# THE IMPLEMENTATION OF THE COUNTERCYCLICAL CAPITAL BUFFER: RULES VERSUS DISCRETION*

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ABSTRACT

One of the key lessons of the global financial crisis is that policymakers need instruments to mitigate the potential impact of a build-up of risks in the financial system. Against this background, the countercyclical capital buffer will be one of the main instruments available to macroprudential authorities. According to the Basel Committee, the calibration of this buffer will be guided by the calculation of the deviations of the credit-to-GDP ratio from its long-term trend. In this article, we perform a sensitivity analysis to the calibration of this so-called "buffer guide", showing that the results are sensitive to the methodologies used and to the assumptions made. Furthermore, we analyze several other indicators with leading and near-coincident properties, which may potentially be relevant in guiding buffer decisions. Our analysis confirms that the credit-to-GDP gap is amongst the best performing indicators in predicting banking crises, but shows that other indicators also display good signalling properties. As such, a large set of quantitative and qualitative information should be considered when setting the countercyclical buffer rate.

## 1. INTRODUCTION

The global financial crisis highlighted that there were some important missing elements in the international regulatory framework of the financial system. The Basel III package intends to fill some of the most relevant gaps identified in this framework, most notably by providing tools to address the risks arising from excessive leverage and maturity mismatches. While microprudential regulation and supervision will be substantially enhanced with this reform, the first steps in setting up an international framework for macroprudential regulation were also taken. The crisis made clear that even if banks are unquestionably sound when taken individually, systemic risks may still be building up. As such, traditional microprudential regulation, focused essentially on the solvency of each financial institution individually, must be complemented by macroprudential oversight. The latter should focus on collective behaviours that potentially increase the risk within the financial system, such as excessive leverage, interconnectedness, or common exposures to similar asset classes or funding sources. Even if these behaviours do not imply a significant increase in risk for each individual institution, their systemic nature may still have important impacts on the stability of the financial system and, ultimately, on long-term economic growth.

Against this background, one of the most important tools available to macroprudential authorities will be the countercyclical capital buffer (CCB). According to the Basel Committee (2010), the main objective of the CCB is to ensure that banks hold a sufficiently large buffer of capital that allows them to absorb

* We are thankful Nuno Alves, Rita Basto, Miguel Boucinha, Mário Centeno, Sudipto Karmakar, Ana Pereira, Nuno Ribeiro and Fátima Silva for insightful comments and suggestions. The analyses, opinions and findings of this article represent the views of the authors, which are not necessarily those of Banco de Portugal or the Eurosystem. Any errors and omissions are the sole responsibility of the authors.

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unexpected losses when faced with a negative systemic shock, thereby not compromising lending to the real economy. To achieve that, banks should build up a capital buffer during periods of excessive credit growth. This build up should also allow achieving the CCB's secondary objective, which is to somehow mitigate the magnitude of these periods of exuberance in credit markets.

When policymakers consider that risks are building up, they may choose to activate the CCB (or to use other macroprudential instruments which are better suited to deal with the risks identified). This activation implies requiring banks to hold additional capital buffers, on top of other regulatory capital requirements. Decisions on the CCB should be revised quarterly, so the build up of the buffer may be gradual. Later on, the accumulated capital buffer may be released under two distinct scenarios. On the one hand, risks previously identified may dissipate gradually, thus allowing for a gradual release of the buffer. On the other hand, a crisis might occur, thus requiring the prompt release of the buffer to cover potential bank losses and maintain the flow of credit to the economy.

One of the main challenges for macroprudential authorities will be to decide when to activate the buffer, *i.e.*, when is credit growth "excessive"? As discussed by Reinhart and Rogoff (2011), it is easy to fall into a "this time is different" fallacy, believing that strong credit growth is associated with the convergence to a new equilibrium, rather than to an unsustainable increase in risk. Moreover, the decision on when to release the buffer is also not straightforward, as dealing with expectations during a period of distress may be highly challenging.

Given these limitations, it is possible to argue that the implementation of the CCB should be, at least to some extent, based on rules. This is important not only to promote the accountability of the macroprudential authority, but also to anchor the expectations of banks and other agents and to mitigate a potential inaction bias of macroprudential authorities. Furthermore, an important dimension of this new macroprudential tool is that, for the first time, a reciprocity regime was established between different jurisdictions. For instance, if the macroprudential authority in a given country determines the activation of the buffer, all banks with exposures in that country will have to build up that buffer, regardless of their country of origin. The mandatory reciprocity between macroprudential authorities makes it desirable that there is some common quantitative understanding about how to manage the CCB.

However, the balance between rules and discretion must be carefully managed in what concerns the implementation of the CCB. Despite the advantages discussed above, a fully rules-based system would be unfeasible, given the complexity of the phenomenon in question. A wide array of indicators should thus be considered to support the decisions taken. Further, judgement is a key element in the decision process, most notably given the uncertainty on the calibration and effectiveness of this new instrument.

In this article, we provide evidence to illustrate the need to complement rules with discretion when setting buffer rates. According to the Basel Committee (2010) and Drehmann *et al.* (2010), the deviation of the ratio between credit and GDP from its long term trend is the indicator that better performs in signalling the need to build up capital before a crisis, when examining several indicators for different countries. Given this evidence, the Basel Committee (2010) proposes that buffer decisions are anchored on the magnitude of these deviations (though recognizing the need to complement the decisions with other indicators, as well as with judgement). In this article, we perform a thorough sensitivity analysis on the estimation of this credit-to-GDP gap and discuss some of the shortcomings of this methodology. Our estimations show that the results may be sensitive to the methodology and assumptions considered. In addition, we examine the predictive power of several other macroeconomic and financial indicators. Our results confirm that the credit-to-GDP gap is among the best performing indicators in predicting banking crises with some anticipation. This does not mean, however, that this indicator will perfectly signal any future banking crises. Furthermore, other indicators, such as house price indicators and credit growth, also display good signalling properties. As such, a thorough and balanced assessment of a broad set of indicators is essential in driving buffer decisions.

The article proceeds as follows. In section 2 we provide further detail on the design and implementation of this new macroprudential tool. In section 3, we assess the performance of the credit-to-GDP ratio as an indicator to signal banking crises, performing a thorough sensitivity analysis on different possible calibrations. In section 4, we evaluate the performance of a set of alternative macroeconomic and financial indicators, both for the build up and the release decisions. Finally, in section 5 we summarize our main findings.

## 2. THE COUNTERCYCLICAL CAPITAL BUFFER AS A KEY MACROPRUDENTIAL POLICY TOOL

### 2.1 Guiding principles for the operation of the countercyclical capital buffer

Most banking crises were preceded by periods of excessive credit growth (Borio and Drehmann, 2009, Moritz, and Taylor, 2012, Reinhart and Rogoff, 2011). While ex-post, with the benefit of hindsight, it is fairly easy to recognize that this growth was unsustainable, the same cannot be said when developments are still building up. While sometimes this excessive credit growth is assessed with concern by policymakers and analysts, in many other situations, developments are perceived as the convergence to a new steady state, with higher potential economic growth (Kindleberger and Aliber, 2011). Against this background, it is easy to fall into the "this time is different" fallacy (Reinhart and Rogoff, 2011) and to give in to the inaction incentives prevailing in such periods. The global financial crisis showed that this paradigm is unsustainable, and that policymakers need tools to act countercyclically. Some authors argue that monetary policy may have a role in this domain, by leaning against the wind (Agur and Demertzis, 2013, Lambertini *et al.*, 2013). However, more important than that, a consensus emerged on the need to establish a macroprudential policy framework, equipped with a toolkit to manage systemic risks in the financial system.

Against this background, the countercyclical capital buffer is a key macroprudential instrument, introduced by the Basel Committee as part of the Basel III regulatory framework. Its main objective is to ensure that banks have an adequate capital buffer to absorb losses when a systemic crisis occurs, thus mitigating the potential impact on the economy (*i.e.*, avoiding excessive restrictions on banks' ability to continue to grant credit to the economy). Furthermore, as banks will build up this buffer when credit growth is deemed excessive by authorities, the CCB will possibly also help to smooth the credit cycle.

The CCB will be implemented as an additional Core Tier 1 capital requirement, varying between 0 and 2,5 per cent of risk weighted assets.1 When banks fail to meet the CCB capital requirements, they will not be faced with the same restrictions as when they do not meet the core capital requirements. Instead, they will face restrictions on the distributions to shareholders and employees, for instance.

The decision to activate the CCB should be guided by the deviation of the ratio between credit and GDP from its long-term trend (credit-to-GDP gap). However, given that there is not a one size fits all approach, this decision must be complemented with the analysis of many other indicators and balanced with informed judgement. For the release phase, judgement becomes even more critical. Indeed, while Drehmann *et al.* (2010) find that the credit-to-GDP gap is the best performing indicator to signal in advance the build up of systemic risks in a wide set of crises and countries, these authors are not able to find any single variable that indicates so consistently when to release the buffer. It should be noted that the buffer may be released under two very different circumstances. On the one hand, the release may be implemented when risks materialize and a systemic crisis emerges. In this case, financial market indicators and other quasi-real time indicators should be the most helpful ones in indicating when to release the

1 The buffer can be set above 2,5 per cent, though this is the limit for (mandatory) international reciprocity.

buffer, though the precise identification of the timing of this decision may be challenging (releasing too early may harm market expectations, eventually leading to self-fulfilling losses, while releasing too late may hinder the loss absorbency role of the buffer). On the other hand, the risks identified may never materialize (possibly because macroprudential policy was effective in mitigating the risks), thus leading to a gradual release on the buffer.

