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This study examines the set of indicators of the early warning system used within the framework of the new Macroeconomic Imbalance Procedure introduced by the European Commission. The primary objective of the procedure is to call the attention of member countries to dangerous developments that may result in macroeconomic imbalances. First, our findings cast light on the fact that it is not expedient to use the same thresholds for all EU member countries and the newly joined countries. Second, we came to the conclusion that in many cases, the indicators used by the Commission do not in their own right prove to be good early warning indicators. However, if a narrower group of them is examined, there is considerable improvement in the forecasting ability of the set of indicators, although this group may be different from country to country. Our findings corroborate what the Commission itself also indicated: it is not expedient to apply the indicators mechanically, and deeper analysis is necessary in each case prior to launching an Excessive Imbalance Procedure.

PRESENTATION OF THE MACROECONOMIC IMBALANCE PROCEDURE

The financial crisis exposed several weaknesses in the governance of the European Monetary Union. In response, the European institutions created the so-called “six-pack” at the end of 2011. Prior to the crisis, economic governance mechanisms had primarily focused on monetary stability and fiscal sustainability, and determined institutionalised solutions accordingly (monetary policy, fiscal rules and related sanctions aiming at price stability). The crisis revealed that even if the above is achieved, serious macroeconomic imbalances may still emerge, which must be monitored, prevented or perhaps managed in an institutionalised framework. This is why the Macroeconomic Imbalance Procedure (MIP) directed by the European Commission was created. The MIP is a surveillance, preventive and corrective Early Warning System (EWS), which is designed to call attention to emerging macroeconomic imbalances. The procedure is a two-step one. First, the European Commission examines the indicators, which are described in detail below, for each member country every year, and prepares the Alert Mechanism Report, the most important objective of which is to call member countries’ attention to the risks that might result in macroeconomic imbalances. As a second

step, if serious risks are identified for some countries in the first report, an in-depth review is prepared for them. It contains a detailed analysis of the factors that have played a role in the emergence of these risks.

In the first step, the Commission examines 11 *scoreboard* indicators, which correspond to the most important vulnerability indicators identified in the literature (Table 1). It may be a sign of the build-up of macroeconomic imbalances if several of these indicators give signals, i.e. exceed a specific threshold. This threshold was defined on a purely statistical basis (at the lower or upper quartile of the variables under review), and according to the European Commission (2012a), it is consistent with the values found in the empirical literature. In addition, this is how they wanted to avoid excessive numbers of false alarms and too frequent failures to alert. At the same time, the indicators should never be applied mechanically; a deeper analysis and understanding of the underlying developments is always necessary. Furthermore, the Commission also emphasises that the set of indicators, the thresholds and the methodology must be treated in a flexible manner. Therefore, they will be continuously examined to enable the procedure to call attention to evolving imbalances as efficiently and precisely as possible. In part, this paper endeavours to highlight such possibilities of development.

* The views expressed in this article are those of the author(s) and do not necessarily reflect the official view of the Magyar Nemzeti Bank.

Table 1
Scoreboard indicators

Type	Abbreviation	Variable	Indicator	Threshold
EXTERNAL	CAB	Current account balance	as a percentage of GDP, 3-year retrospective moving average	+6%/-4%
	NIIP	Net international investment position	as a percentage of GDP	-35%
COMPETITIVENESS	REER	Real effective exchange rate	3-year change, HICP-deflated	±5% (EA)*/±11% (NEA)**
	EMS	Export market share	5-year change	-6%
	ULC	Unit labour cost	3-year change	+9% (EA)*/+12% (NEA)**
INTERNAL	HPI	House price index	annual change	+6%
	PSCF	Private sector credit flow	as a percentage of GDP	+15%
	PSD	Private sector debt	as a percentage of GDP	+160%
	GGD	General government debt	as a percentage of GDP	+60%
	UR	Unemployment rate	3-year retrospective moving average	+10%
	TFSL	Total financial sector liabilities	annual growth	+16,5%

* EA: euro area member countries.

