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Identifying banking crises using money market pressure: New evidence for a large set of countries

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ABSTRACT

We construct a money market pressure index based on central bank reserves and the short-term nominal interest rate to identify banking crises, thereby extending the index proposed by Von Hagen and Ho (2007), also in terms of the number of countries covered. We compare the crises identified by both indices with crises according to Laeven and Valencia. Both indices identify more crises than the Laeven–Valencia database. The crises identified by our index are more in line with the Laeven–Valencia crises than those identified by the Von Hagen–Ho index, while our index also gives fewer ‘false’ signals.

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1. Introduction

Since the collapse of the Bretton Woods system, the frequency of financial crises has doubled (Bordo et al., 2001). Notably after the financial liberalization during the 1990s, the intensity of financial crises has increased. Recent research suggests that financial crises may have a permanent effect on potential output (Furceri and Mourougane, 2012).

In general, three types of financial crises may be distinguished: currency crises, banking crises and debt crises. Compared to other types, banking crises have a more serious impact on the economy (Hutchinson and Noy, 2005). It is therefore important to prevent banking crises and to reduce the costs of banking crises once they occur (Caprio and Klingebiel, 1996; Kaminsky and Reinhart, 1999; Frydl, 1999; Demirgüç-Kunt and Detragiache, 1998, 2005; Honohan and Klingebiel, 2003; Duttagupta and Cashin, 2011; Davis and Karima, 2008a, 2008b).

A serious methodological challenge which researchers face is the identification of (systemic) banking crises. Most studies identify a (systemic) banking crisis based on exceptional events or policy interventions, such as bank closures, deposit

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freezes and government rescues (cf. Laeven and Valencia, 2008, 2010, 2013; Reinhart and Rogoff, 2009). However, Von Hagen and Ho (2007) argue that this events methodology may be biased for several reasons. First, such interventions may refer to a few banks having problems rather than the whole banking sector. Second, it is hard to determine whether a particular policy intervention is taken because of a systemic banking crisis. Third, policy interventions mostly occur when a crisis has a significant impact on the financial system or the economy, which implies that the start of the banking crisis may be identified too late. Finally, not each crisis leads to government interventions as central banks sometimes solve financial problems successfully. Therefore, there may be a selection bias when banking crises are identified based on interventions by government authorities.¹

Drawing on the reasoning of Eichengreen et al. (1996a, 1996b), Von Hagen and Ho (2007) propose an index to identify banking crises based on money market pressure (which will be discussed in more detail in Section 2). A monetary pressure index (MPI) cannot offset all drawbacks of the events methodology, but advantages of a money market pressure index include that it is less subjective, available at a higher frequency (several countries are not included in the most widely used crises databases) and timelier (as it relies on less information). Although the Von Hagen–Ho index is very innovative, we argue that it can be improved upon by using nominal instead of real interest rates and by weighting its components differently.

The objective of this paper is to construct a modified monetary pressure index (MPI) to identify banking crises. We construct our MPI for a larger sample of countries than Von Hagen and Ho (2007). For comparison purposes we use the Laeven–Valencia (2010) database of banking crises, which is based on the events methodology.

The rest of the paper is organized as follows. Section 2 reviews previous research on identifying banking crises. Section 3 discusses the index proposed by Von Hagen and Ho (2007) and presents our proposed amendments. Section 4 describes the data and criteria for identifying banking crises. Section 5 compares crises identified by both indexes with crises according to databases based on the events methodology, and offers a sensitivity analysis. Section 6 discusses the tradeoff between missed crises and false alarms and Section 7 concludes.

2. Identifying banking crises

2.1. The events method

The events method identifies banking crises based on the occurrence of certain events, such as bank runs, closures, mergers and government interventions (Demirgüç-Kunt and Detragiache, 1998). Caprio and Klingebiel (1996) adopt information from supervisors and country experts to identify banking crises. In its World Economic Outlook, the IMF (1998, p.76) extends Caprio and Klingebiel's scheme and identifies a banking crisis as a situation in which actual or potential bank runs and failures lead banks to suspend the internal convertibility of their liabilities or compel the government to provide large-scale interventions in the banking sector.

Demirgüç-Kunt and Detragiache (1998, 2002, 2005) identify an event as a crisis if at least one of the following conditions holds:

- (i) the ratio of non-performing assets to the banking system's total assets exceeds 10%;
- (ii) the cost of the government's rescue operation is at least 2% of GDP;
- (iii) banking sector problems result in a large-scale nationalization of banks;
- (iv) extensive bank runs take place or emergency measures such as deposit freezes, prolonged bank holidays, or generalized deposit guarantees are enacted by the government in response to the crisis.

Laeven and Valencia (2008, 2010) adopt a somewhat different definition to identify banking crises. Laeven and Valencia (2008, p. 5) define a systemic banking crisis as an event where a "country's corporate and financial sectors experience a large number of defaults and financial institutions and corporations face great difficulties repaying contracts on time. This situation may be accompanied by depressed asset prices (such as equity and real estate prices) on the heels of run-ups before the crisis, sharp increases in real interest rates, and a slowdown or reversal in capital flows. In some cases, the crisis is triggered by depositor runs on banks, though in most cases it is a general realization that systemically important financial institutions are in distress."

As pointed out in the Introduction, Von Hagen and Ho (2007) argue that the events method has several shortcomings. Therefore, they suggest an index based on pressure in the money market to identify banking crises.

2.2. Money market pressure index

The basic idea of the money market pressure index of Von Hagen and Ho (2007) is that in a crisis the banking sector will face difficulties, such as an increase in non-performing assets, withdrawals of deposits, and drying up of inter-bank lending,

¹ Likewise, Boyd et al. (2009) argue that the banking crisis indicators they examine—including those of Reinhart and Rogoff (2009) and Laeven and Valencia (2008)—actually measure lagged government responses to systemic bank shocks, rather than the occurrence of crises *per se*. After we had finished the research reported in this paper, Laeven and Valencia (2013) published an update of their dataset.

which will lead to a sharp increase in banks' demand for central bank liquidity. The central bank will react to this increased demand in two ways. If central bank reserves are the operating target of monetary policy, the supply of reserves will be constant and the short-term interest rate will rise. Otherwise, the central bank will sustain the level of the short-term interest rate and inject additional reserves into the banking sector. Thus, a banking crisis is generally characterized by a sharp increase of short-term interest rates, the stock of central bank reserves, or both.

Based on this logic, [Von Hagen and Ho \(2007\)](#) propose the following MPI:

$$VHH_t = \frac{\Delta\gamma_t}{\sigma_{\Delta\gamma}} + \frac{\Delta r_t}{\sigma_{\Delta r}}, \quad (1)$$

where Δ is the difference operator, γ is the ratio of central bank reserves to total bank deposits, r is the short-term real interest rate, while $\sigma_{\Delta\gamma}$ and $\sigma_{\Delta r}$ are the standard deviations of $\Delta\gamma$ and Δr , respectively.