It should be noted that the effective release of the buffer might be challenging in some circumstances, as discussed, for instance, by Hanson, Kashyap, and Stein (2011). On the one hand, when risks materialize, there might be potential conflicts between macro and microprudential goals. More specifically, microprudential supervisors, coupled with market participants and rating agencies, may encourage banks to build up capital to improve their resilience, thus acting procyclically. On the other hand, when risks do not materialize and dissipate only gradually, macroprudential authorities may be afraid of releasing the buffer too soon, thus postponing this decision for longer than what would be optimal from a theoretical perspective.

Given the insurmountable uncertainty that policy makers currently face regarding the effectiveness of this new macroprudential policy instrument in achieving its objectives, it is reasonable to argue against an entirely rules-based approach. Rules are essential to allow for transparency in communication, thus helping to manage the expectations of all involved stakeholders. Further, it is important to note that this is the first instrument in financial regulation where a fully-fledged reciprocity mechanism is in place. This requires that there are some common rules to facilitate communication between the authorities involved. However, the role of judgement will need to assume a critical dimension, both in the build-up and in the release phase. First, it is unfeasible to find an indicator (or set of indicators) that perfectly signals when to activate and deactivate the buffer in all countries and in all possible periods. Though the credit-to-GDP gap has proven to have good leading properties in a large number of countries (Drehmann *et al.*, 2010), it does not perform well in all crises episodes studied (nor will any other indicator). Furthermore, it has been very challenging to find indicators that accurately signal the correct moment to release the buffer. It goes without saying that the specific calibration of buffer decisions presents even more challenges.

Given these limitations, more research is needed to better guide the decisions of macroprudential authorities. With this article, we hope to contribute in at least two ways. First, we illustrate the sensitivity of the buffer calibration to different specifications of a rules-based system. Second, we analyze a broad set of indicators that may be helpful in signalling the build-up and the release of the buffer. Moreover, we also illustrate possible buffer trajectories for the Portuguese economy in the last decades.

All in all, the current state of knowledge supports a constrained discretion approach to buffer decisions and, more generally, to macroprudential regulation. A quantitative approach can only be a starting point for a more thorough analysis, where judgment plays a key role. Furthermore, it should not be forgotten that the countercyclical capital buffer is only one of the many instruments that macroprudential authorities may use. When facing systemic risks, these authorities will have to assess which of the instruments available will be better suited to mitigate those risks and to improve the resilience of the financial system and of the economy. In a broader perspective, macroprudential authorities will also have to balance their decisions with those of central banks (as there might be synergies and conflicts with monetary policy) and with microprudential regulators (as most of the instruments available to macroprudential authorities are managed by these regulators, which may have, at times, conflicting views and goals).

### 2.2 A brief overview of a rapidly expanding literature

The literature on the countercyclical capital buffer (and, more generally, on macroprudential policy) is fairly recent. Borio (2003) was one of the first to discuss a potential role for macroprudential policy, arguing that the regulatory and supervisory frameworks should encompass financial stability concerns. After the collapse of Lehman Brothers, a broad consensus emerged internationally on the need to endow

authorities with specific tools to mitigate risks to financial stability. The countercyclical capital buffer was proposed by the Basel Committee in end-2010 against this background, thus being one of the pillars of the new macroprudential toolkit.

The Basel Committee's proposal was accompanied by an analytical document by Drehmann *et al.* (2010). These authors test several variables, including indicators of aggregate macroeconomic conditions, banking sector activity and cost of funding. These indicators are assessed using a signal extraction methodology. While for the build-up phase indicators should have strong early warning properties, in order to allow authorities to activate the buffers well in advance of the materialization of risks, for the release phase the indicators should be coincident or near-coincident with the financial cycle. The authors conclude that the credit-to-GDP gap is the best performing indicator for the build up phase, displaying the lowest noise-to-signal ratio, while still managing to predict more than 2/3 of the crises in the sample. In turn, credit spreads and loan losses seem to have some useful properties in signalling the release, even though these findings are based on very small samples. Drehmann *et al.* (2011) confirm and expand the previous results of Drehmann *et al.* (2010). For the build-up phase, the credit-to-GDP gap continues to be the best indicator, achieving the lowest noise-to-signal ratio. A group of second-best variables is composed of credit growth, the difference between credit and GDP growth, equity price growth, property prices and their gap. Market-based indicators perform poorly, displaying very high noise-to-signal ratios. For the release phase, none of the macro variables or banking indicators signals enough crises. Market-based indicators show better results for the release, but with many false signals. No single variable manages to predict enough crises and maintain an adequate precision in terms of noise-to-signal ratio at the same time, thus demonstrating the need to rely on a broad set of indicators, as well as on some guided judgement. More recently, Drehmann and Juselius (2013) find that the debt service ratio also has good signalling properties ahead of financial crises.

Alessi and Detken (2011) suggest a different approach to evaluate the performance of indicators when setting buffer rates. These authors propose a loss function for the policy-maker that combines the frequency of type I and type II errors with the policy-maker's aversion to such errors. Based on that, the authors compare the losses of using or ignoring the indicator and compute a usefulness level. While the noise-to-signal ratio is completely independent from the level of aversion to the two types of errors, the major contribution of this usefulness indicator is the consideration of the preferences of each policy-maker. With this more encompassing methodology, the authors test the best indicators for asset price booms using a quasi-real time signalling approach and the latest vintage of available data. The results show that, for the entire group of countries considered, the best indicators for predicting costly asset price booms are cumulated real consumption growth (over 6 quarters), the nominal long term interest rate gap and the real equity price gap. When considering a smaller group of countries from the euro area, the best indicators are the global private credit gap, the nominal long term interest rate gap and the M1/GDP ratio gap. For the euro area countries, financial indicators seem to outperform real variables (namely consumption and investment).

Behn *et al.* (2013) evaluate a set of domestic and global financial indicators, including banking sector variables, using data for 23 EU Member States. In a multivariate early warning model framework, they find that, in addition to the already mentioned credit variables, equity and house prices, and banking sector indicators display good forecasting properties.

Chen and Christensen (2010) stress the fact that coincident indicators will have to be used for the release of the buffer. These may include the performance of the banking sector (earnings, losses and asset quality), the cost and availability of credit (funding spreads), prices of assets (real estate and equity) as well as other measures of financial intermediation. Still, some of these indicators, when used individually, may not provide the best signals. Indeed, when combined, their predictive capabilities increase significantly, as also shown by Borio and Drehmann (2009).

In sum, the credit-to-GDP gap seems to perform well as a leading indicator of banking crises in various countries, even though many other indicators will have to be considered jointly in the analysis. However, Repullo and Saurina (2011) argue that the credit-to-GDP gap suggested by the Basel Committee may not work as intended, enhancing the pro-cyclicality that the buffer was supposed to mitigate. Their argument is based on the fact that credit usually lags the business cycle, thus taking some time for the indicator to react to a downturn. The fact that the variable is a deviation of a ratio with respect to its trend compounds the problem. These authors show that GDP growth and the credit-to-GDP gap are negatively correlated (the hypothetical buffer and GDP growth are also negatively correlated), so when economic growth is high the indicator signals a reduction of the buffer and when GDP growth is low, capital requirements increase. Repullo and Saurina (2011) provide an alternative indicator to support buffer decisions: the deviations of credit growth with respect to its long-term average. They conclude that credit growth appears to be a good indicator for the build-up phase, while not promoting the pro-cyclicality of the minimum capital requirements. In turn, Edge and Meisenzahl (2011) discuss the potential costs of linking the implementation of the buffer to the credit-to-GDP gap. These authors argue that the gap is an unreliable real-time measure, mainly due to ex-post revisions and to the instability of end-of-sample trend estimates. These problems lead to many false positives, *i.e.*, the indicator estimated in real time signals several periods of excessive credit, which are not confirmed *ex-post*, with longer time series. This might generate unnecessary constraints on bank lending.

Countercyclical macroprudential instruments are a relatively new concept. As such, there is virtually no empirical evidence that allows assessing its effectiveness. One of the few exceptions is the dynamic provisioning system implemented in Spain in the late 1990s. The main idea was to require banks to build up a buffer of own funds using retained profits in good times, which can be used in bad times to cover the realized losses. Jiménez *et al.* (2012) analyze three policy experiments in Spain (2000, 2005 and 2008), one of which implemented during "bad times". The main result is that countercyclical bank capital buffers produce positive effects both on firm-level and aggregate credit through the smoothening of credit cycles. The results show that bank pro-cyclicality can be mitigated with these buffers due to the lower accumulation of risks in good times and the support of bank lending during bad times. In turn, Drehmann and Gambacorta (2012) simulate the policy implementation for the Spanish economy. They show that the effects on bank lending are material, indicating that the countercyclical capital buffer scheme may reduce credit growth during the build up phase and attenuate credit contraction with its release. Exploring variations in bank-specific capital requirements imposed by UK regulators, Francis and Osborne (2012) find that countercyclical capital requirements may not effectively limit credit growth if banks are able to fulfil stricter requirements with lower quality and less expensive capital (as opposed to high quality common equity).