** NEA: non euro area member countries.

One direction of development that may make operation of the Macroeconomic Imbalance Procedure more efficient is if member countries are examined with differentiated thresholds. In the set of indicators recommended by the Commission, different thresholds are applied only in the case of two indicators for the examination of euro area and non-euro area countries. In our opinion, the different levels of development of the countries under review justify the application of different thresholds in the case of the other indicators as well. In order to prove this, our analysis separately examines how the indicators perform in the case of all EU countries and in the case of the 10 countries that joined in 2004 (hereinafter: EU10). We found that the indicators behave significantly differently in the newly joined countries, which are at different levels of development, confirming the European Commission's statement that the early warning system cannot be applied mechanically.

This issue is relevant for Hungary in several respects. In February 2012, upon preparing the first Alert Mechanism Report, the European Commission was of the opinion that macroeconomic imbalances were present in Hungary. For their precise identification and understanding, an in-depth review of Hungary was also compiled. These developments are relevant for monetary policy as well. Firstly, because for the sake of efficient cooperation or debate with the European Commission, prior to the evolution of even more serious problems, an understanding of ongoing macroeconomic developments is a must, and secondly,

central banks strive to attenuate income fluctuations even in parallel with their normal operation. This is the case because the financial crisis showed that even the central banks operating in an inflation targeting framework have to pay special attention to the build-up of financial imbalances, as they may evolve in a stable inflation environment as well, and may result in overheating followed by recession (Csermely and Szalai, 2010).

ESSENCE OF THE SIGNALLING METHODOLOGY

There are several methods that allow the assessment of an economy in terms of financial balance (banking sector balance sheet indicators, financial market prices, combined stress indices, multi-module stress tests, VAR models, methods applied by credit rating agencies and developed for individual institutions). Borio and Drehman (2009) examined the advantages and disadvantages of various methods. They came to the conclusion that at present the signalling method is the most suitable one for the task. Their conclusion is based on the fact that the signalling method is sufficiently forward-looking to take into account the time requirement of the transmission of monetary policy as well as to capture the endogenous developments between the indicators and the macroeconomic cycles (upswings and downswings). Another advantage of the method is that it is simple, so based on that, economic policy decision-makers can also easily comprehend and tell the 'stories' behind macroeconomic developments.

Table 2
Categories in the signalling method

		Event	
		Occurs	Does not occur
Indicator	Issues a signal	A	B
	Does not issue a signal	C	D

Taking account of these factors, we decided to evaluate the early warning system developed by the European Commission with the help of the signalling methodology. The method was developed by Kaminsky et al. (1998) as well as by Kaminsky and Reihart (1999). Its essence is that an indicator gives a signal if it exceeds a certain threshold, and there is an event if the explained variable also exceeds a given threshold. Accordingly, the signals can be classified into the four groups shown in Table 2.

Based on the table, each outcome at a point in time can be classified into one of the groups below:

- A: true positive
- B: false positive
- C: false negative
- D: true negative

In the evaluation of early warning systems, interpretation of the indicators that measure the accuracy of the forecast is not trivial. The adjusted noise-to-signal ratio (aNtS) is the most widely used indicator, which can be calculated as follows:

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

According to the literature, an around 0.3 noise-to-signal ratio is already considered expressly good; a similar value is shown in the aforementioned study by Kaminsky and Reihart (1999) as well, which is one of the best-known studies. In addition to this indicator, we also examine what percentage of the events an indicator is able to predict and also the proportion of false alarms given by the indicator. It is easy to understand that if the threshold of the indicator is low, there will be many signals, and thus the proportion of false signals will increase. However, if the threshold of the indicator is high, the indicator will fail to issue signals in many cases, resulting in deterioration in the prediction

ratio, i.e. the two types of errors can be corrected to the detriment of one another.

In addition to the above, there are several indices that can be used for the evaluation of the performance of an indicator. One of them, for example, is the loss and usefulness function applied by Alessi and Detken (2009) as well, with which it is possible to take into account economic policy makers' preferences regarding the costs caused by type I and type II errors.¹ In addition, the latest literature on the subject highlighted that the aforementioned indicators assume in an implicit manner that the various outcomes occur with the same probability. Sarlin (2013) remedied this problem in a way that the usefulness and loss functions developed by him take into account the relative probability of the occurrence of events in an explicit manner as well.