In identifying a banking crisis, [Von Hagen and Ho \(2007\)](#) apply two criteria. First, the index needs to exceed the 98.5 percentile of the sample distribution for the country under consideration. Second, the increase of the MPI from the previous period should at least be 5%. The first condition ensures that only exceptional events are treated as crises, and the second one is applied to avoid signaling crises in countries that did not experience a banking crisis.² Von Hagen and Ho quantify these criteria by selecting the combination of parameters that can best identify crises as listed by [Caprio and Klingebiel \(1996\)](#).

3. Modification of the money market pressure index

The money market pressure index constructed by [Von Hagen and Ho \(2007\)](#) is less subjective than the events methods. However, the index has some drawbacks as well. First, due to data limitations Von Hagen and Ho calculate standard deviations over the whole sample period thereby ignoring possible changes in monetary regimes. As we have sufficiently long samples—each country's sample exceeds 9 years—we apply rolling 24-month periods to calculate standard deviations.³

Second, the index of [Von Hagen and Ho \(2007\)](#) is driven by the most stable component. If the ratio of central bank reserves to total bank deposits γ is constant for a long time (which is the case in some countries), the standard deviation of $\Delta\gamma$ is equal to zero and the MPI index cannot be constructed.⁴ Even if $\sigma_{\Delta\gamma}$ does not equal zero, it will generally be much smaller than the standard deviation of the short-term interest rate $\sigma_{\Delta r}$, so that the ratio of central bank reserves to total bank deposits γ receives more weight than the short-term interest rate r . To avoid this problem, we change the weighting scheme and propose a Modified Monetary Pressure Index (MMPI):

$$MMPI_t = \omega_1 \Delta\gamma_t + \omega_2 \Delta r_t, \quad (2)$$

$$\omega_1 = \frac{\frac{1}{\sigma(\Delta\gamma)}}{\frac{1}{\sigma(\Delta\gamma)} + \frac{1}{\sigma(\Delta r)}}, \quad \omega_2 = \frac{\frac{1}{\sigma(\Delta r)}}{\frac{1}{\sigma(\Delta\gamma)} + \frac{1}{\sigma(\Delta r)}}.$$

The weights fall in the interval (0, 1] and add up to one. In our sample (as discussed in the next section), the ratios of $\sigma_{\Delta r}$ to $\sigma_{\Delta\gamma}$ are in a range of [1, 50], so the weight of $\Delta\gamma$ in constructing MMPI is smaller than in constructing VHH.

Third, Von Hagen and Ho use the short-term real interest rate in their index to capture money market pressure. As pointed out by [Cecchetti and Disyatat \(2010\)](#), three types of liquidity shortages can be distinguished, namely shortages of central bank liquidity, market liquidity, and funding liquidity. Central bank liquidity refers to deposits of financial institutions at the central bank, which are held by financial institutions to meet reserve requirements, if any, and to achieve final settlement of all financial transactions in the payments system. Market liquidity refers to the ability to buy and sell assets in reasonably large quantities without significantly affecting price. Finally, funding liquidity describes the ability of an individual or institution to raise cash, or its equivalent, again in reasonably large quantities, either via asset sales or by borrowing. As pointed out by [Cecchetti and Disyatat \(2010\)](#), all these different types of liquidity shortages are reflected in nominal short-term market rates.

Using the short-term real interest as a proxy for liquidity shortages implies that also inflation has an impact. If the nominal interest rate is constant but the real interest rate decreases due to higher inflation, the money market pressure index will go down thereby wrongly indicating that money market pressure has increased. But the reverse is also possible. So constructing MPIs using inflation may lead to very distorted outcomes. In fact, previous research suggests that, if anything, inflation has a positive impact on banking crises (cf. [Demirgüç-Kunt and Detragiache, 1998, 2002](#)) and not a negative impact as implied by the index of Von Hagen and Ho. Below we analyze the choice of using nominal vs. real interest rates in more detail for some countries. Indexes that are based on real (nominal) interest rates have an R (N) in front of the index.

We deviate from the analysis of [Von Hagen and Ho \(2007\)](#) in two more ways. First, the sample of Von Hagen and Ho includes mostly countries which suffered from at least one banking crisis, while they include only few countries without banking crises. Therefore, there may be a sample selection bias and it is not clear whether the index is reliable in countries

² These two criteria are similar to the extreme-value based identification of currency crises studied by [Lestano and Jacobs \(2007\)](#). In Section 6 we will come back to this rule. In Sections 3 and 4 we follow [Von Hagen and Ho's \(2007\)](#) criteria.

³ To examine the sensitivity of our findings, we have experimented with different lengths of the moving window to calculate the standard deviations.

⁴ In this case we use the value 1e–6 as a proxy.

Table 1
Definition of indices used.

Index	Definition
VHH	Index proposed by Von Hagen and Ho (2007)
RMPI	Index (as in Eq. (1)) constructed using real interest rates and 24-months moving window for standard deviations
NMPI	Index (as in Eq. (1)) constructed using nominal interest rates and 24-months moving window for standard deviations
RMMPI	Index (as in Eq. (2)) constructed by using real interest rates and 24-months moving window for standard deviations
NMMPI	Index (as in Eq. (2)) constructed by using nominal interest rates and 24-months moving window for standard deviations

Note: This table shows the definitions of five indices used in the analysis.

which did not experience banking crises. To avoid this bias, we include more countries with and without banking crises to investigate whether the index can identify banking crises in both types of countries.

Second, although Von Hagen and Ho (2007) consider ‘missed crises’ (i.e. the index does not signal a banking crisis when there is one according to the database used for comparison purposes) and ‘false alarms’ (i.e. the index signals a banking crisis when there is no crisis according to the database used for comparison purposes), they do not consider the tradeoff between ‘missed crises’ and ‘false alarms’. In this paper, we apply a quantitative method to assess this tradeoff (see Section 6).

4. Sample and criteria for identifying banking crises

4.1. Sample

We use monthly data from the IMF’s International Financial Statistics, spanning the period 1975M1 to 2009M12, to construct money market pressure indices. European countries that have joined the euro area are not included after the start of the currency union as country-specific data are not available. As a money market pressure index can only be constructed in a meaningful way if interest rates are market-determined, we exclude countries with a repressed financial system.⁵ To determine to what extent the financial system of countries is repressed, we use information from the Fraser Institute, i.e. the sub-index of “Interest rate controls/negative real interest rates”.⁶ This index ranges between zero and ten. The highest score (10) is given when interest rates are determined primarily by market forces, as evidenced by reasonable spreads between deposit and lending rates. A zero rating is assigned when the deposit and lending rates are fixed by the government and real rates are persistently negative by double-digit amounts or hyperinflation virtually eliminates the credit market. We only include countries in our sample having a Fraser sub-index of 7 or higher.

Following Von Hagen and Ho (2007), total deposits consist of demand deposits, time and saving deposits and foreign liabilities of deposit money banks. Central bank reserves are defined as loans from monetary authorities. The nominal interest rate is the money market rate. If this variable is not available, we follow Von Hagen and Ho (2007) and use (successively) the Treasury bill rate, the government bond yield, the deposit rate, the lending rate, and the discount rate as substitutes. In line with Von Hagen and Ho (2007), the inflation rate is calculated using the consumer price index.

We use five indices, namely VHH (the Von Hagen–Ho index), RMPI, NMPI, RMMPI, and NMMPI. VHH, RMPI and RMMPI are based on real interest rates, while NMPI and NMMPI are constructed using nominal interest rates. These indices are defined in Table 1.