Horváth and Wagner (2013) show that countercyclical capital instruments reduce the impact of shocks on the economy. However, they may also increase systemic risk, by providing the incentives for banks to become more correlated. As such, there might be important interactions between countercyclical tools and those addressed to mitigate systemic risk.

## 3. THE PERFORMANCE OF THE CREDIT-TO-GDP RATIO AS AN INDICATOR TO SIGNAL THE NEED TO BUILD-UP THE BUFFER

In this section, we focus our analysis on the credit-to-GDP gap, given its prominent role in the implementation of the countercyclical capital buffer. We begin by describing the methodology proposed by the Basel Committee to compute this indicator. We also describe the data used in our estimations. We present the baseline estimation of the buffer guide and then we perform an extensive sensitivity analysis on several parameters underlying the computations of the buffer.

### 3.1 Calculating the buffer guide

The starting point for decisions regarding the implementation of the countercyclical capital buffer will be the credit-to-GDP gap, also called the "buffer guide". According to the guidelines of the Basel Committee, the gap between the ratio and its long-term trend is transformed into a buffer recommendation following three steps. First, the ratio between aggregate credit to the non-financial private sector (using the broadest credit aggregated available) and nominal GDP is computed. Second, the trend of this ratio is estimated, using a one-sided Hodrick-Prescott filter.[2] Finally, both the upper and lower boundaries for the variable are set up. The buffer size will be 0 per cent at the lower boundary and linearly increase up to 2,5 per cent as the level of the credit-to-GDP gap approaches the higher boundary:

$$\begin{cases} 0 & if \quad z_t < L \\ \dfrac{z_t - L}{H - L} 2,5 & if \quad L \leq z_t \leq H \\ 2,5 & if \quad H < z_t \end{cases}$$

where $z_t$ represents the credit-to-GDP gap and $L$ and $H$ denote the lower and upper bounds for the gap, which correspond to the minimum and maximum values of the buffer, respectively (the Basel Committee's guide presents in its calculations $L$=2 and $H$=10).

Further remarks are warranted on the use of the Hodrick-Prestcott (HP) filter. This filter is a statistic tool that allows for the separation between the cyclical and the trend components of a time series. By using this detrending method on the credit-to-GDP, one can extract its trend and determine the gap between the observed value and the corresponding trend value for every observation. A crucial component of the HP filter is its smoothing parameter λ. This parameter changes the calculations by affecting the linearity of the trend component, *i.e.* for larger values of λ the filtering technique returns a more linear trend. The value suggested by the Basel Committee (2010) is λ=400.000. According to Ravn and Uhlig (2002), λ should be adjusted according to the frequency ratio of observations, using the rule λ=1.600(freq), where "freq" stands for the ratio of frequencies. Assuming the financial cycle to be four times longer than the business cycle, this frequency ratio is 4, which results in a smoothing parameter of approximately 400.000 (Drehmann *et al.*, 2011).

This choice of λ implies that the trend becomes more linear, changing very slowly as new data becomes available, thus making it harder to predict turning points in the cycles. This may present an important problem, given that the buffer decisions for a certain point in time may not be the most adequate if the early years of the sample are keeping the trend from adapting to recent events and/or structural shifts. A possible solution is to consider a moving sample with fixed size, ensuring that older data is removed from the window of observations and that recent data gets more weight in the determination of the trend.

To evaluate the real-time accuracy of the indicator, the gap should be calculated using only information available at the time, which means that the trend cannot be determined based on a full sample of data (*i.e.*, a one-sided filter is computed). By applying the Hodrick-Prestcott filter recursively to the data available for each point in time, one can surpass this problem and simulate the construction of a buffer as if it were in real-time. Still, the estimations for the most recent period of the sample may not be the most accurate, as discussed by Edge and Meisenzahl (2011), due to the so-called end point problem. Predicting future values of credit and GDP and incorporating them in the sample could help to overcome this, though at the cost of introducing extra uncertainty and noise (Gerdrup *et al.*, 2013, present a proposal to implement this approach).

2 As discussed later, using a one-sided filter implies that only the information available up to a given moment in time is used.

### 3.2 Data

One of the objectives of this study is to evaluate the implementation of the buffer scheme based on the credit-to-GDP gap, as well as identifying other indicators well suited to guide buffer decisions. As such, it is important that the analysis is conducted in a way that allows for a comparison between the different "test subjects" (in this case, the historical data of the various countries for which the buffer was calculated). Therefore, our priority was to gather data series for each country that would allow for adequate consistency and comparability across countries.

Quarterly credit data was collected from the "Long series on credit to private non-financial sectors" (BIS).[3] In turn, GDP data was collected from Thomson Reuters, being based on national official statistics. This ensures that all the credit-to-GDP series are identical and provide the same information for all countries considered, allowing the analysis to focus on the predicting capabilities of the indicator. For each country (Belgium, Finland, France, Germany, Ireland, Italy, Portugal, Spain and United Kingdom), all available data was considered when creating the final dataset. The countries were selected based on data availability constraints. Our objective was to have long and comparable time series for different countries.

Quarterly GDP was annualized using information from the last four quarters in order to create a yearly sum of flows. Even though the Basel Committee guidance does not state it explicitly, the example provided in the guidance document also uses this transformation for GDP data.

In order to test the usefulness of the credit-to-GDP gap and of the other indicators analysed, it is necessary to identify in which periods the buffer should have been activated (periods in which there was a generalized increase in domestic credit and/or in which several imbalances were building up in the financial system and in the economy). Against this background, we use the database compiled by the ESRB/IWG Expert Group on Guidance on Setting Countercyclical Buffer Rates. This database was based on banking crises data compiled in Babecky *et al.* (2012), based on input from the Heads of Research of the Eurosystem. The database was recently updated with contributions from the ESRB/IWG Expert Group (for further details, see ESRB, 2014). This database considers two different definitions of crises: one with actual banking crises and another which also includes episodes of heightened vulnerability which could, ex-post, have justified the implementation of macroprudential tools, even if no crisis effectively occurred.

For instance, for Portugal, it was included one additional stress episode that was not effectively a crisis, but in which sizeable vulnerabilities were building up. Indeed, in the late 1990s/early 2000s, domestic credit developments may have generated sizeable vulnerabilities in the economy, though it is hard to distinguish, even *ex-post*, to what extent these developments were reflecting the convergence to a new equilibrium, related with the introduction of the euro. In this period, there was significant credit growth and increasingly large deviations in credit to GDP. Current account imbalances widened and house price growth was significant. Though it is possible that these developments may have reflected the convergence to a new steady state, it is possible that, in some dimensions, their magnitude was somewhat excessive, leading to the creation of some structural imbalances (*e.g.*, indebtedness ratios became amongst the largest in the EU). These imbalances were not only internal, thus intensifying the vulnerabilities and limiting the ability to adjust to potential shocks. As no crisis occurred, it is difficult to precisely date this vulnerability period. Based on available evidence, the period 1999Q1 – 2000Q1 was classified as a stress event in which, with the benefit of hindsight, the occurrence of an endogenous or exogenous shock could have originated an abrupt adjustment of underlying vulnerabilities.

In our analysis, we consider the broader definition of crises, including heightened vulnerability periods, in addition to the crises actually observed. For robustness purposes, we also present some results with the stricter crises definition.

3 http://www.bis.org/statistics/credtopriv.htm

### 3.3 Buffer guide estimation

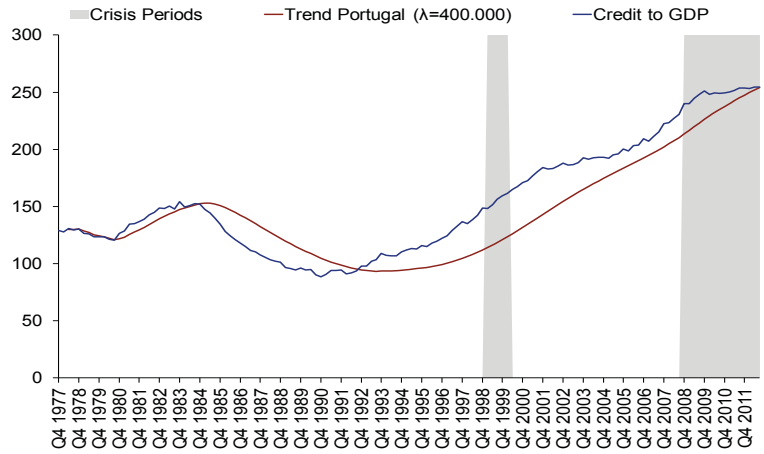
We compute the credit-to-GDP gap for a group of 9 countries (Belgium, Finland, France, Germany, Ireland, Italy, Portugal, Spain and United Kingdom), calculated recursively with all the available data and using λ=400.000, *i.e.*, according to the guidance of the Basel Committee. We test whether this gap works as a leading indicator of the financial stress periods identified in the crises database.

In chart 1, we illustrate the credit-to-GDP ratio for the Portuguese economy and its trend, using the Basel Committee's calibration. The stress or crises periods are identified in grey. Considering data since 1970, there is a long period in which the credit-to-GDP remains above the long term trend (since the early 1990s, starting in 1992Q2). This fact results in an active buffer recommendation that is kept for almost 20 years, as illustrated in chart 2. Of course, this is a static exercise. The activation of the buffer could possibly have mitigated credit growth during this long period, thereby leading to its release.

