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(Korai előrejelző indikátorok: pénzügyi és makrogazdasági egyensúlytalanságok a közép- és kelet-európai országokban)

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Contents

Abstract

In this paper we apply the Early Warning System methodology to ten Central and Eastern European Countries to find useful sets of indicators which could predict macroeconomic and financial imbalances. We argue that finding such indicators is crucial in the current monetary policy framework because significant imbalances could build up without any sign of risk to price stability. We examine the stylised behaviour of the most important macroeconomic variables over the business cycle and select the most preferred indicator variables. Our methodology consists of choosing the most useful combination of variables in terms of false alarms and misses, taken as given the preferences of the decision maker in terms of committing various types of errors. We find, that a certain combination of the global financial variable, the real exchange rate, capital flows and credit is a plausible signal macroeconomic imbalances. The results suggest that although the above indicators should not be used mechanically, they could usefully complement analytical tools available to modern central banks.

JEL: E32, E37, E44, E58.

Keywords: Early Warning Indicators, Signalling Approach, Macroeconomic Stability, Financial Stability, Monetary Policy Strategy.

Összefoglaló

Jelen tanulmányban a korai előrejelző rendszerrel keresünk olyan indikátorokat, amelyek segítségével hatékonyan lehet előre jelezni makrogazdasági és pénzügyi egyensúlytalanságok kialakulását a közép- és kelet-európai országokban. Ilyen indikátorok azonosítása kiemelt jelentőségű a monetáris politika számára, mivel makrogazdasági egyensúlytalanságok a modern jegybankok által elérni kívánt árstabilitás megvalósulása mellett is kialakulhatnak. Először stilizált tényeket ismertetünk a legfontosabb makrogazdasági változók és az üzleti ciklusok együttmozgásáról. Ezen stilizált tények fényében kiválasztjuk azokat az indikátorokat, illetve indikátorkombinációkat, amelyekkel a leghatékonyabban, azaz a lehető legtöbb helyes és legkevesebb téves jelzéssel lehet előre jelezni egyensúlytalanságokat, miközben adottnak vesszük a gazdaságpolitikai döntéshozó preferenciáit a különböző típusú hibákat illetően. Eredményeink szerint egy globális pénzügyi változó, az effektív reálárfolyam, a tőkeáramlás és a hitelállomány bizonyos kombinációja megfelelő megbízhatósággal képes jelezni makrogazdasági egyensúlytalanságok felépülését. Az indikátorokat nem célszerű ugyan mechanikusan, szakértői felülvizsgálat nélkül alkalmazni, de így is hasznos kiegészítője lehet a monetáris politikai eszköztárnak.

1 Introduction

One lesson of the recent financial crisis is that the analytical frameworks used by central banks do not contain all the important indicators of risks to macroeconomic and price stability. Most probably, this omission is due to the secular structural change that has taken place in modern economies over the last decades. That is, while in the past inflation alone could serve as a reasonably good summary indicator of the state of the business cycle, it is clearly not sufficient any more. For this reason, central banks'analytical frameworks could be improved if we could enrich them by analysing additional indicators having information about developing imbalances in the economy.

Modern economies can build up significant imbalances, or even overheat without any sign of risk to price stability at the usual forecast horizon. The exact reasons to this change are not yet clear, but the credibility of stability oriented monetary policies, more disciplined fiscal policies, and increased competition from low cost exporters are likely to have played a role in it. Nonetheless, imbalances and overheating, which do not show up in the inflation forecasts, as these are currently customarily done, could result in the same inefficiencies as before: that is, lasting misallocation of resources based on wrong signals, while the unwinding of them imposes significant adjustment costs to the society.

Thus, a central bank that wants to fulfil its original mandate to preserve macroeconomic stability should look at not only the inflation forecast, but also other indicators not captured in the current forecasting frameworks, but potentially useful in detecting the building up of imbalances and gradual overheating. The first best solution in remedying the above omissions would be to develop and use macroeconomic models which incorporate previously overlooked relations and indices. However, such models are not yet available, thus the next best solution is to find indices, or combination of them, which are able to inform us about the building up of imbalances and use them as add-ons to our existing frameworks.[1]

The paper is organised as follows. In Section 2 we present the motivation behind the choice of indicators and the data used. We then examine the chosen indicators and their stylised behaviour in a group of emerging market economies. In Section 4 we present the preferred method and our motivation for using it. In Section 5 we present and discuss our results. In Section 6, we show how our results could be used in the practice of modern central banks. The final section describes our main conclusions.

[1] Disyatat (2005).

2 Principles related to the selection of the indicator variables

Before constructing any indicators, we need to define the „episode" or „event" to be predicted in an operationally precise way. We will derive the definition from the existing mandates of the modern stability oriented central banks, that is, the goal of price stability. By achieving price stability, central banks aim to smooth out the business cycle, i. e. they want to prevent excessive negative deviation of the GDP from its long-term trend, often preceded by an overshooting of the trend. The reason is that an excessive negative GDP gap often forces economic agents to costly adjustments and means risk to financial stability. We will call a macroeconomic „imbalance episode" any *level of GDP deviation below trend* exceeding a predefined threshold.

Armed with a quantitative definition of an „imbalance episode", we will derive imbalance indicators, or rather a group of them, which behave in significantly different ways before the „imbalance episode", as compared to „normal times". That is, indicator variables deviate from their own „normal" behaviour *well before* GDP starts to deviate. We will capture the deviation of the indicators by measuring the distance from their own trends. We will treat *positive deviations* exceeding a predefined threshold as „signals" of a future imbalance episode. We implicitly assume, that the imbalances are the result of endogenous processes, rather than the result of exogenous shocks. As such, these episodes are, at least in principle, amenable to detection by using appropriate indicators. This is in contrast to the exogenous shocks view, where one has little chance to forecast external shocks; what one could hope for is only to determine if there are any „vulnerabilities" building up in the economy exposing it to „unpredictable shocks".

For the chosen indicators to be useful, they should signal macroeconomic imbalances with an appropriate lead in time, so as central banks could take preventive action. In other words, the lead time should be at least as long as the transmission mechanism of the optimal central bank instrument.

2.1 DESCRIPTION OF DATA

In this paper we attempt to predict macroeconomic imbalances in the countries of Central and Eastern Europe. We decided to use annual, instead of quarterly data, as imbalances tend to build up during longer periods. The source of these and the majority of other data is Eurostat. For GDP we use the 2005=100 annual index to calculate the cyclical component using the HP-filter (with the smoothing parameter $\lambda = 100$, as is common for annual data). A period is considered an „event" if the value of the cyclical component or deviation from trend is lower than -1.68.[2] Accordingly, events occurred in 13 per cent of all years examined.

As we will discuss it in more detail below, we analysed six predictors of macroeconomic imbalances. Data sources and variable definitions are provided in the Table 1. We transformed each variable into a „gap measure". In each case, the HP-filter[3] was used to perform the calculations (with the smoothing parameter set at $\lambda = 100$).

[2] We defined this value by amending the method used by Mendoza and Terrones (2008): we calculated the standard deviation of the cyclical component of ten stable Western European countries' GDP, i. e. Belgium, Denmark, Germany, France, Luxembourg, Netherlands, Austria, Finland, Sweden, United Kingdom (similarly to the above, 2005=100; with lambda set to $\lambda = 100$ for HP-filtering), then we multiplied the average of these standard deviations by 1.75.

[3] We are aware of the drawbacks of the HP filter, such as end point instability and artificial creation of cycles. Despite of these potential disadvantages, HP-filters are still used in the literature, especially if many time series are used. Using more sophisticated methods would require excessive working time and specialist industry or country knowledge. In addition, endpoint problems are prevalent at the end of series, so less of a problem in other segments of long-term series.

Of the above measures the calculation of the global variable gap needs a bit more detailed explanation. The global gap indicator is obviously the same for each country so either it provides a signal in each country or it does not in any of them. The indicator was constructed by calculating average private sector credit-to-GDP of 15 industrial countries playing a significant role in the global economy[4]. The source of credit data used to calculate the credit-to-GDP ratios for the four non-European countries was IMF IFS (Claims on Private Sector), while GDP data (national currency and current prices) were taken from the OECD's database (as previously, the European data were taken from Eurostat MIP database). Then we calculated the PPP-based, GDP-weighted averages of these indicators.[5] Finally, we fitted a HP trend to this indicator and computed its deviation from trend.

Table 1
Summary of data

Variable	Source
Credit-to-GDP gap	Eurostat, MIP [a] , % of GDP
Credit growth gap	Eurostat, MIP, % of GDP
Investment gap	Eurostat, 2005=100 annual index
Real exchange rate gap	Eurostat, MIP
Capital flows gap [b]	Eurostat, % of GDP
Global variable gap	Eurostat, IFS, OECD

[a] Eurostat data provided under the Macroeconomic Imbalance Procedure. This is a new co-ordination instrument adopted in 2011 to prevent developing excessive public and private, internal and external imbalances. The implementation of the MIP is based on a unified and harmonised database called „Scoreboard".

[b] Financial Account, Direct Investment plus Financial Account, Portfolio Investment plus Financial Account, Other Investment plus Financial Account, Official Reserve Assets.

Table 9 of the Appendix A provides detailed information on the time periods in which individual time series for the countries examined are available.