For illustrative purposes, we first zoom in on the results for a subsample of 10 countries which includes three industrial economies (Japan, Korea, and the United States), and seven developing and emerging economies (Argentina, Brazil, Indonesia, Malaysia, Mexico, Philippines, and Turkey). These 10 countries have experienced banking crises during the last three decades.

Table 2 presents descriptive statistics of the five indices in these countries. The means and the standard deviations of RMPI and NMPI are much larger than those of RMMPI and NMMPI. The weights as used in Eq. (2) are less than 1 while in Eq. (1) they can be larger than 1, so that indices based on Eq. (1) can become bigger.

Because VHH is different from the other four indices, Fig. 1 only presents the other four indices for selected countries. The first graph for each country shows RMPI and NMPI, and the second one presents RMMPI and NMMPI. As these figures show, RMPI and NMPI are close to each other in Argentina and Brazil, while RMMPI and NMMPI are also very similar for these countries. In contrast, the indices differ for the other countries, and sometimes quite substantially. Specifically, compared to the indices based on nominal interest rates, those based on real interest rates often show a downward trend. Furthermore, it turns out that in some countries the signs of RMMPI and NMMPI are opposite. This difference is due to the effect of inflation. For instance, both inflation and the short-term interest rate were high in Indonesia in 1997, and the indices based on the nominal interest indicate a banking crisis, while those based on the real interest rate do not. According to Laeven and Valencia (2010), Indonesia experienced a banking crisis in 1997.

⁵ We are grateful to a referee for pointing this out.

⁶ http://www.freetheworld.com/datasets_efw.html.

Table 2

Summary of money market pressure indices for 10 countries.

Country	Index	Mean	Max	Min	Median	S.D	N	Number of crises
Argentina	VHH	−0.062	8.628	−11.26	−0.013	1.423	345	4
	RMPI	6.355	215.571	−16.03	−0.166	115.874	345	
	NMPI	12.524	419.15	−16.053	−0.107	225.876	345	
	RMMPPI	0.080	27.864	−0.368	−0.001	1.501	345	
	NMMPPI	0.166	54.305	−0.528	−0.001	2.925	345	
Brazil	VHH	−0.051	7.866	−7.622	−0.005	1.409	230	2
	RMPI	−0.204	11.785	−21.236	−0.224	2.235	230	
	NMPI	0.034	15.297	−16.027	−0.122	2.232	230	
	RMMPPI	0.000	0.105	−0.031	−0.001	0.010	230	
	NMMPPI	0.000	0.098	−0.054	−0.001	0.010	230	
Indonesia	VHH	−1.228	3.072	−6.885	−0.785	1.376	271	1
	RMPI	−4.423	7.314	−48.022	−4.085	3.979	271	
	NMPI	0.063	41.452	−7.458	−0.150	3.134	271	
	RMMPPI	−0.038	0.025	−0.215	−0.024	0.040	271	
	NMMPPI	0.000	0.115	−0.059	−0.001	0.014	271	
Japan	VHH	−0.926	19.478	−4.327	−0.763	1.441	388	1
	RMPI	0.041	2.829	−50.172	−3.200	111.788	388	
	NMPI	5.762	43.066	−6.697	−0.012	111.438	388	
	RMMPPI	0.000	0.001	−0.01	0.000	0.000	388	
	NMMPPI	0.000	0.002	−0.002	0.000	0.000	388	
Korea	VHH	−1.012	13.575	−5.258	−0.762	1.372	383	1
	RMPI	−9.222	15.794	−35.366	−8.735	6.080	383	
	NMPI	−0.096	32.47	−4.658	−0.184	2.356	383	
	RMMPPI	−0.044	0.079	−0.181	−0.037	0.036	383	
	NMMPPI	0.000	0.134	−0.026	0.000	0.010	383	
Malaysia	VHH	−1.775	1.563	−13.506	−1.239	1.450	183	1
	RMPI	−22.825	−0.475	−89.082	−11.758	23.471	183	
	NMPI	0.269	36.948	−18.293	−0.016	4.373	183	
	RMMPPI	−0.014	0.000	−0.071	−0.011	0.013	183	
	NMMPPI	0.000	0.031	−0.033	0.000	0.005	183	
Mexico	VHH	−0.396	5.771	−5.999	−0.122	1.431	316	2
	RMPI	−5.282	6.477	−72.358	−2.801	10.708	316	
	NMPI	0.142	11.002	−14.671	0.008	2.165	316	
	RMMPPI	−0.020	0.019	−0.108	−0.013	0.020	316	
	NMMPPI	0.000	0.093	−0.021	0.000	0.008	316	
Philippines	VHH	−1.523	3.820	−13.054	−1.186	1.491	230	1
	RMPI	−8.653	2.943	−43.279	−3.830	10.480	230	
	NMPI	−0.072	11.063	−7.978	−0.188	1.962	230	
	RMMPPI	−0.013	0.005	−0.057	−0.008	0.010	230	
	NMMPPI	0.000	0.040	−0.032	0.000	0.005	230	
Turkey	VHH	−0.495	6.421	−9.067	−0.092	1.451	255	1
	RMPI	−2.564	21.27	−12.883	−1.655	3.564	255	
	NMPI	0.074	23.182	−8.574	−0.081	2.763	255	
	RMMPPI	−0.013	0.042	−0.116	−0.009	0.016	255	
	NMMPPI	0.000	0.186	−0.115	0.000	0.019	255	
United States	VHH	−1.163	5.553	−8.289	−0.841	1.431	389	2
	RMPI	−8.475	59.435	−63.06	−6.506	10.467	389	
	NMPI	0.321	60.412	−9.103	0.118	3.560	389	
	RMMPPI	−0.002	0.005	−0.012	−0.002	0.003	389	
	NMMPPI	0.000	0.007	−0.007	0.000	0.001	389	

4.2. Assessing crisis signals

We assess the performance of the indices as follows. First, we compare the crises in the [Laeven and Valencia \(2010\)](#) database with the various pressure indexes as discussed in Section 3.⁷ The sample used for comparison purposes includes 109 countries with 68 banking crises. Column (2) in [Appendix A](#) lists all countries in our sample and their banking crises according

⁷ We follow von Hagen and Ho in comparing our index with a crises database constructed using the events method despite the shortcomings of this method as outlined in section 1. Von Hagen and Ho compare their crisis data and those of [Caprio and Klingebiel \(1996\)](#) for 15 countries and find that there is quite some similarity. We primarily use the Laeven and Valencia dataset for comparison purposes, as this the most recent database available. [Chaudron and De Haan \(2014\)](#) compare several banking crises datasets using the frequency of bank failures and the costs of banking crisis. These authors conclude that the Laeven and Valencia dataset is the most reliable source based on the event studies methodology.

Fig. 1. Money market pressure indices of money market pressure in 10 countries. Note: This figure plots four money market pressure indices for the selected countries. The first graph for each country shows RMPI and NMPI constructed according to Eq. (1), and the second one presents RMMPI and NMMPI constructed according to Eq. (2).

to Laeven and Valencia (2010). Our sample includes 21 industrial economies and 88 developing economies having 11 and 57 banking crises, respectively. In addition, there are 11 industrial and 46 developing economies without a banking crisis.