The results for Portugal suggest that the credit-to-GDP gap may lead to confusing signals when the financial system and the economy undergo structural changes. Indeed, the Portuguese financial system

**Chart 1**

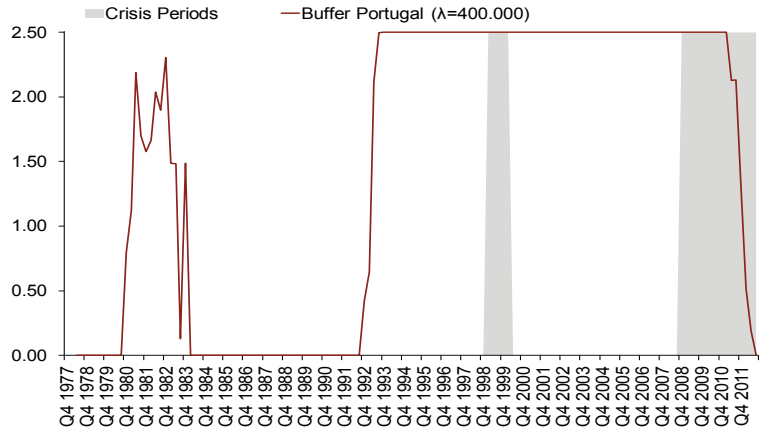
**CREDIT-TO-GDP TREND – PORTUGAL | PER CENT**




**Sources:** Thomson Reuters and authors' calculations.

**Chart 2**

**BUFFER RATE | PER CENT**




**Sources:** Thomson Reuters and authors' calculations.

underwent significant changes in the early 1990s as a result of a liberalization and privatization process. Most state-owned banks were privatized and interest rate and credit ceilings were gradually abandoned. Reserve requirements were also significantly lowered, though very gradually.[4] Given this, it is possible to argue that, at least to some extent, the large and persistent credit-to-GDP gap reflects a structural change in the economy. In such circumstances, it may be very hard to distinguish the building up of vulnerabilities from the convergence to a new steady state, most notably in real-time.

### 3.4 Evaluation methodology

Though the visual inspection of the figures above for each country could provide some insights on the ability of the credit-to-GDP gap to signal banking crises, a more structured evaluation approach may make this assessment clearer.

The first step in our evaluation approach is to determine when can a signal be considered useful. The criteria used to determine what is a "good" signal is defined as a recommendation to accumulate a buffer 4 to 12 quarters prior to the crisis starting date. The choice of the minimum time threshold is related to both the lags in data disclosure and the need to give some time to banks to adopt the regulatory recommendation to build up a buffer (the Basel Committee suggests that the recommendation to build up a buffer should allow for a one year implementation horizon, given that adjusting bank capital ratios in a shorter horizon could be unfeasible without disproportionate costs)).[5] In turn, the choice of the maximum time threshold (12 quarters) is related to an expectable loss of forecasting power when using longer horizons, increasing the uncertainty that policymakers face.

We put the indicator to the test, expecting it to provide a positive signal in all sequential quarters prior to the start of the crisis event (*i.e.*, in the 12 to 4 quarters before the start of the crisis). This ensures that weak (not persistent) signals are discarded, while imposing a stricter goal for indicator performance and keeping only strong and persistent deviations from the trend as signals. At the same time, we focus on predicting the beginning of the crisis (the first crisis quarter alone), as the macroprudential objective is to prepare for the stress period before it starts. This implies that the indicator should issue signals in the $4^{th}$, $5^{th}$ ... $11^{th}$ and $12^{th}$ quarters prior to the crisis starting date. Additionally, we exclude from this test the 3 quarters immediately before the crisis starts (since it would be too late to activate the buffer), as well as the whole crisis period (where indicator signals would have no purpose since the crisis is already ongoing).

In order to evaluate the indicator's performance, we use the AUROC method (DeLong *et al.*, 1988). To do so, the procedure that we followed consisted on setting slightly increasingly larger thresholds for buffer activation (reference values for the indicator, which if surpassed would represent the issuance of a signal). For each threshold, we gathered the signals that the indicator would issue in the dataset. Each increase in the threshold makes the criteria for signal issuance stricter, and lowers the number of signals that the indicator issues during the sample period. This ensures that some false signals that were appearing due to the low threshold start to disappear as the threshold increases, leaving only stronger signals. Still, an excessively high threshold carries with itself a very strict rule for signalling crisis events that can delay, or even miss, the identification of a true signal.

For example, we can consider two possible thresholds for the credit-to-GDP gap: 3 p.p. and 5 p.p. When using the lower one, the indicator signals a crisis every time its value is higher than 3 p.p.. If we consider the second threshold, only in the periods in which the credit-to-GDP gap is higher than 5 p.p. the indicator issues signals. Therefore, all the observations with a credit-to-GDP gap between 3 p.p. and 5 p.p. represent signals of an incoming crisis with the calculations for the first threshold, but disappear

4 For further details, see Antão *et al*. (2009).

5 This recommendation is consistent with that foreseen in the EU Capital Requirements Directive approved in 2013.

when we consider a higher and stricter threshold. Some of these signals could be false signals (with no crisis occurring), which means that the first threshold was possibly too relaxed and allowed more false positives (type I error), but at the same time they could also be true positive signals that are discarded with the more restrictive threshold, resulting in false negatives (type II error). Given this, it is important to evaluate the indicator along a wide range of thresholds and see how it fares as a whole.

Starting with a very relaxed (very low) threshold, and considering increasingly more restrictive ones, we classify indicator signalling behaviour as:

- True Positive (TP): If the indicator issues a positive signal and, in fact, a crisis occurs 4 to 12 quarters afterwards.
- False Negative (FN): If the indicator does not issue a signal when it should, due to an incoming crisis.
- True Negative (TN): If no signal is issued and there is no crisis in the next 4 to 12 quarters.
- False Positive (FP): If the indicator issues a signal but there is no crisis starting in the next 4 to 12 quarters.

**FOR EACH THRESHOLD, A MATRIX OF SIGNALS AND CRISES IS ESTIMATED:**

| | | Crises Events | |
|---|---|---|---|
| | | Crisis | No Crisis |
| Signals | Signal Issued | True Positive | False Positive |
| | No Signal Issued | False Negative | True Negative |

When combining all the results for each threshold, one can compute "Sensitivity" and "Specificity", two measures of performance for binary classification tests. These can be related to the true positive[6] and false positive rates[7] being the true positive rate equal to Sensitivity and the false positive rate equal to (1-Specificity). These relations can be plotted, resulting in a Receiver Operating Characteristic (ROC) curve. Visually, this is a way to interpret the performance of the indicator by comparing it to the expected result of a random decision (represented by the 45º line). By randomly signalling a crisis event, one expects the true positive rate and the true negative rates to be equal (the signals should be balanced between hits and misses). Chart 3 plots the true positive and the false positive rates for each threshold. The 45º line connects the points in which the 2 rates equal each other, resulting in the visual representation of the random signal. To be useful, an indicator must manage to perform better than the 45º line result, by achieving a higher area under the curve.

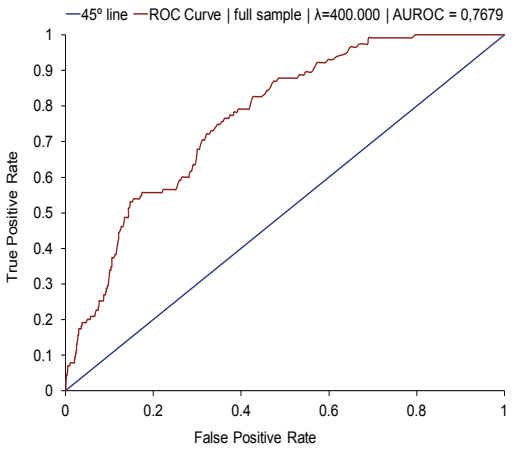
By calculating the area beneath the ROC curve (AUROC), an evaluation measure can be attained. This measure will represent the quality of the indicator as a whole in predicting the stress event. It is more than a measure of a rules-based mechanism with a fixed threshold, as it gathers the information from a wide variety of thresholds and delivers an aggregate measure of its quality to predict this specific stress event. In the case of the credit-to-GDP gap (full sample calculations with a smoothing parameter $\lambda$=400.000), the ROC curve is always superior to the 45º line, which results in an AUROC of 0,7679 (Chart 3). This means that the indicator is useful in signalling the occurrence of periods of financial stress. The credit-to-GDP gap also performs well for Portuguese data, achieving an AUROC of 0,7703 for the baseline calculations (with a lead of 4 to 12 quarters) (Chart 4).

6 True Positive Rate = TP/(TP+FN)

7 False Positive Rate = FP/(FP+TN)

Chart 3

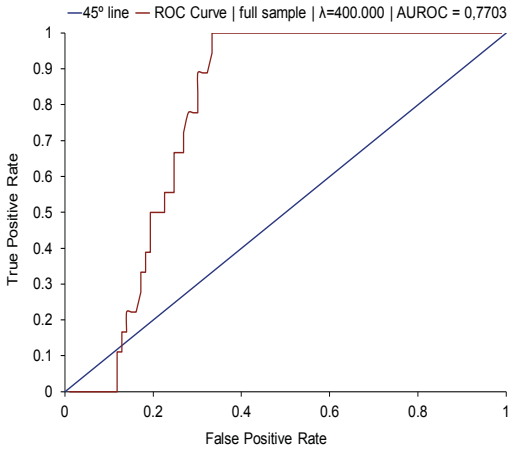
ROC CURVE – CREDIT-TO-GDP GAP




Sources: Thomson Reuters and authors' calculations.

