed under particularly unfavourable, yet still possible, cyclical conditions. According to the EU Commission's methodology, the representative output gap is derived by applying an algorithm. It is the simple mean between the lowest and the highest figures resulting from these three alternative indicators: a) the country-specific largest negative output gap; b) the unweighted average of the largest negative output gaps in each country; c) two times the country-specific standard deviation of the output gap taken with minus sign.

On 26 October 2005, Member States officially called for further methodological work to explore possible methodological improvements (European Commission, 2006). In our view, the EU Commission's existing methodology has some shortcomings, such as: a) the *ex ante* uncertainty on which pair of indicators, out of the three made available, is actually used; b) a non satisfactory way to tackle the issue of the short length of output gap time series, especially of New Member States (NMSs); and finally, c) the fact that, for being meaningful, one of the three indicators implicitly imposes the assumption of normality for the output gaps series.

In this paper, not only we provide arguments and produce evidence questioning the soundness of the existing methodology, but we also put forward an alternative methodology for deriving budgetary safety margins. The intuition underlying our approach is that countries with wider cyclical fluctuations should be more constrained by their MBs than countries whose business cycles are less volatile. Indeed, the higher is the volatility of a country's cyclical fluctuations, the more likely is the outcome of this country being hit by a sizeable recession.

We propose to compute representative output gaps through an identical algorithm for all Member States, that uses both a country-specific and a common component referred to all EU 27 Member States. This allows us to fully exploit the country-specific information, while, by supplementing this information with a common component, also limit the adverse implications of using output gap series not fully representative of typical cyclical developments. In our proposed approach, the country-specific and the 27 EU-wide common components of representative output gap are aggregated by using as weights the relative volatility of their business cycles.

In addition to proposing a new method still based on *ex post* information, we also employ an alternative *ex ante* approach for computing MBs. This alternative *ex ante* approach is based on stochastic simulations of a macroeconomic model. This approach was also adopted in other contributions such as those by Dalsgaard and de Serre (1999) and Artis and Onorante (2006).[1] We perform the stochastic simulations

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[1] See also the studies by Dury and Pina (2003) and Roodenburg *et al.* (1998).

with the Italian Treasury Econometric Model (ITEM) (Department of the Treasury, 2007). In particular, we repeatedly simulate the model by using random drawings of stochastic disturbances that mimic macroeconomic turbulence. This allows us to derive an approximated distribution for the deficit-to-GDP ratio. Importantly for our purposes, this yields an estimated value of the budget balance-to-GDP ratio that would imply compliance with the 3 per cent boundary for a given time horizon and a given probability. We compare estimates of MBs obtained this way with the corresponding values obtained with the other method. We also argue that lower budget sensitivity to output fluctuations should imply less ambitious budgetary safety margins. This hypothesis lends itself to the empirical scrutiny. In particular, we perform stochastic simulations under two counterfactual scenarios, both characterised by a lower degree of budgetary sensitivity to output fluctuations and test whether budgetary safety margins are of lower size than those estimated under the baseline scenario.

Before going through the paper, it is important to highlight an important, and more general, issue that our paper does *not* address. This issue is how to reconcile the margins of uncertainty surrounding cyclically-adjusted budgetary figures with their prominent role in EU fiscal surveillance. Such uncertainty stems from data revisions of output gap series across different vintages, from imperfect estimates of tax elasticities and tax bases as well as from difficulties to appraise the budgetary effects of the changing composition of growth. Admittedly, tackling these issues would require a much broader perspective than the one taken in this paper. We therefore treat the commonly used approach for deriving cyclically-adjusted budget balances as a “maintained hypothesis” and focus our attention on a more limited issue.

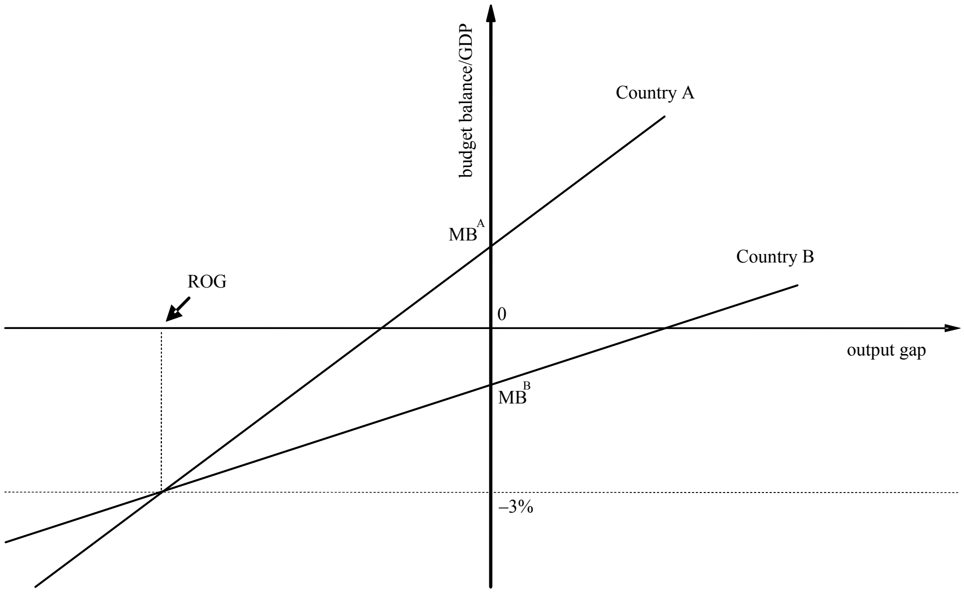
The remainder of the paper is organised as follows. Section 2 illustrates the concept of MB. Section 3 presents the data and the methodology used by the EU Commission for estimation. Section 4 addresses some critical issues pertaining to the existing methodology. In section 5, we outline our proposed methodology. In section 6, we apply it to actual data and compare the estimated values of MBs with those obtained with the existing method. Section 7 provides evidence on safety margins derived from stochastic simulations of a macroeconomic model. The final section draws some conclusions.