2.2 CHOICE OF INDICATOR VARIABLES AND THRESHOLDS

The indicator variables were selected on the basis of the existing literature and empirical results. Our starting point was Borio and Lowe (2002a) and (2002b)[6], who attempted to predict the timing of financial imbalances using four variables: the asset price gap, credit gap, investment gap and real credit growth gap for developed OECD countries. In Borio and Lowe (2002a) the asset price indicator was replaced by the real exchange rate for a group of emerging countries as a better indicator. Their results show that the credit gap and the asset price gap proved to be the most effective indicator in identifying imbalances for developed countries, and the credit gap and the real exchange rate for the emerging market countries.

Thus, in line with Borio and Lowe (2002a) we did not examine the asset price gap for both theoretical and technical reasons. First, it can be assumed that in the period under investigation money and equity markets of the emerging and the selected CEE economies were not sufficiently developed and did not reach a level of efficiency to provide information about the build-up of imbalances. Moreover, data on asset prices is simply not available in a wide group of the selected countries.

Therefore, we used several other variables capable of capturing imbalances in emerging countries. Capital flows could be such a variable because, as Kaminsky and Reinhart (1999), Mendoza and Terrones (2008) and Borio and Lowe (2002a) pointed out, they play a dominant role in the development of credit booms and subsequent currency and bank crises.

The Real Effective Exchange Rate (REER) indicator, used in the Macroeconomic Imbalance Procedure as well as in our analysis, captures a country's price and cost competitiveness vis-à-vis its most important trading partner countries. The index shows the

[4] USA, Canada, Switzerland, Japan, Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Netherlands, Spain, Sweden, United Kingdom.

[5] The source of this is the OECD database; GDP data at 2006 current prices, current PPPs.

[6] The Borio and Lowe (2002b) paper is more detailed in theoretical considerations, stylised facts and methodology for 35 counties (of which 13 is financially developed emerging market economies). However, only Borio and Lowe (2002a) present results separately for the latter group of countries. Moreover, in both papers, the dependent variable is „banking crisis", not, as in our case, excessive negative output gap. Thus, we have to refer to both papers. Output gap is dependent variable only in Borio and Lowe (2004), however, EWS results are not published for the emerging market county group in this paper. This means that our results are not directly comparable with either of these studies because either the country group or the method chosen is not comparable. Nonetheless, comparison is relevant in terms of what counts as meaningful prediction and what does not.

extent to which domestic prices and costs have changed relative to the competitor countries (expressed in the same currency). Consequently, an increase in the indicator suggests deterioration in the country's competitiveness (if there are no „non-price", for example, quality improvements).

Finally, the 'global' variable, constructed following Alessi and Detken (2009), attempts to capture the credit developments of countries with significant global economic weight. As we discussed in the last subsection we arrived at an indicator of global credit-to-GDP ratio, which can be considered as given for each selected country.

3 Statistical behaviour of the selected macroeconomic variables

3.1 STYLISED FACTS RELATED TO CREDIT BOOMS

Economies tend to evolve over time by following a characteristically cyclical movement around some long-term trend. Part of what public policy, or more narrowly, monetary policy seeks to achieve is to prevent the normal cycles from developing into excessively costly boom-bust cycles.

We illustrate the cyclical pattern of the most important macroeconomic variables for the chosen group of countries by using the approach of Mendoza and Terrones (2008). They examined the relationship between credit booms and economic cycles by identifying a credit boom in each country[7] and recording its starting date (t), they also calculated the cyclical component for the most important macro variables and examined their development around the reference date chosen earlier (in the preceding and subsequent three years).[8] According to their results, lending co-moved with the business cycles in both industrial and emerging economies, i.e. periods preceding a credit boom were characterised by an economic expansion and those following a credit boom were characterised by a decline in GDP. Accordingly, output, consumption, investment, asset and real property prices as well as the real exchange rate rose above trend prior to the peak of a credit boom, and fell below trend following a boom (the current account balance moves in the opposite direction). Meanwhile, developments in inflation did not reflect credit cycles.

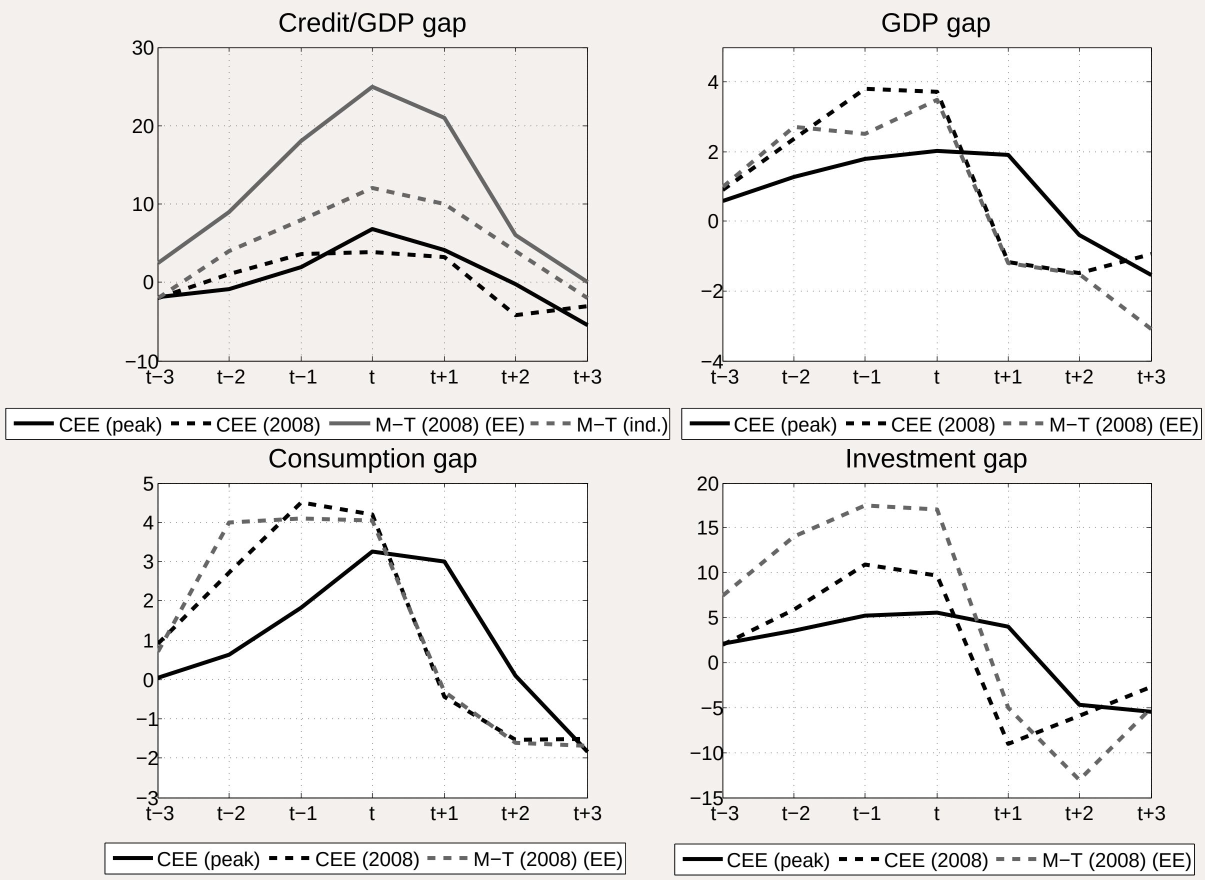
We extend Mendoza and Terrones' (2008) analysis to CEE countries[9]. Our results show that the dynamics of credit booms is very similar to that in the countries examined by Mendoza and Terrones (2008) (see Figure 1). It is slightly surprising that the credit gaps of CEE countries are closer to those of industrialised countries than to those of emerging countries. Furthermore, we also find that the dynamics of lending were much more modest in 2008 – in fact, a boom could not be identified – than in periods of the largest credit booms. To some extent, the fact that the cyclical components of GDP, consumption and investment during the current financial crisis ($t = 2008$) almost fully coincides with the cyclical positions observed during the credit booms of emerging countries examined by Mendoza and Terrones (2008) seems to contradict this finding. Based on these findings, it can be stated that the behaviour of macroeconomic variables identified by Mendoza and Terrones (2008) are also valid for the CEE countries we examined, and, consequently, the approach may be used to examine other issues as well.

[7] They fitted a HP trend to the credit-to-GDP ratio of each country (using the usual $\lambda = 100$ smoothing parameter for annual data), then the deviation of actual data from the HP trend was calculated. A credit boom was identified when the difference between the actual data and the trend was largest.

[8] They calculated the medians of the cyclical components of the countries examined around date t.

[9] Bulgaria (BG), Czech Republic (CZ), Estonia (EE), Latvia (LV), Lithuania (LT), Hungary (HU), Poland (PL), Romania (RO), Slovenia (SI), Slovakia (SK).