Chart 4

ROC CURVE – CREDIT-TO-GDP GAP – PORTUGAL




Sources: Thomson Reuters and authors' calculations.

## 3.4 Sensitivity analysis

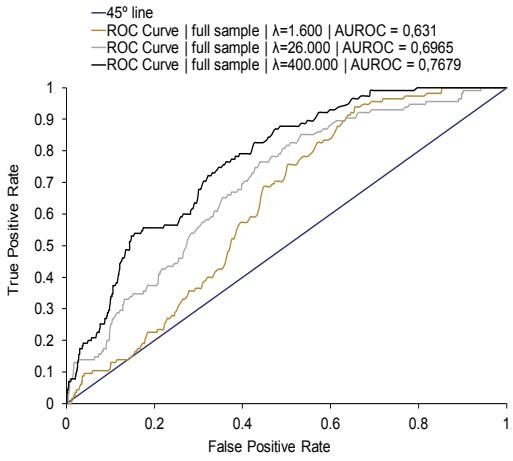
The results presented above reflect the calibration recommended by the Basel Committee. However, it is possible that the results change when different assumptions are considered. To test this, in this subsection we present the results of a sensitivity analysis performed on the choice of the smoothing parameter λ and on using moving windows of data (which entails ignoring older observations in the estimation of the most recent periods, to deal with possible structural breaks).

We consider first the process of detrending the credit-to-GDP series with a different smoothing parameter. With lower λs, the HP-filter trend becomes less linear and the gap variable changes accordingly. This procedure has significant effects in the buffer guide.

Chart 5 shows that, in the case of the credit-to-GDP, the higher smoothing parameter results in a more useful indicator (evaluated by the AUROC). Visually, one can also see that the ROC curve for λ=400.000 is almost always above the other two. Notice that each combination of false positive rate and true positive rate reflects the setting of a determined threshold, and that different thresholds result in different

Chart 5

ROC CURVE – CHANGES IN λS




Sources: Thomson Reuters and authors' calculations.

combinations of true positive and false positive rates. So, this means that for almost all considered thresholds, the indicator calculated with λ=400.000 provides a higher true positive rate (for each false positive rate) and, therefore, has a better performance.

When all the available data at each moment is considered in the estimation, the long term trend is updated every period with a new observation, allowing for a recursive calculation. This ensures that all the data available influences and contributes to the desired long term trend. However, it also implies that all the considered information is relevant, which may not be the case. Data from 40 years ago may not be comparable or relevant to today's values, so using such information may bias the trend towards an outdated reference point, most notably if there are structural breaks.

To mitigate this problem, we test the estimation based on a moving dataset that excludes older data when updating the series with new observations (maintaining a fixed size, ideally long enough to achieve the long term trend's reference capabilities). We test three different sizes for this window: 40, 60 and 80 quarters (10, 15 and 20 years of observations, respectively). As before, we analyze the performance of the credit-to-GDP gap when predicting the starting point of a crisis with a lead of 4 to 12 quarters (Table 1). It should be noted that while considering moving windows may be useful to mitigate potential problems related to structural breaks, it also implies that, in some cases, full credit cycles are not being taken into account, given that its average duration is relatively long (Drehmann *et al.*, 2011).

The results for calculations with moving windows of data result in more flexible trends, which lead to a lower range of values for the gap indicator. As seen in table 1, the moving window calculations also grant good "scores" in terms of AUROC. However, it is the full sample that manages to achieve the best results for almost all smoothing parameters (the only exception is for the sample with 80 quarters window for a smoothing parameter of 1.600). The longer period of data considered in the full sample calculations results in a better suited long-term trend and higher AUROCs. The best overall performance is achieved when combining the full sample of data with a smoothing parameter 400.000.

Chart 6 confirms that both 60 and 80 quarters windows fail to achieve better results than the full sample calculations in terms of AUROC score. It should be recalled that the ROC curve is calculated using a wide variety of thresholds. More restrictive thresholds should result in less signals (both positive and negative) and so, less true and false positive rates. This means that, from bottom to top along the y-axis, we can see the links between sensitivity and specificity for a series of thresholds (decreasingly restrictive). If we focus on the ROC curves for true positive rates (Sensitivity) higher than 0,5, we can see a significant difference in the positioning of the functions and direct our analysis to a specific group of thresholds which grant at least 0,5 true positive rate without using a loose threshold (*i.e.*, a false positive rate below 0,5). Despite being clearly visible that the full sample function is almost always above the other two, in some parts of this section the full sample's result is surpassed by the one from the 60 quarter window. When desiring a very high true positive rate (between 0,8 and 0,9), without excessive false positives (false positive rate lower than 0,5), the 60 quarter moving window sample achieves a slightly better performance.

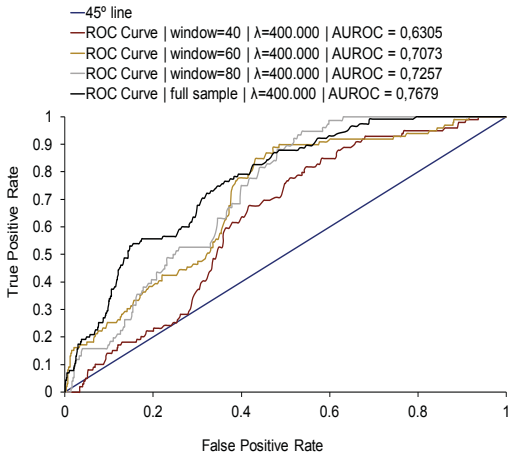
**Table 1**

| AUROC (CREDIT-TO-GDP GAP) | | | | | |
|---|---|---|---|---|---|
| Lambda \ Window | 1.600 | 8.000 | 26.000 | 130.000 | 400.000 |
| 40 Quarters | 0,6274 | 0,6412 | 0,6361 | 0,6315 | 0,6305 |
| 60 Quarters | 0,6207 | 0,6454 | 0,6738 | 0,7005 | 0,7073 |
| 80 Quarters | 0,6470 | 0,6451 | 0,6670 | 0,7130 | 0,7257 |
| Full Sample | 0,6310 | 0,6649 | 0,6965 | 0,7490 | 0,7679 |

**Sources:** Thomson Reuters and authors' calculations.

Chart 6

ROC CURVE – MOVING WINDOWS OF DATA



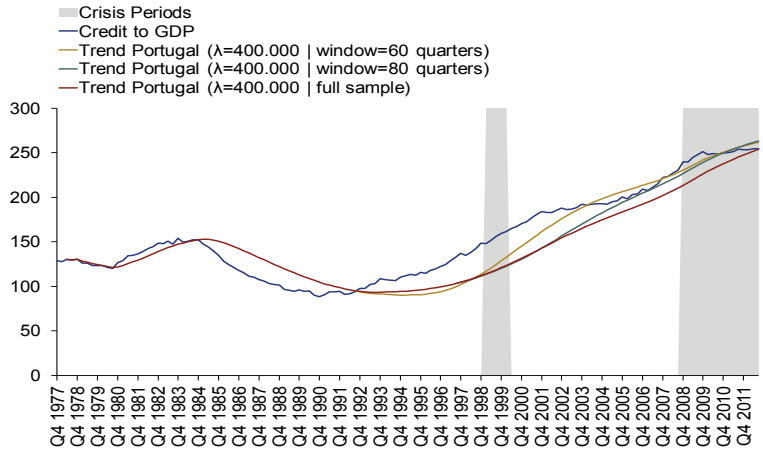

**Sources:** Thomson Reuters and authors' calculations.

The analysis conducted thus far focuses on the performance of the credit-to-GDP ratio for the whole sample, including 9 countries. However, it is also relevant to analyze to what extent buffer settings in Portugal could be sensitive to different calibrations.

Given the structural changes that mark part of the period under analysis, perhaps the most relevant aspect is to understand the impacts of considering a moving window of data. As illustrated in chart 7 and chart 8, the results change significantly. Since the early data is removed from the sample as time passes, the trend becomes much more flexible, resulting in a sharper rise of the trend curves calculated with moving windows of data in the 2000s. This faster convergence between the trend and the actual values results in lower credit-to-GDP gap values which, in turn, imply a small buffer recommendation prior to the crisis in 2008 for the 60 and 80 quarter window calculations (the results for the 40 quarter window calculations are almost the same as those achieved when using a window of 60 quarters; for that reason the 40 quarter results are not shown in the figures). The 1990s are still identified as a period of fast credit growth and the buffer build up recommendation is present for all the considered windows. However, for the crisis in 2008, only the full sample calculations grant a sufficient and early buffer accumulation.