Second, following Von Hagen and Ho (2007) there is a crisis if (i) the index exceeds the 98.5 percentile of the sample distribution for the country under consideration and (ii) the index increases by at least 5% compared to the previous period.

Third, we adopt Von Hagen and Ho (2007)'s rule to decide whether a signal identifies a banking crisis in line with Laeven and Valencia (2010). If the signal indicates a banking crisis at most 2 years prior to the start of the crisis according to

Fig. 1 (continued)

Laeven–Valencia or if the signal indicates a banking crisis at most 1 year later than Laeven–Valencia, this signal is considered to be ‘correct’.⁸ If the index does not signal a banking crisis when there is one according to Laeven–Valencia, it is labeled as a ‘missed crisis’. If the index signals a banking crisis when there is none according to the benchmark, it is labeled as a ‘false alarm’ (see Table 3).

The frequency of ‘missed crises’ is defined as the number of crises listed in Laeven–Valencia that are not signaled by the index compared to the total number of crises listed in Laeven–Valencia, while the frequency of ‘false alarms’ is defined as the number of crises signaled by Laeven–Valencia which are not listed in Laeven–Valencia compared to the total number of crises signaled by the index.

⁸ In the sensitivity analysis we also employ a window of $(T - 2, T + 2)$ where T is the crisis period according to Laeven–Valencia.

Table 3

Contingency table for concepts in assessing crisis signals.

Crises	Identified in Laeven–Valencia	Not identified in Laeven–Valencia
Identified in this paper	‘Correct crises’	‘False alarms’
Not identified in this paper	‘Missed crises’	

5. Results

5.1. Comparison of five indices

We first compare the five indices. A first important conclusion is that money market pressure indexes, be it the original index of [Von Hagen and Ho \(2007\)](#) or our index, indicate many more banking crises than the databases based on the events methodology. [Table 4](#) zooms in on ‘missed crises’ and ‘false alarms’. The indices based on nominal interest rates have fewer ‘missed crises’ than those based on real interest rates. Among the five indices, NMMPI has the lowest frequency of ‘missed crises’ and ‘false alarms’, so that we prefer this index to the others.⁹ Moreover, VHH performs ‘worse’ than the other indices.

All indices have very high ratios of ‘false alarms’. However, these signals may not be all wrong. First, the database of [Laeven and Valencia \(2010\)](#) may not identify all banking crises. Indeed, 19 crises ‘wrongly’ identified by NMMPI are crises identified by [Reinhart and Rogoff \(2009\)](#). And another 15 ‘false alarms’ are in line with the crises database of [Caprio and Klingebiel \(1996\)](#) (see [Appendix B](#) for further details).

Second, many ‘false alarms’ identified by NMMPI may indicate events which are not severe enough to be identified as banking crisis by the Laeven–Valencia or other crises databases. For example, even though in Algeria over 4% of GDP was lost each year in public banks during 1991–2002 [Laeven and Valencia \(2010\)](#) do not identify this as a systemic crisis. Likewise, in many other cases there are severe economic problems, such as currency devaluations or economic downturns, which can all lead to periods with high stress in the banking system even though Laeven–Valencia do not consider this stress as sufficient reason to consider the period as a banking crisis. [Appendix C](#) provides further details of these cases. In our view, most of the ‘false alarms’ indicate crises missed by Laeven–Valencia, crises not severe enough to be considered as systemic by Laeven–Valencia, or reflects stress in the banking sector.

5.2. Sensitivity analysis

In this subsection we compare the performance of RMMPI and NMMPI for different samples of countries, sample periods, window lengths, and benchmarks. We use RMMPI for comparison purposes, as it performs better than VHH and RMPI.¹⁰

We first compare the performance of the two indices for different subsamples of countries. [Table 5](#) shows the results of identifying banking crises in industrial economies and developing economies. According to Laeven–Valencia, there were 11 and 57 banking crises in industrial economies and developing economies, respectively. In industrial economies, both RMMPI and NMMPI can signal 8 out of 11 banking crises, while the frequency of ‘false alarms’ of NMMPI is larger than that of RMMPI. Therefore, RMMPI performs better than NMMPI in industrial countries. In developing economies, NMMPI signals crises more ‘accurately’ with fewer ‘missed crises’ and ‘false alarms’ than RMMPI.

To investigate the performance of our indices over time, we divide our sample period into three sub-periods: 1970–1989, 1990–1999, and 2000–2009. [Table 6](#) shows that the frequency of ‘missed crises’ and ‘false alarms’ of NMMPI is lower than that of RMMPI in all three sub-periods.

Because the weights used in constructing the indices are based on the standard deviations of a certain time window, empirical results may differ if we use different window lengths. So, we compare the four indices which are constructed using a moving window to calculate the standard deviations for different time windows. For this test, we choose windows of 12 months, 18 months, 30 months, and 36 months.¹¹ According to the results (available on request), NMMPI has the lowest frequency of ‘missed crises’ and ‘false alarms’ in all four cases.

As outlined in [Section 4](#), we have followed [Von Hagen and Ho’s \(2007\)](#) rule to determine whether a signal ‘correctly’ identifies a banking crisis, i.e. if the signal is in the window of $(T - 2, T + 1)$ where T is the crisis period according to the benchmark it is considered as a correct signal. We have checked how sensitive our results are for this choice. It turns out that slightly enlarging the window to $(T - 2, T + 2)$ gives very similar results. For illustrative purposes, [Table 7](#) shows the outcomes for NMMPI.

⁹ If we follow [Von Hagen and Ho \(2007\)](#) and use the standard deviations of the whole period to construct NMMPI, the results show that the index identifies one less correct crisis, and 12 more wrong crises according to Laeven–Valencia. If we use the crises database of [Reinhart and Rogoff \(2009\)](#) as an alternative, the index identifies one less correct crises, and 9 more wrong crises. As a result, we conclude that NMMPI constructed with rolling standard deviations performs better than that based on standard deviations measured over the entire sample period.

¹⁰ We have done the sensitivity analysis using all indices. The results (available on request) show that RMMPI and NMMPI perform better than the other indices, so we do not show the results for the other indices.

¹¹ If the length of time window is too long, observations will be lost and the signal accuracy will be lower.

Table 4

Assessing the predictive power of the indices.

Index	VHH	RMPI	RMMPI	NMPI	NMMPI
Total number of crises in Laeven–Valencia	68	68	68	68	68
'Correct crises'	37	45	42	49	51
'Missed crises'	31	23	26	19	17
'False alarms'	147	156	130	179	131
Frequency of 'missed crises'	45.59%	33.82%	38.24%	27.94%	25.00%
Frequency of 'false alarms'	79.89%	77.61%	75.58%	78.51%	71.98%

Note: This table shows the predictive power of five monetary pressure indices (see Table 1 for their definition), and zooms in on 'missed crises' and 'false alarms' in identifying banking crises. 'Correct crises' is the number of crises identified in line with Laeven and Valencia (2010).

Table 5

Results for different samples of countries.

