Macro-Financial Vulnerabilities and Future Financial Stress

- Assessing Systemic Risks and Predicting Systemic Events[1]

This version: 1 April 2010

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Abstract

The paper develops a framework for assessing systemic risks stemming from domestic and global macro-financial vulnerabilities, and for predicting systemic events. We consider both "stand-alone" macroprudential indicators of vulnerabilities and composite indicators using discrete choice models. We evaluate the ability of the indicators to predict systemic events on the basis of assumptions on policy makers' preferences between issuing false alarms and missing systemic events. The results show that there are significant gains in modelling jointly global and domestic vulnerabilities, together with their interactions. Our model displays a good out of sample performance in predicting the 2008/2009 financial crisis.

JEL Codes: E5, F3, G01
Keywords: systemic risk, systemic event, financial stress, macroprudential analysis, asset boom, credit bubbles, emerging economies

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[1] The authors want to thank Marcel Fratzscher, Daniela Bragoli, Alexander Chudik, Michael Fidora, Emilia Perez, Mardi Dungey, Jean Imbs and Livio Stracca for useful discussions. Also comments from the ECB Workshop "Tools for detecting asset price imbalances, the role of money and credit and the impact on consumer price inflation", held in Frankfurt 15 December 2009. All remaining errors are of our own. The views presented in the paper are those of the authors and do not necessarily represent the views of the European Central Bank or the Eurosystem.
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Non-technical summary

The paper develops a framework for assessing systemic risks stemming from domestic and global macro-financial vulnerabilities, and for predicting systemic events. To capture systemic events, we construct a country-level Financial Stress Index (FSI) that measures a broad set of tensions in a country's financial markets due to realisations of negative shocks, such as bursts of asset price bubbles, banking, currency and financial crises. We then evaluate the performance of a set of indicators in predicting episodes of extreme financial stress (systemic events). We consider both "stand-alone" macroprudential indicators of vulnerabilities and composite indicators using discrete choice models. The evaluation of the indicators is done on the basis of assumptions on policy makers' preferences between issuing false alarms and missing systemic events (Bussière and Fratzscher, 2008). Policy makers' preferences are also used to estimate the optimal thresholds for potential policy action.

We extend the existing literature in several ways. First, in contrast to Borio and Lowe (2002) and other more recent contributions in macroprudential literature, we use quarterly data and extend the coverage to emerging economies. Second, we construct a country-specific Financial Stress Index that improves the approaches by the IMF (2009) and the ECB (2009a) by adopting a robust method of aggregation that makes the index more stable for updates. In the analysis, we focus on the prediction of systemic events, i.e. episodes of extreme financial stress that could lead to negative real economic consequences[3]. Third, when analysing the effectiveness of "stand-alone" indicators in predicting systemic events, on top of traditional indicators of domestic and global vulnerabilities, we also test the interaction between domestic factors, as well as the interplay of global asset price and credit developments with the domestic conditions. Fourth, when assessing systemic risks with discrete choice models, we jointly model domestic and global macro-financial vulnerabilities as well as their interactions.

Our results show, in line with Borio and Lowe (2002) and Gerdesmeier et al. (2009) that stand-alone measures of asset price misalignments and credit booms are in general useful leading indicators of systemic events. Interestingly, in line with other studies (e.g. Alessi and Detken, 2009), global measures of liquidity and asset price developments perform better as stand-alone leading indicators than indicators of domestic fragilities. Interactions between domestic variables as well as between global and domestic variables are among the best stand-alone indicators. However, our results highlight the importance of considering jointly various indicators in a multivariate framework, as we find that discrete choice models outperform stand-alone indicators of vulnerabilities. There are significant gains in taking into account jointly domestic and global macro-financial vulnerabilities as well as their interactions. Interestingly, we find that the determinants of systemic risks are the same in emerging and advanced economies. The main difference between emerging markets and advanced economies is the relative importance of the different factors, with the emerging markets being more exposed to global factors. Moreover, we show that our preferred model outperforms several benchmarks and displays a good out of sample performance in predicting the 2008/2009 financial crisis.

[3] In the benchmark case, we consider extreme financial stress episodes when the FSI is in the 90^{th} percentile of the country-specific distribution.

Finally, we use our framework to analyse the current vulnerabilities, and find that the systemic risks are generally low across key economies in the global economy. However, this situation can evolve rapidly due to domestic overheating pressures, especially in emerging Asia.

1 Introduction

The current financial turmoil has demonstrated the importance of understanding and measuring systemic risks and predicting systemic events, i.e. events *when financial instability becomes so widespread that it impairs the functioning of the financial system to the extent that economic growth and welfare suffer materially*. Consequently, systemic risk can be defined as the probability that a systemic event occurs.[4]

Recently, Cardarelli et al. (2009) show that out of 113 financial stress episodes since 1980 identified for 17 main advanced economies, 29 were followed by an economic slowdown and an equal number by recessions. The remaining 55 financial stress episodes were not followed by an economic downturn[5].

Financial instability and stress can impact economic activity through various channels. First, shocks that affect the creditworthiness of borrowers tend to strengthen the output fluctuations through the financial accelerator, as changes in the values of collateral impact the willingness of the financial system to provide credit to the economy (Bernanke and Gertler, 1995, and Bernanke et al., 1999, Kiyotaki and Moore, 1997). Second, factors that impact lenders' balance sheets can magnify economic downturns as if banks' capital is weakened, banks may become more reluctant to provide capital to the real sector or can even be forced to deleverage, leading to sharper economic downturns (Bernanke and Lown, 1991, Kashyap and Stein, 1995). Third, the development and structure of the financial system determine how large is the interconnection between real and financial sectors in the economy (IMF, 2006, Rajan and Zingales, 2003).

Borio and Lowe (2002) show that widespread financial distress typically arise from the unwinding of financial imbalances that build up disguised by benign economic conditions, such as low inflation. In particular, the authors show, using annual data for 34 countries (13 emerging economies) for 1960-1999 that sustained rapid credit growth combined with large increases in asset prices (equity) appear to increase the probability of episodes of financial instability. Recently, Cardarelli et al. (2009) show that a building up of balance sheet vulnerabilities, associated with a rapid expansion of credit and a run-up in house prices contribute to a higher likelihood that stress in the financial system will lead to more severe economic downturns in 17 main advanced economies. Moreover, in a paper closely related to our study, Misina and Tkacz (2009) investigate whether credit and asset price movements can help to predict financial stress in Canada by using linear and non-linear threshold models. According to their findings, business credit emerges as an important leading indicator among all variables considered in their study. Moreover, at the one-year horizon, which could be

[4] See the definition of the concept of systemic risk in the ECB Financial Stability Review, December 2009.

[5] The authors find that on average, the time lag between the onset of financial stress and the slowdown or recession that follows was about seven months. More importantly, the median cumulative output losses (relative to trend or until recovery) in downturns that follow financial stress episodes were about 2.8 percent of GDP for slowdowns and about 4.4 percent of GDP for recessions, significantly larger than in episodes of slowdowns and recessions that were not preceded by financial stress (about 1.6 and 2.3 percent, respectively). One should note, however, that the authors do not control for the economic policy responses, while calculating the output losses.

of interest to forward-looking policy-makers, there is little to distinguish the linear and threshold specifications.

This paper builds upon the above studies to develop a framework for assessing systemic risks, stemming from domestic and global macro-financial vulnerabilities, and for predicting systemic events. To capture systemic events, we construct a country-level Financial Stress Index (FSI) that measures a broad set of tensions in a country's financial markets due to realisations of negative shocks, such as bursts of asset price bubbles, banking, financial and currency crises.

We then evaluate the performance of a set of indicators in predicting episodes of extreme (high) financial stress. In our benchmark case, we focus on episodes of extreme financial stress that have often, i.e. on average and median cases, led in the past to negative consequences for the real economy.[6] However, in order to avoid selection bias by choosing only cases were extreme financial stress have for certainty led to negative real economic consequences, we also consider cases where extreme financial stress has not necessarily led to negative economic outcomes. This is because a policy action (that we cannot control for) might have potentially prevented the negative economic outturn. We define these episodes as **systemic events**, and the probability of a systemic event to occur as **systemic risk**.

In the analysis, we consider both "stand-alone" macroprudential indicators of vulnerabilities and composite indicators based on discrete choice models. The evaluation of the indicators is done on the basis of assumptions on policy makers' preferences between issuing false alarms and missing systemic events (Bussière and Fratzscher, 2008). Policy makers' preferences are also used to estimate the optimal thresholds for potential policy action.[7]

Our results show, in line with Borio and Lowe (2002) and Gerdesmeier et al. (2009) that stand-alone measures of asset price misalignments and credit booms are in general useful leading indicators of systemic events. Interestingly, in line with other studies (e.g. Alessi and Detken, 2009), global measures of liquidity and asset price developments perform better as stand-alone leading indicators than indicators of domestic fragilities. Interactions between domestic variables and between global and domestic variables are among the best stand-alone indicators. However, our results highlight the importance of considering jointly various indicators in a multivariate framework, as we find that discrete choice models outperform stand-alone indicators of vulnerabilities. There are significant gains in taking into account jointly domestic and global macro-financial vulnerabilities as well as their interactions. Interestingly, we find that the determinants of systemic risks are the same in emerging and advanced economies. The main difference between emerging markets and advanced economies is the relative importance of the different factors, with the emerging markets being more exposed to global factors (see e.g. Dungey et al. 2009). Moreover, we show that our preferred model outperforms several benchmarks and

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[6] We consider extreme financial stress episodes when the FSI is in the 90th percentile of the country-specific distribution.

[7] Instead of using arbitrary thresholds as it is common in the currency and banking crisis literature, we calculate, for the first time, the optimal thresholds for the estimated probabilities from the logit model, by using the approach suggested by Alessi and Detken (2009).

displays a good out of sample performance in predicting the 2008/2009 financial crisis.

Finally, we use our framework to analyse the current vulnerabilities, and find that the systemic risks are generally low across key economies in the global economy. However, the situation can evolve rapidly when the recovery of the world economy, especially in the advanced economies, accelerates. Under this scenario, the balancing negative effect of the currently weak global macro environment would vanish and the probability of a systemic event would increase in economies with domestic overheating pressures, especially in emerging Asia.

The remaining of the paper is organised as follows. Chapter 2 introduces the measure for financial stress and definition of systemic events. Chapter 3 describes the data. Chapter 4 presents the empirical analysis, while Chapter 5 concludes.

2 Measuring financial stress and defining systemic events

Construction of the Financial Stress Index

In order to measure financial stress and define systemic events, we construct a *Financial Stress Index (FSI)* for each country in our sample, and evaluate at which levels it has, on average, had negative implications for the real economy[8].

The financial stress index aims at capturing the level of tensions in financial markets that are due to the realisations of negative shocks, such as bursts of asset price bubbles, or banking, financial and currency crises. Typically, when these types of shocks hit the economy, it is possible to observe tensions in one or more market segments, as for example, high volatility in equity, bond and currency markets, high spreads in bond markets and large negative movements in stock prices. The larger and broader is the shock, the higher the co-movement among variables reflecting tensions in different market segments.

Our FSI is a country-specific composite index and it consists of the following five components: (1) the spread of the 3-month interbank rate over the 3-month Government bill rate (Ind_1); (2) negative quarterly equity returns (multiplied by minus one, so that negative returns increase stress; positive returns are disregarded and set to 0) (Ind_2); and the realised volatility (average daily absolute changes over a quarter) of (3) the main equity index (Ind_3); (4) the nominal effective exchange rate (Ind_4); (5) the yield on the 3-month Government bill (Ind_5)[9].

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[8] To our knowledge, the first Financial Stress Index was created by Illing and Liu (2006), who constructed it for Canada. Goldman Sachs, JP Morgan, and Kansas City Fed (see Hakkio and Keeton, 2009) have created financial stress indices for the United States. Moreover, IMF (2008, 2009), presented the work by Cardarelli et al. (2009) and Balakrishnan et al. (2009), who constructed financial stress indices for a broad set of advanced and emerging economies. Finally, ECB (2009a) presents a financial stress index for the global economy, based on work by Fidora and Straub (2009). It should be highlighted that the research on the measurement of financial stress and the construction of indices of capturing systemic events is currently very active (see e.g. Hollo, Kremer and Lo Duca (2010)).

[9] In the calculation of realised volatilities for equity, nominal effective exchange rate and Government bill rate, i.e. components (Ind3) to (Ind5), average daily absolute changes over a quarter were used.

Each component j of the index at quarter t for country i is transformed into an indicator that ranges from 0 to 3 according to the country-specific quartile of the distribution the observation at quarter t belongs to ($q_{j,i}$). For example, a value for component j falling into the fourth quartile of the distribution would be transformed into "3"[10]. Note that each variable is measured in a way that higher values indicate higher stress levels, therefore higher values of the transformed variables indicate higher stress.

The financial stress index is computed for country i at time t as a simple average of the transformed variables as follows:

$$FSI_{i,t} = \frac{\sum_{j=1}^{5} q_{j,i}(Ind_{j,t})}{5}, \; FSI_{i,t} \in [0,3], \text{ where } t \in [1,T], \; i \in [1,N], \text{ and } j \in [1,J] \qquad (1)$$

The key advantage of the standardization method based on quartiles used here is that it is more robust than a standardization based, for example, on mean and variance, i.e. those used by e.g. the IMF (2008, 2009) or the ECB (2009a). Thus, one of the largest advantages of our FSI is that it avoids having substantial revisions of the historical levels of the index as new observations are added to the sample. Revisions of the historical level of the index could complicate the analysis of the financial stress index and its use in econometric models.