Chart 7

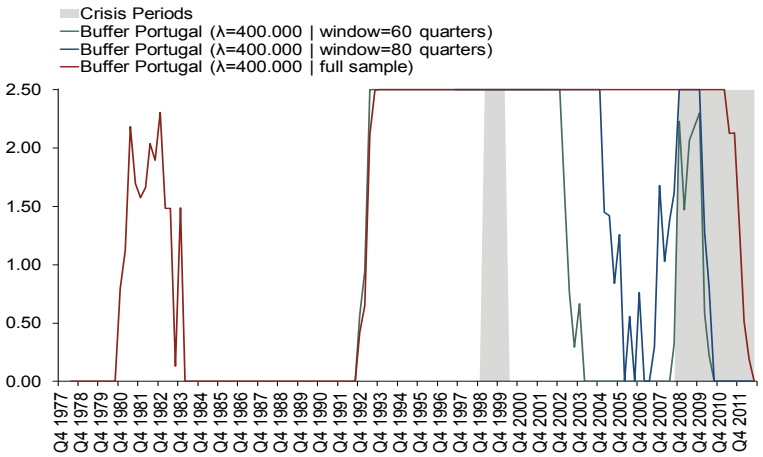
CREDIT-TO-GDP TREND – PORTUGAL – MOVING WINDOWS OF DATA | PER CENT




**Sources:** Thomson Reuters and authors' calculations.

Chart 8

BUFFER RATE – PORTUGAL – MOVING WINDOWS OF DATA | PER CENT




**Sources:** Thomson Reuters and authors' calculations.

Table 2

AUROC (CREDIT-TO-GDP GAP)

| Window \ Lambda | 1.600 | 8.000 | 26.000 | 130.000 | 400.000 |
|---|---|---|---|---|---|
| 40 Quarters | 0,5268 | 0,5347 | 0,5432 | 0,5595 | 0,5446 |
| 60 Quarters | 0,5756 | 0,4660 | 0,5023 | 0,5440 | 0,5324 |
| 80 Quarters | 0,8485 | 0,6326 | 0,4337 | 0,2273 | 0,1439 |
| Full Sample | 0,5809 | 0,6126 | 0,6311 | 0,6992 | 0,7703 |

**Sources:** Thomson Reuters and authors' calculations.

In table 2 we present AUROCs for different smoothing parameters and moving window datasets for the Portuguese economy. The results are, as expected, poorer than when all countries in the sample are included. Still, it is clear that the full sample dataset combined with the smoothing parameter 400.000 (*i.e.*, the Basel Committee baseline recommendation) achieves a good performance, with the AUROC reaching 0,7703. However, the combination of a smoothing parameter of 1.600 and a moving window of 80 quarters achieves a significantly better result (0,8485). Despite being a good signal for indicator adequacy, we must not forget that these single country results were estimated using a very small and specific dataset.

## 4. OTHER INDICATORS POTENTIALLY RELEVANT FOR THE IMPLEMENTATION OF THE COUNTERCYCLICAL CAPITAL BUFFER

### 4.1 Data

Though there is consistent evidence that the credit-to-GDP gap performs well in predicting banking crises with some anticipation, there are also many other potentially relevant indicators suggested in the literature. In this section, we test some of these indicators in our sample, assessing their relative performance using the AUROC estimation described in the previous section.

The credit-to-GDP gap combines developments in credit markets with the real economy. Its intention is to signal potential persistent mismatches between credit and economic growth, which may be unsustainable. Given the criticisms put forth by Repullo and Saurina (2011), we also look at credit and GDP growth separately, computing year-on-year growth rates.

As discussed, for instance, by Alessi and Detken (2011), asset prices booms and busts are often associated with crises episodes. To test this relationship, we consider equity prices, house prices, consumer price indexes (CPI), and long-term interest rates on government bonds. For equity and house prices, which may be expected to have good signalling properties, we also test year-on-year growth rates. Interest rates and consumer price indexes help to characterize monetary conditions in an economy. We complement this assessment by looking at M1 developments.

Finally, we test a few other macroeconomic indicators which have been pointed out in the literature as potentially relevant, such as the current account balance (as a percentage of GDP), external debt (as a percentage of GDP), gross government debt (both in levels and as a percentage of GDP), and the unemployment rate.

All time series were collected from Thomson Reuters. The original data sources are Eurostat (government debt), OECD (current account balance and unemployment rate), IMF (long-term interest rates on government bonds), and Oxford Economics (consumer price index, M1, house price index, and external debt). Equity prices are the total market index calculated by Thomson Reuters for each country. Some series are seasonally adjusted (unemployment rate, current account balance, CPI). We collected quarterly data since 1957, though there is substantial heterogeneity in data availability across countries and indicators. All variables, except those that are presented as year-on-year growth rates, are deviations from long-term trends computed using a HP filter with a smoothing parameter $\lambda$=400.000.

## 4.2 AUROC evaluation

### 4.2.1 Global assessment

All the indicators mentioned in the previous subsection may have leading and near-coincident properties in signalling banking crises. To compare their relative performance, we compute ROC curves for each indicator and the respective AUROC, as in section 3. The results are summarized in the first column of table 3 (ROC curves for each indicator are presented in the annex).

The indicator with the best signalling properties in the sample analyzed is, by far, the credit-to-GDP gap. The second best performing indicator is the house price index, followed with some distance by its year-on-year growth rate. Our results thus show that developments in real estate markets should be closely monitored by macroprudential authorities, as they display strong signalling properties. These results are consistent with evidence obtained by Behn *et al.* (2013) and Drehmann *et al.* (2011), who also find good forecasting accuracy for real estate indicators.

Credit developments also deserve careful monitoring, as suggested by most of the literature on this topic (Drehmann *et al.*, 2010, 2011, Moritz and Taylor, 2012, Reinhart and Rogoff, 2011). The year-on-year growth of credit displays good signalling accuracy, as suggested by Repullo and Saurina (2011), being the third indicator with highest AUROC (after to the credit-to-GDP ratio and the house price index).

Stock price developments also seem to be relevant, in line with the results obtained by Alessi and Detken (2011) and Drehmann *et al.* (2011).

The indicators with the weakest predictive ability are the current account, external debt and the year-on-year growth rate of GDP. In turn, government debt, M1, government bond yields, CPI and the unemployment rate are in an intermediate situation.

Table 3

| EVALUATION OF INDICATORS | | |
|---|---|---|
| Indicator | AUROC | |
| | All episodes | Actual crises |
| Credit-to-GDP | 0,7679 | 0,7423 |
| House price index | 0,6468 | 0,7026 |
| Credit (% yoy) | 0,5995 | 0,6023 |
| Equity price index | 0,5879 | 0,5943 |
| House price index (% yoy) | 0,5815 | 0,6196 |
| Government consolidated gross debt | 0,5799 | 0,5799 |
| Equity price index (% yoy) | 0,5677 | 0,5502 |
| Gross government debt (% of GDP) | 0,5669 | 0,5979 |
| Money supply, M1 | 0,5642 | 0,5760 |
| Interest rates: government securities, government bonds | 0,5475 | 0,6018 |
| Consumer price Index | 0,5286 | 0,5617 |
| Unemployment rate | 0,5041 | 0,4771 |
| GDP (% yoy) | 0,4660 | 0,4620 |
| External debt (% of GDP) | 0,4591 | 0,4566 |
| Current account balance (% of GDP) | 0,3055 | 0,3316 |

**Sources:** Thomson Reuters and authors' calculations.
**Note:** yoy - year-on-year growth rate.

In the second column of table 3 we present, for robustness purposes, the results using only crises actually observed (as discussed before, the baseline definition includes heightened vulnerability periods that did not materialize in a crisis). The results are broadly consistent. For most indicators, the AUROC is actually higher when this tighter definition is used. In relative terms, the performance of the house price growth rate, government debt as a percentage of GDP and government bond yields is slightly better, though the main conclusions are not affected.

All in all, the credit-to-GDP ratio seems to be the indicator with better signalling properties, being closely followed by house prices, credit growth and equity prices.

### 4.2.2 Signalling properties through time: build-up versus release

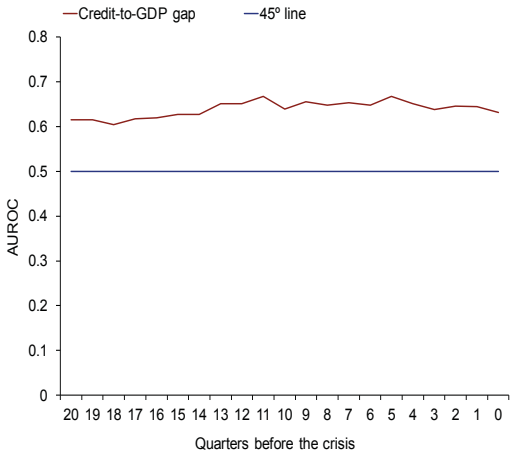
The analysis presented above allows for the comparison of the overall performance of the different indicators. It is interesting to complement this analysis with the assessment of forecasting power at different horizons. This allows to understand at which horizons does each indicator perform better, thus providing some guidance to macroprudential authorities about when should a given indicator be taken more seriously when taking decisions both about the build-up and release of the buffer. With performances for different horizons, we can see which indicators are better suited to predict a crisis event with long enough lead to activate the countercyclical capital buffer regime, and which indicators are near-coincident to the crisis, thus being more useful to signal that it is time to release the buffer previously accumulated.

Chart 9 shows the performance of the credit-to-GDP gap for several prediction horizons. The highest AUROC value is achieved for a 5 quarter lead on the crisis event, though this indicator has a very smooth behaviour in terms of predictive ability in the 5 years before the crisis.

Chart 10 presents the AUROC estimations for different horizons ahead of crises, starting 20 quarters before the beginning of each crisis. The indicators with the highest global AUROCs, which focus on real estate and credit market developments, display good signalling properties well in advance of the beginning of the crisis. The year-on-year growth rates of credit and of house prices have the highest signalling power around 3 years before the crisis starts. The house price index shows the highest AUROC nearly 2 years before the crisis hits.