2 The definition of “minimal benchmark”

The MB is defined as the value of the cyclically-adjusted budget balance that allows a country to let automatic stabilisers work freely without risking to breach the 3 per cent deficit-to-GDP ceiling under normal cyclical circumstances. This indicator is relevant in the assessment of countries’ stability and convergence programmes. It is obtained by subtracting from the 3 per cent ceiling a “cyclical safety margin” calculated as the product of the budgetary sensitivity to output fluctuations times a “representative output gap” (ROG) that captures by how much

Figure 1

The Minimal Benchmark for Two Countries with the Same Representative Output Gap



output would go below potential in case of particularly weak, yet still likely, cyclical conditions. In analytical terms,

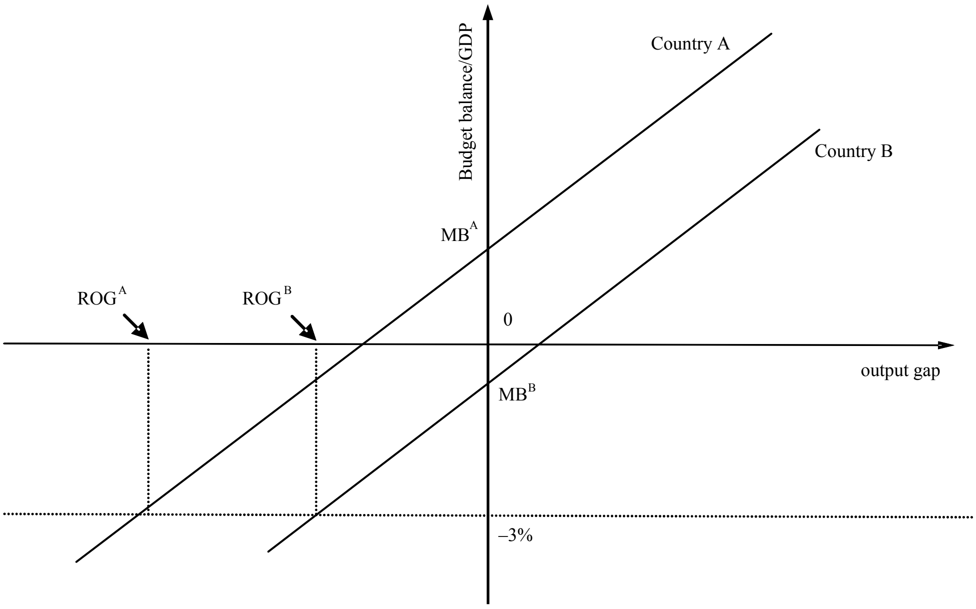
$$MB = -3 - \varepsilon \cdot ROG \tag{1}$$

where MB is the minimal benchmark, ε is the budgetary sensitivity to growth and ROG is the representative output gap. The latter variable measures the wedge between actual and potential output in the case of particularly severe, yet still possible, cyclical conditions. ε is measured as the change in the budget balance-to-GDP ratio in response to a unit percentage increase of output gap. Hence, the computation of MBs requires, for each Member State, (i) an estimate of the budgetary sensitivity to output fluctuations and (ii) the identification of a representative output gap for particularly weak cyclical conditions.

In Figure 1, we compare two countries, A and B, having the same ROG, with one of them (A) exhibiting a higher budgetary sensitivity to output gap with respect to the other (B). The slope of the two lines indicates the degree of such sensitivity. Given the definition of MB, although the two countries share the same ROG, for the country with a higher budgetary sensitivity (A) the required cyclical safety margin for the deficit-to-GDP ratio is larger than that for the other country. In particular, the

Figure 2

The Minimal Benchmark for Two Countries with the Same Budgetary Sensitivity



MB of the country with the higher budgetary sensitivity is positive (MB^A), suggesting that the safety margin for the budget balance has to be particularly sizeable.

Similarly, in Figure 2 we consider the situation in which two countries, A and B, exhibit the same budgetary sensitivity although they differ in the degree of volatility of their cycle as measured by the representative output gap. The country with the largest negative representative output gap (A) requires a safety margin for the budget balance-to-GDP ratio which is larger than that for the other country (B). In the example of the figure, the MB of the country with a higher (in absolute value) ROG is positive (MB^A), indicating that the safety margin is of a large size. Conversely, the MB is negative (MB^B) for the other country. Of course, it is straightforward to compare MBs of countries when both budgetary sensitivities and representative output gaps are different (see European Commission, 2002).

3 Data and the existing method

The EU Commission estimated MBs for EU-15 Member States for the first time in 2001 and then updated them in 2002 and the following years. Starting from

2005, measures of MBs were also made available for the New Member States (EU 10). As we have seen before, the notion of MB is inherently country-specific and for its computation the following information is needed for each Member State: (i) an estimate of the budgetary sensitivity to output fluctuations and (ii) an estimate of a representative output gap (ROG).

New and updated estimates of budgetary sensitivities are currently available for both the EU 15 and the New Member States, although official estimates for Bulgaria and Romania are not yet available.[2] The sample of output gap data used to estimate ROGs refers to the period 1980-2005 for the EU 15 countries.[3] By contrast, for the NMSs the starting period of output gap data is 1995 at the earliest. Despite the official dataset maintained by the Commission services (AMECO) contains data on output gap of the EU 15 countries starting from 1965 (except for Germany and Luxembourg), the entire sample is not used for computing ROGs as using time series that start far back in the past may increase the risk of dealing with past cyclical characteristics of the economy that are structurally different from those currently prevailing. For example, the economic cycle volatility of a specific country may have been higher over the past 20 years than it had previously been. Considering a time series dating back to 1965 may underestimate the size of a typical adverse cyclical outcome which is likely to occur in the future. This would erroneously lead to a lower-than-required budgetary safety margin.

This is also true for NMSs where available data on output gap starts quite recently. Because of a variety of structural shifts hitting these economies in the early nineties, using output gap data that go far back in the past would not be a correct strategy. Indeed, the cyclical patterns observed in these economies before the mid-1990s are likely to be profoundly different from those prevailing now. Hence, data on output gap before then are likely to be scarcely informative for identifying a representative unfavourable cyclical outcome as of today. Therefore, the EU Commission's approach to use a sub-sample of the available data rather than the whole sample seems to be reasonable. On the other hand, however, the resulting short length of the time series, especially for NMS, is problematic as the sole

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[2] The methodology for deriving budget sensitivities is the one developed by OECD and has recently undergone a number of revisions. The joint work of the OECD and Economic Policy Committes's output gap working group (EPC OGWG) has produced the new and updated budget sensitivities for the EU 25 countries which have been approved by the EPC. For each country, budget sensitivity is obtained from budget elasticities. On the revenue side of the budget, four different tax elasticities to output were estimated: on personal income tax, on corporate income tax, on indirect taxes and, finally, on social contributions. The four elasticities are then aggregated using as weights the share of each item on total current tax revenues. This provides an estimate of the elasticity of tax revenues to output. On the expenditure side, only the elasticity to output of unemployment-related transfers is considered. Both revenue and expenditure elasticities are converted into sensitivity parameters by multiplying the tax revenue and expenditure elasticities by, respectively, the share of current tax revenues on GDP and the share of current expenditure on GDP. Finally, the difference between the sensitivity of tax revenue to output and the sensitivity of expenditure to output provides the country-specific estimate of the sensitivity of the budget balance to output fluctuations.

[3] Germany and Luxembourg are the two exceptions: their samples start, respectively, in 1991 and 1982.

country-specific output gap data may not be sufficient to convey the necessary information.