The financial stress indexes for countries in the sample are plotted in Charts A1 and A2 in the Appendix. As can be from the Charts, the FSI index captures well the past episodes of high financial stress or crisis, such as the Asian financial crisis of 1997-98, the burst of the IT bubble in 2001 and the global financial crisis of 2008/09. For many advanced economies, the global financial crisis of 2008/09 led to the highest level of financial stress since the start of the sample in 1990, while in many emerging economies the level of financial stress was even higher during the Asian financial crisis, or during some country-specific crisis, such as the Russian crisis of 1998 or the crisis in Argentina of 2001.

Financial stress and the real economy

Policy makers' main concern regarding financial stress is that financial instability could become so widespread that it would impair the functioning of the financial system to the extent that economic growth and welfare suffer materially. Therefore, it is important to study the relationship between the Financial Stress Index and measures of real economic activity, and to calibrate the thresholds for the FSI at which negative economic outcomes have occurred in the past[11]. One way to do this is to analyse the relationship between the financial stress index and the real GDP.

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[10] The only exception to this standardisation method is the indicator for negative stock market returns. As this indicator is most of the time equal to zero, the standardisation through quartiles leads often to a very volatile variable jumping directly from 0 to 3. Therefore to standardise this variable we just divide this indicator by its maximum value over the sample. We then rescale the transformed indicator so that it ranges from 0 to 3, as all the other components of the financial stress index.

[11] Hakkio and Keeton (2009) perform a similar analysis of the linkages between financial stress shocks and economic performance.

Chart 1 reports the average and median deviation (in percents) of the real GDP from its trend[12] (output gap) for different percentiles of the distribution of the financial stress index. As can be seen from the chart, the levels of the financial stress index above the 70% of the distribution across time and countries in the sample are correlated with negative deviations of the real GDP from its trend (i.e. economic slowdowns or recessions).

(INSERT CHART 1 HERE)

Furthermore, Chart 2 shows the orthogonal impulse response function of a bivariate VAR model[13] with the financial stress index and the real GDP, where the impulse variable is the FSI and the response variable is the deviation of the real GDP from its trend. As can be seen from the chart, a shock that leads the financial stress index above 90% of its distribution leads to a significant slowdown in economic activity after 4 or 5 quarters.

(INSERT CHART 2 HERE)

These findings confirm that high level of financial stress should be a concern for policy makers, as it could lead to a slowdown of the economy or even to a loss of the level of the real output. Thus, our focus will be on periods of extreme financial stress.

Periods of extreme financial stress and systemic events

In order to pursue the objective of the study, namely to assess the level of systemic risks and to predict systemic events, we proceed with the following two steps.

First, we transform our financial stress index into a binary variable that we call a period of "extreme financial stress", taking value 1 when the FSI is above the predefined threshold, which set to 90% of the country distribution of the FSI. Furthermore, every episode of "extreme financial stress" within 6 quarters from the end of another one is considered as a continuation of the first episode.

Second, we define the endogenous variable as a binary variable that takes value 1 if the level of financial stress increases to an extreme level within a time horizon of 6 quarters.[14] Moreover, we disregard the information during periods of extreme stress, as we drop the consecutive observations of extreme financial stress from the sample. We do this as we are interested in predicting whether the level of financial stress could rise to an extreme level within the forecast horizon, and the signal that occurs when the financial stress is already at the extreme level, is not informative of a switch from a low to high period of stress.[15]

[12] The trend is calculated using HP filter with a parameter of 1600.
[13] The ordering of the variables is the real GDP and then the FSI.
[14] We also try time horizons of 2, 4 and 8 quarters. The results are discussed in the section on the robustness tests.
[15] Bussière and Fratzscher (2006) point out that including in the estimation of early warning models the period of economic recovery after a crisis produces the so called "post crisis bias". In recovery periods,

We focus on episodes of extreme financial stress that have often, i.e. on average and median cases, led in the past to negative consequences for the real economy. However, in order to avoid selection bias by choosing only cases were extreme financial stress have for certainty led to negative real economic consequences, we consider also cases where extreme financial stress has not led to negative economic outcomes. This is because a policy action (that we cannot control for) might have potentially prevented the negative economic outturn. We define these episodes as **systemic events**, and the probability of a systemic event to occur as **systemic risk**.

3. Data

In order to assess the level of systemic risks and to predict systemic events, we construct indicators commonly used in the macroprudential literature (see e.g. Borio and Lowe, 2002), to capture building up of vulnerabilities and imbalances both in the domestic and global economy. In this regard, we focus on asset price and credit developments, valuation levels and proxies for leverage in the economy. However, we also control for macroeconomic conditions with a broad set of indicators.

We build a comprehensive dataset of quarterly macro and financial data for period 1990:1-2009:4 for 28 countries, of which 10 advanced countries and 18 emerging economies[16]. All data is obtained either from Haver Analytics, Bloomberg or Datastream. Credit and money variables are seasonally adjusted using X12 seasonal adjustment procedure, and all real variables are deflated using CPI price index.

Table 1 summarises the variables included in the study and provides details on the transformations that are used to ensure that the transformed variables are stationary.

(INSERT TABLE 1 HERE)

Following the approach used in the literature, we test several transformations of the indicators, such as annual changes and deviations from moving averages or trends[17].

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economic variables go through an adjustment process before reaching again the path they have during tranquil periods. The recovery period therefore should be excluded from the analysis as it is not informative of the path leading from the pre-crisis regime to the crisis. Bussière and Fratzscher address this issue by using a multinomial logit model with "three regimes" for the endogenous variable (calm period, crisis and recovery). In our paper, as we drop periods in which stress is high, potentially we already disregard recovery periods, at least partially. However, we check the robustness of our results by dropping observations up to two quarters after the end of the stress periods to ensure that the post crisis bias is addressed. Only marginal gains in the performance of the model are obtained when dropping the additional two quarters.

[16] The advanced countries are the following: Australia, Denmark, Euro area, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. The emerging economies are the following: Argentina, Brazil, China, Czech Republic, Hong Kong, Hungary, India, Indonesia, Malaysia, Mexico, the Philippines, Poland, Russia Singapore, South Africa, Taiwan, Thailand, and Turkey.

[17] We estimate the trend with the Hodrick-Prescott filter. Following Borio and Lowe (2004), we try two different values of the smoothing parameter, namely 1600 and 400,000.

To proxy for global macro-financial imbalances and vulnerabilities, we calculate a set of global indicators by averaging the transformed variables for the following four countries or regions: the United States, euro area, Japan and the United Kingdom.

We also calculate interactions between domestic variables and among domestic and international variables of credit and asset price dynamics, leverage and valuation levels.

Our analysis it is a real time analysis. At each point in time, only the information available to the policy makers up to that point in time is used. This implies that we take into account that certain variables, as for example the GDP, are not available for the policy makers in real time because they are published with delay. To take into account publications delays, we used lagged variables. For GDP, money and credit related indicators the lag ranges from 1 to 2 quarters depending on the country[18].

The real time analysis also implies that de-trended variables are computed using only real time information. Therefore, we recursively calculate trends at each time *t*, using only the information available up to that moment.

4. Empirical Analysis

In order to test the performance of different stand-alone indicators of vulnerabilities and their joint performance in the discrete choice model framework, we follow the approach suggested by Bussière and Fratzscher (2008) and Alessi and Detken (2009). In particular, we evaluate the indicators on the basis of assumptions on policy makers' preferences between issuing false alarms and missing systemic events.

In doing so, we calculate optimal thresholds for policy intervention for both stand-alone indicators of vulnerabilities and, for the first time in the literature, for the probabilities of systemic events estimated with discrete choice models.

The remaining of the section is organised in the following way. First, we describe the approach used to extract signals, while taking into account policy makers' preferences. Second, we report the empirical investigation using stand-alone measures of financial fragilities. Third, we report the empirical investigation with the discrete choice models. Finally we discuss the robustness of our analysis.

Evaluation of signals and calculation of optimal threshold for the indicators

To find out which vulnerabilities are the best indicators of systemic risks and systemic events, and to calibrate the optimal threshold for policy action, we follow the approaches by Bussière and Fratzscher (2008) and Alessi and Detken (2009). According to Alessi and Detken (2009), the optimal threshold for policy action for an indicator is the one that maximises a measure of utility (i.e. "usefulness") that takes into account policy maker preferences between Type I and Type II errors[19]. Once the

[18] However, concerning variables that are subject to revisions, as for example GDP data, we use the latest release of historical values (i.e. the value available when we constructed the dataset).

[19] Normally, the threshold for an indicator is chosen based on some kind of information criteria, e.g. noise-to-signal ratio. Authors such as Bussière and Fratzscher (2008) and Alessi and Detken (2009) highlight that this approach has several drawbacks.

optimal threshold is found for each indicator on the basis of a set of preferences, the best performing indicator is the one that maximises the measure usefulness among all indicators. We discuss next how to calculate the measure of usefulness for an indicator for a given threshold and set of preferences.

As it is common in the signalling literature (Kaminsky, Lizondo and Reinhart, 1998), a signal is issued when the indicator is above the predefined threshold. Consequently, the performance of the indicator can be classified according to the following schema:

	Systemic event within a given time horizon	No systemic event within a given time horizon
The indicator is above the threshold (Signal)	A (correct signals)	B (wrong signals)
The indicator is below the threshold (No Signal)	C (missing signals)	D (correct absence of signals)

Once the occurrence of A, B, C and D are counted, Alessi and Detken (2009) define a loss function that depends on the preferences of the policy maker between Type I and Type II errors:

$$L(\mu) = \mu\ (C\ /(A + C)) + (1 - \mu)\ (B\ /\ (B + D)) \qquad (2)$$

The term $C / (A + C)$ is the share of systemic events that have not been signalled (i.e. the share of missing signals or Type I errors), while $B / (B + D)$ is the share of tranquil (normal) periods that were incorrectly signalled as systemic events (i.e. the share of false alarms or Type II errors).

The parameter μ describes the relative preference of the policy maker between Type I and Type II errors. For a value of $\mu = 0.5$, the policy maker is equally concerned about Type I and Type II errors. The policy maker is less concerned of missing signals when $\mu < 0.5$. Conversely, the policy maker is less concerned of issuing wrong signals when $\mu > 0.5$.

Alessi and Detken (2009) show that if the policy maker disregards the signal given by the indicator (i.e. either she assumes that a signal is never issued or that the signal is always issued) she faces a loss equal to $\text{Min}\ [\mu\ ,\ 1 - \mu]$.

Thus, an indicator is "useful" for the policy maker if the loss obtained by ignoring the indicator is higher than the loss obtained by taking it into consideration. Therefore, Alessi and Detken (2009) define the usefulness U in the following way:

$$U = \text{Min}\ [\mu\ ,\ 1 - \mu] - L\ (\mu) \qquad (3)$$

The measure of usefulness U is computed for each indicator and for each threshold (and for different set of preferences). For a given set of preferences, the best threshold for an indicator is the one that achieves the highest score in terms of U among the tested thresholds. The best indicator is the one that achieves the highest U among all the indicators.

At this stage it is important to clarify (i) how thresholds are selected and (ii) the assumptions on the parameter μ describing policy maker preferences.

We express thresholds as percentiles of the distribution of the indicators by country.[20] This procedure generates country-specific cut off levels for each indicator. Thus, our approach lies between those of Borio and Lowe (2004) and Alessi and Detken (2009). The former test the predictive power of constant cut-off levels across time and countries. The latter express thresholds at time *t* as percentiles of the distribution of the indicators by country up to time *t*, therefore the cut-off levels are country and time dependent. The approach of Alessi and Detken (2009) is the ideal choice for real time analysis, as only the information available to policy makers in real time is used. In our paper we have to depart from this approach as the length of our data sample does not allow us to compute percentiles in real time. However, we adopt the real time approach used in Alessi and Detken (2009), when we evaluate the out of sample performance of our indicators in predicting the 2008-2009 financial crisis.

Regarding policy makers' preferences, in our benchmark analysis we take the point of view of a policy maker who is equally concerned of issuing false alarms and missing systemic events, i.e. we assume that $\mu = 0.5$. This could be considered the point of view of a neutral external observer who does not want to commit any mistakes and is only concerned of correctly calling a systemic event. As discussed by Bussière and Fratzscher (2008) and Alessi and Detken (2009), the point of view of local policy makers or international institutions in charge of giving policy recommendations could be different, as the costs of missing systemic events and issuing false alarms are different (e.g. through reputational costs or real costs). It is likely that the 2008-2009 crisis increased the concerns of policy makers of missing systemic events. However, it is difficult to assess whether policy makers could be assumed to be relatively more concerned of missing crises versus issuing false alarms[21].

Stand-alone indicators of vulnerability

In the following, we test the predictive power of several domestic and global stand-alone indicators of vulnerabilities from the macroprudential literature based on asset price (equity and property prices), and credit (credit and monetary aggregates) developments. We evaluate the performance of the different indicators according to the evaluation method discussed in the previous section.