	NMMPI	RMMPI
<i>Industrial countries</i>		
Total crises in Laeven–Valencia	11	11
'Correct crises'	8	8
'Missed crises'	3	3
'False alarms'	30	25
Frequency of 'missed crises'	27.27%	27.27%
Frequency of 'false alarms'	78.95%	75.76%
<i>Developing countries</i>		
Total crises in Laeven–Valencia	57	57
'Correct crises'	43	34
'Missed crises'	14	23
'False alarms'	101	105
Frequency of 'missed crises'	24.56%	40.35%
Frequency of 'false alarms'	70.14%	75.54%

Note: See notes to Table 4.

Table 6

Results for different periods.

Index	Period	1970–1989	1990–1999	2000–2009
NMMPI	Total crises in Laeven–Valencia	14	41	13
	'Correct crises'	8	32	11
	'Missed crises'	6	9	2
	'False alarms'	30	45	56
	Frequency of 'missed crises'	42.86%	21.95%	15.38%
	Frequency of 'false alarms'	78.95%	58.44%	83.58%
RMMPI	'Correct crises'	4	30	8
	'Missed crises'	10	11	5
	'False alarms'	20	41	69
	Frequency of 'missed crises'	71.43%	26.83%	38.46%
	Frequency of 'false alarms'	83.33%	57.75%	89.61%

Note: See notes to Table 4.

Finally, we check whether our results depend on the crises database used for comparison purposes. As an alternative, we use the banking crises listed by Reinhart and Rogoff (2009). According to this database, our sample includes 65 banking crises from 1977 to 2009.

As Table 8 shows, NMMPI still has the lowest frequency of missed crises and false alarms, in line with our previous findings. Particularly, NMMPI with a time window of 24 months to calculate standard deviations signals banking crises 'more accurately' than the other indices.¹²

6. Decision rule to identify crises

Our main conclusion from the results in the previous section is that NMMPI with a time window of 24 months to calculate standard deviations signals banking crises most 'accurately'. However this conclusion is based on the decision rule of Von

¹² If we compare the signals according to the Von Hagen and Ho (2007) index using the Reinhart–Rogoff database, the results show that VHH can identify 40 crisis 'correctly' and 143 'incorrectly'. So NMMPI performs better than VHH.

Table 7

Two types of errors for different crises periods.

	'Missed crises'	'False alarms'
NMMPI	17	131
NMMPI with different window	13	125

Note: This table shows the two types of errors for two indices. If there is a crisis at time T in the benchmark, the signal of NMMPI is correct if it falls in the period of $[T - 2, T + 1]$. In the alternative this period is set at $[T - 2, T + 2]$.

Table 8

Robustness test using the benchmark of Reinhart and Rogoff (2009).

Index	RMPI	RMMPI	NMPI	NMMPI
<i>Window = 12 Months</i>				
Total crises in Reinhart–Rogoff	67	67	67	67
'Correct crises'	46	44	47	45
'Missed crises'	21	23	20	22
'False alarms'	168	148	181	140
Frequency of 'missed crises'	31.34%	34.33%	29.85%	32.84%
Frequency of 'false alarms'	78.50%	77.08%	79.39%	75.68%
<i>Window = 18 Months</i>				
Total crises in Reinhart–Rogoff	67	67	67	67
'Correct crises'	44	42	42	48
'Missed crises'	23	25	25	19
'False alarms'	160	141	187	140
Frequency of 'missed crises'	34.33%	37.31%	37.31%	28.36%
Frequency of 'false alarms'	78.43%	77.05%	81.66%	74.47%
<i>Window = 24 Months</i>				
Total crises in Reinhart–Rogoff	65	65	65	65
'Correct crises'	46	44	39	46
'Missed crises'	19	21	26	19
'False alarms'	152	125	182	133
Frequency of 'missed crises'	29.23%	32.31%	40.00%	29.23%
Frequency of 'false alarms'	76.77%	73.96%	82.35%	74.30%
<i>Window = 30 Months</i>				
Total crises in Reinhart–Rogoff	64	64	64	64
'Correct crises'	41	40	40	44
'Missed crises'	23	24	24	20
'False alarms'	154	129	167	134
Frequency of 'missed crises'	35.94%	37.50%	37.50%	31.25%
Frequency of 'false alarms'	78.97%	76.33%	80.68%	75.28%
<i>Window = 36 Months</i>				
Total crises in Reinhart–Rogoff	62	62	62	62
'Correct crises'	42	39	38	43
'Missed crises'	20	23	24	19
'False alarms'	149	128	164	134
Frequency of 'missed crises'	32.26%	37.10%	38.71%	30.65%
Frequency of 'false alarms'	78.01%	76.65%	81.19%	75.71%

Note: This table shows the results of four indices with the crises given by Reinhart and Rogoff (2009). In this table, we show the results with the rolling time window of 12, 18, 24, 30, and 36 months for calculating the standard deviations. "Correct crises" is the number of crises the index identifies correctly according to Reinhart–Rogoff.

Hagen and Ho (2007) to identify banking crises, i.e. a threshold equal to the 98.5% percentile and a 5% growth rate of the MPI compared to the previous period.

In this section we try to find the optimal decision rule in identifying banking crises when using our preferred index, NMMPI. To this purpose, we will adopt the loss function given by Demirgüç-Kunt and Detragiache (2000) to weight 'missed crises' and '(false) alarms'.¹³

First, we describe how to construct a loss function for a money market pressure index. Let H be the value of the threshold in the decision rule, i.e. the 98.5% percentile set by Von Hagen and Ho.¹⁴ If the value of the index exceeds H , and its growth rate is larger than 5%, the index will issue a crisis signal. Let $p(H)$ be the probability that the index issues a crisis signal, and $e(H)$ be

¹³ An alternative way to introduce the trade-off between missed crises and false alarms is the receiver operating characteristic as recently used in business cycle analysis (see Berge and Jorda, 2011).

¹⁴ Changing the second condition of the decision rule, i.e. the index shows an increase compared to the previous period of at least 5%, has little impact on the empirical results. Results are available on request.

Fig. 2. Loss functions for NMMPi with different values of $(c_2 - c_1)$. Note: This figure plots the values of loss function shown in Eq. (4). The vertical axis shows values of the loss function, the horizontal axis shows values of the first threshold for identifying crises set by Von Hagen and Ho (2007). For instance, Von Hagen and Ho (2007) uses the 98.5% percentile.

the probability of a ‘missed crisis’, i.e. the joint probability of a crisis occurring and no crisis signal issued. Also, let c_1 be the cost of taking preventive actions when there is a crisis signal, and let c_2 be the cost of a banking crisis if it is not recognized relative to the case when the crisis has been identified. Then, a simple expected loss function can be constructed as follows:

$$L(H) = p(H)c_1 + e(H)c_2. \quad (3)$$

In addition, let $a(H)$ be the probability of no signals conditional on a crisis occurring, let $b(H)$ be the probability of issuing a crisis signal conditional on no crises occurring, and let p_0 denote the (unconditional) probability of a banking crisis. Then, Eq. (3) can be rewritten as

$$L(H) = c_1[(1 - a(H))p_0 + b(H)(1 - p_0)] + c_2a(H)p_0 = p_0c_1 \left[1 + \left(\frac{c_2 - c_1}{c_1} \right) a(H) + \left(\frac{1 - p_0}{p_0} \right) b(H) \right]. \quad (4)$$

It follows that the larger c_2 is relative to c_1 , missed crises are considered more important than false alarms (and vice versa).