Figure 1
Comparison of the cyclical behaviour of macroeconomic variables in times of credit booms



3.2 STYLISED FACTS RELATED TO INSTABILITY EPISODES

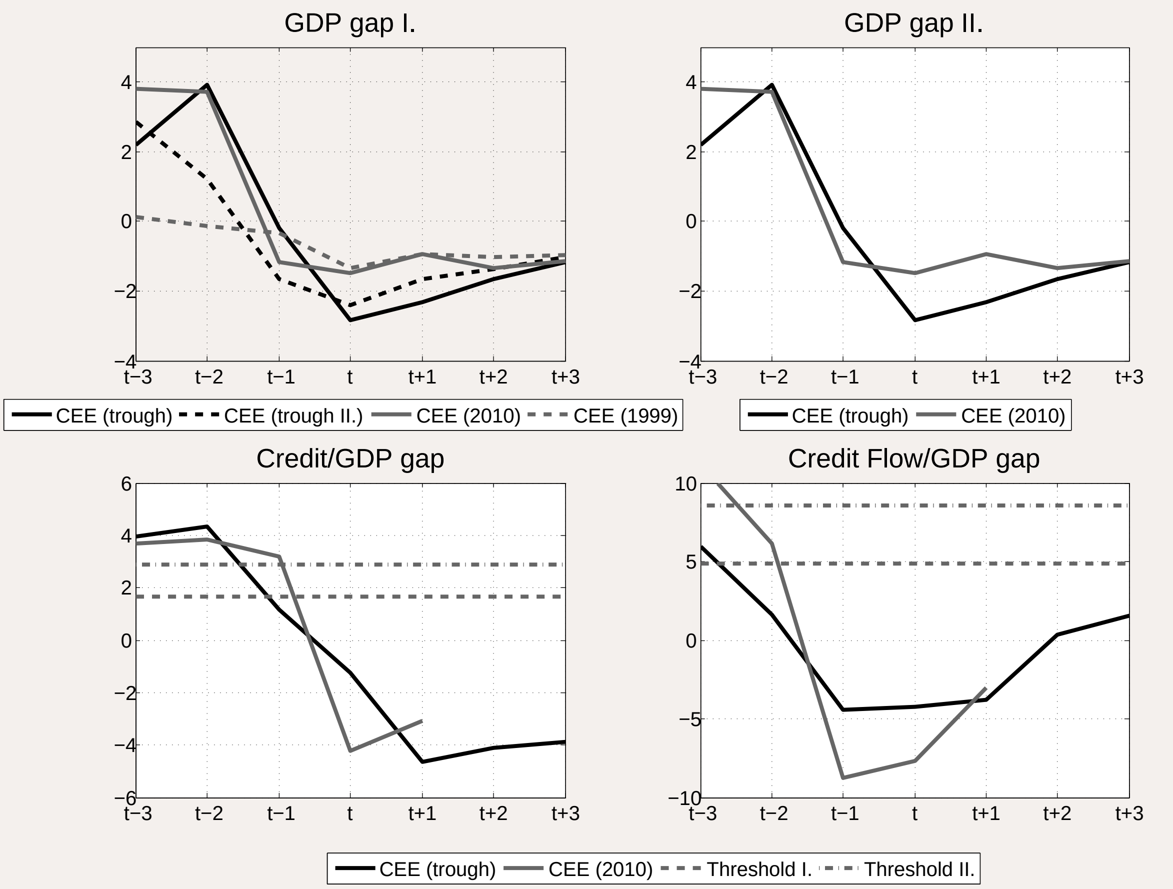
Mendoza and Terrones (2008) find that booms in output are not associated with credit booms. We also examined this pattern for CEE countries, i.e. what cyclical position is characteristic for the most important or most interesting macro variables during periods of the largest decline in GDP (the year in which the cyclical component of GDP is the most negative was chosen as the reference period). Accordingly, we looked for variables which were capable of predicting falls in GDP, i.e. exhibited some kind of a typical behaviour before such declines.

Figure 2 shows the results of this exercise. As can be seen, before the cyclical component of GDP reaches its trough, it strongly deviates in positive direction from its trend, not only at the time of the trough, but also, for example, at $t = 2010$, while it remains negative throughout the following three years. Before these dates t, both the credit-to-GDP ratio (stock) and its growth (flow) exhibit a significant positive deviation from their long-term trend, i.e. there is a credit boom.[10]

Finally, Figure 3 shows that during the periods preceding the reference dates, we identify not only a credit boom, but also a boom in investment and capital flows. Moreover, the real effective exchange rate increases significantly, and there is a slight positive deviation in our so-called global variable from its trend.

[10] We refined the definition of credit boom suggested by Mendoza and Terrones (2008): they determine a credit boom when the cyclical component exceeds 1.75 times the standard deviation of the cyclical components. In our view, this value cannot be applied to emerging countries, due to the higher volatility of the macro variables in those countries. Therefore, taking the European developed countries as a reference, we determined an event a credit boom when the cyclical component exceeds 1.75 times the standard deviation of the cyclical components for those countries.

Figure 2
The cyclical behaviour of macroeconomic variables in times of significant GDP losses I.



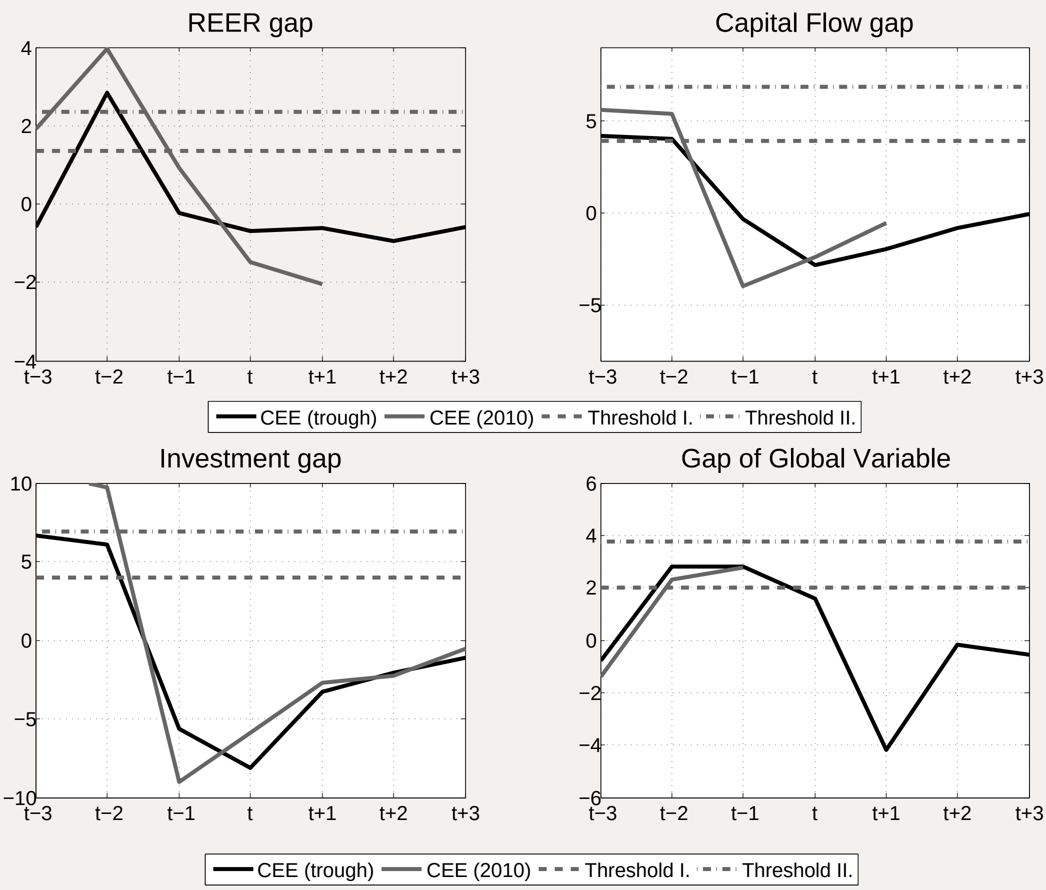
3.3 COUNTRY SPECIFIC PATTERNS OF THE SELECTED VARIABLES

Turning to country level data, we find the following stylised facts for the CEE countries. Lithuania is the country which experienced the largest inflow of capital, in addition to a credit boom (while its real exchange rate increased at around the average), followed by a greater-than-average decline and a significant volatility in the cyclical component of its GDP. In Romania, the credit boom was associated with a sharp increase of the real exchange rate, while the volume of capital flows was less significant; the country's GDP declined by more than the average. Slovenia and the Czech Republic are counter-examples. During the financial crisis, Slovenia's GDP deviated only slightly from its trend, and the country experienced no credit boom or an excessive decline in its competitiveness before the crisis (meanwhile the dynamics of capital flows was largely consistent with the average). The Czech Republic also performed well, as the most negative cyclical component of its GDP was only slightly negative, in which the fact that neither a credit boom, nor a competitiveness loss, nor a large capital inflow into the country occurred in the period before year *t*, must have played a role.

In Table 2 the cyclical components of GDP or the indicators are signalled with „!" if they performed worse than the average (the cyclical component of GDP more negatively, while the indicators more positively), and they are signalled with „X" if they performed better. The table indicates that in those countries which experienced a more negative output gap than the average, at least two of their indicators[11] deviated significantly from their trends; while in countries where there was no significantly negative output gap, the cyclical component of none or only one of the indicators was greater than the average, except in

[11] The global variable gap was left out from the above analysis and the tables, as in this case we focused on country-specific developments.

Figure 3
The cyclical behaviour of macroeconomic variables in times of significant GDP losses II.



Hungary and Poland. However, in the case of Hungary the more sophisticated methods of measuring the output gap indicated a significantly negative output gap for 2009, and, consequently, we might believe that the behaviour of the indicators examined could have drawn attention to the build-up of imbalances.