Similarly to the noise-to-signal ratio, the expectation regarding the real value of indicators is not clear either. Assuming that there may be various reasons for individual events (crisis types or greater recessions), it is natural that an indicator capturing one specific type of risk does not forecast the majority of events, only the ones that are directly related to the risk captured by it. This means that a high ratio of predicted events is not necessarily the right requirement. It is also difficult to decide what the optimum ratio of false signals is, because it is conceivable that these signals are really false, i.e. economic policy does not have to react. At the same time it is also possible that in spite of the high risks, a lucky outcome materialised, or economic policy measures were taken that prevented the development of more serious problems, and thus the signal cannot even be considered false.

In order to have a comparison basis for these indicators as well, we examined other authors' results in applying the signalling method. According to the findings of Borio and Lowe (2002),² over the various time horizons an indicator was able to predict some 45–75 per cent of events. When they examined a combination of several indicators, which

¹ Type I error: event occurring, but no signal issued, as share of all events; type II error: the share of false alarms compared to all the periods when there is no event.

² At the same time, these figures cannot be directly compared to our results either, as the predicted event (bank crisis) is different in the study by Borio and Lowe (2002).

we will also do later, this figure declined to some 25–45 per cent. Using the signalling method, Alessi and Detken (2009) examined more than 80 variables, which were able to predict 60–85 per cent of the events,³ while the ratio of false signals was also around 65–75 per cent.

PERFORMANCE OF THE INDICATORS ON THE BASIS OF THE SIGNALLING METHOD

This chapter presents how efficient the indicators recommended by the European Commission⁴ can be in identifying the emergence of imbalances according to the early warning system. Although we applied the early warning system to several thresholds of the indicators and to several time horizons (0, 1, 2 and 3 years), we only present here the findings relating to the threshold recommended by the Commission and the time horizons relevant for monetary policy (1 and 2 years).⁵ Among other things, excessive negative deviation of GDP from the trend may be a sign of a build-up of imbalances. Therefore, ‘events’ were defined as follows: we examined the GDP of each country, then we applied the HP trend, which is often used in the EWS literature as well, to it.⁶ Then we took the difference between the basic time series and trend (cyclical position or gap).⁷ We determined the threshold of the critical difference at the first quartile (–2 per cent), similarly to the early

warning system of the European Commission.⁸ (The Commission did not define ‘events’, only indicators.)

The first indicator, the **current account balance** captures the changes in the net lending position of a country during a given period (e.g. 1 year); therefore, it captures important information about the developments in economic relations between a country and the rest of the world. Both a current account deficit and a surplus may indicate the emergence of macroeconomic imbalances, as a persistent deficit may lead to unsustainable external indebtedness, whereas a surplus may be a sign of subdued domestic demand. As opposed to the current account deficit, weak domestic demand does not result in a major downturn within a given country. However, it is an important indicator in an integration when we assume that a symmetrical adjustment of imbalances is the optimum adaptation among participating countries. A current account deficit with a 4 per cent threshold proved to be an efficient indicator. An indication of this is the below 1 noise-to-signal ratio and the fact that significant current account deficits were observed prior to more than half of the events. This applies in particular to the newly joined countries, where 72–78 per cent of the events were preceded by a current account deficit, and the ratio of false signals was also below 60 per cent. In view of the above reasons, it is unreasonable to examine the current account surplus with our method (Table 3).

Table 3
Current account deficit

Indicator	Current account deficit			
Recommended threshold	–4%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.62	0.51	0.90	0.81
Prediction ratio	51%	59%	72%	78%
False alarms/alarms total	69%	64%	59%	54%

³ These results cannot be compared directly either, because the costly asset price booms considered by Alessi and Detken (2009) as result variables entailed relatively serious real-economy consequences.

⁴ The description of the indicators is based on the European Commission's study (2012a).