To estimate the values of the probabilities, we can use in-sample frequencies. Specifically, we take p_0 to be equal to the frequency of banking crises occurring in the whole sample according to Laeven–Valencia, namely 0.099. The probabilities $a(H)$ and $b(H)$ depend on the value of the threshold H .¹⁵ For example, if we set $H = 98.5\%$, then $a(0.985)$ is the associated probability of ‘missed crises’. Similarly, $b(0.985)$ is the probability of ‘false alarms’.

¹⁵ In our paper, $a(H)$ equals $\#(\text{missed crises})/\#(\text{total crises in the benchmark})$, and $b(H)$ equals $\#(\text{years of false alarms})/\#(\text{years of no crises according to the benchmark})$.

In our analysis we let the value of H vary between 90% and 99% (with steps of 0.1%) to examine which value of the threshold gives the best performance of the indices. Without loss of generality, we set c_1 equal to 1 and let $(c_2 - c_1)$ vary from 5 to 50 in steps of 5.

Fig. 2 shows the values of the loss function for NMMPI using a time window of 24 months to calculate standard deviations.¹⁶ When $c_2 - c_1 = 5$ or 10, the minimum of the loss function is obtained when the threshold of H is very close to the threshold of Von Hagen and Ho (2007) that we also use (98.5%).

Increasing the costs of ‘missed crises’ (c_2) compared to the costs of ‘(false) alarms’ (c_1), the optimal threshold decreases as expected. Moreover, when $c_2 - c_1$ equals 25 or more, the optimal threshold will converge to about 92.1%.

Thus, the Von Hagen and Ho threshold of 98.5% is better suited for policy makers who dislike ‘false alarms’, and who believe that even ‘false alarms’ can bring about large costs. In contrast, policy makers who are afraid of ‘missing crises’ should choose the 92.1% threshold.

7. Conclusion

The identification of banking crises is crucial for further research on banking crises. Without a proper identification of crises, research on the determinants or consequences of crises will be rather futile. Different from the events methods, Von Hagen and Ho (2007) proposed an index of money market pressure to identify banking crises. In our view, the advantages of a monetary market pressure index include that it is less subjective, available at a higher frequency (several countries are not included in the most widely used crises databases) and timelier (as it relies on less information). We modify the Von Hagen–Ho index and apply it to a large set of countries, excluding countries with a repressed financial system. The main change is that in our modified index nominal interest rates are used instead of real interest rates as the former better capture money market stress, notably in developing countries. To avoid sample selection bias, our sample includes not only countries that suffered from one or more banking crises but also includes countries without banking crises. Our sample consists of 109 countries (21 industrial economies and 88 developing economies). We employ the database of banking crises of Laeven and Valencia (2010) for comparison purposes.

Our findings suggest that our preferred index outperforms the index of Von Hagen and Ho (2007). The crises identified by our MPI are more in line with the crises identified by Laeven and Valencia (2010), while the index also gives fewer ‘false alarms’. This conclusion is robust when we use different groups of countries, different periods and different time windows.

We also find that money market pressure indexes, be it the original index of Von Hagen and Ho (2007) or our modified index, suggest many more banking crises than those included in the database of Laeven and Valencia (2010). We argue that most of the ‘false alarms’ are crises missed by Laeven–Valencia, crises not severe enough to be considered as systemic by Laeven–Valencia, or reflects stress in the banking sector. Finally, we show that the 98.5% threshold used in the Von Hagen and Ho decision rule corresponds to a policy maker who dislikes ‘false alarms’ relative to ‘missed crises.’

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Appendix A

Summary of crises identified by different indicators.

Country	(1) L&V (2010)	(2) NMMPI	(3) VHH (2007)	(4) VHH replicated in this paper
Albania	No	1997–1998		1997
Algeria	No	1998		1998–1999
		2005		
Angola	No	1999–2001		1999
				2009
Argentina	1980–1982	1983		1982
	1989–1991	1989–1990	1989–1990	1989–1991
	1995			
	2001–2003			

¹⁶ Due to space limitations, we only show figures for $c_2 - c_1 = 5, 10$, and 25. Outcomes for higher values of $c_2 - c_1$ are available on request.

Appendix A (continued)

Country	(1) L&V (2010)	(2) NMMPI	(3) VHH (2007)	(4) VHH replicated in this paper
Armenia	No	1999		1999 2008
Austria	No	1977–1981 1988		1977–1981
Azerbaijan	No	2009		2001 2006
Bahamas, The	No	1983–1987 1990		1978–1980 1984–1985 1990
Bangladesh	No	2006–2008		1996
Barbados	No	1981–1983 1989–1992		1981–1983 1989–1991
Benin	No	2007–2008		2008
Bolivia	No	2002–2003		2002–2004
Botswana	No	2004		2005
Brazil	1990–1994 1994–1998	1994–1998	1989	1990 1997 2001
Bulgaria	1996–1997	1996		1995–1996
Burkina Faso	1990–1994	1979–1981 1992 2007		1977–1981
Burundi	1994–1998	1995–1996 2001		1991 1995–1996
Cameroon	1987–1991 1995–1997	1988–1990 1994–1997		1984 1987–1990
Canada	No	1985–1986 1991–1992		1979–1980 1985–1986
Cape Verde	No	2000–2003		2000–2003
Central African Republic	1995–1996	1994–1996 1998		1983–1985 1994 1999
Chad	1992–1996	1990–1994		1988–1989 1997 1998
Chile	No	2004	1984	2004
Colombia	1998–2000	1999		2005–2007
Congo, Republic of	1992–1994	1994–1995 2007		1995 1998–2000
Costa Rica	1987–1991 1994–1995	1986–1990 1994–1995		1985–1986 1994 1997
Croatia	1998–1999	2008–2009		2003 2001 2009

(continued on next page)

Appendix A (continued)

Country	(1) L&V (2010)	(2) NMMPI	(3) VHH (2007)	(4) VHH replicated in this paper
Cyprus	No	1998		
		2006		2004–2006
Czech Republic	1996–2000	1997–1998		
		2005		2005–2008
Denmark		1977–1980		
		1982	1982	
		1993	1993	1993–1995
				2001–2004
	2008–2009			2008
Dominican Republic	No	2003–2004		2003
				2009
Ecuador	1982–1986			
		1992–1993		1992
	1998–2002	1998		1998–1999
Egypt	No	2003		
		2008		2007
El Salvador	No	1999		1999
Estonia	No	1997		1996
				2005–2006
Fiji	No	1994–1996		1994–1997
		2000		
Finland		1986	1989	
	1991–1995	1991–1992		1991–1996
				1997
France	No	1979–1982		1978–1979
		1992		1992–1993
Gabon	No	1994–1998		1992–1995
				2002
Gambia, The	No	1987–1990		
				1998
		2002		
				2008
Georgia	No	2003–2006		2004–2006
Greece	No	1991	1984	
		1997		1997–2000
Guatemala	No	2001		2001
Haiti	1994–1998			
		2000–2003		2000–2003
Honduras	No			1986
		1994–1995		1991
Hungary	1991–1995	1993		
				2001
	2008–2009	2008		2006–2008
Iceland	No	2001–2002		2002–2005
Indonesia			1985	1990–1993
	1997–2001	1997–1998		1998
				2005
Israel	No	1988–1991		1989–1993
		1993		
Italy	No		1992	
		1995–1997		1998
Jamaica	No	2002		2000
		2009		2009
Japan			1980	
			1985	