The above results confirm our expectation that signals issued by certain indicators can be capable of predicting significant declines in GDP or macroeconomic imbalances. We can see that although the variables presented above rarely move exactly together, the positive deviation of one or two indicators from trend is capable to predict significant negative output gap with a greater probability. In addition, we can see that in countries where the indicators examined did not behave abnormally, there was no or only slightly negative output gap.

Table 2
Deviation the cyclical behaviour of macroeconomic variables from the average

	GDP gap	Credit/GDP gap	REER gap	CF gap
Bulgaria [a)]	X	X	!	X
Czech Republic	X	X	X	X
Estonia	!	X	!	!
Latvia [a)]	!	X	!	!
Lithuania	!	!	!	!
Hungary	X	!	!	!
Poland	X	!	!	X
Romania	!	!	!	X
Slovenia [a)]	X	X	X	!
Slovakia	X	!	X	X

[a)] *Due to the lack of data, we took into account the path of the indicators during the financial crises, rather than that during the period of the most negative cyclical component of GDP.*

4 Description of the Early Warning System (EWS) Approach

In developing our method we accepted the argument put forward by Borio and Drehmann.[12] They explain the merits and demerits of different methods that could potentially be used or are already used in practice as indicators for risk to macroeconomic stability. They find, that taken into account all the pros and cons, the „early warning system approach" is probably the best method currently available for the task. It is forward looking enough to be useful, given the transmission lag of monetary policy. It is compatible with the view of endogenous processes, in other words interactions, leading to macroeconomic booms and busts if the indicators are selected appropriately. It is a sufficiently simple system, and is amenable to communication as policy makers could „tell stories" with it.[13]

4.1 THE SIGNALLING APPROACH

The EWS method is based on the signalling approach, proposed by Kaminsky et al. (1998) as well as Kaminsky and Reinhart (1999). Since then the method has been frequently used to predict episodes of macroeconomic imbalances, for example, in Borio and Lowe (2002a), (2002b), (2004) and Alessi and Detken (2009), as listed in the references section at the end of the paper. The essence of the signalling approach is simple: the „early warning" indicator or, system of indicators, issues a signal if it crosses a certain threshold and an „event" occurs if the dependent variable also exceeds a given threshold value. Accordingly, signals and events can be classified into four groups (see Table 3):

Table 3
The signalling approach

		Event	
		Event	No Event
Indicator	Signal issued	**A**	**B**
	No signal issued	**C**	**D**

- *A*: indicator issues a correct signal (true positive)
- *B*: indicator issues a false signal (false positive)
- *C*: indicator fails to issue a signal (false negative)
- *D*: indicator correctly does not issue a signal (true negative)

Based on the above, false negative rate „type I error" and false positive rate „type II errors") can be defined as:

- False negative rate (FNR): number of missed events as a percentage of all events ($C/(A + C)$)
- False positive rate (FPR): ratio of false signals („noise", „false alarm") to all periods in which no event occurs ($B/(B + D)$)

It is easy to see that if the threshold chosen for the indicator is low, then there will be many signals, and, consequently, the false positive rate will increase; conversely, if the set threshold is high, then the indicator will fail to provide a signal in many

[12] Borio and Drehmann (2009), section titled „A taxonomy", pp. 11-24.
[13] On the merits and demerits of other methods see Borio and Drehmann (2009), section titled „A taxonomy", pp. 11-24.

instances, thereby increasing the false negative rate. In other words, the two types of error can be corrected to the detriment of each other, and therefore we use the adjusted noise-to-signal ratio (*aNtS*)[14] introduced by Kaminsky et al. (1998) to select the optimal threshold level:

$$aNtS = \frac{\frac{B}{B+D}}{1-\frac{C}{A+C}} = \frac{\frac{B}{B+D}}{\frac{A}{A+C}}$$

The minimum condition for an indicator to be useful that it has an *aNtS* of at least less than 1; and it is a particularly good indicator if its value is less than 0.3, according to Kaminsky and Reinhart (1999) results. Furthermore, we also examined the percentage of events that an indicator is able to predict, which, ideally, is as high as possible:

$$PRED = \frac{A}{A+C}$$

As a further point of reference, we also calculated the values for a standard loss function and in the EWS literature e. g. Alessi and Detken (2009). The loss function is stated as the weighted sum of false negative signal frequency (type I error) and false positive signal frequency (type II error):

$$L(\theta) = \theta FNR + (1-\theta)FPR$$

$$L(\theta) = \theta\frac{C}{A+C} + (1-\theta)\frac{B}{B+D}$$

In this formulation the $\theta \in [0,1]$ is interpreted as the decision maker's preference between losses caused by false negative and false positive predictions. For any $\theta \in [0,1]$, $L(\theta)$ gives the expected loss a decision maker would incur if θ were the (relative) cost of a missed event, $1-\theta$ were the (relative) cost of a false alarm, while the cost of correct prediction were zero, and the unconditional probability of events and non-events were both equal to 1/2[15].

Using the above definitions, Alessi and Detken (2009) further define the usefulness of indicator as:

$$U(\theta) = min[\theta,(1-\theta)] - L(\theta)$$

An indicator is useful if the value of the utility function is greater than zero; and if $\theta = 0.5$, then its optimal value is 0.5.[16] In words, we subtract the loss generated by our model from the loss when the model is ignored. A positive value means positive usefulness, an improvement over not using the model at all.

It is to be noted that it is only worthwhile to calculate an early warning indicator if the probability of the costlier outcome is lower than the probability of the less costly outcome. Otherwise, it would be optimal for the decision maker to always expect the more frequent outcome and disregard the early warning indicator[17].

[14] Type II error divided by one minus Type I error.

[15] As it was pointed out to us by Robert Lieli, this interpretation implicitly assumes that the two realisations have equal probability. However, if $Prob(event) \neq 1/2$, the interpretation of θ is more complex, see the definition of $L_1(\theta_1)$ below. We thank for Robert Lieli to draw our attention to this, and helping us reinterpret our results in this light.

[16] For the sake of illustration let us suppose equal probabilities for the outcomes and equal weight of preferences. Then the decision maker is always able to realise $min(\theta, 1-\theta)$ by ignoring the indicator. When $\theta < 0.5$, it is equivalent to the case of never having a signal. In this case the loss equals θ. In case of $\theta > 0.5$, ignoring the signal is equivalent to always having signal. In this case the loss equals $1-\theta$. An indicator is useful when it secures smaller than $min(\theta, 1-\theta)$ loss, at a given θ. See Alessi and Detken (2009) and Knedlik and von Schweinitz (2011).

[17] Sarlin 2013, p. 8.

A final indicator can be defined, following Sarlin (2013) as „relative utility”:

$$U_r(\theta) = \frac{U(\theta)}{min[\theta, (1-\theta)]}$$

It shows the usefulness of our imperfect model for the decision maker, compared to a perfect model (i.e. where, the loss, $L(\theta) = 0$) in percents.

In the literature, θ is frequently interpreted as the decision maker's relative (dis)preference regarding the false negative and false positive outcomes. However, recent development in the loss function literature[18] emphasizes the importance of the unequal outcome probabilities. If we suppose, for example, that events are more rare outcomes than non-events, as they are in most of the cases in practice, we have to use the relative probabilities of realisations as weights in the loss function, along with the relative preferences.[19] The simplest way to do this is to use the sample frequencies as proxies for expected future relative probabilities for event and non-event outcomes (Sarlin, 2013). If P stands for the frequency of events in the sample, P can calculated as follows:

$$P = \frac{A+C}{A+B+C+D}$$

If we take into account explicitly the unequal probabilities of outcomes, we can generalise the interpretation of the loss function as follows: let $\theta_1 \in [0,1]$ be the (relative) cost of a missed event,$(1-\theta_1)$ the relative cost of a false alarm, let the cost of correct prediction be zero, and let the unconditional probability of events be P. Then the expected loss of a decision maker missing the EWS is given by:

$$\begin{aligned} L_1(\theta_1) &= P\theta_1\frac{C}{A+C} + (1-P)(1-\theta_1)\frac{B}{B+D} \\ &= [P\theta_1 + (1-P)(1-\theta_1)] \times L\left(\frac{P\theta_1}{P\theta_1 + (1-P)(1-\theta_1)}\right) \end{aligned}$$

With the subscript we indicate that θ_1 is the „genuine” or „unbundled” preference parameter, different form θ used in the loss function in the beginning of this section, where it is a combined parameter of relative preferences and probabilities, „bundled” together.[20]

In these relationships, θ_1 represents the decision maker's „genuine” preference between losses caused by false negative and false positive predictions. If we suppose the fact that the costs related to an event (e.g. a crisis) are generally higher than the costs of introducing preventive measures, then the value of θ_1 should be relatively higher than $1-\theta_1$. Following the standard literature, first we set the value of the θ parameters at 0.5 in our baseline calculations. However, we will show our results using other values of relative preferences as well. It can be seen, that the genuine (dis)preference, θ_1 is above 0.8 in most cases.

Next, in Section 5 of the paper we look for the threshold values of the indicators using the *aNtS* and *PRED* as well as $U(\theta)$ measures, which would help predict macroeconomic imbalances the most effectively. In addition, we will also show by way of illustration how some of our results would be affected by taking into account the expected relative frequencies of event and non-event realisations.