The EU Commission methodology for estimating output gap has changed after the 2002 Council decision to endorse the production function approach for measuring potential output. The previous method was based on the application of the Hodrick-Prescott (HP) filter to estimate trend GDP. In 2003, the EPC OGWG refined the production function methodology and extended it to all EU countries, including the New Member States. Moreover, in 2006 a number of additional modifications have been introduced and a detailed description of the EU revised production function approach is presented in Denis, Grenouilleau, Mc Morrow and Röger (2006).[4]

According to the existing method, the sample of the output gap values used to calculate the ROG is first trimmed to exclude those observations that are not representative of standard cyclical fluctuations. The original version of the SGP provided a definition of a "severe and exceptional economic downturn" as a decline in GDP growth greater than 0.75 per cent. Thus, in the old SGP framework, output gap observations corresponding to such declines were considered outliers and excluded from the sample. Since 2005, all observations for which the output gap is below the 2.5th percentile or above the 97.5th percentile of the whole set of data are dropped. This methodology, without assuming any specific statistical distribution for output gaps, provides a solution to the problem arising from the removal of the reference to "severe economic downturn" in the new SGP.

Once outliers are excluded, ROGs are derived for each EU country by applying, in the period considered, the simple average of the minimum and the maximum values resulting from the following three alternative criteria:

(i) the largest negative output gap ever observed for the Member State concerned;

(ii) the simple average of the largest negative output gaps in EU Member States;

(iii) two times the country-specific standard deviation of the output gap taken with minus sign.

In October 2005, the Member States, whilst agreeing on the new release of data on MBs for the EU-25, invited the European Policy Committee to undertake methodological work to improve the current approach (European Commission, 2006). Indeed, the reform of the SGP and the EU enlargement make the notion of MB extremely important in EU budgetary surveillance. However, there are a

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[4] Potential output is derived within a Cobb-Douglas production function framework where the following inputs are considered: a) a capital stock series of the business sector constructed under the hypothesis that investment responds to potential output with a unit elasticity, b) a measure of trend labour input and c) a measure of trend TFP. Potential labour input stems from both potential employment and trend, average hours worked. Potential employment is obtained by combining an estimate of structural unemployment rate (NAIRU), working age population and an estimate of trend participation rate. The latter is obtained by applying the HP filter on participation rate data, whilst the NAIRU estimate stems from a Kalman filter approach where a Phillips curve relationship is used to identify the cyclical components of unemployment. The HP filter is applied to standard TFP estimates to derive its trend component (see Denis, Grenouilleau, Mc Morrow and Röger, 2006).

number of critical features in the current methodological approach. In the following sections we discuss them and argue in favour of a revision of the existing method.

4 Issues related to the current methodology

The existing MB method features three different indicators, although only two of them are relevant for each country, namely the ones providing the lowest and the highest value. The obvious implication of this algorithm is that the identification of an adverse cyclical outcome hinges on different indicators depending on the country concerned. Moreover, new data releases and/or revision may imply a switch, for a given country, from one pair of indicators to another, with unpleasant implications on the stability of outcomes. The *ex ante* uncertainty on which pair of indicators is used casts some doubts on the soundness of the existing approach.

Another relevant issue deals with the short length of output gap time series for the NMSs. In 2004, EPC OGWG decided not to use data before 1995 in computing output gaps for EU-10 countries. We have already discussed the reasons as to why the informative gains from increasing back into the past the NMS sample data would be more than offset by the drawbacks stemming from the structural transformations occurred in the early 1990s. However, considering a relatively short time series of output gap data is also problematic, as the country-specific data may not be sufficiently informative on the typical size of adverse cyclical developments. In Table 1 we report descriptive statistics of the output gap data for both the whole and the restricted samples. In general, if we compare figures in columns (3) and (5), they indicate country's standard deviations being larger when the longest sample is considered. The EU wide standard deviation is 2.30 for the whole sample (excluding Bulgaria and Romania), while it is 1.95 for the restricted sample. Moreover, if we look at figures in column (5) it turns out that in 9 cases out of 12, the country-specific standard deviation of output gap of the EU-12 (the NMS) is lower than the figure calculated on the whole sample (1.95). If we take the standard deviation of output gap as a measure of the intensity of business fluctuations, one might infer that cycles of NMS are inherently less volatile. However, if we compute the standard deviation of output gap over the entire EU 27 sample, but with observations only from 1995 onward, this value is 1.66. Importantly, such value is lower than the one obtained on the whole sample and no more is it systematically higher than the country-specific standard deviation of NMS. Hence, the evidence for the EU 27 over the period of interest seems to indicate that, with too short a sample of the output gap series, the degree of cyclical volatility might be underestimated and so would be the representative output gap. Should this happen, the ensuing budgetary safety margin against the risk of infringing the 3 per cent deficit-to-GDP ratio would be biased downward. One of the three indicators used in the existing methodology is not country-specific but common to all EU countries. It is the unweighted average of the largest negative output gap in Member States. The presence of this indicator is likely to mitigate the problem of ROG and safety margin underestimation in the case of too short output gap time series. Nevertheless, further

Table 1

Descriptive Statistics for the Output Gap Series

EU 27 Countries (1)	**Whole Sample**		**Restricted Sample**		
	Mean (2)	**St. Dev. (3)**	**Mean (4)**	**St. Dev. (5)**	**5th Percentile (6)**
AT	–0.10	1.57	–0.36	1.39	–2.10
BE	–0.18	1.73	–0.43	1.53	–2.43
BG	.	.	–0.14	1.83	–3.55
CY	0.10	1.55	0.09	1.57	–2.04
CZ	–2.40	0.98	–2.41	0.98	–3.61
DE	0.11	1.50	0.10	1.50	–1.29
DK	–0.30	2.01	–0.51	2.02	–4.13
EE	–2.10	2.51	–1.13	1.40	–4.39
EL	–0.26	2.80	–0.80	1.92	–3.72
ES	–0.41	2.78	–1.20	2.61	–4.83
FI	–0.39	2.99	–0.34	2.06	–3.22
FR	–0.09	1.48	–0.43	1.44	–2.18
HU	–0.33	1.07	–0.32	1.08	–1.25
IE	0.05	2.58	–0.56	2.58	–4.70
IT	–0.06	1.72	–0.25	1.63	–2.62
LT	–1.56	2.98	–0.56	2.20	–3.65
LU	–0.35	3.42	–0.88	2.73	–5.15
LV	–0.93	1.33	–0.93	1.32	–2.87
MT	0.16	2.59	–0.31	2.15	–3.18
NL	–0.27	1.60	–0.53	1.75	–3.32
PL	–1.15	1.67	–1.15	1.66	–4.95
PT	–0.01	3.63	–0.03	2.64	–4.06
RO	.	.	–1.23	2.53	–4.47
SE	–0.58	1.98	–0.85	2.08	–3.51
SI	–0.28	1.04	–0.28	1.03	–1.81
SK	–0.75	1.85	–0.76	1.85	–2.98
UK	–0.07	2.05	–0.58	2.10	–4.13
EU	–0.31	2.30	–0.58	1.95	–3.82

Legenda: The whole sample refers to the longer time series available from AMECO database. These series cover the period 1965-2005 for EU 15, excluding Germany and Luxembourg whose data start in 1991 and 1982, respectively. For the NMS, the first year of the sample varies between 1995 and 1997. The restricted sample refers to the sub-sample used for computing ROGs and MBs. It is 1980-2005 for EU 15, excluding Germany and Luxembourg. The statistics reported on columns (4) through (6) and referred to the restricted sample are computed after removing the outliers (see text).

methodological work is warranted so as to make MBs for NMSs more demanding than what they are with the existing approach.