Appendix A (continued)

Country	(1) L&V (2010)	(2) NMMPI	(3) VHH (2007)	(4) VHH replicated in this paper
	1997–2001	1995–1997		1995
Jordan	No	2006		2003–2004
Kazakhstan		2004–2006		2004–2005
		1999		2003–2004
Kenya	2008–2009	2007		
	1985	1982		1978
	1992–1994	1993–1994	1993	1992–1994
		2002		2002–2003
Korea, Republic of		1984		1984–1987
		1989–1992		1989–1992
Kuwait	1997–1998	1997		1997
	No	1995–1998		1998–2000
		2000		2009
Kyrgyz Republic	1995–1999	1998		1999–2000
Latvia	1995–1996			
		2001		2001
Lithuania	2008–2009	2009		2008
	1995–1996	1996		
		1999		1998–1999
Macedonia, FYR ^a	No	1996		
		2006		2006–2007
Malawi	No	1992		1992
				1997
		2006–2008		2006–2008
Malaysia	1997–1999	1997–1998		1997
				2001
				2008
Mali	1987–1991	1992		
				1996–1998
		2008		2007
Mauritius	No	1983		1981
		1993–1994		1993
		2001		2001
		2008		2008
Mexico	1981–1985			
	1994–1996	1994–1995		1994
		1998–1999		
				2005–2009
Moldova	No	1998		
		2006		2009
Mongolia		1997–1998		1998
	2008–2009	2008		2008
Morocco	No	2000		
		2005		2008–2009
Mozambique	No	2001–2005		2001–2005
Myanmar	No	1996		
		2006		2003
Namibia	No	2007		2006
Nepal	1988	1989		1985
		1990		1988
		2005–2008		2003–2006
				2008
Netherlands	No	1978–1979		
			1981	1983–1984

(continued on next page)

Appendix A (continued)

Country	(1) L&V (2010)	(2) NMMPI	(3) VHH (2007)	(4) VHH replicated in this paper
		1988	1986	1990
Nicaragua	1990–1993 2000–2001	1990		1996 1990
Norway	1991–1993	1982–1986 1992		1986–1987
Oman	No	2004		2004–2006 2004
Pakistan	No	1981–1985 1991–1992 1996–2000		1981 1997–2000 2003–2006
Panama	No	2006		2005
Paraguay	1995	1997		1997 2005–2006
Peru	No	2009 1998 2008		2005–2008 1990
Philippines	1997–2001	1989–1990 2001		2000–2001
Poland	1992–1994	1993–1994		1997 2002 2008
Portugal	No		1985	
Romania	No	1990–1992 1999	1991	1993–1994
Russian Federation	1998 2008–2009	1998 2008		2008–2009 2008
Rwanda	No	2005		2005
Senegal		1981–1983		1987–1988
	1988–1991	1992 1993	1995	1994–1998
Sierra Leone	1990–1994	1996 2008–2009		1996 2008–2009
Slovak Republic	1998–2002	2006		2006
Slovenia	No	1995–1999		2001–2002
South Africa	No	1981–1983 1989 2001		2001–2002 2007
Spain	1977–1981	1978 1983–1987	1983 1993	1990–1993 1981–1983
Sri Lanka	1989–1991	1981–1983 1989–1990		1990 2004 2009
Suriname	No	1995–1997		1995
Swaziland	1995–1999	1998 2004–2006		2004–2006

Appendix A (continued)

Country	(1) L&V (2010)	(2) NMMPI	(3) VHH (2007)	(4) VHH replicated in this paper
Sweden	2008–2009	2008	1992	2008
Syrian Arab Republic	No	2003–2005		1995–1998
Tanzania	No	2008		
Thailand	1983	1997–1998		1997–1998
Trinidad and Tobago	1997–2000	1985	1981	1997–2001
Tunisia	No	1997		1986–1988
Turkey	1991	1986–1989		1991–1994
Uganda		1991–1995		1994–1996
Ukraine		1989–1991		2001–2004
United States		1994	1996	
Uruguay	2000–2001	2000–2001		1999–2001
Yemen, Republic of	1994	2001–2005		2001–2005
Zambia				2006
	1998–1999	2008–2009		2008
	2008–2009	1978–1980		
	1988			
	2007–2009	2008		2008
			1981–1984	
		1998		1998
	2002–2005	2002		
		2008		2007–2008
	No	2009		2009
	1995–1998	1993–1995		1990
				1995

Note: This table shows banking crises according to [Laeven and Valencia \(2010\)](#), and signalled crises according to several pressure indexes for all countries in our sample. Column (1) shows the crises listed in [Laeven and Valencia \(2010\)](#) using our sample, where “No” indicates that there is no crisis. Column (2) shows all crises identified by our preferred index, *NMMPI*. Column (3) shows the crises according to the index of [Von Hagen and Ho \(2007\)](#), while column (4) shows the crises if we apply the method of [Von Hagen and Ho \(2007\)](#) to our data.

^a For Macedonia, FYR, our sample starts from 1996, and there is a banking crisis during 1993–1995 according to Laeven–Valencia.

Appendix B

Signaled crises according to NMMPI that are in line with crises according to [Reinhart and Rogoff \(2009\)](#) and/or [Caprio and Klingebiel \(1996\)](#).

Country	Signaled crises	Crises periods in the literature
Angola	1999–2001	1992–1998
Bahamas, The	1983–1987; 1990	Late 1980s
Canada	1985–1986	1983–1985
Central African Rep	1998	1988–1999
Dominican Rep	2003–2004	2003
Estonia	1997	1998
France	1992	1994–1995
Gabon	1994–1998	1995–?
Gambia, The	1987–1990	1985–1992
Greece	1991	1991–1995

(continued on next page)

Appendix B (continued)

Country	Signaled crises	Crises periods in the literature
Guatemala	2001	2001
Italy	1992–1995	1990–1995
Kenya	1982	1985–1989
Kenya	2002	1996–2002
Korea, Rep	1984; 1989–1992	1983–1988
Latvia	2001	1995–2002
Mexico	1998–1999	1994–2000
Myanmar	1996	1996–?
Nepal	1990	1988
Norway	1982–1986	1988–1993
Paraguay	1997	1995–2002
Peru	1998	1999
Philippines	1989–1990	1981–1987
Romania	1999	1990–2002
Senegal	1993	1988–1991
Sierra Leone	1996	1990–2002
Spain	1983–1987	1977–1985
Tanzania	1997–1998	Late 1980s; 1990s
Thailand	1985	1980–1987
Tunisia	1994	1991–1995
Turkey	1994	1994
Uganda	2001–2005	1994–2002

Note: This table summarizes the crises identified by NMMPI that are not in line with the database of [Laeven and Valencia \(2010\)](#), while they are in line with the crises periods as identified by [Reinhart and Rogoff \(2009\)](#) and [Caprio and Klingebiel \(1996\)](#). The second column indicates the crises periods identified by NMMPI. The third column indicates the crises periods given by [Reinhart and Rogoff \(2009\)](#) and/or [Caprio and Klingebiel \(1996\)](#).