The full set of results and the scores of all the tested indicators are reported in the Appendix[22]. Table 2 reports the top 5 global indicators (upper part) and the top 5 domestic ones (lower part), as well as some statistics to assess the efficiency of the indicators in predicting systemic events over an horizon of 6 quarters, under the assumption that preferences are balanced between issuing false alarms and missing signals (μ=0.5). More specifically, the Table 2 reports usefulness U, the noise to signal ratio (NtSr), the percentage of systemic events predicted by the indicator

[20] We test the thresholds ranging from 50 to 99 in terms of percentile of the country distribution.
[21] For a more comprehensive discussion of the issue see Bussière and Fratzscher (2008) and Alessi and Detken (2009).
[22] In table A1 we report the results for all indicators for μ=0.5 while looking at four different forecasting horizons (2, 4, 6 and 8 quarters), and for μ=0.4 and μ=0.6 using the benchmark forecasting horizon of 6 quarters.

(%predicted), the probability of a systemic event conditional to a signal (Cond Prob) and the difference between the conditional and the unconditional probability of the systemic events (Prob Diff)[23].

(INSERT TABLE 2 HERE)

The following observations can be made regarding the top indicators selected by the signalling approach:

- The majority of indicators have a positive value for the usefulness indicator U, which means that the neutral observer would benefit from using the indicators rather than ignoring them (see Table A1 in the Appendix).
- The best stand-alone indicator among all is a global indicator[24], namely the deviation from HP (λ=400000) trend of the ratio equity market capitalisation to GDP. This is in contrast with other studies that find that the ratio credit to GDP as the best indicator (Alessi and Detken, 2009 for example). However, according to our results, global credit to GDP ratio ranks as second best stand-alone indicator. In general, the performance of indicators based on equity prices is very similar to the performance of indicators based on credit aggregates.
- The credit indicators dominate indicators for monetary aggregates, as the latter do not appear among the top indicators. This confirms the finding of the literature that credit is a better predictor of financial crisis/stress than money aggregates (see e.g. Alessi and Detken 2009, Borio and Lowe 2004, or Schularick and Taylor 2009).
- Global indicators perform better than domestic indicators (in line with Alessi and Detken, 2009). The top 5 global indicators are the best performers among all indicators, while the first domestic indicator ranks only seventh among all the indicators.
- Interactions among indicators are important. The interaction between real equity prices growth and equity valuations (price/earning ratio) in advanced countries is among the top 5 global indicators. Also, among the domestic factors the interaction between growth in real equity prices and valuation ratios (price/earning ratio) ranks the second best.
- Contrary to what the literature suggests (Borio and Drehmann 2009), property prices do not appear among the best indicators (see the full results in the Table A1 in the Appendix).

[23] As in Kaminsky et al. (2008) the efficiency measures are calculated in the following way: the noise to signal ratio (NtSr) is the ratio between false signals as a proportion of periods in which false signals could have been issued and good signals as a proportion of periods in which good signals could have been issued (i.e. NtSr = (B/(B+D))/(A/(A+C))). The lower the NtSr the better the indicator performs. The percentage of crisis predicted by the indicator (%predicted) is simply the ratio between good signals and the number of periods in which good signals could have been issued (% predicted = A/(A+C)). The probability of a crisis conditional on a signal (Cond Prob) is the ratio between good signals and the total number of signals issued (Cond Prob = A/(A+B)). Finally the difference between the conditional and the unconditional probability of a jump (Prob Diff) is calculated as Cond Prob – (A + C) / (A + B + C + D).

[24] The global indicators are calculated as an average of the United States, euro area, Japan and the United Kingdom.

Discrete choice models – a Logit model

In this part of the empirical analysis we use a logit model to jointly estimate the impact of multiple vulnerability indicators to the probability of a systemic event. Furthermore, instead of using arbitrary thresholds for the estimated probabilities as it is common in the currency and banking crisis literature, we calculate the optimal thresholds for policy intervention, by using the approach suggested by Alessi and Detken (2009) as before.

The benchmark specification of the logit model is the following:

$$\Pr ob\left[SystemicEvent_{it}\right] = 1 \qquad (4)$$

if $\Pr ob\left[\beta' x_{it} + \varepsilon_{it} > 0\right]$ and 0 otherwise, where

$$x_{it} = \begin{bmatrix} MacroEnvironment_{it} + \\ Asset\Pr iceDynamics_{it} + \\ Asset\Pr iceValuation_{it} + \\ Asset\Pr iceDynamics_{it} * Asset\Pr iceValuation_{it} + \\ CreditDynamics_{it} + \\ Leverage_{it} + \\ CreditDynamics_{it} * Leverage_{it} + \\ \\ MacroEnvironment_{t}^{Global} + \\ Asset\Pr iceDynamics_{t}^{Global} + \\ Asset\Pr iceValuation_{t}^{Global} + \\ Asset\Pr iceDynamics_{t}^{Global} * Asset\Pr iceValuation_{t}^{Global} + \\ CreditDynamics_{t}^{Global} + \\ Leverage_{t}^{Global} \\ CreditDynamics_{t}^{Global} * Leverage_{t}^{Global} + \\ \\ Asset\Pr iceDynamics_{it} * Asset\Pr iceDynamics_{t}^{Global} + \\ Asset\Pr iceValuation_{it} * Asset\Pr iceValuation_{t}^{Global} + \\ [Asset\Pr iceDynamics_{it} * Asset\Pr iceValuation_{it}] * [Asset\Pr iceDynamics_{t}^{Global} * Asset\Pr iceValuation_{t}^{Global}] + \\ [CreditDynamics_{it} * CreditDynamics_{t}^{Global} + \\ Leverage_{it} * Leverage_{t}^{Global} + \\ [CreditDynamics_{it} * Leverage_{it}] * [CreditDynamics_{t}^{Global} * Leverage_{t}^{Global}] \end{bmatrix}$$

and $\varepsilon_{it} \sim N[0,1]$, $i = 1,...,n; t = 1,...,T_i$

$\Pr ob\left[SystemicEvent_{it}\right] = 1$ is the probability of a systemic event for a country i at time t within the next 6 quarters, and x_{it} is the set of macro-financial vulnerabilities.

The country specific probability of a systemic event, i.e. systemic risk is a function of vulnerabilities that are selected from the macro-prudential literature to capture asset price and credit developments, potential misalignments in asset valuation levels or excessive level of leverage, while also controlling for the macroeconomic environment. The independent variables are grouped into three main sets, namely the domestic, the global and the interactions between domestic and global factors.

The first set consists of variables that measure domestic conditions. It includes growth in domestic asset prices (equity) and bank credit, asset price valuation levels, and the level of leverage in the economy. In our benchmark specification, growth in equity prices and bank credit are measured by the real (net of inflation) annual growth of the main domestic equity index and of the amount outstanding of credit granted to the private sector[25]. Asset price valuations are measured by the deviation of the ratio equity market capitalisation to GDP from its trend, while leverage is measured as the deviation of the ratio private credit to GDP from its trend[26]. The domestic block of variables also includes the interaction between asset price developments and valuation levels, as well as the interaction between credit growth and leverage. The interactions are computed by the product of the two relevant variables. Finally, domestic macroeconomic environment is controlled for with the following variables: annual real GDP growth, annual CPI inflation, Current Account deficit in percentage of GDP, and Government deficit in percentage of GDP.

The second set of variables aims at capturing the global macro-financial environment. These variables are included as from the recent literature on macroprudential indicators and from our empirical analysis of stand-alone indicators of vulnerabilities, it emerges that global factors have a significant influence on domestic financial stability. Similarly to the domestic set of variables, we include growth in global asset prices and bank credit, global asset price valuation levels, and the global level of leverage to the model. In addition, the model also includes the interaction between global asset price developments and valuation levels, as well as the interaction between global credit growth and leverage. Finally, global macroeconomic conditions are proxied by real GDP growth and inflation. In our benchmark specification, the global variables are the same used in the domestic block, however they are constructed as simple averages of the data for the United States, euro area, Japan and the United Kingdom.

Finally, the third set of variables includes the interplay between domestic and global indicators of vulnerabilities, computed as the product between the relevant domestic and international variables. The introduction of this variable group captures additional fragilities that emerge when the overheating of the domestic economy coincides with the vulnerabilities in the global conditions.

In the robustness section, we evaluate our results by changing the specification of the benchmark model and the variables used to measure the different fragilities.

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[25] Credit to the private sector (source the IMF) excludes loans to the government and to banks.

[26] Trends are computed with the Hodrick-Prescott filter setting the smoothing parameter λ to 400 000. Regarding, equity valuations it would be optimal to use price earning ratios, however time series for these data are not available since 1990 for a large portion of our set of countries. Therefore, we opted to use the ratio equity market capitalisation to GDP as a proxy for valuations after de-trending the ratio to correct for the non-stationarity due the progress in developing local stock markets. Regarding leverage, the deviation from the trend of the ratio private credit to GDP is a commonly used measure of leverage (Borio and Lowe, 2002).

Regarding the estimation strategy, due simplicity and data limitations, we pool the information of our unbalanced panel, and assume that the constant *c* and the slope coefficients β of the logit model do not change across time and countries. The appropriateness of a pooled approach is discussed by Fuertes and Kalotychou (2006) and Davis and Karim (2007).

To take into account country specific fixed effects and potential cross country differences in the scale of the regressors, as well as to avoid that our results are affected by large outliers, we follow the method by Berg, Borensztein and Pattillo (2005), and measure variables in country specific percentile terms.

(INSERT TABLE 3 HERE)

Table 3 reports the estimated coefficients for the benchmark model (column 5), as well as alternative models that are estimated for comparison (columns 1-4). The table also includes the estimated marginal effects of the independent variables in the benchmark model (column 6), as well as two models that use data only for emerging markets (columns 7 and 8).

Column 5 reports our benchmark model, which includes both domestic and global factors as well as their interactions. Regarding the benchmark model, we note that several domestic factors, as well as global factors and the interaction between domestic and global ones have statistically significant impacts on the probability of systemic events. It is worth nothing that the estimated coefficients have, in most cases, the expected signs, while those with counterintuitive signs are mostly either not statistically significant or are economically not relevant.[27]

Due to data transformations, the interpretation of the estimated coefficients is not straightforward, but one can draw qualitative conclusions on the relative importance of various factors on the probability of a systemic event. According to the results, the computed marginal effects (column 6) show that global factors, especially global credit growth and leverage, equity valuation and inflation have the largest marginal effects to the probability of a systemic event. From domestic variables, the most important ones (highest marginal effects) are equity price dynamics and valuation levels (and their interaction), as well as credit growth, and leverage (and their interaction). In addition, interactions between domestic and global credit growth and equity price dynamics have relatively large marginal effects.

Column 8 reports the estimated model, which includes data only for emerging markets. The main findings can be summarised as follows. First, the overall fit of the model increases significantly (the R-squared rises to 0.46 from 0.39) compared to the benchmark model including data also for advanced economies. Second, most statistically significant coefficients are the same as those of the benchmark model, indicating that the mechanisms and the fragilities leading to systemic events are common to emerging markets and advanced economies. In this regard, some differences are worth to highlight. Among the domestic macroeconomic factors, inflation and Current Account deficit play a more important role in anticipating

[27] For instance, regarding both the domestic and global real GDP and inflation, the estimated positive signs indicate that overheating of domestic and global macro conditions precede systemic events.

systemic events in emerging markets than in advanced countries. Furthermore, the estimated coefficients (and marginal effects) capturing the impact of global variables as well as those capturing the interaction between domestic and global variables are, in most cases, larger in the model for emerging markets only.

We evaluate our benchmark model against several alternative models, which estimation results are presented in Table 3 (columns 1-4). Column 1 of the Table 3 reports the estimated coefficients for the first alternative model, the "currency crisis" model that contains variables often used in the currency crises literature. In this model, credit growth, leverage and real GDP growth are estimated to be statistically significant, but variables such as the Current Account deficit or the overvaluation of the real exchange rate are not significant[28]. The overall fit (R-squared) of the model is 0.13. In the column 2, we depart from the currency crisis model by excluding the variable capturing real exchange rate overvaluation and by adding equity price dynamics and valuations. As the new variables are standard indicators in macroprudential analysis, we call this the "macroprudential" model. Interestingly, all variables included in the model besides credit growth are statistically significant. Also the overall fit of the model increases compared to the "currency crisis" model as the R-squared rises to 0.19. In the column 3, we report a model with interactions among domestic variables, i.e. the "domestic" model. Although the overall fit (R-squared 0.20) of the model does not improve much from the "macroprudential" model, it is worth noting that some of the interactions are statistically significant (the interaction between equity growth and valuations, and the one between leverage and equity valuation). All statistically significant variables have the expected positive sign, except Government deficit.

Finally, it is worth noting that the fit of the benchmark model (column 5) is better than the fit of any alternative model. Furthermore the fit of the benchmark model is better than the equivalent model excluding the interactions among variables (column 4). Similarly, for emerging markets, the important role of interactions is highlighted by comparing the model in column 8 to the model in column 7, which excludes the interactions between the variables. Once the interactions are excluded, the explanatory power of the model remains elevated, but it is considerably lower than when they are included.