⁵ At the same time, it needs to be seen that various indicators may be able to issue signals efficiently over various time horizons, and it is worth keeping in mind that among the indicators there are typically forward-looking ones (e.g. house price), simultaneous ones (e.g. export market share) and ones that react with a delay (e.g. unemployment).

⁶ Annual nominal GDP time series published by Eurostat. For calculating the cycle, we used the longest available time series (data are typically available as of approximately the 1980s for the developed countries and only as of the 1990s in the case of the Central East European countries), then during the application of the signalling method we monitored the data uniformly, starting from 1990.

⁷ It is known in the literature that the endpoint uncertainty of the HP filter is very high, i.e. with the receipt of new data, the simultaneously estimated output gap may change considerably. There are better filters than the HP filter, which cause smaller errors, but due to country-specific factors, their use would require too much work, and nor is any generally accepted methodology. Accordingly, for the comparability of the results, we used the HP filter. In our case, the simultaneous error is of lesser importance, because it is not the size of the output gap in itself that is important, but rather the sudden significant fall in the GDP growth rate, irrespective of the exact size of the output gap.

⁸ Accordingly, one quarter of all observations can be considered ‘events’, and thus not only the 2008 financial crisis became an event (we typically identified events in the early 1990s, at the time of the 2001 dotcom bubble and at the bottom of the financial crisis).

Table 4
Net international investment position

Indicator	Net international investment position			
Recommended threshold	-35%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.60	0.60	0.94	0.93
Prediction ratio	42%	40%	52%	48%
False alarms/alarms total	67%	68%	58%	58%

Table 5
Real effective exchange rate

Indicator	Real effective exchange rate			
Recommended threshold	-5%		-11%	
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.93	1.09	0.00	0.00
Prediction ratio	11%	10%	2%	2%
False alarms/alarms total	76%	79%	0%	0%

Indicator	Real effective exchange rate			
Recommended threshold	5%		11%	
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.85	0.70	1.54	1.24
Prediction ratio	43%	53%	34%	43%
False alarms/alarms total	75%	71%	71%	64%

The **net international investment position** also captures the net external position of a country; it corresponds to the stock counterpart of the current account balance as flow variable. Similarly to the previous indicator, this one also has better performance in the case of the EU10 countries (Table 4).

The **real effective exchange rate** captures the price and cost competitiveness of a country vis-à-vis its trading partners. Outliers for this indicator may indicate a disengagement of prices from productivity without entailing adjustment of the nominal exchange rate. The Commission determined positive and negative thresholds for this indicator as well. They differ across all EU Member States and non-euro area countries (EU10 in our case). The decline in the real effective exchange rate performed very weakly in both cases, while in the case of an increase in the indicator it can be considered an acceptable indicator considering the EU as a whole. At the same time, the application of the 5 per cent threshold could be more efficient in the case of the EU10 countries as well; it would have preceded 57–69 per cent of the events, with a 67–60 per cent false alarm ratio (Table 5).

The competitiveness of a country is influenced not only by price factors such as the real effective exchange rate. Therefore, the European Commission considered it justified to include the **export market share** in the set of the indicators. This indicator measures to what extent a country's exports are able to keep up with the changes in the global export volume. However, the performance of this indicator was very weak in every respect (Table 6).

The price and cost competitiveness of exports is captured by the **labour cost** per unit of output. An increase indicates that the growth in production costs exceeds the rise in labour productivity. In this context, an increase in the indicator – especially if it is accompanied by a rise in the current account deficit or a decline in the export market share – reflects considerable erosion in the competitiveness of the given country. The threshold recommended by the Commission is proving good for the member countries collectively on the basis of the noise-to-signal ratio and the prediction ratio, but for the EU10 countries this is only partly true. If a 9 per cent (i.e. stricter) threshold was applied for this group of countries as well, both the noise-

Table 6
Export market shares

Indicator	Export market shares			
Recommended threshold	-6%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	3.14	3.11	0.60	0.64
Prediction ratio	12%	11%	5%	6%
False alarms/alarms total	91%	90%	40%	40%

Table 7
Unit labour cost

Indicator	Unit labour cost			
Recommended threshold	9%		12%	
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.72	0.68	1.44	1.16
Prediction ratio	57%	59%	48%	58%
False alarms/alarms total	71%	68%	65%	58%

to-signal ratio and the ratio of false alarms would decline, while the prediction ratio would rise significantly, to 71 and 75 per cent, respectively (Table 7).