Appendix C

Signals which coincide with stress.

Country	Signaled crises	Events	Source
Albania	1997–1998	In 1997, the Rural Commercial Bank, a state-owned bank, was closed	http://www.bankofalbania.org/web/Brief_History_of_Banking_Supervision_in_Albania_52_2.php
Algeria	1998; 2005	Public banks' losses averaged over 4% of GDP each year from 1991 to 2002. Financial restructuring of banks occurred in 1991–1994, 1995–1998, and 2001	http://www.imf.org/external/pubs/ft/scr/2004/cr04138.pdf
Armenia	1999	In 2000, RNPL reached a peak of 17.5%	http://www.financebycountry.com/Armenia/indicator-non_performing_loans/
Bolivia	2002–2003	The average RNPL for 2001–2003 is about 17%	http://www.financebycountry.com/Bolivia/indicator-non_performing_loans/
Canada	1991–1992	In 1991–1992, 9 financial companies collapsed.	http://en.wikipedia.org/wiki/Canada_Deposit_Insurance_Corporation#List_of_financial_collapses_since_1967
Chile	2004	Affected by the crisis in Argentina in 2002	http://www.eclac.cl/cgi-bin/getProd.asp?xml=/prensa/noticias/comunicados/9/10739/P10739.xml&xsl=/prensa/tpl-i/p6f.xsl&base=/tpl/top-bottom.xslt
Czech Republic	2005	The average RNPL in 2001–2003 is about 8.5%	http://www.financebycountry.com/Czech-Republic/indicator-non_performing_loans/
Denmark	1993	Crises occurred in 1987–1992	Von Hagen and Ho (2007)

Appendix C (continued)

Country	Signaled crises	Events	Source
El Salvador	1999	Two bank failures in 1997 and 1998	http://www.frbatlanta.org/filelegacydocs/erq306_quispe.pdf
Finland	1986	The incompatibility of prudential regulation with the more competitive environment of the late 1980 was a reason for the fragility of the banks which was revealed in the Finnish banking crisis of the early 1990s	http://www.bancaditalia.it/studiricerche/convegni/atti/Financial_Market_Regulation/sessione_a/paper_TARKKA.pdf
Fiji	1994–1996	State-owned banks failed in the 1990s, requiring restructuring and recapitalization	http://www.microfinance-pasifika.org/assets/newsitefiles/reports/ADB_Pacific_Financial_Sector_Review_Vol_1.pdf
Georgia	2003–2006	The average RNPL for 2001–2002 is about 10.3%.	http://www.financebycountry.com/Georgia/indicator-non_performing_loans/
Greece	1997	Up to the second half of the 1990s almost 2/3 of Greek banks were controlled by the State and were moreover, badly run	http://www.bis.org/review/r060907c.pdf
Honduras	1994–1995	The average RNPL for 1998–2000 is about 11%	http://www.financebycountry.com/Honduras/indicator-non_performing_loans/
Iceland	2001–2002	In 2001 the banking system was deregulated in Iceland. The big and aggressive growth of Iceland's banks started to become remarkable, because of the small economy of Iceland	http://www.studymode.com/essays/Icelandic-Bank-System-972315.html
Israel	1988–1991	In 1986, the Shekel's link to the U.S. Dollar was broken	http://intl.econ.cuhk.edu.hk/exchange_rate_regime/index.php?cid=24
Jamaica	2002	From 1996 to 2002, the banking system had a negative asset growth rate and the RNPL was 12.43%	http://boj.org.jm/uploads/pdf/papers_pamphlets/papers_pamphlets_An_Early_Warning_Model_of_Bank_Failure_in_Jamaica_An_Information_Theoretic_Approach.pdf
Kazakhstan	1999	Between 1998 and 2001 the number of banks decreased from 71 to 48 due to bank regulation	http://images.mofcom.gov.cn/ozs/table/kaza/banking.pdf
Kuwait	1995–1998; 2000	From 1998 to 2000, the RNPL increase from 10.3% to 19.2%	http://www.financebycountry.com/Kuwait/indicator-non_performing_loans/
Macedonia, FYR	2006	The average RNPL for 2002–2005 is about 20%	http://www.financebycountry.com/Macedonia/indicator-non_performing_loans/
Moldova	1998	Affected by the crisis in Russia in 1998	http://en.wikipedia.org/wiki/Economy_of_Moldova
Mongolia	1997–1998	There was a banking crisis in 1998–1999	http://www.mongolbank.mn/eng/listfinstability.aspx?did=5
Morocco	2000; 2005	The average RNPL for 2001–2003 is about 20%	http://www.financebycountry.com/Morocco/indicator-non_performing_loans/
Mozambique	2001–2005	The average RNPL for 2001–2005 is about 17.5%	http://www.financebycountry.com/Mozambique/indicator-non_performing_loans/
Oman	2004	The average RNPL for 2003–2004 peaked at about 12%	http://www.financebycountry.com/Oman/indicator-non_performing_loans/
Pakistan	1991–1992; 1996–2000	The banking sector of Pakistan went through major reforms since 1990; at the end of the 1990s loan default rates increased	http://www.ukessays.com/essays/economics/how-privatization-effects-banking-sector-of-pakistan-economics-essay.php#ixzz2enUEcGaB
Portugal	1990–1992	Crises occurred in 1986–1989	Demirgüç-Kunt and Detragiache (2005)

(continued on next page)

Appendix C (continued)

Country	Signaled crises	Events	Source
Rwanda	2005	The average RNPL for 2001–2005 is about 45%	http://www.financebycountry.com/Rwanda/indicator-non_performing_loans/
Slovenia	1995–1999	The only bankruptcy in the banking system in Slovenia took place in the year 1996	http://www.oecd.org/finance/financial-markets/49497940.pdf
South Africa	1981–1983	Financial crises occurred due to default of foreign banks in 1985	Demirgüç-Kunt and Detragiache (2005)
South Africa	2001	Three banks failed in 2001–2002	http://www.resbank.co.za/Publications/Reports/Documents/Annual%20Report%202001.pdf
Suriname	1995–1997	In 1994 the inflation rate was over 400%	http://www.encyclopedia.com/topic/Suriname.aspx
Syrian Arab Republic	2003–2005	In 2004–2005, the fast-paced credit expansion is likely to have weakened the quality of banks' loan portfolios – given weak risk management practices—and made banks run into liquidity problems	http://www.bi-me.com/main.php?id=5344&t=1&c=6&cg=2&mset=
United States	1978–1980	Crises occurred in 1980–1992	Von Hagen and Ho (2007)

Note: This table indicates important events during the periods identified by NMMPI. The second column lists the crises periods, the third column lists the important events, and the last column lists the resources from where we collect the information. “RNPL” denotes the ratio of non-performing loans to total assets.

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