We now turn to the evaluation of the performance of the models in predicting systemic events. The selection of the best model is done in the following way: once the probability of financial stress is estimated, we use the approach by Alessi and Detken (2009) to evaluate whether the policy maker can extract "useful" signals from it. Thus, we find the thresholds for the estimated probability that maximises the "U" statistic for each model (for the given preference parameter μ=0.5). The best model is the one that that achieves the highest usefulness U score for the given preference parameter.

Table 4 reports the performance statistics for the above models. The main results are the following: First, all models have a positive usefulness score U that means that the models provide statistical gains for policy makers who are equally concerned of

[28] The low performance of the model is not surprising as we are trying to predict systemic events that differ from pure currency crises.

issuing false alarms and missing systemic events. Second, all the models except the "currency crisis" model outperform stand-alone indicators (see Table 2) in terms of their usefulness. The "currency crisis" model, however, would rank third among stand-alone indicators. Third, the benchmark model including global variables and all the interactions clearly outperforms the other models. The benchmark model successfully predicts more than 80% of the systemic events. Furthermore, the difference between the unconditional probability and probability of a systemic event conditional to observing a signal from the model is almost 40%.

To sum up, our results highlight that analysing multiple signals from various sources of vulnerabilities in a multivariate framework, such as the discrete choice models, are more comprehensive tools than stand-alone indicators (signalling approach) to assist policy makers in evaluating systemic risks and predicting systemic events. Furthermore, it is crucial to take into consideration both domestic and international sources of vulnerabilities as well as their interaction.

We turn now to the evaluation of the out of sample performance of the Logit models.

Out of sample performance of the models

We evaluate the out of sample performance of the Logit models over the period 2005q2 2007q2 (8 quarters) in the following way:

1) We recursively estimate the model at each time *t* using the information that would have been available in real time from the beginning of the sample (1990q1) to that quarter.
2) We collect the real time signals from the model (assuming the benchmark scenario of a forecast horizon of 6 quarters and policy preference parameter of μ=0.5).
3) We compute *ex post* the number of missed signals and false alarms issued by the model over out of sample evaluation period (2005q2 – 2007q2), and compute the measure of usefulness according to the Alessi and Detken (2009).
4) We rank the models according to the usefulness parameter (U). This provides a new, structured way to assess the out of sample performance of the models.

Table 5 summarises the results of the out of sample evaluation, which indicate that the benchmark model and the three alternative models would have been useful tools for policy makers in predicting the 2008/09 crisis. As was the case with in sample predictions, once again the benchmark model that incorporates both domestic and global variables as well as their interactions outperforms by far the other models.

Chart 3 shows the out of sample performance of the benchmark model for the United States for the 2008/2009 financial crisis. It shows that the probability of a systemic event within 6 quarters in the United States crossed the optimal policy threshold already in 2006q2. According to our financial stress index, the switch from the tranquil period to the extreme financial stress period occurs in 2007q4, when the tensions in the money markets spread to other segments of the financial system.[29] Therefore, our benchmark model is able to correctly anticipate the systemic event

[29] According to our financial stress index, the financial pressure moves to a extreme financial pressure regime in other economies in early 2008, making the crisis of 2008/09 truly a global crisis.

with a lead of 6 quarters. Furthermore, it flags that the systemic risks are elevated for all the 6 quarters preceding the crisis.

Finally, Charts 4 and 5 present the snapshot of the out-of-sample forecast for the probability of a systemic event within 6 quarters for all 28 countries in our sample for two periods: in 2005q3 and 2006q2. While in 2005q3, there are no countries with the predicted probability of a systemic event above the threshold, in 2006q2, the predicted probability of a systemic event is very high in several countries.

Robustness checks

In order to ensure the robustness of the results, we conducted several robustness tests for the stand-alone indicators of vulnerabilities and the discrete choice models. Regarding the stand-alone indicators, we tested several different definitions of vulnerabilities (see Table A1 in the Appendix), different forecast horizons, as well as different policy makers' preferences.

Regarding the discrete choice models, we conducted the following robustness tests:

- **Definitions of vulnerabilities.** We tested various definitions and transformations of the vulnerabilities (see Table 1). Overall, the results from the alternative models were qualitatively the same as in the benchmark model. Moreover, they always had relatively high positive values of the usefulness parameter U, compared to the stand-alone indicators of vulnerabilities. For instance, regarding asset valuations, we used price/earnings ratios as it is common in the literature, and obtained similar results as with the benchmark model (the usefulness of the alternative model was 0.30 instead of 0.32). However, in this case, due to availability of data, our sample size was reduced and the analysis was not possible for all the countries in the sample.
- **Alternative models**. Besides the benchmark model that was estimated for the whole sample and only for emerging markets, as well as the models excluding interactions between the variables, we also estimated three alternative models using different sets of independent variables. While the policymaker would benefit from the signals of any of these models (as the usefulness parameters are positive), and the overall results would be qualitatively the same, our benchmark model including both domestic and global vulnerabilities together with their interactions performs the best.
- **Forecasting horizon**. We test the following forecast horizons for predicting systemic events: 2 quarters, 4 quarters, 6 quarters (benchmark) and 8 quarters. Overall, the performance of the model is relatively robust across forecasting horizons (see Table A2 in the Appendix). The best performance is achieved on average over the 6 quarter period, followed by the 8 quarter period. Normally, over the 4 and 2 quarter periods, the model performance slightly decreases.
- **Policy markers' preferences**. In our benchmark analysis we assume that the policy maker has the preferences of a neutral observer (she is equally concerned of Type I and Type II errors). If we change this assumption (see Table A3 in the Appendix), we find that overall policy makers would benefit from the signals of the models as their usefulness score is positive, especially

when the policy maker's preferences are close to the balanced preferences (i.e. either μ=0.4 or μ=0.6).

- **Post crisis bias**. We test whether our results are affected by a post crisis bias. Bussière and Fratzscher (2006) point out that including in the estimation of early warning models the economic recovery period after a crisis produces so called "post crisis bias". In recovery periods, economic variables go through an adjustment process before reaching again the path they have during tranquil periods. The recovery period, therefore, should be excluded from the analysis as it is not informative of the path leading from the pre-crisis regime to the crisis. Bussière and Fratzscher address this issue by using a multinomial logit model with "three regimes" for the endogenous variable (calm period, crisis and recovery). In this paper, as we exclude from the estimation sample the periods in which financial stress is high following the switch from tranquil regime to an extreme stress regime, we at least partially disregard some periods of economic recovery. However, we check the robustness of our results by excluding observations up to two quarters after the end of the stress periods to ensure that the post crisis bias is addressed. Only marginal gains in the performance of the model are obtained when dropping the additional two quarters from the sample.
- **Estimation method**. The benchmark models were estimated using independent variables transformed into their quartiles as in Berg, Borensztein and Pattillo (2005). In order to see whether this impacts the results, we used several ways of cleaning the data from outliers (e.g. min-max transformation), as well as estimating the models using the fixed effects panel logit model with robust standard errors. Due to several outliers in the data, the other data transformations solve the issues related to outliers less satisfactorily than the method used in this paper, thus providing less stable estimates of the models.

Analysis of the current situation

To many observers, recent increases in equity, bond, and property prices may appear to be overly strong, particularly when coupled with credit booms in certain emerging economies, such as China. This section analyses whether we are currently observing the building up of vulnerabilities that could lead to a systemic event in the medium run. We do this by estimating the logit model using the latest available information and calibrating the optimal thresholds for the policy marker.

The main results of the analysis are shown in Chart 6, which shows the estimated probabilities of a systemic event within a time horizon of 6 quarters, as well as the country specific thresholds (black horizontal lines) at which a "neutral" observer (μ=0.5) would call a systemic event.

The overall picture that emerges from Chart 6 is that the probability of a systemic event is generally low across the key economies. According to our estimates, the domestic factors, mainly asset price and credit developments, are pointing towards building up of vulnerabilities in certain emerging Asian economies, and in particular China. However, besides domestic factors, global factors, such as the overheating of the macroeconomic environment, asset price misalignments and booming credit conditions, and their interactions with the domestic factors are also important determinants of systemic risks in emerging markets. Currently, the sizeable output gaps and the low inflation environment are the main factors balancing the positive contributions of strong increases in domestic equity prices and credit to the probability of a systemic event in those economies with overheating pressures, stemming from domestic asset price and credit developments (emerging Asia).

To give an idea of how the situation could evolve if the economic recovery in the world economy, and especially in advanced economies accelerates, Chart 7 shows the probability of a systemic event and the thresholds under the assumption that *ceteris paribus* global growth and inflation are back to their long term averages. Under this scenario, the balancing negative effect of the currently weak global macro environment would vanish and the probability of a systemic event would increase across economies with domestic overheating pressures, especially in emerging Asia.

To sum up, systemic risks in key economies in the global economy are currently generally low, but can increase in the medium term, especially in emerging Asia. Thus, it is reassuring that in several emerging economies policy interventions are already being introduced to counter the overheating of domestic conditions.

5. Conclusions

The paper develops a framework for assessing systemic risks stemming from domestic and global macro-financial vulnerabilities, and for predicting systemic events. To capture systemic events, we construct a country-level Financial Stress Index (FSI) that measures a broad set of tensions in a country's financial markets due to realisations of negative shocks, such as bursts of asset price bubbles, banking, currency and financial crises. We then evaluate the performance of a set of indicators in predicting episodes of extreme financial stress (systemic events). We consider both "stand-alone" macroprudential indicators of vulnerabilities and composite indicators using discrete choice models. The evaluation of the indicators is done on the basis of assumptions on policy makers' preferences between issuing false alarms and missing systemic events (Bussière and Fratzscher, 2008). Policy makers' preferences are also used to estimate the optimal thresholds for potential policy action.

Our results show, in line with Borio and Lowe (2002) and Gerdesmeier et al. (2009) that stand-alone measures of asset price misalignments and credit booms are in general useful leading indicators of systemic events. Interestingly, in line with other studies (e.g. Alessi and Detken, 2009), global measures of liquidity and asset price developments perform better as stand-alone leading indicators than indicators of domestic fragilities. Interactions between domestic variables as well as between global and domestic variables are among the best stand-alone indicators. However, our results highlight the importance of considering jointly various indicators in a multivariate framework, as we find that discrete choice models outperform stand-alone indicators of vulnerabilities. There are significant gains in taking into account jointly domestic and global macro-financial vulnerabilities as well as their interactions. Interestingly, we find that the determinants of systemic risks are the same in emerging and advanced economies. The main difference between emerging markets and advanced economies is the relative importance of the different factors, with the emerging markets being more exposed to global factors (contagion effects).

Moreover, we show that our preferred model outperforms several benchmarks and displays a good out of sample performance in predicting the 2008/2009 financial crisis.

Finally, we use our framework to analyse the current vulnerabilities, and find that the systemic risks are generally low across key economies in the global economy. However, the situation can evolve rapidly when the recovery of the world economy, especially in the advanced economies, accelerates. Under this scenario, the balancing negative effect of the currently weak global macro environment would vanish and the probability of a systemic event would increase in economies with domestic overheating pressures, especially in emerging Asia.

Our analysis is not without caveats. First, the jury is still out on the best ways to measure financial stress and to identify systemic events. Thus, the chosen approaches for constructing the financial stress index and the way defining systemic events could be further refined. Second, despite of the efforts of finding good indicators of vulnerabilities, the paper focuses on measures stemming from asset price and credit developments. Therefore, certain aspects of macroprudential analysis could be further developed.