Changes in **house prices** may also be efficient as an early warning indicator. Numerous studies have already discussed the aspect that they have an effect on real economy through several channels and may also be the source of the evolution of macroeconomic imbalances. For example, asset prices and house prices usually move closely together with monetary and credit aggregates, which may jeopardise financial stability as well. Nevertheless, our findings suggest that house prices only rarely exceeded the threshold recommended by the European Commission; therefore, it cannot be said that – in their own right, without the credit aggregates – they called attention to the development of imbalances or ‘events’ (Table 8).

Among other things, the 2008 financial crisis also revealed that **high private sector indebtedness** jeopardises both economic growth and financial stability, and it is also

generally believed that an economic crisis is a greater shock for more indebted countries. However, the threshold recommended by the EU does not prove to be too efficient, since the ratio of false alarms is very high for the EU countries collectively, and only a small portion of ‘events’ is preceded by the exceeding of the threshold. Moreover, while there is no false alarm in the EU10 countries, the threshold is too high (there are only 4 and 5 signals, respectively), and thus the prediction ratio is even lower than in the case of all the EU member countries. With a lower (80 per cent) threshold, the prediction ratio would improve significantly (to 53–52 per cent) in the EU countries, while the ratio of false alarms would remain nearly unchanged (83–84 per cent). Even the lower threshold does not help in the EU10 countries: although the prediction ratio would improve to 37–35 per cent, the ratio of false alarms would also increase significantly (to 50–47 per cent) (Table 9).

The flow counterpart of the above stock variable, i.e. the **private sector credit flow**, may also be a good predictor

Table 8
House prices

Indicator	House prices			
Recommended threshold	6%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	6.14	–	6.09	–
Prediction ratio	3%	0%	5%	0%
False alarms/alarms total	96%	100%	88%	100%

Table 9
Private sector loans outstanding

Indicator	Private sector loans outstanding			
Recommended threshold	160%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	1.75	1.73	0.00	0.00
Prediction ratio	17%	16%	8%	7%
False alarms/alarms total	86%	86%	0%	0%

Table 10
Private sector credit flow

Indicator	Private sector credit flow			
Recommended threshold	15%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	1.62	0.98	1.52	1.09
Prediction ratio	19%	30%	19%	25%
False alarms/alarms total	85%	78%	69%	61%

of financial and/or bank crises both in emerging and developed countries, as rapid increases in loans are usually accompanied by an easing of credit conditions, resulting in the vulnerability of the banking sector. However, this variable in itself cannot be considered a good early warning indicator either, as the prediction ratio is low in both country groups, while the ratio of false alarms is well above 50 per cent (Table 10).

The financial tensions experienced in recent years highlighted that not only the indebtedness of the private sector, but also **government debt** plays a significant role in a country, because an increase in government debt adds to the vulnerability of the given country and limits the room for manoeuvre of the country/government in crisis management. However, the 60 per cent threshold, which is applied during the excessive deficit procedure as well, has a low prediction ratio and very high false alarms/alarms total ratio, similarly to the aforementioned indicator (Table 11).

High **unemployment rate** may also indicate a build-up of imbalances, as it may point to inefficient allocation and weak utilisation of resources available in the economy as well as to lack of adaptability of the economy. Compared to other indicators, unemployment rate as early warning indicator performs very well, as the prediction ratio is above 50 per cent, while the ratio of false alarms is well below that in the case of the EU10 countries. Accordingly, the noise-to-signal ratio is also favourable (Table 12).