[18] As Sarlin (2013). We thank for Róbert Lieli for drawing our attention to the latest developments of the loss function literature.

[19] A low chance for event realisation for example alters the loss function: it will cost less for the decision maker to ignore the model, as events, and losses will occur more rarely. E. g. before the crisis, it seemed very unlikely for advanced economies to experience significant crisis events, thus, ignoring financial imbalances seemed costless. After the crisis, this is likely to change. See Alessi and Detken (2009) and Sarlin (2013).

[20] The link between the two θ-s is the following: $\theta_1 = \frac{\theta(1-P)}{\theta(1-P)+P(1-\theta)}$, which simplifies to $\theta_1 = (1-P)$, for $P = 0.5$. In Appendix B we show some examples of for various θ and θ_1, using the above formula and sample frequencies.

5 Results

In this section, by using the EWS signalling method we examine the extent to which the indicators examined are capable of predicting the significant negative deviation of GDP from trend (henceforth: „event”) and the build-up of imbalances. As it has been explained above, in the following we will search for indicators and optimal threshold values that help us identify accumulating imbalances with the greatest efficiency at various time horizons (1, 2 and 3 years). We will compare our results to those arrived at by Borio and Lowe (2002a) and (2002b).[21] [22] In the following, we will also examine the extent to which the results can be improved by using different combinations of indicators.

5.1 PERFORMANCE OF INDIVIDUAL INDICATORS

Of their indicators, Borio and Lowe (2002a) and (2002b) found the credit-to-GDP ratio to be the best, in the sense that it had the lowest aNtS, while it was capable of predicting a high number of events. In particular, they found that the threshold value of 4 percentage points produced the best results for both the 22 developed and 13 financially developed emerging market economies (henceforth BL-35) at the one-year horizon, as the authors were able to predict some 80 per cent of the events at a one-year horizon, while the proportion of false positive signals was only 18 per cent. In addition, they came to the conclusion that the credit-to-GDP gap performed better compared to the credit growth indicator, i.e. it was more useful to focus on cumulative processes. Furthermore, the asset price gap and the investment gap provided relatively noisy signals; and the performance of the indicators improved with the lengthening of the time horizon.

Of the indicators proposed by Borio and Lowe (2002a) and (2002b), the credit-to-GDP gap also proved best for the countries featuring in our analysis (see Table 4), and the predictive power of the indicator improved with the lengthening of the time horizon. It should be noted, however, that that indicators performed significantly worse than for the BL-35: for example, above the threshold value of 4 percentage points a large credit gap preceded 79 per cent of the events at the two-year horizon in BL-35 countries, while only 21 per cent of the events in Central and Eastern European emerging countries. The result improves somewhat at the three-year horizon, with the indicator predicting 38 per cent of the events compared to 79 per cent in the case of BL-35 countries.

Consistent with Borio and Lowe (2002a) and (2002b), the credit growth gap proved to be a considerably worse indicator: for example, it failed to predict any event at the one-year horizon. In terms of the ability of the indicators to predict the events, the investment gap came closest to the results of Borio and Lowe (2002a) and (2002b): the indicator predicted 40–45 per cent of events at the two-year horizon and 61–67 per cent at the three-year horizon, albeit with a relatively high aNtS ratio.

Table 5 shows the results based on the indicators used in our analysis. It presents the values of *aNtS* ratios, the ratio of the predicted events and the value of the classical utility function with $\theta = 0.5$. It has to be kept in mind that in this case the $\theta = 0.5$ does not mean that the decision maker has the same preferences related to false negative and false positive predictions as $P \neq 0.5$, implied by θ_1.

The 4 percentage point threshold value for the real exchange rate gap seems promising: deterioration in competitiveness precedes 38–40 per cent of events with a very good *aNtS* ratio of below 0.3 at the 1–2 year time horizon. The capital flow

[21] Remember that the results are not directly comparable, because in our case the dependent variable is the output gap, instead of banking crisis as in Borio and Lowe (2002a) and (2002b). Note that Borio and Lowe (2004) did not present results of EWS for the output gap for the emerging countries, only probit estimations. See Borio and Lowe (2004).

[22] We applied the same methodology in Csortos and Szalai (2013) on Scoreboard indicators used by the European Commission's in its Macroeconomic Imbalance Procedure.

Table 4
Individual Indicators suggested by Borio and Lowe (2002a) and (2002b)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
Credit/GDP gap												
	Results		B-L (2002)		Results		B-L (2002)		Results		B-L (2002)	
	aNtS	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*
3	1.16	19	0.29	79	0.48	43	0.27	79	0.27	62	0.25	79
4	1.98	6	0.24	79	0.54	21	0.21	79	0.21	38	0.20	79
5	1.36	6	0.24	63	0.34	21	0.20	71	0.20	31	0.17	74
6	0.99	6	0.25	55	0.40	14	0.19	63	0.11	31	0.16	66
7	0.62	6	0.20	55	0.23	14	0.15	63	0.08	23	0.13	63
Credit growth gap												
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
	Results		B-L (2002)		Results		B-L (2002)		Results		B-L (2002)	
	aNtS	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*
7	inf	0	0.54	74	0.64	18	0.43	87	0.26	38	0.39	89
8	inf	0	0.47	74	0.55	18	0.38	84	0.21	38	0.35	87
9	inf	0	0.44	68	0.41	18	0.36	79	0.14	38	0.31	84
10	inf	0	0.39	68	0.28	18	0.31	79	0.11	31	0.27	84
11	inf	0	0.36	66	0.28	18	0.29	74	0.11	31	0.24	82
Investment gap												
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
	Results		B-L (2002)		Results		B-L (2002)		Results		B-L (2002)	
	aNtS	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*
2	1.18	33	0.57	58	0.90	45	0.43	71	0.61	67	0.37	79
3	1.46	24	0.54	55	0.76	45	0.42	66	0.51	67	0.36	74
4	1.14	24	0.5	50	0.67	40	0.42	55	0.43	61	0.40	55
5	1.00	24	0.52	42	0.58	40	0.43	47	0.37	61	0.41	47
6	1.11	19	0.61	32	0.49	40	0.42	42	0.30	61	0.37	45

gap performs very well at the three-year horizon: at a threshold value of 4 percentage points, the *aNtS* is only 0.12, while it is able to predict 63 per cent of events; and considering all indicators, the value of the utility function is highest here. Finally, the gap of the global variable performs best in the short run. At one-year horizon, it functions with a relatively high *aNtS* ratio (0.5–0.54)and it predicts almost all of the events (89–95 per cent). We calculated the utilities for the selected variables and our results are in accordance with the *aNtS* ratios in this case, too. The highest values of utilities (its maximum would be 0.5 when the $\theta = 0.5$) are at the one year horizon for the global variable gap; at the two years horizon for the real exchange rate gap, and at the three years horizon for the capital flow gap.

For these variables we calculated not only the classical utility function, but also the utility function weighted by relative expected frequencies and the relative utilities along the absolute preferences, as recommended by Sarlin (2013). The results provided by utilities weighted by relative frequencies and relative utilities in the most cases are in line with the results presented in Table 5. For example, in the case of real exchange rate gap the $U_1(\theta_1)$ and the $U_r(\theta_1)$ have the highest value at 4 percentage threshold value and at $\theta_1 = 0.75$. On the other hand the weighted utilities in most of the cases are quite near to zero and we have the most favourable values when the $\theta_1 = 0.75$. It is not a surprising result as only the 10-13 per cent of the all observations can be regarded as an event, therefore for the decision maker it would be relatively costly to react to a false alarm. You can see the detailed results in Appendix B (Table 10-12.).

Table 5
The performance of further selected indicators

Real Exchange Rate gap												
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$	
2	0.44	52	0.15		0.39	60	0.18		0.52	47	0.11	
4	0.16	38	0.16		0.16	40	0.17		0.32	26	0.09	
6	0.14	19	0.08		0.24	15	0.06		0.44	11	0.03	
8	0.14	5	0.02		0.14	5	0.02		0.15	5	0.02	
10	0.00	5	0.02		0.00	5	0.03		0.00	5	0.03	

Capital Flow gap												
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$	
2	0.82	31	0.03		0.56	44	0.10		0.30	75	0.26	
4	0.62	19	0.04		0.27	38	0.14		0.12	63	0.28	
6	0.53	13	0.03		0.15	31	0.13		0.05	50	0.24	
8	0.29	13	0.04		0.05	31	0.15		0.00	44	0.22	
10	0.58	6	0.01		0.06	25	0.12		0.00	38	0.19	

Global Variable gap												
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$	
1	0.54	95	0.22		0.66	80	0.14		0.82	63	0.06	
2	0.50	89	0.22		0.90	55	0.03		0.78	58	0.06	
3	1.00	32	0.00		1.29	25	<0		0.89	37	0.02	
4	0.88	21	0.01		2.00	10	<0		4.21	5	<0	
5	1.22	11	<0		2.71	5	<0		2.76	5	<0	

This table shows the results provided by the indicators featuring in our analysis and it presents the values of aNtS ratios, the ratio of the predicted events and the value of the classical utility function with $\theta = 0.5$.