An additional shortcoming stems from the criterion (iii) of the current methodology, the one that uses as indicator "two times the standard deviation of the output gap taken with minus sign". For being meaningful, this indicator implicitly requires the assumption that output gaps follow a normal distribution. According to the stylized facts about business fluctuations for industrialised countries, there are no large asymmetries between rises and falls in production. In other words, GDP growth tends to be distributed roughly symmetrically around its mean (Romer, 2005).[5] This would not be inconsistent with assuming normality of output gap. Such hypothesis, however, would be more likely to hold over the entire sample for which data have been constructed (1965-2005 for the EU 15). On the contrary, in computing the MBs, output gap data before 1980 are not considered for any EU country. Therefore, the assumption of symmetry and, *a fortiori*, of normality might fail to hold for the output gap series of some countries.

Thus, since the assumption of normality lends itself to the empirical scrutiny, we performed two different tests for normality on each of the EU 27 countries' time series of output gap. These tests are the Shapiro-Wilk and the test described in D'Agostino *et al.* (1990), which combines into a general test a pair of tests for normality each based, respectively, on skewness and kurtosis. The statistic for this second test is distributed as an adjusted χ^2. In Table 1 we report the results of these tests performed on the output gap data used for computing MBs.

It turns out that in about 20 per cent of the EU 27 countries, the hypothesis of normality of the output gap is rejected at standard level of confidence. In general, when the normality assumption is rejected this outcome is obtained no matter whether we include or exclude the outliers of the output gap dataset. The latter, we recall it, are identified as those values lower and greater than, respectively, the 2.5th and 97.5th percentiles of the whole EU 27 data set. Rejection of normality is not limited to data of the NMSs where, arguably, the lower length of the time series may render the tests for normality less informative. Indeed, evidence of departure from normality is found for output gap data of countries such as Spain and Germany (see Table 2).

In light of the above shortcomings, a reformulation of the current methodology for measuring MBs is appropriate. Thus, it would be important for a new method to be based on a unique indicator common to all countries, without *a priori* uncertainty on which one is used for each of the various countries. This would clearly enhance the degree of transparency. Second, an improvement over the existing algorithm would be a computation of MBs not affected by the limited cyclical volatility in NMSs that derives, as it was documented, from the short length

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[5] Romer (2005) argues convincingly that the asymmetry might be of a different type. In particular, real GDP tends to be characterised by relatively lengthy periods when it is a little bit above its usual path, interrupted by short periods when it is relatively far below (see also Acemoglu and Scott, 1997).

Table 2

Tests for Normality of Output Gap Data

Country	**Sample Adjusted for Outliers**					**Sample Not Adjusted for Outliers**				
	N. obs.	**(1) adj-χ^2**	**(2) *p*-val.**	**(3) W**	**(4) *p*-val.**	**N. obs.**	**(5) adj-χ^2**	**(6) *p*-val.**	**(7) W**	**(8) *p*-val.**
AT	26	2.60	0.27	0.94	0.10	26	2.60	0.27	0.94	0.10
BE	26	2.37	0.31	0.97	0.53	26	2.37	0.31	0.97	0.53
BG	9	2.73	0.26	0.86	0.10	11	5.37	0.07	0.88	0.12
CY	11	1.56	0.46	0.93	0.45	11	1.56	0.46	0.93	0.45
CZ	9	1.63	0.44	0.93	0.44	9	1.63	0.44	0.93	0.44
DE	15	6.05	0.05	0.83	0.01	15	6.05	0.05	0.83	0.01
DK	26	0.13	0.93	0.99	0.98	26	0.13	0.93	0.99	0.98
EE	9	8.47	0.01	0.78	0.01	11	3.60	0.17	0.79	0.01
EL	26	1.65	0.44	0.97	0.57	26	1.65	0.44	0.97	0.57
ES	26	6.72	0.03	0.93	0.06	26	6.72	0.03	0.93	0.06
FI	22	0.15	0.93	0.97	0.70	26	0.74	0.69	0.97	0.75
FR	26	4.21	0.12	0.94	0.11	26	4.21	0.12	0.94	0.11
HU	11	11.36	0.00	0.73	0.00	11	11.36	0.00	0.73	0.00
IE	24	0.42	0.81	0.97	0.74	26	0.43	0.81	0.98	0.87
IT	26	1.34	0.51	0.97	0.71	26	1.34	0.51	0.97	0.71
LT	9	3.02	0.22	0.88	0.15	11	1.50	0.47	0.92	0.28
LU	20	2.18	0.34	0.96	0.55	24	1.80	0.41	0.97	0.64
LV	11	1.03	0.60	0.97	0.90	11	1.03	0.60	0.97	0.90
MT	10	1.70	0.43	0.93	0.47	11	1.01	0.60	0.94	0.54
NL	26	1.52	0.47	0.95	0.21	26	1.52	0.47	0.95	0.21
PL	11	5.53	0.06	0.88	0.12	11	5.53	0.06	0.88	0.12
PT	23	1.94	0.38	0.97	0.57	26	1.19	0.55	0.97	0.54
RO	7	.	.	0.93	0.52	11	1.29	0.53	0.94	0.51
SE	26	0.01	0.99	0.98	0.77	26	0.01	0.99	0.98	0.77
SI	9	0.56	0.76	0.97	0.89	9	0.56	0.76	0.97	0.89
SK	10	1.38	0.50	0.90	0.20	10	1.38	0.50	0.90	0.20
UK	26	0.08	0.96	0.97	0.67	26	0.08	0.96	0.97	0.67

Legenda: adj. χ^2 is the distribution of the test statistic for the null hypothesis of normality (the degree of freedom are two). The associated *p*-values are reported. W is the Shapiro-Wilk statistic for testing the hypothesis of normality; again, the corresponding *p*-values are reported. The tests are performed for both the sample adjusted for outliers and the one not adjusted.

of their time series on output gap. Finally, it would be appropriate to disconnect the selected indicator from any implicit assumption of normality.

5 The proposed method

The methodology we put forward builds on the idea of computing the ROG by using both a country-specific and a common component referred to all EU 27 Member States. The algorithm used is the same for all Member States. Arguably, the use of a common component should reduce the adverse implications of using output gap observations not being fully representative of typical cyclical fluctuations. This issue deals with the relatively short length of time series data and is thus particularly relevant for NMSs.

Since shortened output gap series lacks significance and may not be representative of standard cyclical fluctuations, in shaping the methodology we use the available information for each country but we also supplement it with cross-countries information stemming from the EU 27 Member States.