The last indicator – which was included in the macroeconomic imbalance procedure subsequently – is related to the **financial sector**, and captures the relations between the real economy and the financial sector well. This indicator must comply with various requirements,⁹ based on which the choice finally fell on the increase in the liabilities of the financial sector. This indicator may be able to capture the risks to the financial sector, which is important, because experiences show that financial crises are often preceded

Table 11
Government debt

Indicator	Government debt			
Recommended threshold	60%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	1.60	1.93	2.65	1.77
Prediction ratio	24%	20%	5%	7%
False alarms/alarms total	84%	87%	81%	73%

⁹ For details see: European Commission (2012b).

Table 12
Unemployment

Indicator	Unemployment			
Recommended threshold	10%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.33	0.42	0.44	0.64
Prediction ratio	51%	45%	59%	51%
False alarms/alarms total	52%	60%	35%	42%

Table 13
Liabilities of the financial sector

Indicator	Liabilities of the financial sector			
Recommended threshold	16.5%			
	EU		EU10	
	1 year	2 years	1 year	2 years
Noise-to-signal ratio	0.89	0.77	1.39	1.37
Prediction ratio	27%	32%	35%	38%
False alarms/alarms total	76%	74%	68%	66%

by turbulences evolving in the financial sector. It is emphasised, however, that the assessment of this variable cannot be mechanical or isolated from the other indicators either. In spite of the relevance of the variable, the results were weaker than expected, as the prediction ratio is around a mere 30 per cent, while the ratio of false alarms is above 60 per cent (Table 13).

ON THE PRINCIPLES OF PROPER APPLICATION OF THE INDICATORS

Based on the previous chapter, with the given thresholds, the majority of the indicators recommended by the European Commission do not prove to be good early warning indicators by themselves. Only in the cases of the current account deficit and the unemployment rate do we see results where the prediction ratio is better than the ratio of false alarms to alarms total, or where the results received are at least as good or are in conformity with the findings of the aforementioned studies by Borio and Lowe (2002) or Alessi and Detken (2009). In addition to the above, perhaps the net investment position, the real effective exchange rate and the unit labour cost provide more or less acceptable results. On the basis of the signalling method, many of the variables under review cannot be applied efficiently as early warning indicators (current account balance surplus, export market share, house prices, private sector credit flow and outstanding debt, government debt, liabilities of the financial sector). At the same time, we

came to the conclusion that it would be possible to apply some of the above variables as well, but not with the thresholds recommended by the Commission (application of another threshold is proposed for the real effective exchange rate and the unit labour cost in the case of the EU10 countries, and for private sector debt in the case of all the countries).

This is in line with the findings of the study by Csontos and Szalai (2013), which points out that indicators by themselves perform weakly, but an adequate combination of indicators (e.g. if at least 2 of 4 indicators issue signals) may efficiently call attention to the development of imbalances. Accordingly, we examined how many of the 11 indicators recommended by the European Commission have to give signals so that the early warning system can operate well.

The fourth rows of partial tables 14 show at least how many of the indicators (and the relevant thresholds) recommended by the European Commission generate signals simultaneously. Accordingly, the results improved in both country groups. For the EU countries collectively, if at least two indicators generate signals, the prediction ratio is already around 60 per cent, although the ratio of false alarms is still high (above 70 per cent). The results are more favourable in the case of the EU10 countries, where if at least two indicators generate signals, the prediction ratio is already close to 70 per cent, while the ratio of false alarms is only around 60 per cent. Although there is no guideline or rule of thumb for the