Consider the global variable gap at one year horizon – where we have very similar results to Alessi and Detken (2009). At the threshold value of 2 the global variable gap was able to predict 89 per cent of events, i.e. costly macroeconomic busts at one year horizon. To these conditions we have a quite favourable utility (0.22) which means that this indicator reduces the loss by 22 percentage points compared to a situation in which the decision maker would ignore the indicator.

5.2 THE COMBINATION OF INDICATORS

As a next step, we look weather the above results can be improved by combining the various indicators. The credit growth gap and the investment gap are left out from the combinations, because taken individually, they perform very poorly. One can see in Table 5 that the global variable yields the best results at the one-year horizon, the real exchange rate gap at the two-year horizon and the capital flow gap at the three-year horizon. Accordingly, we examine the indicator combinations shown in Table 6.

Table 6
The combination of indicators

Variable combination	Threshold values	Most relevant time horizon
Global variable gap AND	**1:5**	**1 year**
OR REER gap	4 (3)	
OR Capital Flow gap	4 (3)	
OR Credit/GDP gap	3 (2)	
REER gap AND	**1:5**	**2 year**
OR Capital Flow gap	4 (3)	
OR Global variable gap	4 (3)	
OR Credit/GDP gap	3 (2)	
Capital Flow gap AND	**1:5**	**3 year**
OR REER gap	4 (3)	
OR Global variable gap	4 (3)	
OR Credit/GDP gap	3 (2)	

Using the combinations in the Table 6, we examine how the indicators used in our analysis perform at various time horizons if one of the best performing indicators and *one of the other three issue a signal*. We test several threshold values of the first indicator, and choose one of the optional indicators that appear to be the best based on the individual results or rather a 1 percentage point lower value (see in Table 6 the numbers in brackets) in order to reduce the probability of the problem that the number of signals would be insufficient.

In terms of the time horizon, the results produced by the model combinations were consistent with our expectations (see Table 7). For example, if at the one-year horizon the global variable and one of the other three indicators issued a signal, then we succeeded in reducing the noise-to-signal ratio significantly compared to the individual results of the global variable, while the number of predicted events did not fall considerably. At the two-year horizon, the real exchange rate improved only slightly, while at the three-year horizon the capital flow combination provided the best result: with an only 0.26 *aNtS* ratio, 92 per cent of events were predicted, so the value of the utility function proposed by Alessi and Detken (2009) was the most favourable in this set-up.

Table 7
The performance of selected indicator combinations

Global variable gap AND

REER gap (threshold =3) OR Capital flow gap (threshold =3) OR Credit/GDP gap (threshold =2)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	0.35	93	0.22		0.37	93	0.20		0.66	54	0.06
2	0.30	93	0.24		0.46	71	0.14		0.56	54	0.08
3	0.68	21	0.03		0.50	29	0.05		0.73	23	0.02
4	0.61	14	0.02		0.64	14	0.02		1.45	8	<0
5	0.81	7	0.00		0.86	7	0.00		0.87	8	0.00

REER gap AND

Capital flow gap (threshold =3) OR Global variable gap (threshold =3) OR Credit/GDP gap (threshold =2)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	0.54	57	0.12		0.42	79	0.19		0.47	77	0.16
2	0.44	50	0.12		0.37	64	0.17		0.38	69	0.16
3	0.39	36	0.09		0.29	50	0.15		0.46	38	0.08
4	0.19	36	0.13		0.16	43	0.15		0.23	38	0.11
5	0.18	29	0.10		0.13	36	0.13		0.22	31	0.09

Capital flow gap AND

REER gap (threshold =3) OR Global variable gap (threshold =3) OR Credit/GDP gap (threshold =2)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	0.75	36	0.04		0.63	43	0.07		0.26	92	0.28
2	0.56	36	0.07		0.47	43	0.10		0.21	85	0.27
3	0.50	29	0.06		0.32	43	0.13		0.15	77	0.27
4	0.55	21	0.04		0.30	36	0.11		0.12	69	0.27
5	0.43	21	0.05		0.23	36	0.12		0.08	69	0.25

This table shows the results provided by the indicators featuring in our analysis and it presents the values of aNtS ratios, the ratio of the predicted events and the value of the classical utility function with $\theta = 0.5$.

As in the previous subsection, we calculated not only the classical usefulness (see Table 7 with $\theta = 0.5$), but the usefulness weighted by relative expected frequencies and the relative usefulness for the indicator combinations. You can find these results and calculations with different θ values in the Appendix B[23]. As you can see in the Table 8 the value of the utility function is the highest at the indicator combinations and threshold values where the *aNtS* is low and the ratio of predicted events is relatively

[23] Here we present the results of the indicator combinations only for the best time horizons.

high. Furthermore the combinations of the selected indicators could improve the values of the weighted usefulness and the relative utility, too. In more cases we got positive values for the weighted and so for the relative usefulness (mostly when we set the value of the θ' to 0.75). See Appendix B Tables 10-13.

5.3 LESSONS LEARNT FROM THE RESULTS

The results shown in Table 6 proved better than the indicator combination considered by Borio and Lowe (2002a) and (2002b) to be the best: this is the combination of the credit gap (threshold = 4 %) and the asset price gap (threshold = 40%) – in this set-up the *aNtS* ratio fell to 0.06 at the three-year horizon; however, this came at the expense of a decline in the ratio of predicted events from 79 per cent to 55 per cent. This reflected a significant fall in the number of false positive signals (leading to a decline in the *aNtS*). However, because of the „AND" relationship requirement, the number of signals also could fall sharply, and so the number of false negative signals could increase (and thus decline in the number of events predicted).

Our method was largely successful in eliminating this problem. As we have seen in the case of the stylised facts, we cannot tell which two indicators' co-movement will lead to events; however, it could be seen that if two variables issue a signal (or behave more unfavourably than the average), this will result in significantly below-trend GDP with a high probability. This was also confirmed by the results of the signalling approach. With the use of the „AND-OR-OR" relationship, we managed to reduce the noise-to-signal ratio, while the number of predicted events increased in several cases, rather than falling. This may be explained by the fact that the „AND" relationship is strict enough to reduce the noise, while the „OR" relationship makes it possible to avoid a significant fall in the number of signals, and so more events can be predicted with less noise. Furthermore, our results reduce uncertainty about the time of occurrence of events, although only slightly.

The above results proved to be robust to the choice of the threshold of the GDP cycle, as, after we performed the above calculations (for both the individual indicators and the indicator combinations), our main conclusions did not change (see Table 14, 15 and 16 in the Appendix C). The new threshold for GDP is country-specific; for each country we considered a more negative cyclical component than the first quartile as an „event". In this case the indicators tested deteriorated. The indicators used predicted fewer events and functioned with a higher noise-to-signal ratio. However, our main conclusions did not change: of the indicators also used by Borio and Lowe (2002a) and (2002b), the credit-to-GDP gap proved to be the best at the three-year horizon, while of the indicators that we introduced, the global variable gap performed best at the one-year horizon, the real exchange rate gap at the two-year horizon and the capital flow gap at the three-year horizon. In terms of the combinations, our conclusions only changed to the extent that the combination pertaining to the global variation proved to be the best at the two-year horizon.

It is important to note that this method reduces false negative rate (missed events/total number of events) and false positive rate (false signals/total no-event period) errors significantly. However, an important error is ignored in calculating the *aNtS* ratio, namely, the ratio of false signals to the total number of signals. This ratio is very high both at individual analysis and at the combination of indicators (see Table 8). But it is good news that this indicator also could improve relative to the results arrived at during the individual analyses.

Table 8
The value of different type of errors

	Global var. (2) AND ...	REER gap (2) AND ...	CF gap (1) AND ...
Horizon (year)	1	2	3
ants	0.30	0.37	0.26
PRED	93	64	92
False negative rate	0.32	0.35	0.25
False positive rate	0.21	0.27	0.20
False signal/Total signals	0.69	0.76	0.66

To summarise, at different time horizons the appropriate combination of the tested indicators is able to significantly improve the examined indicators: the value of both false negative and false positive rates falls and so does the *aNtS* ratio, while the number of predicted events increases. As a result, monitoring the indicators may help draw the attention of monetary as well as macroprudential policy decision makers to the imbalances building up; however, they must be careful, as the ratio of false signals to the total number of signals could not be reduced to a satisfactory level.

6 Monetary policy implications

One lesson of the crisis is that the analytical frameworks used by central banks do not contain all the important indicators informative about macroeconomic stability. Our results could improve the operation of monetary policy by complementing it with additional indicators that can provide information about the build-up of imbalances in the economy. Central banks make the inflation forecast roughly in the same way as before the crisis with the existing framework. What would be different is consideration of a few additional indicators – called imbalance indicators – not necessarily included in the forecasting framework. If those indicators do not signal risks to macroeconomic stability, then everything goes the same way as before. However, when one or more signals show risks to macroeconomic stability, then the decision making procedure would be slightly different.[24]

A signal would not prompt immediate and mechanical action, rather, because these indicators show only the balance of risks, but not certainties, they would prompt in-depth further analyses of what could be the cause of the imbalances. Only the result of this in-depth analysis would complement the decision making, including recommendations based on both the inflation forecast and the in-depth analysis of the balance of risks. Thus, the decision maker would be informed of the probabilities of type I and type II risks, and - based on their preferences - could make a more informed decision.