We consider first the 5th percentile of the country output gap data over the entire period ($\boldsymbol{P}^{c}_{5\%}$). Whilst the concept of representative output gap is inherently country-specific, in its computation we also include information from other countries' output gap. This information is abridged in the 5th percentile of the output gap data for the whole sample of EU 27 countries ($\boldsymbol{P}^{E}_{5\%}$). The key issue is how to put the two pieces of information together in a sensible way. Our proposal is that of computing the ROG for a specific country, *c*, according to the following expression:

$$\boldsymbol{ROG}^{c} = \frac{\boldsymbol{\sigma}_{c}^{2}}{\boldsymbol{\sigma}_{c}^{2} + \boldsymbol{\sigma}_{E}^{2}} \boldsymbol{P}^{c}_{i5\%} + \frac{\boldsymbol{\sigma}_{E}^{2}}{\boldsymbol{\sigma}_{c}^{2} + \boldsymbol{\sigma}_{E}^{2}} \boldsymbol{P}^{E}_{j5\%} \tag{2}$$

where $P^{c}_{i5\%}$ is the 5th percentile for the country *c*'s output gaps over the period starting on the year (*i*) in which values become available for the country; $P^{E}_{j5\%}$ is the 5th percentile for the whole sample of EU 27 countries starting from the earliest possible year *j*. Moreover, $\boldsymbol{\sigma}_{c}^{2}$ is the variance of country *c*'s output gaps calculated over the sample starting on the year (*i*) in which values become available for *c* and $\boldsymbol{\sigma}_{E}^{2}$ is the variance for the whole sample of output gap data.[6]

In equation (2), the country-specific and the common component of ROGs, as measured by the country-specific and the EU 27-wide 5th percentiles respectively, are aggregated by using as weights the relative volatility of their business cycles. We

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[6] Before applying equation (2), the preliminary exclusion of outliers from the dataset is carried out. Consistently with the currently used method, observations of the whole data set for which the output gap is below percentile 2.5 or above percentile 97.5 are dropped.

believe that any alternative way to weight the two percentiles – for example, by using 0.5 and 0.5 – would be quite arbitrary. Our argument is that relative volatility is a valuable piece of information for assessing the required budgetary safety margin. In particular, a country with a more volatile business cycle should be more constrained by its MB with respect to countries whose fluctuations are less dramatic.

The intuition underlying our approach is the following: the higher is the volatility of the business cycle of a given country the more likely is for that country's economy to experience a sizeable and severe downturn. In other words, if we take a country's output gap as the variable that suitably represents its cyclical conditions, it turns out that the larger is the variance of the output gap series, the larger (in absolute value) tends to be the representative (negative) output gap for this country. If we take the 5th percentile of the output gap series of a country as the statistic that measures the typical size of the country's cyclical downturn that is severe but yet not exceptional, it turns out that the size of this percentile is correlated with the degree of volatility of output gap. In particular, if the output gap of two countries, A and B, have different standard deviation (σ) with $\sigma_A > \sigma_B$, then, in general, the representative negative output gap, as measured by the 5th percentile of the time series is higher, in absolute value, for country A: $|\boldsymbol{P}_A^5| > |\boldsymbol{P}_B^5|$.

The important point is that this result holds under a variety of alternative hypotheses on distribution of output gap that are relevant for our purposes. In particular, if the output gaps of two countries have both a symmetric distribution around the same mean – not necessarily a normal one – then the distribution with the higher standard deviation (σ) is indeed the one with a larger wedge between the mean and the 5th percentile.[7] This is quite intuitive: if we compare two distributions that are symmetric, the one with a larger value of σ has a lower peak of its probability distribution function and is more concentrated around the mean. Indeed this distribution is relatively flat and is spread out more widely over the real line and the value of the 5th percentile is further away from the mean with respect to the 5th percentile of the less disperse distribution.

In general, one may argue that output gap figures are likely to be symmetrical around potential GDP over a long-run horizon. However, since the sub-samples used to compute MBs are relatively low-sized for reasons discussed in earlier sections, then it is possible that the distribution of output gaps is not symmetric in the sub-sample.

Yet, the above argument would continue to hold if the output gap of two countries has both an asymmetric distribution with skewness going in the same direction – either left or right – and with different standard deviation. That is, the country with the higher standard deviation of output gap would still be expected to have a larger value (in absolute value) of the (negative) 5th percentile.

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[7] As it is well known, if the distribution of a random variable is normal then the 5th percentile is equal to $1.96 \cdot \sigma$.

In order to lend support to the above statement, we have conducted Monte Carlo simulations on random samples drawn from a variety of asymmetric distributions. In particular, we considered the chi-square distribution with different degrees of freedom, the exponential distribution and the F-distribution with different degrees of freedom. Through our Monte Carlo simulations, 10,000 randomly generated samples of 100 observations are drawn every time from each of the above probability distributions, pre-specifying the value of the mean (always set equal to zero) and of the standard deviation. For each simulation, we thus obtain 10,000 values of the 5th percentile. The average of these values is the Monte Carlo approximation of the 5th percentile from its sampling distribution. If we take this value and perform other simulations with a similar probability distribution having, however, a different standard deviation and an unchanged mean, we can verify whether by increasing the variance of the distribution, there is a parallel increase of the wedge between the 5th percentile and the mean. It turns out that this positive relationship is systematically displayed (see Tables 6 and 7 in the Appendix).

By contrast, if the distributions of output gaps for two countries are asymmetric and with different standard deviation but with skewness going in the opposite directions, then the link between the higher standard deviation of output gap and the larger value (in absolute value) of the (negative) 5th percentile may not necessarily hold. In particular, if a country has a distribution of the output gap which is skewed left whilst the other has a distribution which is skewed right, then it might be the case that the (negative) 5th percentile of the former is higher (in absolute value) even if its output gap variance is lower. Again, the Monte Carlo simulations that we performed confirm the possibility of this outcome, as it is documented in Tables 6 and 7. This evidence suggest that under, a large array of hypotheses on output gap distribution, the positive link between its volatility and the (absolute value of) 5th percentile is obtained.

If we look at actual data on output gap for the EU-27 countries we note that the variance of output gaps significantly differs across countries with some having more pronounced cyclical swings with respect to others (see Table 1). We also note that the sample mean is not zero for the 27 countries. In Table 1, we can see that the time averages of each country’s output gaps are different among each other, ranging from a value of 0.09 for Cyprus to a value of –2.41 for the Czech Republic. We can also see that if the sample considered were the largest one available (for example, 1965-2005 for the EU 15, except Germany and Luxembourg), then the time average would be, in general, much closer to zero.[8]

Because of these discrepancies in the output gap’s sample means and because asymmetry in the countries’ distribution of output gap can, in principle, go in both direction (left or right), we constructed some simple statistics to lend additional support to the contention that the higher the volatility of a country’s output gap, the more likely it is that the output gap’s 5th percentile is further away from zero. In

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[8] For some countries, however, the sample means reported in column (2) of Table 1 continue to diverge from zero.