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Table 1: List of variables

PART A - core indicators

Variable Name	Description	level	ma08	ma20	d4	hpsh	hplo	i4
		Domestic Variables						global variables
moneygdp	ratio money to gdp		x	x		x	x	x
m2mgdp	ratio m2 to gdp		x	x		x	x	x
fxreer	real effective exchage rate		x	x	x	x	x	
fxneer	nominal effective exchange rate		x	x	x	x	x	
gdpr	real gdp		x	x	x	x		x
cpi	consumer price index		x	x	x	x		x
creditpgdp	ratio credit to the private sector to gdp		x	x		x	x	x
rmoney	real money				x			x
rm2m	real m2				x			x
rhousep	real house prices				x			x
reqmsci	real equity prices (MSCI based)				x	x	x	x
rcreditp	real credit to the private sector to GDP				x			x
ggd	general government debt (% of gdp)	x						
ggb	general government deficit (% of gdp)	x						
bca	current account deficit (% of gdp)	x						
pe	price earning ratios	x				x	x	x
mcapgdp	stock market capitalisation over gdp					x	x	x
eqlev	d4reqmsci-d4gdpr	x						x

PART B - transformations of core indicators

Interactions between growth and level of domestic variables

Variable Name	Definition	level	i4
d4grleeqpe	d4reqmsci * pe	x	x
hpshgrleeqpe	hpshreqmsci * pe	x	x
hplogrleeqpe	hploreqmsci * pe	x	x
d4grleeqpesh	d4reqmsci * hpshpe	x	x
hpshgrleeqpesh	hpshreqmsci * hpshpe	x	x
d4grleeqpmc	d4reqmsci * hplomcapgdp	x	x
d4grleeqpmsci	d4reqmsci * hploreqmsci	x	x
d4grlecr	d4rcreditp * hplocreditpgdp	x	x
hpshgrlecr	hpshrcreditp * hplocreditpgdp	x	x

Interactions among domestic variables

Variable Name	Definition	level	i4
d4docreq	d4rcteditp * reqmsci	x	x
hpshdocreq	hpshcreditpgdp * reqmsci	x	x
hplodocreq	hplocreditpgdp * reqmsci	x	x

Interaction between domestic and international variables (for the growth)

Variable Name	Definition	level	i4
inind4grleeqmsci	d4grleeqmsci*i4d4grleeqmsci	x	
inind4grleeqpe	d4grleeqpe*i4d4grleeqpe	x	
inind4grleeqmc	d4grleeqmc*i4d4grleeqmc	x	
inind4grlecr	d4grlecr*i4d4grlecr	x	
hplodoinliq	hplocreditpgdp*i4hplocreditpgdp	x	
hplodoinequ	hploreqmsci*i4hploreqmsci	x	
hplodoinequmc	hplomcapgdp*i4hplomcapgdp	x	
hpshdoinliq	hpshcreditpgdp*i4hpshcreditpgdp	x	
hpshdoinequ	hpshreqmsci*i4hpshreqmsci	x	
d4doinliq	d4rcreditp*i4d4rcreditp	x	
d4doinequ	d4reqmsci*i4d4reqmsci	x	

excess growth over international factors

Variable Name	Definition	level	i4
ed4reqmsci	d4rcreditp-i4d4rcreditp	x	
ed4rcreditp	d4reqmsci-i4d4reqmsci	x	

Notes: Part A lists the core set of variables and their transformations. The first column reports the name of the variable, the second column reports the description of the variable. Column 3 (“level”) indicates whether the level of the original variable is used while columns 4 (“ma08”) to 8 (“hplo”))indicate the transformations applied to the original variables. The last column indicates whether global averages have been computed for all the computed transformations of the variables. Transformations of the original variables: “ma08” (“ma20”) is the difference between the original variable and the moving average computed on a period of 8 quarters (20 quarters); “d4” is the annual percentage change of the variable; “hpsh” (“hplo”) is the percentage deviation of the original variable from the Hodrick-Prescott trend computed with the smoothing parameter λ set to 1600 (400000). Naming conventions for the variables: the level of the variable keeps the original name reported in the first column; the name of the transformed variable is composed by the code of the transformation (for example, “d4”) followed by the name of the original variable; the name of global variables is the name of the transformed domestic variable with the addition of the code “ i4” upfront. Part B lists the variables capturing the interactions between domestic variables as well as between domestic and international variables. The first column reports the name of the variable, the second how the variable is computed.

Table 2. Performance of stand-alone indicators of vulnerabilities (μ=0.5 and forecasting horizon 6 quarters).

Global variables

Variable	Explanation	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff
i4hplomcapgdp	Deviation from HP (λ=400000) trend of the ratio equity market capitalisation to GDP (G4)	55	0.21	0.45	76.91%	48.44%	18.72%
i4hpshcreditpgdp	Deviation from HP (λ=1600) trend of the ratio private credit to GDP (G4)	55	0.21	0.43	73.09%	49.36%	19.63%
i4hpshgdpr	Deviation from HP (λ=1600) of real GDP (G4)	60	0.16	0.50	64.69%	45.93%	16.21%
i4hplogrleeqpe	Interaction between real equity prices (Deviation from HP (λ=400000) trend) and price earning ratios (G4)	67	0.16	0.45	57.22%	48.80%	18.99%
i4d4doinliq	Interaction between international and domestic real credit growth (G4)	63	0.16	0.48	61.04%	44.32%	16.47%

Domestic variables

Variable	Explanation	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff
hplomcapgdp	Deviation from HP (λ=400000) trend of the ratio equity market capitalisation to GDP	68	0.15	0.46	54.22%	48.67%	18.44%
hplogrleeqpe	Interaction between deviation from HP (λ=400000) trend of real equity prices (MSCI) and PE ratios	71	0.14	0.44	50.21%	49.68%	19.52%
hploreqmsci	Deviation from HP (λ=400000) trend of real equity prices (MSCI)	53	0.13	0.60	66.04%	42.38%	11.92%
hplocreditpgdp	Deviation from HP (λ=400000) trend of the ratio private credit to GDP	50	0.12	0.63	66.34%	38.73%	10.28%
ma20creditpgdp	Deviation from 20 quarter moving average of the private credit it GDP ratio	79	0.12	0.35	37.54%	51.52%	24.49%

Notes: The Table reports the best indicators for both the global (upper part) and domestic (lower part) category, and the optimal threshold in terms of percentile of the country distribution at which the indicator issues a signal. Thresholds are calculated for μ=0.5 (neutral observer). The Table also reports in columns the following efficiency measures: usefulness "U" according (see formula 3); the noise to signal ratio (NtSr) i.e. the ratio between false signals as a proportion of periods in which false signals could have been issued and good signals as a proportion of periods in which good signals could have been issued (NtSr = (B/(B+D))/(A/(A+C))); the percentage of crisis predicted by the indicator (%predicted) i.e. the ratio between good signals and the number of periods in which good signals could have been issued (% predicted = A/(A+C)); the probability of a crisis conditional on a signal (Cond Prob) i.e. the ratio between good signals and the total number of signals issued (Cond Prob = A/(A+B)); the difference between the conditional and the unconditional probability of a jump (Prob Diff) i.e Cond Prob – (A + C) / (A + B + C + D).

Table 3. Estimation results of the Logit models (μ=0.5 and forecasting horizon 6 quarters).

		(1) Currency crisis model	(2) Macro Prudential model	(3) Domestic model	(4) Domestic and international (no interactions)	(5) Benchmark	(6) Benchmark (marginal effects)	(7) Domestic and international (no interactions only EMEs)	(8) Benchmark (only EMEs)
Domestic variables	real GDP growth	0.0152 ***	0.0069 **	0.0047	0.0057	0.0066 *	0.0008 *	0.0015	-0.0002
	inflation	0.0027	0.0082 ***	0.0070 **	0.0050	0.0061	0.0008 *	0.0164 ***	0.0266 ***
	current account deficit	0.0012	0.0060 **	0.0070 ***	0.0079 **	0.0075 *	0.0009 **	0.0118 ***	0.0107 **
	general government deficit			-0.0073 **	-0.0032	-0.0011	-0.0001	-0.0040	-0.0018
	real effective exchage rate overvaluation	0.0014							
	real equity growth		0.0049 *	0.0015	0.0089 ***	0.0188 ***	0.0023 ***	0.0146 ***	0.0313 ***
	equity valuation		0.0291 ***	0.0266 ***	0.0142 ***	0.0119 ***	0.0015 ***	0.0011	0.0036
	(A1) equity interaction (growth&valuation)			0.0063 **		0.0045	0.0006		0.0012
	real credit growth	0.0107 ***	0.0011	-0.0011	0.0013	-0.0068	-0.0008	0.0043	-0.0198 **
	leverage	0.0195 ***	0.0222 ***	0.0160 ***	0.0180 ***	0.0105 *	0.0013 *	0.0201 ***	0.0050
	(B1) credit interaction (growth&leverage)			0.0032		0.0135 ***	0.0017 ***		0.0362 ***
	interaction leverage&valuation			0.0067 **					
	interaction equity&credit growth			0.0019					
Global variables	real GDP growth				0.0015	0.0004	0.0000	-0.0003	0.0003
	inflation				0.0170 ***	0.0303 ***	0.0038 ***	0.0182 ***	0.0685 ***
	real equity growth				-0.0014	-0.0123 ***	-0.0015 ***	-0.0062	-0.0177 ***
	equity valuation				0.0396 ***	0.0347 ***	0.0043 ***	0.0403 ***	0.0434 ***
	(A2) equity interaction (growth&valuation)					0.0133 ***	0.0017 ***		-0.0021
	real credit growth				0.0146 ***	0.0093	0.0012	0.0266 ***	0.0004
	leverage				0.0032	0.0415 ***	0.0052 ***	0.0017	0.1195 ***
	(B2) credit interaction (growth&leverage)					-0.0430 ***	-0.0054 ***		-0.1292 ***
Interaction between domestic and global variables	interaction domestic&international leverage					0.0078 **	0.0010 **		0.0103 *
	interaction domestic&international valuations					-0.0029	-0.0004		-0.0065
	interaction domestic&international credit growth					-0.0074 **	-0.0009 **		-0.0020
	interaction domestic&international equity growth					0.0168 ***	0.0021 ***		0.0355 ***
	A1 x A2					-0.0124 **	-0.0015 **		-0.0181 **
	B1 x B2					-0.0008	-0.0001		0.0020
	Constant	-3.7562 ***	-5.1805 ***	-4.8874 ***	-8.4201 ***	-9.2450 ***		-9.2059 ***	-12.0821 ***
	Number of countries	28	28	28	28	28		17	17
	Number of observations	902	1275	1275	1275	1275		745	745
	Pseudo R-squared	0.1278	0.1903	0.2036	0.3398	0.3894		0.3191	0.4585

Notes: Robust standard errors have been used in the estimation. *** denotes statistical significance at 1% level, ** at 5% level and * at 10% level.

Table 4. Performance of Logit models (μ=0.5 and forecasting horizon 6 quarters).

Model	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff
Benchmark (EME only)	65	0.33	0.22	84.73%	63.24%	35.99%
Benchmark	68	0.32	0.20	80.95%	65.83%	37.83%
Benchmark (no interactions)	58	0.31	0.31	88.80%	55.52%	27.52%
Benchmark (no interactions - EME only)	68	0.30	0.24	78.33%	61.39%	34.14%
Domestic model	67	0.26	0.28	71.71%	57.79%	29.79%
Macro Prudential	63	0.24	0.34	74.23%	53.32%	25.32%
Currency crisis	69	0.19	0.38	60.33%	49.16%	22.33%

Notes: See notes to Table 2.

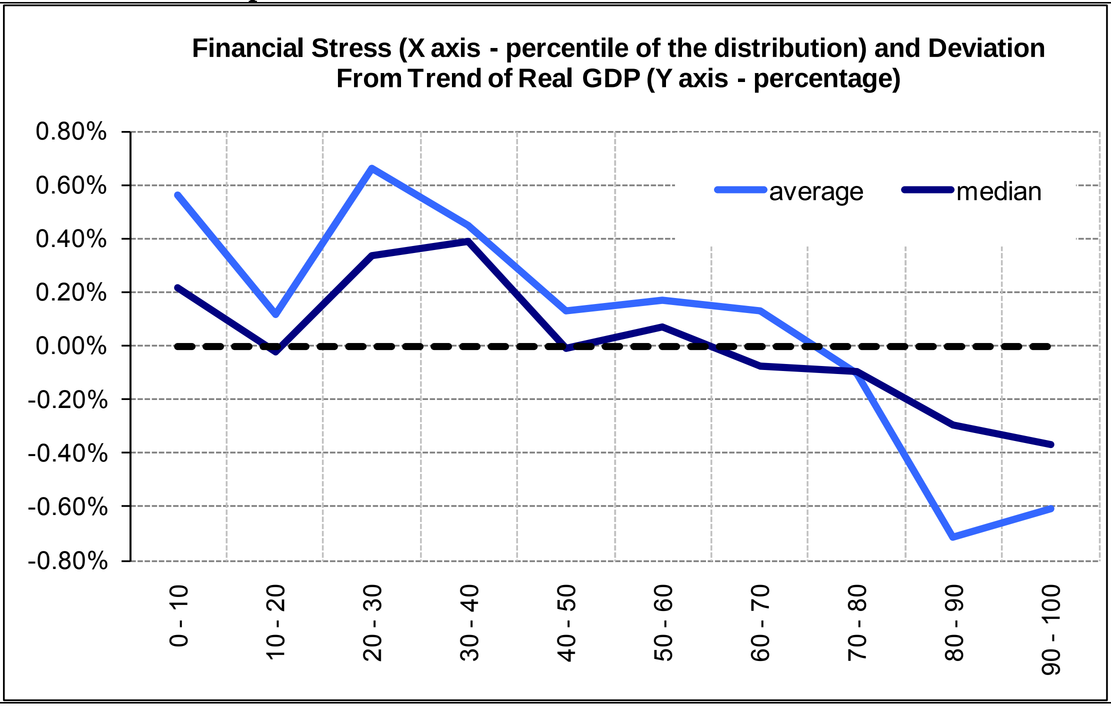
Table 5. Out of sample performance of Logit models (μ=0.5 and forecasting horizon 6 quarters).

Model	U	NtSr	%Predicted	Cond Prob	Prob Diff
Benchmark (EMEs only)	0.22	0.55	97.50%	39.39%	13.08%
Benchmark	0.18	0.57	83.91%	48.34%	13.54%
Benchmark (no interactions)	0.15	0.64	85.06%	45.40%	10.60%
Domestic Model	0.12	0.67	72.41%	44.37%	9.57%
Macro Prudential	0.10	0.75	77.01%	41.61%	6.81%
Benchmark (no interactions - only EMEs)	0.09	0.81	100.00%	30.53%	4.22%
Currency Crisis	0.06	0.84	77.01%	38.95%	4.15%

Notes: See notes to Table 2.