Chart 9

**AUROC – DIFFERENT PREDICTION HORIZONS – CREDIT-TO-GDP GAP**




**Sources:** Thomson Reuters and authors' calculations.

The year-on-year change of stock prices displays signals very early, with the AUROC peaking around 17 quarters before the crisis begins. The stock price index peaks later (around 5 or 6 quarters ahead of the crisis, though it starts displaying useful signals at least one year before that). Yields on sovereign bonds start to display signals one and a half years before the crisis.

Besides allowing to identify how much in advance are the indicators able show strong signals, this analysis can also assess which indicators are the potentially most useful to signal the adequate time to release the buffer. It should be recalled that the release can be done in two different scenarios. On the one hand, the risks that lead to the build-up of the buffer may dissipate gradually. In this case, the indicators that have contributed to support the decision to activate the buffer may be again the most relevant to justify the gradual release of the accumulated buffer. On the other hand, the buffer can be released to allow banks to absorb losses in a stress scenario, thereby avoiding an excessive contraction of credit supply. In a crisis scenario, macroprudential authorities should be guided primarily by information available in real time, as well as by some guided judgment, given the uncertainty prevailing in such periods. Nevertheless, the analysis of the results shown in chart 10 can be a relevant input for this analysis.

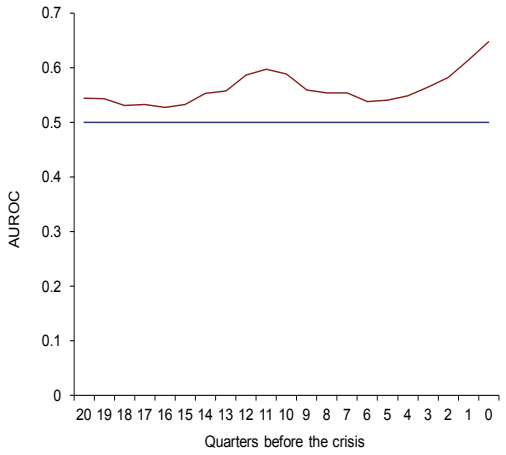
On the one hand, it is possible to assess which indicators have higher AUROCs in the quarter in which the crisis begins or in the previous quarter. Sovereign debt, the unemployment and the yield on sovereign bonds have an AUROC larger than 0,6 in at least one of these quarters. On the other hand, some of these indicators already showed significant signs in previous quarters. In this sense, it could be more useful to consider only those indicators whose signalling power became particularly strong near the outbreak of a financial crisis. According to this criterion, the most relevant indicators would be sovereign debt, the unemployment rate and, to a lesser extent, the yields of sovereign bonds, *i.e.*, the results are broadly consistent in the two approaches.

It should be noted that these results are specific to the sample and time period considered, as well as to the crises database used. Most of the crisis episodes in the sample relate to the 2008 global financial crisis, which may limit the generalization of the results. Furthermore, we only tested a limited set of indicators and many more could be tested. As such, even though we hope to provide relevant guidance for macroprudential authorities with this analysis, it should be borne in mind that the past forecasting performance of these indicators will not necessarily be replicated in the future.

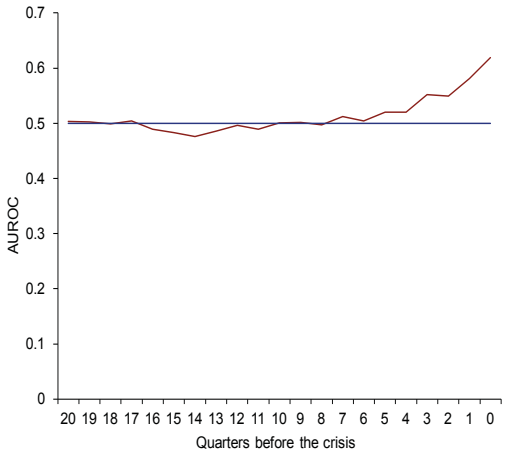
Chart 10 (to be continued)

AUROC – DIFFERENT PREDICTION HORIZONS – OTHER INDICATORS

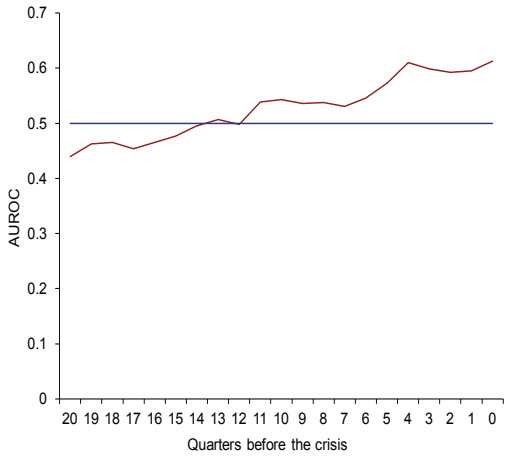
Gross Government debt (% of GDP)



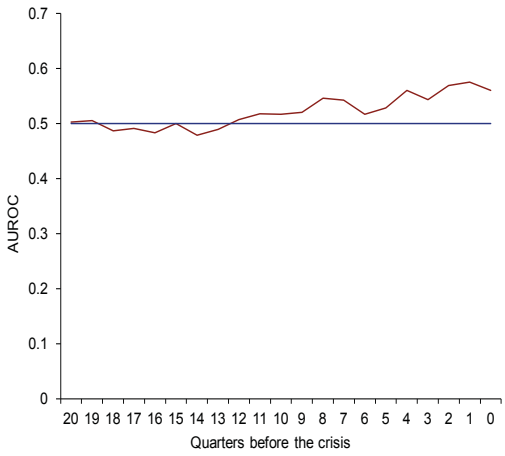

Unemployment rate



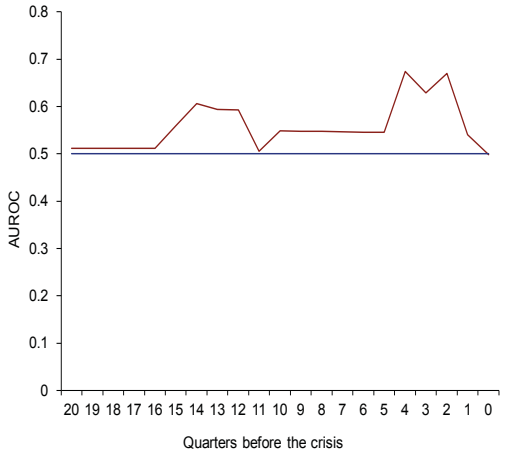

Interest rates: Government securities, Government bonds




Consumer Price Index




Money Supply, M1




House Price Index

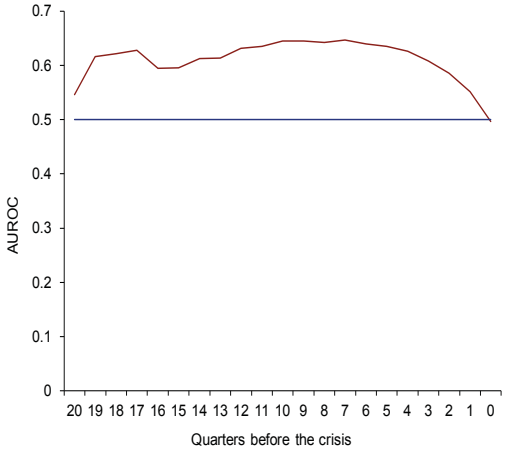
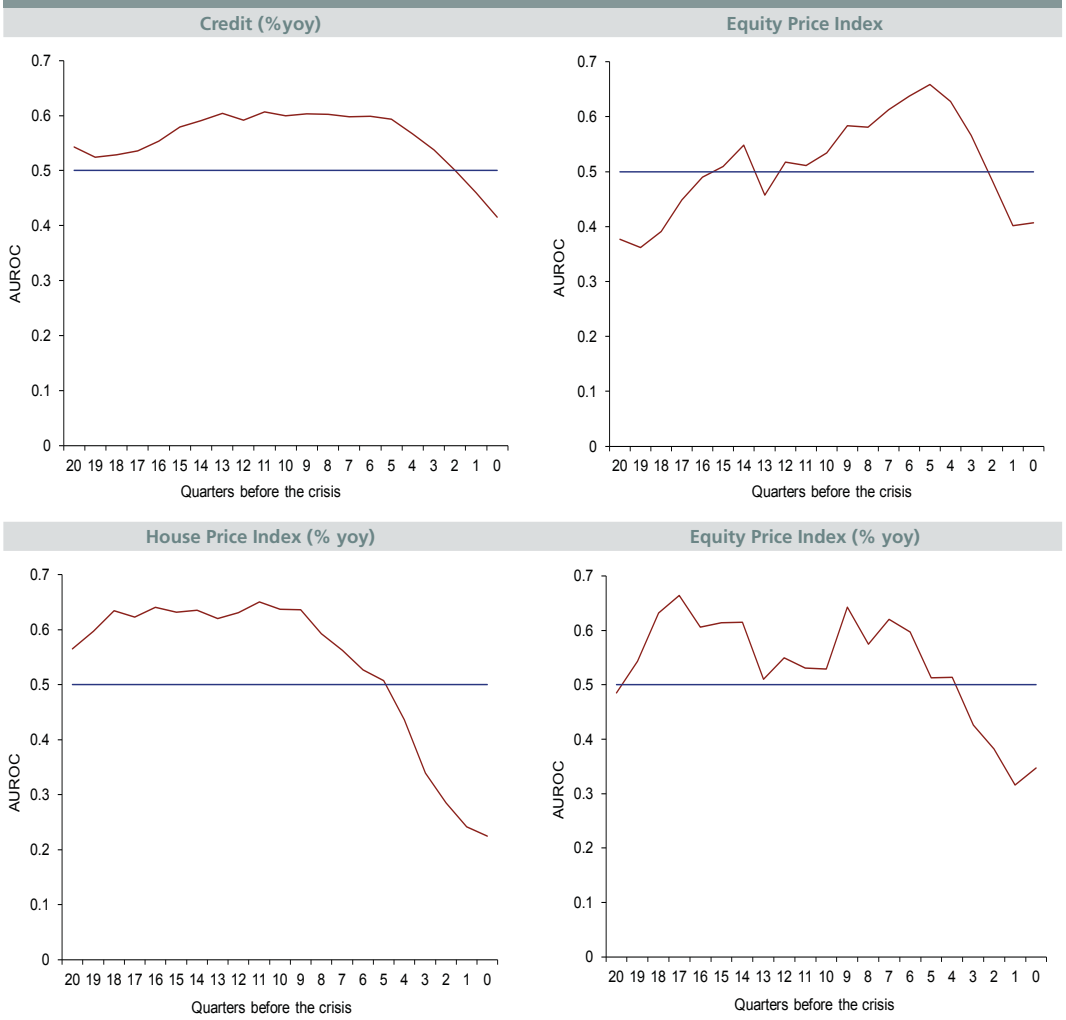