However, a closer look reveals that this type of dilemma is not so much different from the dilemmas associated with the present framework, because both inflation targeting (or more broadly, macroeconomic stability), and financial stability goals involve more or less forward looking approaches by which the central bank tries to prevent realising various risks: risks to price stability or financial stability well in advance.

Csermely and Szalai (2010) among others, proposed to develop and use imbalance indicators as additional considerations[25] for the decision makers using existing inflation targeting frameworks. There are other tools with similar goals. For example there are macroprudential tools aimed at detecting vulnerabilities of the financial sector as a whole (hence the name „macro prudential"). These typically do not directly assess the risk of of a large negative GDP gap, rather, they look at developments which could result in a banking or a financial crisis. This group of tools, typically use VARs, regime switching VARs, stress-tests etc. In these estimations, the dependent variable is not the GDP or output gap, but some other variables. However, these methods are either not comprehensive enough (i. e. look at only a particular segment of the economy) or not forward looking enough, to be useful for decision makers, whose goal is to maintain macroeconomic (price and income) stability on a monetary policy relevant time horizon.

[24] See for example Disyatat (2005), Borio and Drehman (2009).

[25] See Disyatat (2005).

7 Conclusions

In this paper we apply the Early Warning System methodology to 10 Central and Eastern European Countries (CEE-10) to find useful sets of indicators capable of predicting macroeconomic and financial imbalances. We argue that finding useful indicators is crucial in the current monetary policy framework because significant imbalances could build up without any sign of risk to price stability. Firstly, we examined what cyclical position is characteristic for a number of important macro variables during periods of the largest decline in GDP. The stylized facts reveal that the largest downturns are preceded by not only a credit boom, but also a boom in investment and capital flows. Furthermore, while the real effective exchange rate increased significantly, and there was a slight positive deviation in our global variable from its trend.

In the light of these stylised facts we applied and adapted the Early Warning System methodology used by Kaminsky et al. (1998) and Borio and Lowe (2004) to the CEE-10. Accordingly, we searched for indicators and optimal threshold values of the indicators that help identify accumulating imbalances with the greatest efficiency at various time horizons (1, 2 and 3 years). The performance of the indicator set was assessed by different statistics based mainly on the ratio of false negative and false positive signals. We also calculated statistics involving the decision maker's hypothetical preferences with regard to two types of errors (failing to prevent an imbalance episode versus reacting to „noise", instead of „signal"). In addition, we took into account the unconditional frequency of the events.

In a univariate setting, the gap of the global variable, the real exchange rate gap and the capital flow gap yielded the best results at different time horizons. We also examined how different combinations of the indicators perform at various time horizons if one of the best performing indicators and one of the other three issue a signal. In these kinds of combinations, the performance of the indicators improved significantly. In general, some combination of the global variable gap, the real effective exchange rate gap, the capital flow gap and the credit to GDP gap constitute the best signalling system. This is in line with the stylised facts, i. e. if at least two variables issue a signal (or behave more unfavourably than the average), then using this combination, we can assume that below-trend GDP will result with a high probability.

Our main innovation was the application of the 'AND-OR-OR' relationship. By the help of them we were able to reduce the noise-to-signal ratio, while the number of predicted events increased in several cases, rather than falling. Nonetheless, the above results can not be used mechanically, because the ratio of wrong signals is still quite high. Despite this drawback, we believe that the above indicators could usefully complement the existing analytical tools available to modern central banks.

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Appendix A Data availability

Table 9
Data availability for individual countries and time periods

	Credit/GDP	Credit growth	Investment	Real eff. Exchange Rate	Capital flows	Global variable
Bulgaria	2000-2010	1994-2011	1995-2011	1994-2011	2002-2011	1994-2009
Czech R.	1995-2010	1995-2010	1995-2011	1994-2011	1993-2011	1994-2009
Estonia	1994-2010	1995-2010	1993-2011	1994-2011	1993-2011	1994-2009
Latvia	1998-2010	1998-2010	1995-2011	1994-2011	1996-2011	1994-2009
Lithuania	1995-2010	1995-2010	1995-2011	1994-2011	1993-2011	1994-2009
Hungary	1991-2010	1991-2010	1995-2011	1994-2011	1993-2011	1994-2009
Poland	1995-2010	1995-2010	1995-2011	1994-2011	2000-2011	1994-2009
Romania	1998-2010	1998-2010	1996-2011	1994-2011	1996-2011	1994-2009
Slovenia	2001-2010	2002-2011	1991-2011	1994-2011	1994-2011	1994-2009
Slovakia	1995-2010	1995-2010	1992-2011	1994-2011	1994-2011	1994-2009

Appendix B Loss, usefulness and relative usefulness with different theta values

Table 10
Values of different types of utilities for Real Exchange Rate gap

Real Exchange Rate gap, Horizon: 1 year											
	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95
2	0.29	0.35	0.41		-0.04	0.15	-0.16		-0.17	0.29	-0.66
4	0.20	0.34	0.48		0.05	0.16	-0.23		0.20	0.32	-0.92
6	0.22	0.42	0.61		0.03	0.08	-0.36		0.11	0.16	-1.46
8	0.24	0.48	0.72		0.01	0.02	-0.47		0.03	0.04	-1.86
10	0.24	0.48	0.71		0.01	0.02	-0.46		0.05	0.05	-1.86

Real Exchange Rate gap, Horizon: 2 years											
	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95
2	0.28	0.32	0.36		-0.03	0.18	-0.11		-0.11	0.36	-0.44
4	0.20	0.33	0.47		0.05	0.17	-0.22		0.21	0.34	-0.86
6	0.24	0.44	0.65		0.01	0.06	-0.40		0.04	0.11	-1.59
8	0.24	0.48	0.71		0.01	0.02	-0.46		0.03	0.04	-1.86
10	0.24	0.48	0.71		0.01	0.03	-0.46		0.05	0.05	-1.86

Real Exchange Rate gap, Horizon: 3 years											
	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95
2	0.31	0.39	0.46		-0.06	0.11	-0.21		-0.26	0.23	-0.82
4	0.25	0.41	0.57		0.00	0.09	-0.32		0.01	0.18	-1.29
6	0.26	0.47	0.68		-0.01	0.03	-0.43		-0.03	0.06	-1.73
8	0.24	0.48	0.71		0.01	0.02	-0.46		0.03	0.04	-1.85
10	0.24	0.47	0.71		0.01	0.03	-0.46		0.05	0.05	-1.84

θ_1 values are calculated using the formula in footnote 22.

Table 11
Values of different types of utilities for Capital inflow

Capital inflow gap

Horizon: 1 year

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.74	$\theta =$ 0.50 $\theta_1 =$ 0.90	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.74	$\theta =$ 0.50 $\theta_1 =$ 0.90	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.74	$\theta =$ 0.50 $\theta_1 =$ 0.90	$\theta =$ 0.75 $\theta_1 =$ 0.96
2	0.36	0.47	0.58		-0.11	0.03	-0.33		-0.45	0.06	-1.32
4	0.29	0.46	0.64		-0.04	0.04	-0.39		-0.16	0.07	-1.5
6	0.27	0.47	0.67		-0.02	0.03	-0.42		-0.07	0.06	-1.69
8	0.25	0.46	0.67		0.00	0.04	-0.42		0.02	0.09	-1.66
10	0.26	0.49	0.71		-0.01	0.01	-0.46		-0.05	0.03	-1.85

Capital inflow gap

Horizon: 2 years

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.73	$\theta =$ 0.50 $\theta_1 =$ 0.89	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.73	$\theta =$ 0.50 $\theta_1 =$ 0.89	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.73	$\theta =$ 0.50 $\theta_1 =$ 0.89	$\theta =$ 0.75 $\theta_1 =$ 0.96
2	0.33	0.40	0.48		-0.08	0.10	-0.23		-0.30	0.19	-0.93
4	0.23	0.36	0.49		0.02	0.14	-0.24		0.08	0.28	-0.98
6	0.21	0.37	0.53		0.04	0.13	-0.28		0.17	0.27	-1.11
8	0.18	0.35	0.52		0.07	0.15	-0.27		0.27	0.30	-1.08
10	0.20	0.38	0.57		0.05	0.12	-0.32		0.20	0.23	-1.27

Capital inflow gap

Horizon: 3 years

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.72	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.72	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.72	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95
2	0.23	0.24	0.24		0.02	0.26	0.01		0.08	0.53	0.03
4	0.15	0.23	0.30		0.10	0.28	-0.05		0.40	0.55	-0.20
6	0.14	0.26	0.38		0.11	0.24	-0.13		0.43	0.48	-0.53
8	0.14	0.28	0.42		0.11	0.22	-0.17		0.44	0.44	-0.69
10	0.16	0.31	0.47		0.09	0.19	-0.22		0.38	0.38	-0.88

θ_1 values are calculated using the formula in footnote 22.