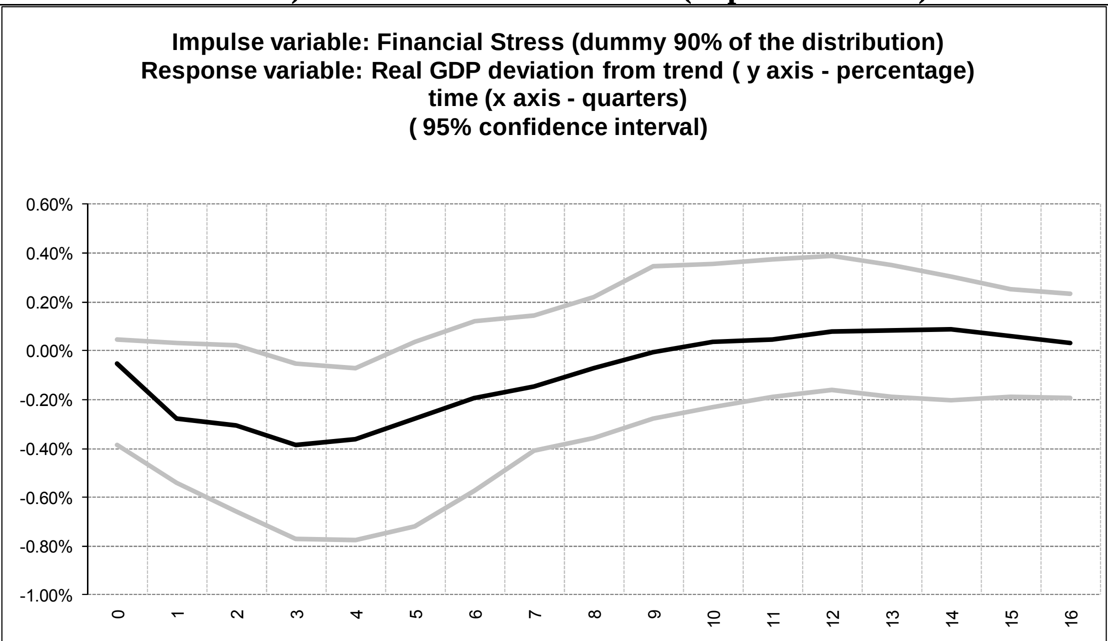
CHARTS

Chart 1. Contemporaneous correlation of real GDP and Financial Stress Index



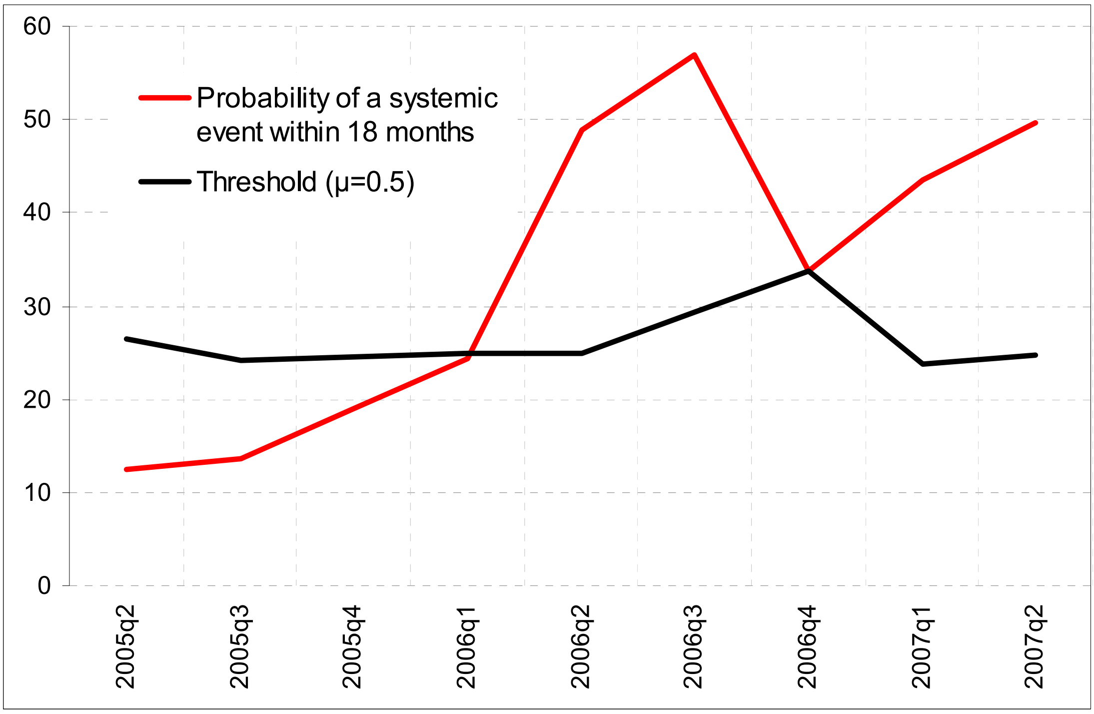
Note: The X-axis represents the percentile of the distribution of the Financial Stress Index for all 28 countries in the sample, while the Y-axis represents real GDP deviation from its trend, measured in percents.

Chart 2. Impulse response analysis of a bivariate VAR with real GDP (response variable) and Financial Stress Index (impulse variable)



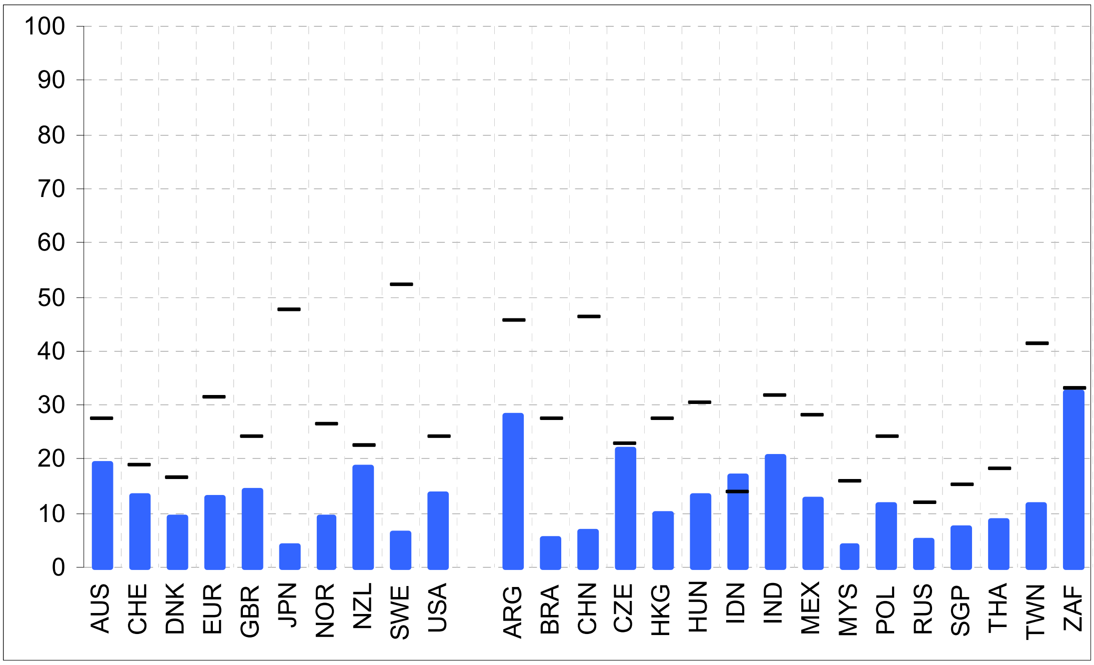
Note: The X-axis represents quarters in time, while the Y-axis represents real GDP deviation from its trend, measured in percents.

Chart 3. Predicting the 2008/2009 financial crisis in the United States. Out of sample performance of the model in the period 2005q2 – 2007q2



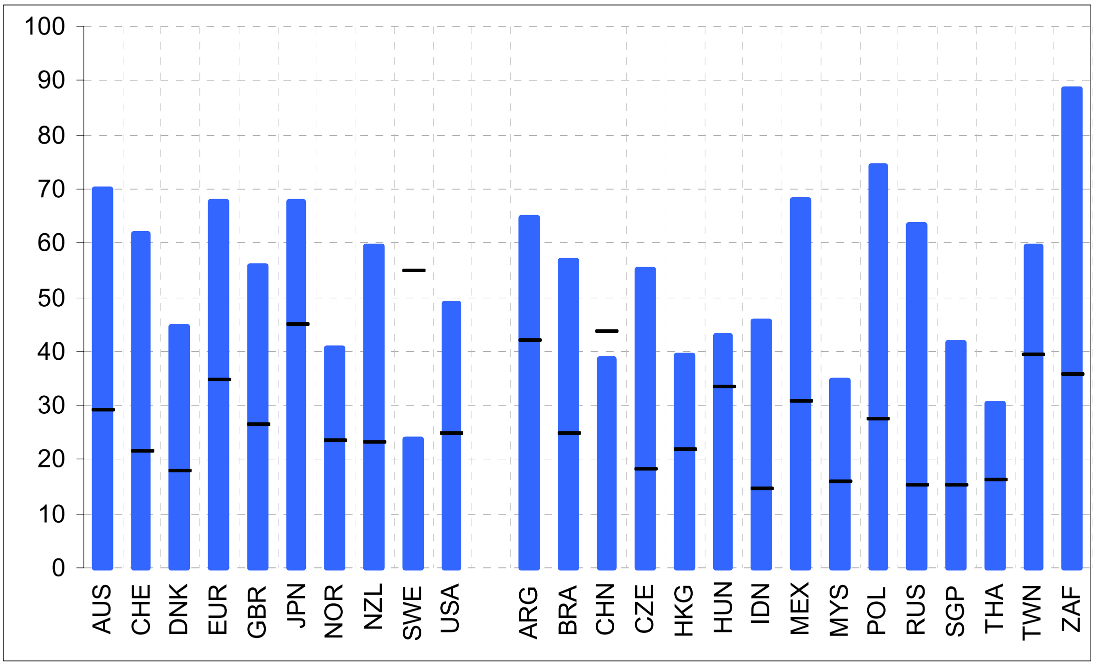
Note: The X-axis represents quarters in time, while the Y-axis represents the probability of a systemic event within the next 6 quarters (threshold optimised for μ=0.5).

Chart 4. Predicting the 2008/2009 financial. Out of sample prediction in 2005q3



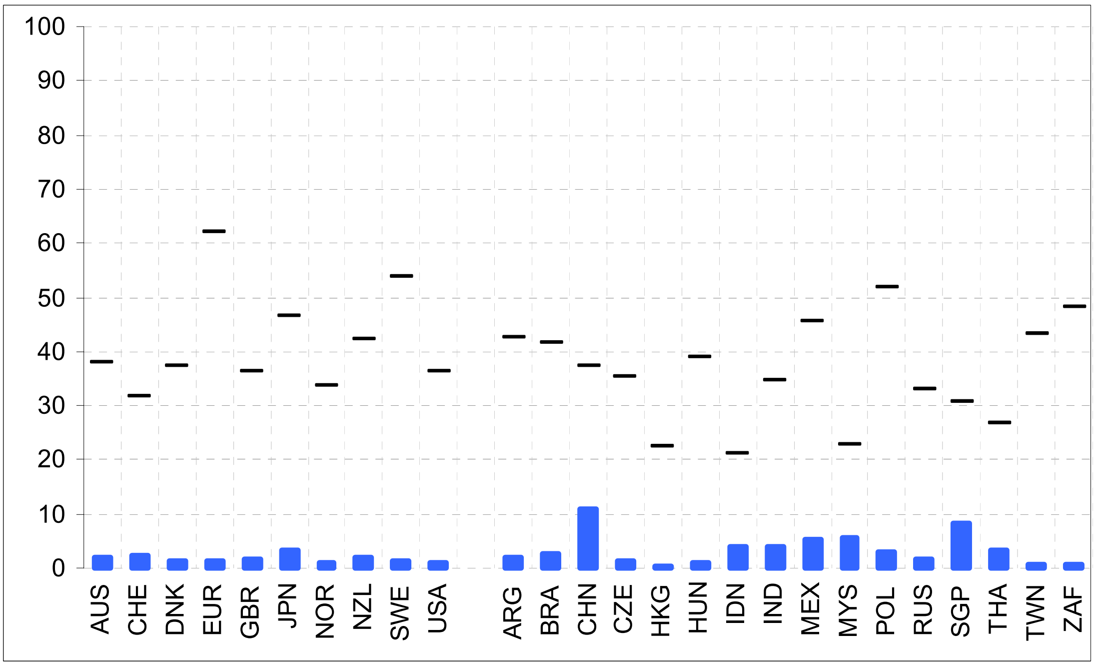
Note: Y-axis represents the probability of a systemic event within the next 6 quarters (threshold optimised for μ=0.5). In the X-axis first advanced countries then emerging markets are presented in alphabetical order. Note that the chart reports only 26 out of the 28 countries in our sample as for Turkey and Philippines it was not possible to estimate the benchmark model.