Table 3

Correlation between Standard Deviation and 5th and 10th Percentiles of Output Gap Data

	Sample Not Adjusted for Outliers		Sample Adjusted for Outliers	
	Correlation Coefficient	**Spearman's Rank Correlation Coefficient**	**Correlation Coefficient**	**Spearman's Rank Correlation Coefficient**
5th percentile and standard deviation	–0.83*	–0.84 (.00)	–0.70*	–0.67 (.00)
10th percentile and standard deviation	–0.77*	–0.77 (.00)	–0.63*	–0.64 (.00)

Legenda: see text.

* indicates significance at the 1 per cent level. In parentheses we report *p*-values for the test of the hypothesis that the 5th (or 10th) percentile and standard deviation are independent.

particular, we computed the correlation coefficient between the countries' standard deviation of output gap and the corresponding countries' 5th percentile of the same variable. The correlation coefficient is equal to –.83 and it is significant at better than the 1 per cent level. We also computed the Spearman's rank correlation coefficient between the same variables. The value of the statistic is –.84 and the hypothesis that the two variables are independent is strongly rejected (*p*-value: 0.00). We computed these statistics on the entire sample, *i.e.* the sample that includes outliers. We also considered the sample where output gap outliers are excluded. When we adjust the sample, the correlation coefficient between the countries' standard deviation of output gap and the 5th percentile is –.70 and, again, it is significant at better than the 1 per cent level. The Spearman's rank correlation coefficient between the same variables is –.67 and the hypothesis of independence of the variables is again strongly rejected. These findings are reported in Table 3, where the 10th percentile is also considered.

The way equation (2) is devised allows us to, at least partly, tackle the issue of the relative short length of output gap data for the NMSs. Since the lower degree of volatility of output gaps was shown to be associated with the limited length of their output gap series, this might downwardly bias the absolute value of the 5th percentile ($P^c_{5\%}$). Therefore, we assign a relatively low weight to this potentially biased piece of information. In particular, if we use the weights used in expression (2), based on the relative volatility of business cycles, a lower weight would be assigned to the country-specific information, $P^c_{5\%}$ when the latter is not enough informative. In principle this should reduce the risk of underestimating the country's representative output gap and its required budgetary safety margin.

6 The application of the methodology: some results

In this section the results obtained applying the proposed methodology are presented.[9] Consistently with what the Commission does, the treatment of outliers leads to the exclusion of observations below and above the 2.5th and 97.5th percentiles, respectively. Thus, all the values of output gap below –5.63 and above 4.12 are excluded from the sample. These figures are obtained by looking at EU 27 countries, including Bulgaria and Romania. With regard to the common component of the representative output gap the standard deviation of output gap for the whole EU 27 sample is 1.95 and the 5th percentile calculated on the same common sample is –3.82.

Table 4 documents the values of ROGs and MBs as obtained through the proposed approach. We compare these values with the corresponding figures resulting from the EU Commission existing methodology. Interestingly enough, the differences in MBs across the two approaches are not substantial. Based on the empirical findings we cannot conclude that one method systematically leads to more severe budgetary requirements in terms of cyclical safety margins. However, by comparing columns (3) and (5) it turns out that in the majority of cases (15 countries out of 10) the proposed method points to a higher required safety margin. For some countries, the estimated MB varies considerably depending on the methodology. By looking at Sweden and Finland, for example, the MBs obtained through the two methods diverge by 0.54 and 0.44 percentage points, respectively, with the existing method being more severe. Such divergence is 0.35 percentage points for the Czech Republic and Hungary and about 0.3 for Slovenia. For these NMS, it is the proposed method that requires a higher budgetary safety margin. By contrast, in countries like Denmark and Spain the divergence of MBs based on the two methods is almost zero.[10] We also computed the correlation coefficient between MBs of column (3) and those of column (5) and its value is .92.

As a sensitivity inspection of our findings, we introduced the following two alternative modifications. The first is to eliminate Bulgaria and Romania from the sample. So far, in computing the common component of ROGs we have considered data for all EU 27 countries, including the two countries that joined EU in January 2006. Not surprisingly, if we eliminate data for these two economies the results are virtually unchanged. The second modification is the following. In deriving the weights of equation (2) and, in particular, the variance of the common component, we computed the variance of output gaps on the whole sample of EU 27 countries but considering only observations whose first year coincides with the year in which data become available for the specific country, *c*. For example, let us consider Hungary, whose output gap data are available from 1995 onward. In calculating its

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[9] Output gap series are taken from the AMECO database, maintained by the European Commission's Directorate General for Economic and Financial Affairs (DG ECFIN). Data are updated up to the 6th of November 2006.

[10] It is worth noting that MBs are not computed for Bulgaria and Romania because official estimates of their budgetary sensitivity parameters are not yet available.

Table 4

Representative Output Gap (ROG) and Minimal Benchmark (MB)

EU 27 Countries	Proposed Method Equation (2)		Commission's Actual Method	
(1)	ROG (2)	MB (3)	ROG (4)	MB (5)
AT	–3.24	–1.48	–3.13	–1.53
BE	–3.29	–1.23	–3.37	–1.18
BG	–3.69	.	–3.61	.
CY	–3.12	–1.78	–2.86	–1.88
CZ	–3.78	–1.60	–2.82	–1.96
DE	–2.88	–1.53	–2.48	–1.73
DK	–3.98	–0.41	–4.00	–0.40
EE	–4.01	–1.80	–3.59	–1.92
EL	–3.77	–1.38	–3.90	–1.32
ES	–4.47	–1.08	–4.45	–1.09
FI	–3.50	–1.25	–4.38	–0.81
FR	–3.24	–1.41	–3.04	–1.51
HU	–3.21	–1.52	–2.46	–1.87
IE	–4.38	–1.25	–4.56	–1.18
IT	–3.33	–1.34	–3.42	–1.29
LT	–3.72	–1.99	–4.03	–1.91
LU	–4.70	–0.70	–4.65	–0.72
LV	–3.52	–2.01	–3.16	–2.12
MT	–3.46	–1.72	–3.74	–1.62
NL	–3.59	–1.02	–3.57	–1.04
PL	–4.29	–1.28	–4.13	–1.35
PT	–3.97	–1.21	–4.49	–0.98
RO	–4.23	.	–4.37	.
SE	–3.65	–0.88	–4.58	–0.34
SI	–3.38	–1.51	–2.74	–1.79
SK	–3.42	–2.01	–3.34	–2.03
UK	–3.98	–1.33	–3.94	–1.35

Legenda: see text.

ROG through equation (2), the variance of both the country-specific and EU 27-wide output gaps are computed using observations starting from 1995 at the earliest. Again, this modification in the way we compute the weights in equation (2) does not lead to significant changes in the broad picture.[11]

7 An alternative approach for deriving Minimal Benchmark

In this section we explore an alternative approach for assessing a safety margin for the fiscal imbalance with respect to the 3 per cent ceiling. We employ an econometric model of the Italian economy and perform stochastic simulations in order to derive estimates of MBs. Obtaining safety margins by using model simulations is not a new approach in the literature. Dalsgaard and de Serres (1999) estimate structural VARs and provide MBs for 11 EU member States. Similarly, Artis and Onorante (2006) use structural VARs and, by identifying fiscal shocks through long-run restrictions, estimate a simultaneous equation model that derives safety margins consistent with the budget requirements stemming from the revised SGP. Dury and Pina (2003) attempt to formalise the forward-looking provisions of the SGP and, by using a structural macroeconomic model (NiGEM), they estimate the probability of having deficits above 3 per cent of GDP and that of declaring deficits excessive. The approach based on stochastic simulations of a structural macroeconomic model cannot be used for multilateral surveillance. Still, it can provide useful insights on budgetary developments in different cyclical conditions and double-check estimates based on *ex post* data.