Table 12
Values of different types of utilities for Global variable

Global variable
Horizon: 1 year

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96
1	0.40	0.28	0.17		-0.15	0.22	0.08		-0.60	0.43	0.33
2	0.36	0.28	0.19		-0.11	0.22	0.06		-0.46	0.44	0.23
3	0.41	0.50	0.59		-0.16	0.00	-0.34		-0.63	0.00	-1.37
4	0.34	0.49	0.64		-0.09	0.01	-0.39		-0.35	0.02	-1.55
5	0.32	0.51	0.70		-0.07	-0.01	-0.45		-0.28	-0.02	-1.81

Global variable
Horizon: 2 years

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.95
1	0.45	0.36	0.28		-0.20	0.14	-0.03		-0.79	0.27	-0.13
2	0.48	0.47	0.46		-0.23	0.03	-0.21		-0.93	0.06	-0.84
3	0.43	0.54	0.64		-0.18	-0.04	-0.39		-0.71	-0.07	-1.57
4	0.38	0.55	0.73		-0.13	-0.05	-0.48		-0.50	-0.10	-1.90
5	0.34	0.54	0.75		-0.09	-0.04	-0.50		-0.36	-0.09	-1.99

Global variable
Horizon: 3 years

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.87	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.87	$\theta =$ 0.75 $\theta_1 =$ 0.95		$\theta =$ 0.25 $\theta_1 =$ 0.70	$\theta =$ 0.50 $\theta_1 =$ 0.87	$\theta =$ 0.75 $\theta_1 =$ 0.95
1	0.48	0.44	0.41		-0.23	0.06	-0.16		-0.93	0.11	-0.62
2	0.44	0.44	0.43		-0.19	0.06	-0.18		-0.77	0.13	-0.71
3	0.40	0.48	0.56		-0.15	0.02	-0.31		-0.62	0.04	-1.22
4	0.40	0.58	0.77		-0.15	-0.08	-0.52		-0.61	-0.17	-2.06
5	0.35	0.55	0.75		-0.10	-0.05	-0.50		-0.38	-0.09	-1.99

θ_1 values are calculated using the formula in footnote 22.

Table 13
Values of different types of utilities for selected indicator combinations I.

Global variable gap AND
REER gap (threshold =3) OR Capital flow gap (threshold =3) OR Credit/GDP gap (threshold =2)
Horizon: 1 year

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96
1	0.26	0.28	0.30		-0.01	0.22	-0.05		-0.04	0.44	-0.19
2	0.23	0.26	0.29		0.02	0.24	-0.04		0.06	0.48	-0.15
3	0.29	0.47	0.66		-0.04	0.03	-0.41		-0.16	0.05	-1.63
4	0.27	0.48	0.69		-0.02	0.02	-0.44		-0.09	0.04	-1.75
5	0.27	0.50	0.72		-0.02	0.00	-0.47		-0.08	0.01	-1.88

REER gap AND
Capital flow gap (threshold =3) OR Global variable gap (threshold =3) OR Credit/GDP gap (threshold =2)
Horizon: 2 years

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.72	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.72	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.72	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96
1	0.29	0.31	0.33		-0.04	0.19	-0.08		-0.16	0.38	-0.33
2	0.26	0.33	0.40		-0.01	0.17	-0.15		-0.05	0.34	-0.61
3	0.24	0.35	0.47		0.01	0.15	-0.22		0.06	0.29	-0.88
4	0.20	0.35	0.50		0.05	0.15	-0.25		0.19	0.30	-1.00
5	0.21	0.37	0.54		0.04	0.13	-0.29		0.18	0.25	-1.16

Capital flow gap AND
REER gap (threshold =3) OR Global variable gap (threshold =3) OR Credit/GDP gap (threshold =2)
Horizon: 3 years

	Loss ($L(\theta)$)				Utility ($U(\theta)$)				Relative Utility ($U_r(\theta)$)		
Thres-hold	$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96		$\theta =$ 0.25 $\theta_1 =$ 0.71	$\theta =$ 0.50 $\theta_1 =$ 0.88	$\theta =$ 0.75 $\theta_1 =$ 0.96
1	0.21	0.22	0.24		0.04	0.28	0.01		0.16	0.55	0.05
2	0.19	0.23	0.27		0.06	0.27	-0.02		0.25	0.54	-0.08
3	0.16	0.23	0.30		0.09	0.27	-0.05		0.34	0.53	-0.22
4	0.16	0.25	0.35		0.09	0.25	-0.10		0.36	0.49	-0.38
5	0.14	0.24	0.34		0.11	0.26	-0.09		-0.43	0.52	-0.36

Appendix C Robustness check

Table 14
Individual Indicators suggested by Borio and Lowe (2002a) and (2002b)

Credit/GDP gap

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
	Results		B-L (2002)		Results		B-L (2002)		Results		B-L (2002)	
	aNtS	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*
3	0.93	21	0.29	79	0.69	28	0.27	79	0.35	41	0.25	79
4	0.65	15	0.24	79	0.52	19	0.21	79	0.21	28	0.2	79
5	0.54	12	0.25	63	0.28	19	0.20	71	0.16	24	0.17	74
6	2.18	3	0.25	55	0.35	13	0.19	63	0.17	17	0.16	66
7	1.36	3	0.20	55	0.57	6	0.15	63	0.19	10	0.13	63

Credit growth gap

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
	Results		B-L (2002)		Results		B-L (2002)		Results		B-L (2002)	
	aNtS	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*
7	4.73	3	0.54	74	0.54	18	0.43	87	0.35	25	0.39	89
8	4.14	3	0.47	74	0.59	15	0.38	84	0.27	25	0.35	87
9	3.25	3	0.44	68	0.41	15	0.36	79	0.22	22	0.31	84
10	2.37	3	0.39	68	0.37	12	0.31	79	0.25	16	0.27	84
11	2.37	3	0.36	66	0.37	12	0.29	74	0.25	16	0.24	82

Investment gap

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years			
	Results		B-L (2002)		Results		B-L (2002)		Results		B-L (2002)	
	aNtS	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*	*aNtS*	*PRED*
2	2.08	21	0.57	58	1.07	39	0.43	71	0.65	61	0.37	79
3	2.44	16	0.54	55	0.98	36	0.42	66	0.52	61	0.36	74
4	2.34	13	0.5	50	0.91	31	0.42	55	0.47	52	0.40	55
5	2.05	13	0.52	42	0.78	31	0.43	47	0.39	52	0.41	47
6	1.75	13	0.61	32	0.64	31	0.42	42	0.38	45	0.37	45

Table 15
The performance of further selected indicators

Real Exchange Rate gap											
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
2	0.56	39	0.09		0.56	43	0.09		0.61	39	0.08
4	0.25	24	0.09		0.32	23	0.08		0.62	15	0.03
6	0.17	13	0.06		0.28	11	0.04		1.97	3	<0
8	0.28	3	0.01		0.28	3	0.01		inf	0	<0
10	0.00	3	0.01		0.00	3	0.01		inf	0	0.00
Capital Flow gap											
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
2	1.44	18	<0		0.69	35	0.06		0.33	60	0.20
4	0.95	12	0.00		0.37	26	0.08		0.17	40	0.17
6	0.68	9	0.02		0.22	19	0.08		0.16	23	0.10
8	0.64	6	0.01		0.11	16	0.07		0.05	20	0.10
10	1.27	2	0.00		0.13	13	0.06		0.00	20	0.10
Global Variable gap											
	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	0.63	77	0.15		0.65	77	0.13		0.74	67	0.09
2	0.56	74	0.17		0.79	60	0.06		0.71	61	0.09
3	0.86	34	0.02		0.89	34	0.02		0.66	45	0.08
4	0.75	23	0.03		0.65	26	0.04		1.41	15	<0
4	0.63	17	0.03		0.84	14	0.01		2.54	6	<0

This table shows the results provided by the indicators featuring in our analysis and it presents the values of aNtS ratios, the ratio of the predicted events and the value of the classical utility function with $\theta = 0.5$.

Table 16
The performance of selected indicator combinations

Global variable gap AND
REER gap (threshold =3) OR Capital flow gap (threshold =3) OR Credit/GDP gap (threshold =2)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	0.48	61	0.13		0.45	60	0.14		0.56	48	0.09
2	0.40	61	0.15		0.50	50	0.11		0.52	44	0.09
3	0.71	18	0.02		0.56	20	0.04		0.44	26	0.06
4	0.73	11	0.01		0.49	13	0.03		1.27	7	<0
5	0.68	7	0.01		0.70	7	0.01		1.69	4	<0

REER gap AND
Capital flow gap (threshold =3) OR Global variable gap (threshold =3) OR Credit/GDP gap (threshold =2)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	0.77	43	0.04		0.53	53	0.11		0.65	48	0.07
2	0.65	36	0.05		0.51	40	0.08		0.56	41	0.07
3	0.58	25	0.04		0.40	30	0.08		0.71	22	0.03
4	0.32	21	0.06		0.24	23	0.08		0.45	19	0.04
5	0.27	18	0.05		0.19	20	0.07		0.66	11	0.02

Capital flow gap AND
REER gap (threshold =3) OR Global variable gap (threshold =3) OR Credit/GDP gap (threshold =2)

	Horizon: 1 year				Horizon: 2 years				Horizon: 3 years		
Threshold	*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$		*aNtS*	*PRED*	$U(\theta)$
1	1.26	21	<0		0.63	37	0.06		0.27	67	0.23
2	0.93	21	0.01		0.50	33	0.08		0.21	59	0.22
3	0.79	18	0.02		0.45	27	0.07		0.21	44	0.16
4	0.80	14	0.01		0.40	23	0.07		0.15	41	0.16
5	0.61	14	0.03		0.28	23	0.08		0.11	37	0.15

This table shows the results provided by the indicators featuring in our analysis and it presents the values of aNtS ratios, the ratio of the predicted events and the value of the classical utility function with $\theta = 0.5$.

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