Chart 5. Predicting the 2008/2009 financial. Out of sample prediction in 2006q2



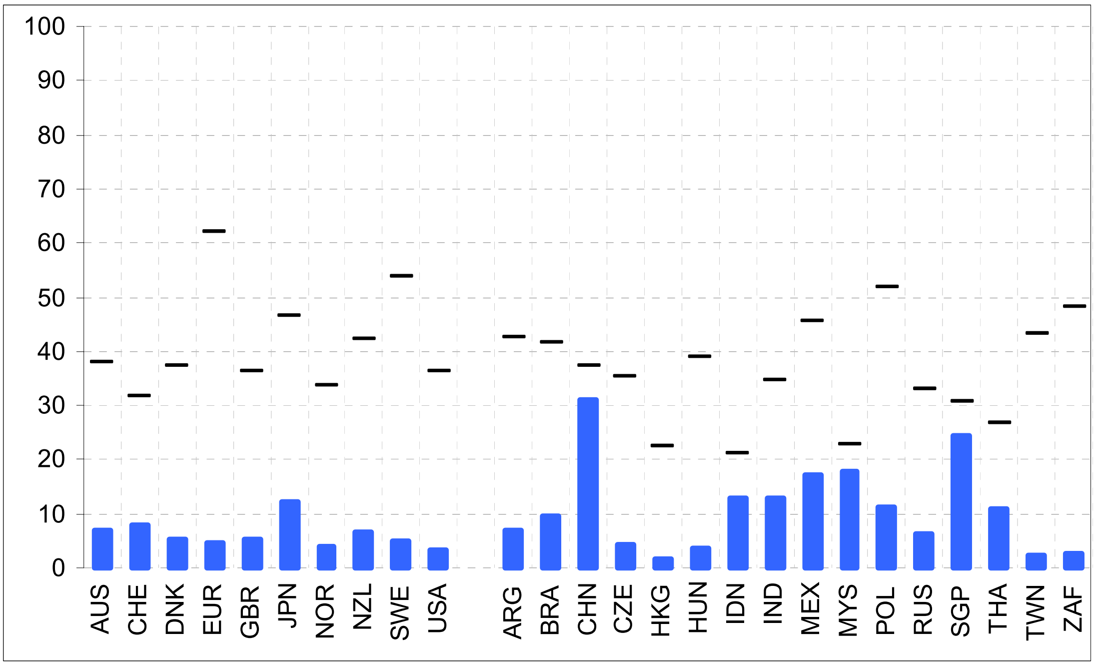
Note: Y-axis represents the probability of a systemic event within the next 6 quarters (threshold optimised for μ=0.5). In the X-axis first advanced countries then emerging markets are presented in alphabetical order. Note that the chart reports only 26 out of the 28 countries in our sample as for Turkey and Philippines it was not possible to estimate the benchmark model.

Chart 6. Current situation (2009q4)



Note: Y-axis represents the probability of a systemic event within the next 6 quarters (threshold optimised for μ=0.5). In the X-axis first advanced countries then emerging markets are presented in alphabetical order. Note that the chart reports only 26 out of the 28 countries in our sample as for Turkey and Philippines it was not possible to estimate the benchmark model.

Chart 7. Forward looking assessment– global recovery scenario



Note: Y-axis represents the probability of a systemic event within the next 6 quarters (threshold optimised for μ=0.5). In the X-axis first advanced countries then emerging markets are presented in alphabetical order. The chart has been drawn by assuming that global inflation and global real GDP growth are back to their average levels, while all the other factors are as in 2009q4. Note that the chart reports only 26 out of the 28 countries in our sample as for Turkey and Philippines it was not possible to estimate the benchmark model.

Appendix

Chart A1. Financial Stress Index for emerging economies in the sample.

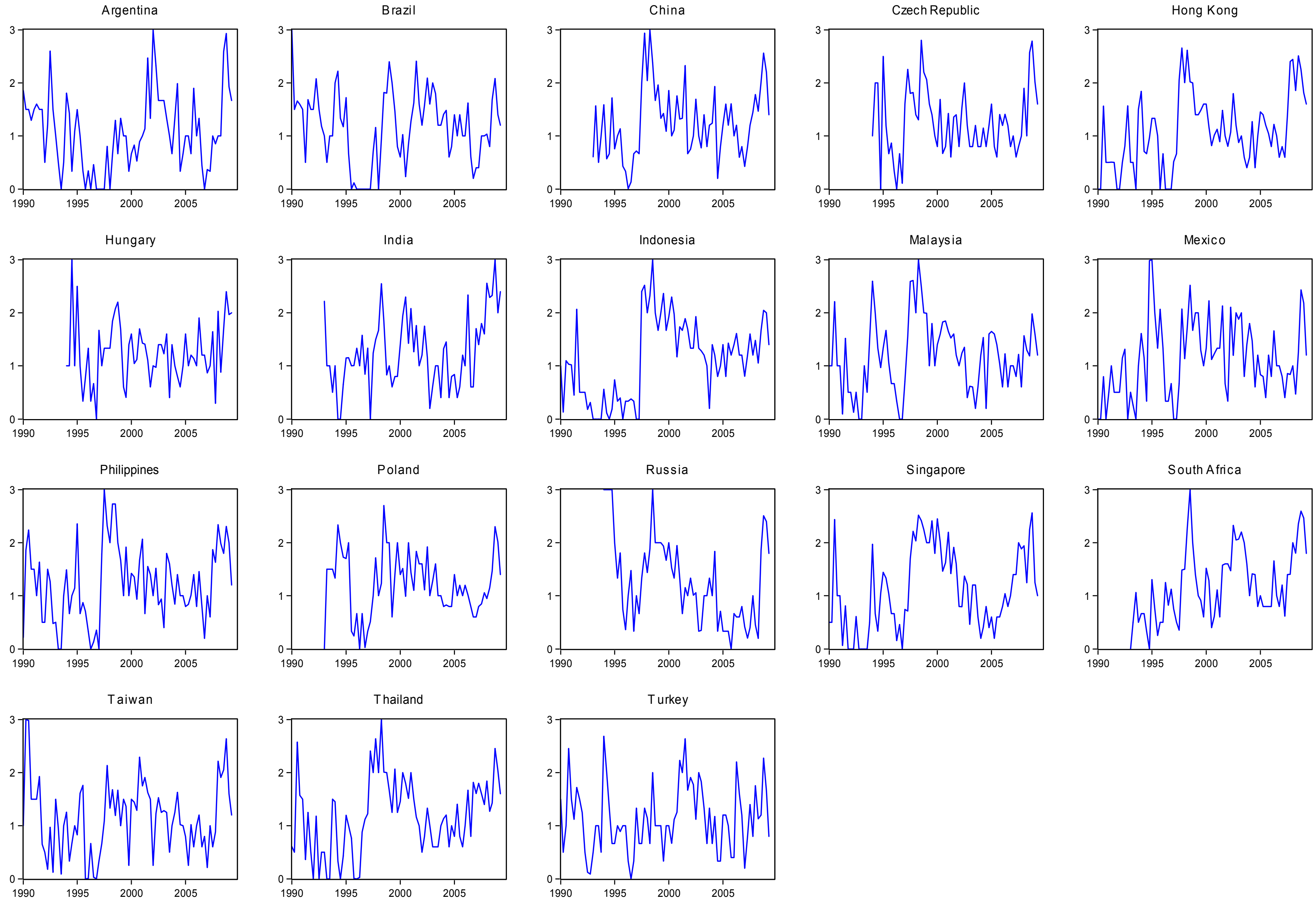


Chart A2. Financial Stress Index for advanced economies in the sample.

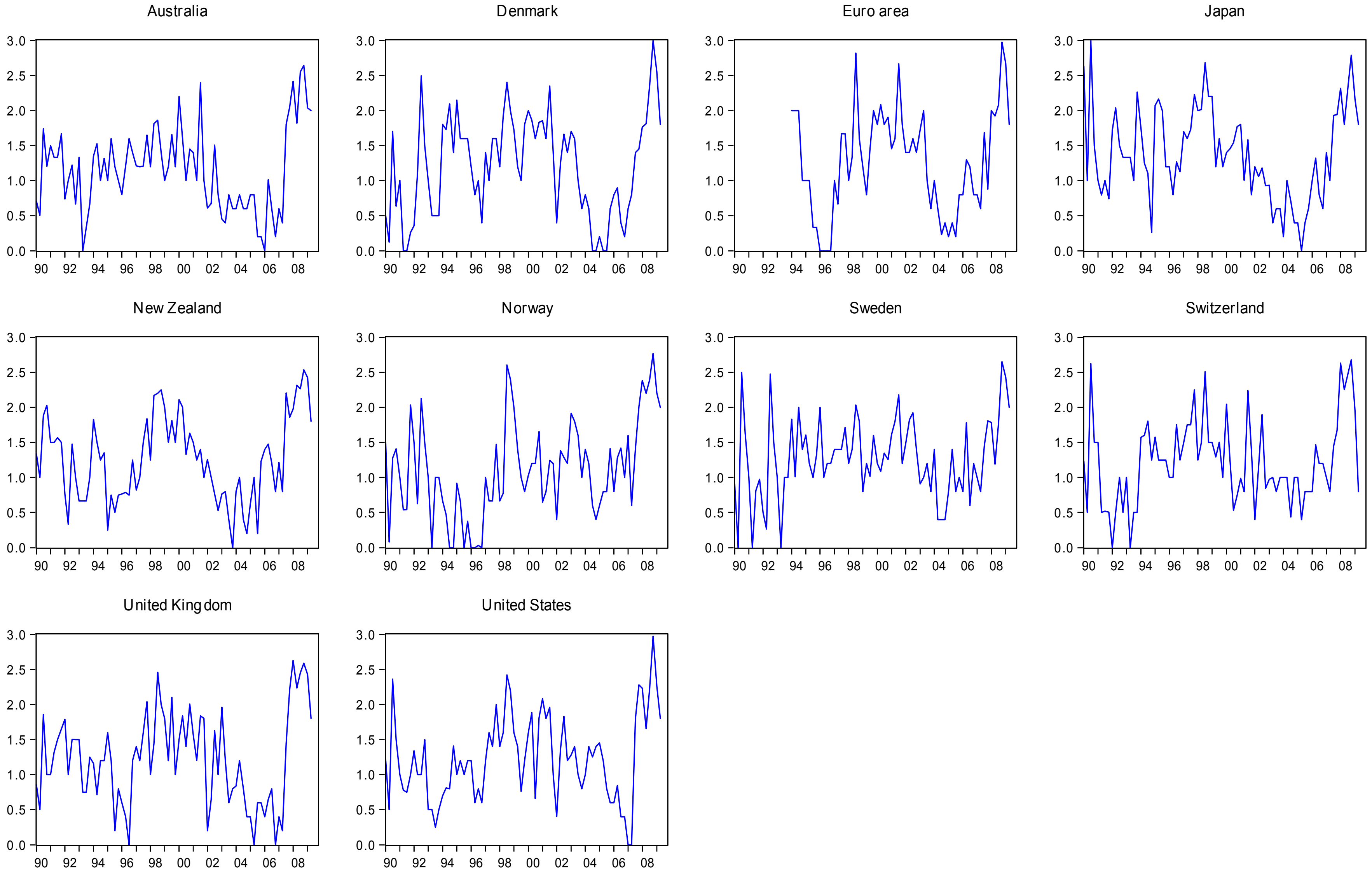


Table A1. Results of the signalling approach on the stand-alone indicators (horizon 6 quarters, μ=0.5)

(see the notes to table 1 for the naming conventions of the variables)