The model we use, ITEM (Italian Treasury Econometric Model), is a quarterly macro-econometric model estimated over the period 1982-2006. It features 36 behavioural equations and 211 identities. Both the supply and the demand side of the economy are designed in the model's structure and the public finance block is developed in detail with fiscal revenues and expenditure being disaggregated in a variety of different items (see Department of Treasury, 2007).

The MB model-based approach identifies the deficit-to-GDP ratio that is required to maintain the economy, at various confidence levels and at various time horizon, within the 3 per cent limit. For example, we are able to estimate a specific value of the budget balance-to-GDP ratio that would allow the ratio itself to be below the 3 per cent boundary for three years with a probability of 95 per cent. Through stochastic simulations we are able to mimic the macroeconomic turbulence that typically characterises the economy and assess the budget balance-to-GDP ratio that would guarantee fulfilment of the 3 per cent requirement even under adverse cyclical developments.

We solve the model repeatedly and use each time different draws of the stochastic components of the model itself. During each of the 1,000 repetitions that we performed, randomly drawn shocks are imparted to the model so that, for each

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[11] The empirical findings of these two investigations are not reported for space constraints.

single repetition, a model simulation is obtained. Of course, we are particularly interested in tracking the budget balance-to-GDP endogenous variable. Hence, for each of the 1,000 simulations, a path is obtained for the budget balance-to-GDP ratio. For any period, we are able to rank the 1,000 values of the ratio in ascending order, from the most unpleasant ratio to the most favourable one. This generates a distribution and, of course, the budget balance-to-GDP ratio that ranks in 50th position from the bottom is an approximation for the 5th percentile of the budget balance-to-GDP ratio. This value can be interpreted as the budget balance-to-GDP ratio classified as the worst with a 95 per cent confidence level. Once this value is identified, the MB for that period becomes readily available and it is the following:

$$\boldsymbol{MB_t} = \left(\frac{\boldsymbol{DEF}}{\boldsymbol{PIL}}\right)_t^{avg} - \left[\left(\frac{\boldsymbol{DEF}}{\boldsymbol{PIL}}\right)_t^{5th} - 3\right] \tag{3}$$

where $\left(\frac{\boldsymbol{DEF}}{\boldsymbol{PIL}}\right)_t^{avg}$ is the average value of the ratio in period t out of the 1,000 replications whilst $\left(\frac{\boldsymbol{DEF}}{\boldsymbol{PIL}}\right)_t^{5th}$ is the value corresponding to the 5th percentile.[12]

The value of MB calculated according to (3) can be interpreted as the value of budget balance-to-GDP ratio such that, even in unfavourable cyclical conditions, the probability of remaining within the 3 per cent limit is 95 per cent.

We first estimated the model up to 2006. Then we stochastically simulated the model over the following twelve and twenty quarters (2007-09 and 2007-11). In the simulation, the values of the exogenous public finance variables (public expenditures, tax and social contribution rates) are set equal to official projections at current legislation. International and demographic exogenous variables are set equal to the projections used in the benchmark forecasting scenario. We considered first a two-sided confidence interval of size .90 to get the 5th percentile of the approximated sampling distribution of the budget balance-to-GDP ratio. Combining this information with the average value in the interval, we can compute MBs for each period as in equation (3).

In Table 5 we report the key findings of our investigation. Column (2) shows the values of model-based MBs for three- and five-year horizons. These values represent the budget balance-to-GDP ratio required to avoid, with a probability of 95 per cent, a deficit higher than 3 per cent of GDP under unfavourable cyclical developments. The MB on a three-year horizon is equal to –1.33, a value almost identical to the one estimated with the other approach (–1.34 in Table 4). Not surprisingly, if we extend the length of the simulation horizon from three to five

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[12] Not surprisingly, the average value of the deficit-to-GDP ratio out of the 1,000 repetitions is always very closed to the value resulting from a deterministic simulation.

Table 5

Model-based Measures of Minimal Benchmark: Results From Stochastic Simulations with the ITEM Model

Time Horizon (1)	Out-of-sample stochastic simulation (2)	In-sample stochastic simulation (3)	In-sample recursive stochastic simulation (4)	Stochastic simulation with a different fiscal structure: (A) (5)	Stochastic simulation with a different fiscal structure: (B) (6)
2001		–1.77	–1.86	–1.81	–1.85
2002		–1.39	–1.87	–1.51	–1.72
2003		–1.02	–1.84	–1.39	–1.38
2004		–0.53	–1.89	–0.99	–0.94
2005		0.36	–1.77	–0.36	–0.48
2007	–1.82				
2008	–1.67				
2009	–1.33				
2010	–1.24				
2011	–1.11				
MB 3-year horizon	–1.33	–1.02	–1.84	–1.39	–1.38
MB 5-year horizon	–1.11	0.36	–1.77	–0.36	–0.48

Legenda: see text.

years, the required budgetary safety margin becomes larger, as the size of cyclical swings tends to increase. The in-sample stochastic simulation (column 3) points to a slightly more restrictive value.

In order to gauge the implications of an increase in model uncertainty associated with a longer time horizon, we also performed stochastic simulations recursively over shorter horizons (column 4). The lower size of the required safety margins are simply explained by the lower degree of cyclical uncertainty which is, by construction, associated with a shorter time horizon of the simulation.

Finally, we try to assess the impact on budgetary safety margins of a change in the fiscal structure of the economy. To tackle this issue, we performed two stochastic simulations over the period 2001-05 under a counterfactual scenario. We assumed that the Italian fiscal structure is different from the actual one by considering a lower degree of cyclicality of fiscal revenues. Under the hypothesis (A), we assume that revenues from corporate income taxes are significantly lower than those actually observed and, at the same time, revenues from social security contributions paid by the employers are significantly higher. The assumed shift is *ex ante* neutral for the budget balance. In particular, fiscal revenues from corporate income tax are lowered by 4 percentage points of nominal GDP, through adjustment of the corporate income tax rates (both IRPEG and IRAP), and revenues from social contributions equally increased by adjusting the employers' social contribution rate. Typically, revenues from social contributions are less sensitive to cyclical fluctuations compared to other fiscal revenues, such as those from corporate income taxes (see Girouard and André, 2005). Therefore, we would expect that the fiscal structure that was counterfactually devised is such that the deficit-to-GDP ratio becomes less sensitive to business cycle and the required budgetary safety margin is lower than that computed under the baseline fiscal structure. This is exactly what we document in column (5) of Table 5. Indeed, if we compare the minimum benchmarks of column (3) and (5), those in the latter columns are less severe. For example, with a three-year horizon, the minimum benchmark ranges from –1.39 in the baseline case to –1.02 in the counterfactual scenario. Under hypothesis B, revenues from personal income taxes are reduced by 4 percentage points of nominal GDP through a cut in the corresponding tax rate.[13] Revenues from social contributions paid by employers are increased accordingly (column 6). MBs become even less restrictive than in the previous exercise.