Table 14
Combined performance of indicators

Indicator	Indicators jointly				
Time horizon	1 year				
	EU				
	1	2	3	4	5
Noise-to-signal ratio	1.08	1.04	0.92	0.95	1.13
Prediction ratio	75%	60%	46%	31%	17%
False alarms/alarms total	77%	76%	74%	74%	77%
Indicator	Indicators jointly				
Time horizon	2 years				
	EU				
	1	2	3	4	5
Noise-to-signal ratio	1.04	0.99	0.91	0.81	0.97
Prediction ratio	75%	59%	45%	34%	18%
False alarms/alarms total	76%	75%	73%	71%	75%
Indicator	Indicators jointly				
Time horizon	1 year				
	EU10				
	1	2	3	4	5
Noise-to-signal ratio	1.06	1.02	0.91	1.02	1.54
Prediction ratio	75%	68%	54%	35%	14%
False alarms/alarms total	61%	60%	57%	60%	69%
Indicator	Indicators jointly				
Time horizon	2 years				
	EU10				
	1	2	3	4	5
Noise-to-signal ratio	0.92	0.93	0.77	0.80	1.49
Prediction ratio	79%	68%	59%	41%	14%
False alarms/alarms total	58%	59%	54%	55%	69%

optimum value of these indicators, the results presented here are much better than the ones described in the previous chapter and provided by individual indicators, and in many cases they are even better than the results in the studies considered to be references.¹⁰ It is possible to evaluate the indicators on the basis of the noise-to-signal ratio as well. In this case, a signal from 3 indicators could be guiding, because this is when this indicator reaches its minimum value. These results may be important because the European Commission has not determined the total number of indicators whose signals suggest the existence of macroeconomic imbalance; the Commission only expressed that the signals of several indicators provide more information.

It should be noted that when the results that can be considered the best were received, the same 2-3 indicators which were also found to be suitable for indicating imbalances in the previous chapter always generated signals. Nevertheless, the Commission compiled a comprehensive set of indicators on purpose, because experiences show that crises occurring over time are not identical. A wider set of indicators may facilitate the timely identification of new imbalances as well. Moreover, an argument for the application of the comprehensive set of indicators may be that various types of indicators issue signals in various countries and country groups (e.g. indicators related to competitiveness or developments in

¹⁰ At the same time, in many cases the indicator combinations presented in the study by Csontos and Szalai (2013) had even better results than that; for example, in certain cases they showed prediction ratios exceeding 90 per cent.

lending). At the same time, the Commission is also aware of the disadvantages of too many alarm signals. The Commission's task is to continuously monitor the experiences related to the set of indicators and the thresholds chosen,

and to propose changes if and when it is necessary.¹¹ Our findings show that different thresholds according to level of economic development may be justified in the case of less developed and developed country groups.

Changes in indicators in Hungary

We have examined the indicators recommended by the European Commission for the case of Hungary in detail as well, as shown in Table 15.

Table 15
Forecasting ability of indicators in Hungary

Indicators	GDP	CAB	NIIP	REER	EMS	ULC	HPI	PSCF	PSD	GGD	UR	TFSL	Total
Threshold	-2	-4	-35	11	-6	12	6	15	160	60	10	16,5	
1997	7.0	-3.7	-65.6	2.9				8.4	46.2	62.9		15.6	2
1998	7.2	-3.5	-65.7	6.9		60.6		4.9	46.3	60.9	9.2	15.3	3
1999	2.4	-4.9	-75.1	6.8	115.9	40.6		9.3	52.5	60.8	8.2	12.8	4
2000	1.7	-7.1	-72.6	2.9	55.1	32.1		19.6	67.2	56.1	7.3	12.4	4
2001	3.1	-7.5	-66.3	12.2	65.0	31.1		10.3	67.3	52.7	6.2	6.5	4
2002	4.0	-7.2	-65.2	20.6	43.0	34.2		15.3	71.1	55.9	5.8	5.7	5
2003	2.8	-7.0	-78.1	20.1	43.0	27.4		18.3	84.9	58.6	5.6	19.8	6
2004	3.5	-7.8	-85.4	17.7	33.7	19.8		12.8	86.4	59.5	5.8	16.7	5
2005	2.1	-7.8	-94.4	9.3	30.9	13.3		17.4	102.2	61.7	6.3	21.1	6
2006	2.6	-7.6	-102.8	3.0	16.9	9.3		18.0	110.8	65.9	6.9	18.0	5
2007	2.2	-7.3	-105.1	8.0	20.8	11.3		22.0	125.7	67.0	7.3	13.4	4
2008	3.3	-7.3	-106.0	9.3	13.9	13.1		29.2	155.7	73.0	7.5	14.6	5
2009	-4.5	-4.9	-117.2	8.0	6.6	14.0	-9.8	5.4	170.6	79.8	8.4	8.2	5
2010	-4.7	-2.2	-112.8	-0.4	1.4	6.4	-6.4	-21.6	154.0	81.8	9.7	3.2	2
2011	-3.7	0.6	-105.9	-3.3	-2.8	3.7	-4.1	6.4	167.3	81.4	10.7	-2.6	4