Chart 10 (continued)

AUROC – DIFFERENT PREDICTION HORIZONS – OTHER INDICATORS




**Sources:** Thomson Reuters and authors' calculations.
**Note:** yoy - year-on-year growth rate.

## 5. CONCLUDING REMARKS

The new countercyclical capital buffer will be one of the main instruments available to macroprudential authorities worldwide. The Basel Committee recommends that buffer decisions are, to some extent, based on the analysis of deviations of the credit-to-GDP ratio from its long-term trend, though highlighting the need to consider other indicators and to balance the available quantitative and qualitative information with guided judgement.

In this article, we assess the sensitivity of the credit-to-GDP gap to different parameters underlying its calculation. The calibration proposed by the Basel Committee delivers the best results for the set of hypothesis tested. Nevertheless, the forecasting accuracy of this indicator changes considerably depending on the assumptions used in its estimation. Since these results refer to a specific sample of countries, where most crisis events are related with the 2008 global financial crisis, it is important to note that the generalization of these results may have some limits, since all crises assume specific characteristics that may constrain the predictive ability of indicators that offered useful signals in the past. As such, the considerable risks that an approach based on rigid rules to guide decisions macroprudential may have

should be underscored, reinforcing the idea that every decision must be supported by informed judgment, as well as by a wide range of indicators.

That said, we also test the forecasting performance of other macroeconomic and financial indicators, finding that even though the credit-to-GDP gap is the indicator with the best overall performance, there are other indicators that also offer useful signalling properties. Indeed, house prices, credit growth and equity prices are also useful indicators to signal crises with a significant lead. In turn, government debt, the unemployment rate, and the yield on sovereign bonds display a good near-coincident behaviour, thus providing potentially useful signals for the release phase.

All in all, our analysis shows that it is necessary to rely on a wide set of indicators and information to support the build up and release decisions concerning the countercyclical capital buffer. This information set should be complemented with guided judgement, to build a constrained discretion approach to macroprudential policy.



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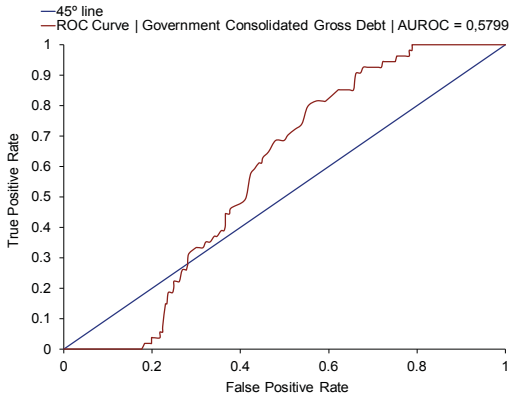
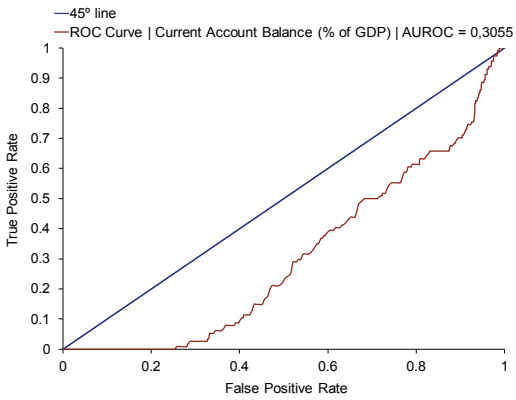
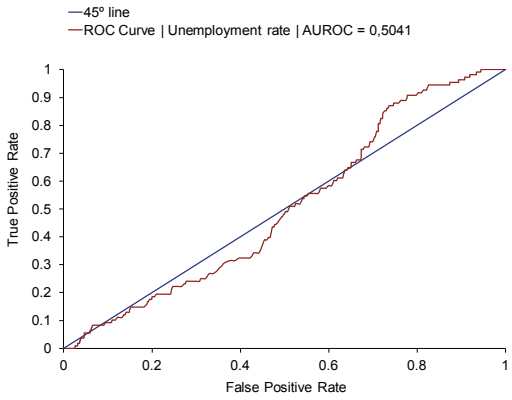
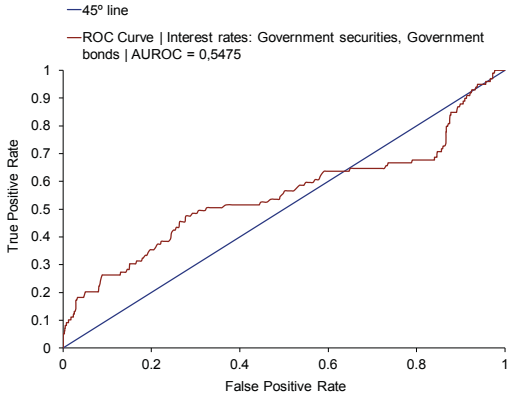
## Annex (to be continued)

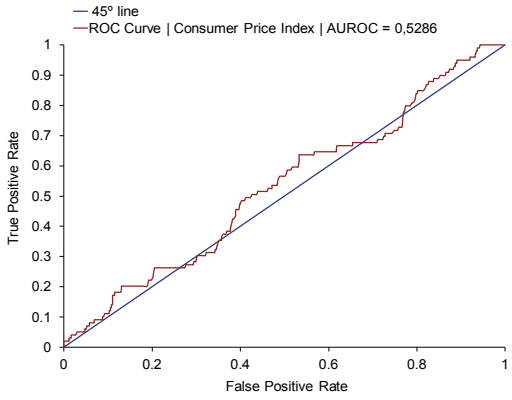
### ROC CURVES FOR SEVERAL INDICATORS

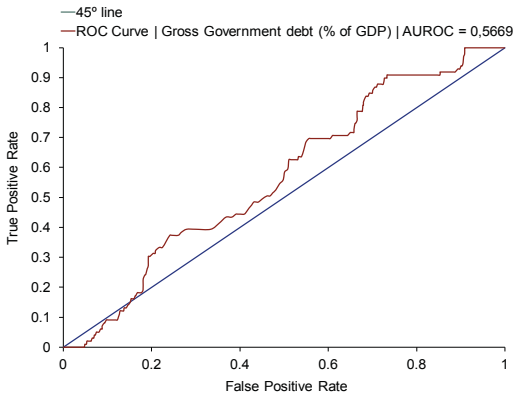


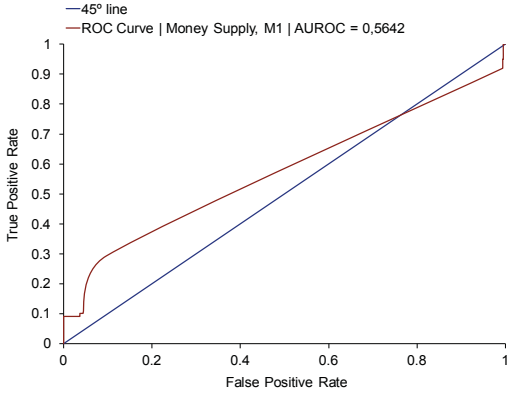



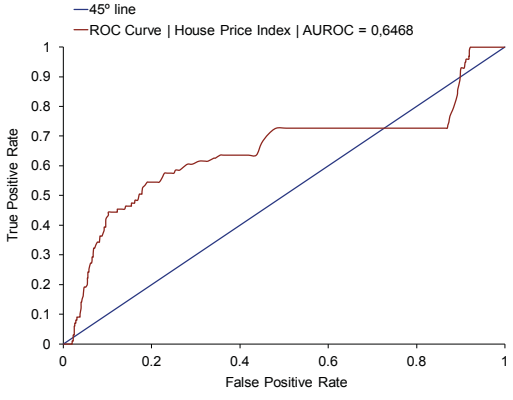



## Annex (continued)

### ROC CURVES FOR SEVERAL INDICATORS