The model-based approach represents a useful complementary analytical tool to the approach based on *ex post* information and discussed in previous sections. Although confined to the Italian economy and totally different from the *ex post* approach chosen by the EU Commission, the investigation provides results that are not too dissimilar.

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[13] These type of revenues are also considered quite sensitive to cyclical fluctuations, especially for the Italian economy, as it was documented by Girouard and André (2005).

8 Concluding remarks

This paper deals with alternative approaches for computing appropriate budgetary safety margins. It highlights some critical issues pertaining to the existing EU Commission's methodology, especially on the identification of a representative output gap (ROG). It provides evidence and arguments that cast some doubts on the soundness of the existing methodology.

Our proposed alternative method addresses the main issues. In particular, it features an identical algorithm for all Member States in computing ROGs, which uses both a country-specific and a common component referred to all EU 27 Member States. The two components are aggregated by using as weights the relative volatility of business cycles. The application of our method to EU 27 data does not yield estimates of MBs that diverge extensively from those derived through the EU Commission's current methodology. In the majority of cases (15 countries out of 10), however, the revised method leads to a higher required budgetary safety margin.

We also provide estimates of MBs through an alternative method that is complementary to the one based on *ex post* information. This approach is based on stochastic simulations of a structural macro-econometric model for the Italian economy. The findings from this approach are similar to those obtained with the other method. Moreover, simulations provide empirical evidence supporting the view that a fiscal structure that exhibits lower budget sensitivity to cyclical fluctuations is conducive to less ambitious safety margins.

These findings from the model-based approach point to the importance of budgetary sensitivity to output fluctuations in shaping the required budgetary margins. We believe that a more comprehensive assessment of budgetary sensitivities to business cycle is necessary even under the "institutional" method based on *ex post* information. For example, further research could provide country estimates of budgetary sensitivities to business cycle fluctuations that are conditional on specific shocks.

APPENDIX
ADDITIONAL TABLES

Table 6

Monte Carlo Approximations of the 5th Percentiles by Repeatedly Sampling from Chi-square (χ^2) Probability Distributions

(a) skewness right*

Probability Distribution	Repetitions on 100 Observation Samples	Mean	Variance	Monte Carlo Approximation of 5th Percentile
$\chi^2(1)$	10,000	0	2	–0.99
$\chi^2(2)^{**}$	10,000	0	4	–1.89
$\chi^2(3)$	10,000	0	6	–2.63
$\chi^2(4)$	10,000	0	8	–3.27
$\chi^2(5)$	10,000	0	10	–3.83
$\chi^2(6)$	10,000	0	12	–4.34
$\chi^2(7)$	10,000	0	14	–4.80
$\chi^2(8)$	10,000	0	16	–5.24
$\chi^2(9)$	10,000	0	18	–5.64
$\chi^2(10)$	10,000	0	20	–6.03
$\chi^2(20)$	10,000	0	40	–9.10
$\chi^2(100)$	10,000	0	200	–21.96

(a) skewness left*

Probability Distribution	Repetitions on 100 Observation Samples	Mean	Variance	Monte Carlo Approximation of 5th Percentile
$\chi^2(1)$	10,000	0	2	–2.86
$\chi^2(2)(**)$	10,000	0	4	–4.01
$\chi^2(3)$	10,000	0	6	–4.83
$\chi^2(4)$	10,000	0	8	–5.49
$\chi^2(5)$	10,000	0	10	–6.07
$\chi^2(6)$	10,000	0	12	–6.58
$\chi^2(7)$	10,000	0	14	–7.07
$\chi^2(8)$	10,000	0	16	–7.51
$\chi^2(9)$	10,000	0	18	–7.92
$\chi^2(10)$	10,000	0	20	–8.30
$\chi^2(20)$	10,000	0	40	–11.39
$\chi^2(100)$	10,000	0	200	–24.29

[*] We recall that if X is a random variable drawn from a $\chi^2(n)$ distribution with n degrees of freedom, $E(X)=n$ and $\mathrm{Var}(X)=2n$. Moreover, the transformations $X–n$ and $n–X$ are still distributed as $\chi^2(n)$ with mean equal to zero in both cases. In the first case, however, skewness is right whilst in the second skewness is left. These are exactly the cases considered here.

[**] the χ^2 distribution with two degrees of freedom is an exponential distribution.

Table 7

Monte Carlo Approximations of the 5th Percentiles by Repeatedly Sampling from F-probability Distributions

(a) skewness right[*]

Probability Distribution	Repetitions on 100 Observation Samples	Mean	Variance	Monte Carlo Approximation of 5th Percentile
F(3.5)	10,000	0	11.1	–1.55
F(4.5)	10,000	0	9.7	–1.50
F(5.5)	10,000	0	8.9	–1.46
F(6.5)	10,000	0	8.3	–1.43
F(7.5)	10,000	0	7.9	–1.41
F(8.5)	10,000	0	7.6	–1.39
F(9.5)	10,000	0	7.4	–1.37
F(10.5)	10,000	0	7.2	–1.36
F(11.5)	10,000	0	7.1	–1.35
F(12.5)	10,000	0	6.9	–1.34
F(20.5)	10,000	0	6.4	–1.33

(a) skewness left[*]

Probability Distribution	Repetitions on 100 Observation Samples	Mean	Variance	Monte Carlo Approximation of 5th Percentile
F(3.5)	10,000	0	11.1	–3.89
F(4.5)	10,000	0	9.7	–3.65
F(5.5)	10,000	0	8.9	–3.51
F(6.5)	10,000	0	8.3	–3.40
F(7.5)	10,000	0	7.9	–3.32
F(8.5)	10,000	0	7.6	–3.29
F(9.5)	10,000	0	7.4	–3.25
F(10.5)	10,000	0	7.2	–3.20
F(11.5)	10,000	0	7.1	–3.14
F(12.5)	10,000	0	6.9	–3.12
F(20.5)	10,000	0	6.4	–3.11

[*] We recall that if X is a random variable drawn from a $F(n_1, n_2)$ distribution with n_1 and n_2 degrees of freedom, $E(X)=n_2/(n_2-2)$ if $n_2>2$ and $\mathrm{Var}(X)=2\ (n_2)^2\ (n_1+n_2-2)\ /\ n_1\cdot(n_2-2)^2\ (n_2-4)$ if $n_2>4$. Moreover, the transformations $X-E(X)$ and $E(X)-X$ are still distributed as $F(n_1, n_2)$ with mean equal to zero in both cases. In the first case, however, skewness is right whilst in the second skewness is left. These are exactly the cases considered here.

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