The second column shows that in terms of the changes in GDP, there was excessive negative deviation (more than -2 per cent) from the trend in 2009-2011. In the period presented, however, at least two indicators (marked in red) always issued signals. Therefore, it would not have been appropriate to apply the threshold of 2-3 recommended above, because we would have faced false alarms practically during the whole period. Ex post, it can be said that the third quartile (5) of the indicator signals could have been a good threshold: in 2008 and 2009 five indicators issued signals that could have called attention to the imbalances that unfolded in 2009, 2010 and 2011. (Three of these five indicators are identical with the ones that were found suitable for forecasting in the previous chapter as well. They are the current account deficit, the net investment position and the unit labour cost.) At least five indicators issued signals between 2002 and 2006 as well. In these cases, it is questionable whether all of them were false alarms or economic policy measures that finally prevented GDP from departing from the trend in a negative direction were implemented.

CONCLUSIONS

Our article evaluated the efficiency of the indicators of the early warning system applied by the European Commission. It presented the purpose, course and the motive of the macroeconomic imbalance procedure as well as the methodology that allows the assessment of the indicators used in the procedure. We discussed the results provided by

the methodology in detail, and made a proposal for a more efficient application of the set of indicators. Finally, we mentioned how they could have been or could be applied appropriately in Hungary.

This subject is relevant for the Magyar Nemzeti Bank in several respects. Firstly, it is important that in parallel with the analysis prepared annually by the Commission, for the

¹¹ European Commission (2012a), pp. 4-5.

sake of efficient cooperation or debate with the Commission, we also need to be aware of potentially hazardous developments. Secondly, as an inflation targeting central bank, the MNB must pay special attention to the build-up of financial imbalances, because they may also evolve in a stable inflation environment and may result in overheating or unwanted excessive income fluctuations followed by recession.

According to our current knowledge and experiences, the signalling method is the most suitable one for the evaluation of early warning systems. Using the method, we examined the noise-to-signal, prediction and false alarms/alerts total ratios shown by individual indicators. Firstly, our findings highlighted that due to different levels of development and macroeconomic characteristics it may be justified to apply different thresholds for all the EU member countries and the newly joined ones. Secondly, we came to the conclusion that the indicators applied by the Commission often do not prove to be good early warning indicators by themselves. However, the forecasting ability of the set of indicators may improve considerably if different types and numbers of indicators are applied for each country and different thresholds are used according to level of development. In addition, our results are able to provide a numerical guideline as well, suggesting how many indicators in total may point to a build-up of macroeconomic imbalance. All of this confirms the statement of the European Commission that the early warning system cannot be applied mechanically.

In summary, only some of the variables of the set of indicators applied by the European Commission are able to efficiently call attention to the build-up of imbalances. Our results show that there are variables that are not suitable at all for the above purpose, while other variables may be, but not with the threshold applied by the Commission. Accordingly, one of our main conclusions is that it would be possible to improve the forecasting ability of the set of indicators if the applied threshold was differentiated according to level of development in the case of several indicators. In addition, if the indicators are examined together, i.e. in certain combinations, the results are much better than the ones shown by individual indicators, and in many cases they are even better than the results of the studies that are considered to be references. All of this, in turn, may indicate that in individual countries groups of various types of indicators (e.g. indicators related to competitiveness or developments in lending) may be able to

generate efficient signals, although this would require a country-specific analysis. Consequently, a differentiation of thresholds according to level of development and an appropriate grouping of indicators may provide efficient help in preventing the build-up of macroeconomic imbalances and excessive income fluctuations.

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