Horizon	Variable	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff	nobs
18m	i4hplomcapgdp	0.5	55	0.211419	0.450207	0.769084	0.484375	0.1871544	1763
18m	i4hpshcreditpgdp	0.5	55	0.206862	0.433964	0.730916	0.4935567	0.1963361	1763
18m	i4hpshgdpr	0.5	60	0.162456	0.497775	0.6469465	0.4593496	0.162129	1763
18m	i4hplogrleeqpe	0.5	67	0.158626	0.445588	0.5722327	0.488	0.1899016	1788
18m	i4d4doinliq	0.5	63	0.157222	0.484873	0.6104218	0.4432432	0.164736	1447
18m	i4hploreqmsci	0.5	56	0.157001	0.540211	0.6829268	0.4401451	0.1420467	1788
18m	hplomcapgdp	0.5	68	0.14724	0.456875	0.5421941	0.4867424	0.1844465	1568
18m	hplogrleeqpe	0.5	71	0.141249	0.437418	0.5021459	0.4968153	0.1951972	1545
18m	i4hpshmcapgdp	0.5	53	0.138507	0.59679	0.6870229	0.4147466	0.1175259	1763
18m	i4ma20creditpgdp	0.5	87	0.138144	0.095157	0.3053435	0.8163266	0.5191059	1763
18m	i4hplodocreq	0.5	66	0.134777	0.509562	0.5496183	0.4535433	0.1563227	1763
18m	i4d4docreq	0.5	69	0.134551	0.477745	0.5152672	0.4695652	0.1723446	1763
18m	hploreqmsci	0.5	53	0.133584	0.595455	0.6604167	0.4237968	0.1192283	1576
18m	i4hplocreditpgdp	0.5	85	0.132973	0.160506	0.3167939	0.7248908	0.4276702	1763
18m	i4d4gdpr	0.5	50	0.132164	0.624641	0.7041985	0.4037199	0.1064993	1763
18m	i4ma20d4gdpr	0.5	50	0.128091	0.633227	0.6984733	0.4004376	0.103217	1763
18m	i4d4grlecr	0.5	88	0.126294	0.167573	0.3034351	0.7162162	0.4189956	1763
18m	hplocreditpgdp	0.5	50	0.123022	0.629099	0.6633663	0.3872832	0.1027762	1420
18m	ma20creditpgdp	0.5	79	0.122277	0.348543	0.3753943	0.5151515	0.2449043	1173
18m	i4d4rcreditp	0.5	76	0.119419	0.436257	0.4236641	0.4922395	0.1950188	1763
18m	i4ma08creditpgdp	0.5	87	0.117744	0.193494	0.2919847	0.6860986	0.388878	1763
18m	hpshcreditpgdp	0.5	57	0.114212	0.617081	0.5965347	0.3918699	0.1073629	1420
18m	i4hpshdocreq	0.5	72	0.110326	0.512146	0.4522901	0.4522901	0.1550694	1763
18m	i4d4grleeqmc	0.5	51	0.109078	0.664769	0.6507633	0.3888255	0.0916049	1763
18m	ma08creditpgdp	0.5	56	0.107603	0.635371	0.5902062	0.3868243	0.1006886	1356
18m	d4rcreditp	0.5	62	0.10609	0.613083	0.5483871	0.3863636	0.1078564	1447
18m	i4hpshdoinliq	0.5	59	0.104267	0.628863	0.5618812	0.387372	0.102865	1420
18m	d4grlecr	0.5	75	0.100637	0.489485	0.3942559	0.4467456	0.1634615	1352
18m	pe	0.5	66	0.100214	0.587404	0.4857724	0.4192982	0.1214774	1652
18m	i4eqlev	0.5	55	0.098725	0.676675	0.610687	0.3846154	0.0873947	1763
18m	eqlev	0.5	52	0.093545	0.702324	0.6285047	0.3810198	0.0791863	1418
18m	d4docreq	0.5	55	0.09296	0.688215	0.5963061	0.3593005	0.0808288	1361
18m	i4d4cpi	0.5	50	0.091112	0.719292	0.6491557	0.3712446	0.0731462	1788
18m	i4d4reqmsci	0.5	52	0.090702	0.706114	0.6172608	0.3755708	0.0774723	1788
18m	hplodocreq	0.5	62	0.089991	0.656154	0.5234375	0.3799622	0.093181	1339
18m	d4rm2m	0.5	58	0.089877	0.672849	0.5494506	0.3807107	0.0881062	933
18m	i4hplodoinequ	0.5	63	0.089089	0.645122	0.5020834	0.4043624	0.0997939	1576
18m	d4grleeqmc	0.5	62	0.087212	0.660175	0.5132743	0.4	0.0943881	1479
18m	i4hpshreqmsci	0.5	52	0.084893	0.728241	0.6247655	0.3683628	0.0702644	1788
18m	i4hplodoinliq	0.5	84	0.083452	0.363876	0.2623762	0.5221675	0.2376605	1420
18m	hpshmcapgdp	0.5	50	0.082452	0.739452	0.6329114	0.3694581	0.0671622	1568
18m	i4d4grleeqmsci	0.5	52	0.081256	0.73511	0.6135085	0.3661814	0.068083	1788
18m	ma08m2mgdp	0.5	57	0.076262	0.71321	0.5318352	0.3697917	0.074764	905
18m	hplope	0.5	52	0.076106	0.739385	0.5840517	0.3647375	0.0667286	1557
18m	i4hpshpe	0.5	53	0.075874	0.733065	0.5684803	0.3668281	0.0687296	1788
18m	bca	0.5	51	0.075614	0.748742	0.6018868	0.3679354	0.0643844	1746
18m	i4pe	0.5	65	0.074388	0.686572	0.4746717	0.3821752	0.0840768	1788
18m	hpshm2mgdp	0.5	55	0.072739	0.735745	0.5505226	0.3665893	0.0679421	961
18m	d4grleeqpe	0.5	54	0.071562	0.745982	0.5634409	0.3674614	0.0651207	1538
18m	ma20fxreer	0.5	54	0.069834	0.754594	0.5691319	0.3397313	0.060055	1112
18m	hplofxreer	0.5	62	0.068923	0.718314	0.4893617	0.3569845	0.0718891	1154
18m	i4hplope	0.5	57	0.064732	0.761229	0.5422139	0.3581165	0.060018	1788
18m	d4gdpr	0.5	52	0.064631	0.783025	0.5957447	0.35533	0.0538546	1559
18m	i4ma20d4cpi	0.5	81	0.064411	0.562662	0.2945591	0.430137	0.1320385	1788
18m	i4hpshcpi	0.5	75	0.061876	0.647272	0.3508443	0.3961864	0.098088	1788
18m	i4ma08d4cpi	0.5	69	0.060562	0.706548	0.412758	0.3754266	0.0773282	1788
18m	hpshgrlecr	0.5	53	0.060468	0.784765	0.5618812	0.3362963	0.0517893	1420
18m	i4hpshm2mgdp	0.5	59	0.058089	0.759212	0.4824903	0.3563218	0.0604093	1737
18m	i4hplodoinequmc	0.5	67	0.057053	0.716828	0.4029536	0.3767259	0.0744299	1568
18m	d4grleeqmsci	0.5	76	0.056941	0.657635	0.3326316	0.3989899	0.0950871	1563
18m	d4reqmsci	0.5	59	0.055984	0.768762	0.4842105	0.3622047	0.058302	1563
18m	hplom2mgdp	0.5	74	0.055713	0.663377	0.3310105	0.3909465	0.0922993	961
18m	i4d4grleeqpe	0.5	53	0.055363	0.800619	0.5553471	0.3466042	0.0485058	1788
18m	hpshpe	0.5	53	0.051749	0.803988	0.5280172	0.3455571	0.0475481	1557
18m	ma20d4cpi	0.5	69	0.047739	0.750204	0.3822222	0.3510204	0.0623738	1559
18m	d4cpi	0.5	50	0.041329	0.855061	0.570297	0.3348837	0.0339302	1678
18m	ma20fxneer	0.5	68	0.040237	0.793159	0.3890578	0.3248731	0.0486346	1191
18m	ed4rcreditp	0.5	72	0.039684	0.774749	0.3523573	0.3325527	0.0540454	1447
18m	hpshcpi	0.5	51	0.039379	0.856881	0.5502958	0.3345324	0.0334635	1684
18m	i4d4rm2m	0.5	50	0.032023	0.880291	0.5350195	0.3231492	0.0272367	1737
18m	hpshgdpr	0.5	62	0.030062	0.864723	0.4444444	0.3366337	0.0316503	1505
18m	i4hpshgrleeqpe	0.5	55	0.029404	0.885183	0.5121951	0.324228	0.0261296	1788
18m	hplofxneer	0.5	50	0.026919	0.90087	0.5431035	0.3038585	0.0216201	1233
18m	ma08fxreer	0.5	54	0.026537	0.896064	0.5106383	0.3111111	0.0230201	1142
18m	hpshdocreq	0.5	50	0.026049	0.905188	0.5494792	0.3075802	0.020799	1339
18m	d4rhousep	0.5	52	0.023991	0.911235	0.5405405	0.2972399	0.0190444	931
18m	ma08d4cpi	0.5	58	0.022183	0.902636	0.4556701	0.3184438	0.0218077	1635
18m	i4ma08d4gdpr	0.5	75	0.020892	0.8569	0.2919847	0.3304536	0.0332329	1763
18m	ed4reqmsci	0.5	83	0.018658	0.813419	0.2	0.3492647	0.045362	1563
18m	ma20m2mgdp	0.5	66	0.018227	0.898582	0.359447	0.3058824	0.0222222	765
18m	i4hpshgrlecr	0.5	58	0.017362	0.922901	0.4503817	0.3142477	0.017027	1763
18m	ma08d4gdpr	0.5	50	0.015892	0.941539	0.5436893	0.3027027	0.0125619	1420
18m	ma20d4gdpr	0.5	50	0.012121	0.955172	0.5407609	0.2979042	0.0095029	1276
18m	i4d4doinequ	0.5	51	0.012031	0.95335	0.5157894	0.3141026	0.0101998	1563
18m	d4fxreer	0.5	53	0.010797	0.956679	0.4984802	0.294964	0.0091256	1151
18m	d4fxneer	0.5	63	0.01028	0.948151	0.3965517	0.293617	0.01092	1231
18m	ma08fxneer	0.5	52	0.009739	0.961488	0.5057471	0.2928452	0.0080662	1222
18m	d4grleeqpesh	0.5	96	0.008609	0.684348	0.0545455	0.3870968	0.0853135	1458
18m	hpshgrleeqpesh	0.5	57	0.008165	0.964173	0.4557823	0.3087558	0.0077319	1465
18m	hpshgrleeqpe	0.5	53	0.00611	0.975456	0.4978541	0.3068783	0.0052602	1545
18m	ggb	0.5	98	0.004078	0.72829	0.0300188	0.372093	0.0706224	1768
18m	hpshreqmsci	0.5	99	-0.000852	1.20438	0.0083333	0.2666667	-0.0379018	1576
18m	hpshfxreer	0.5	99	-0.0018	1.296061	0.0121581	0.2352941	-0.0498012	1154
18m	hpshfxneer	0.5	98	-0.002581	1.179661	0.0287356	0.25	-0.0322385	1233
18m	i4hpshdoinequ	0.5	99	-0.00828	3.649635	0.00625	0.1071429	-0.1974257	1576
18m	i4d4rhousep	0.5	99	-0.011447		0	0	-0.2959125	1737

Table A1. Results of the signalling approach on the stand-alone indicators (horizon 8 quarters, μ=0.5)

Horizon	Variable	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff	nobs
2y	i4hpshcreditpgdp	0.5	55	0.220425	0.379715	0.7107195	0.6237113	0.237438	1763
2y	i4hplomcapgdp	0.5	50	0.198525	0.479016	0.7621145	0.5678337	0.1815603	1763
2y	i4hpshgdpr	0.5	60	0.192524	0.412067	0.6549192	0.604336	0.2180626	1763
2y	i4hploreqmsci	0.5	54	0.184282	0.479188	0.70767	0.5679442	0.1814789	1788
2y	i4hplogrleeqpe	0.5	65	0.180821	0.387512	0.5904486	0.6191199	0.2326546	1788
2y	i4d4doinliq	0.5	56	0.177228	0.478386	0.6795367	0.5382263	0.1802443	1447
2y	i4d4docreq	0.5	63	0.176747	0.405607	0.5947136	0.6081081	0.2218347	1763
2y	i4hpshdocreq	0.5	71	0.165858	0.350867	0.5110132	0.6420664	0.255793	1763
2y	i4d4gdpr	0.5	50	0.15785	0.556718	0.7121879	0.5306346	0.1443612	1763
2y	i4ma20d4gdpr	0.5	50	0.156654	0.559169	0.7107195	0.5295405	0.1432671	1763
2y	i4hpshmcapgdp	0.5	51	0.153635	0.562238	0.7019089	0.5281768	0.1419034	1763
2y	i4d4rcreditp	0.5	65	0.148985	0.460325	0.5521292	0.5775729	0.1912996	1763
2y	hplogrleeqpe	0.5	52	0.148821	0.561906	0.679402	0.5318596	0.1422155	1545
2y	hploreqmsci	0.5	50	0.143851	0.577673	0.6812298	0.5275689	0.135437	1576
2y	hplomcapgdp	0.5	50	0.143246	0.58445	0.6894309	0.5247525	0.1325331	1568
2y	i4eqlev	0.5	55	0.141908	0.560729	0.6461087	0.5288461	0.1425728	1763
2y	i4hplocreditpgdp	0.5	83	0.135023	0.148606	0.3171806	0.8089887	0.4227154	1763
2y	i4d4grlecr	0.5	85	0.133827	0.152225	0.3157122	0.8052434	0.41897	1763
2y	i4ma20creditpgdp	0.5	84	0.130915	0.134433	0.3024963	0.824	0.4377266	1763
2y	i4ma08creditpgdp	0.5	81	0.126001	0.243993	0.3333333	0.7206349	0.3343616	1763
2y	i4hpshreqmsci	0.5	50	0.116539	0.649112	0.6642547	0.4924893	0.106024	1788
2y	i4d4grleeqmc	0.5	51	0.113936	0.642442	0.6372981	0.4948689	0.1085955	1763
2y	hplocreditpgdp	0.5	50	0.113704	0.639593	0.6309751	0.4768786	0.1085688	1420
2y	i4d4reqmsci	0.5	51	0.112471	0.644314	0.6324168	0.4943439	0.1078786	1788
2y	d4rcreditp	0.5	62	0.110105	0.58968	0.5366796	0.486014	0.1280319	1447
2y	ma20creditpgdp	0.5	52	0.109829	0.643703	0.6165048	0.4568345	0.1055984	1173
2y	ma08creditpgdp	0.5	69	0.109682	0.508151	0.446	0.5347722	0.1660406	1356
2y	hpshcreditpgdp	0.5	57	0.108195	0.620229	0.5697896	0.4845529	0.116243	1420
2y	i4hplodocreq	0.5	66	0.104937	0.570798	0.4889868	0.5244095	0.1381361	1763
2y	i4hpshdoinliq	0.5	55	0.102066	0.649963	0.583174	0.4728682	0.1045583	1420
2y	d4docreq	0.5	55	0.101439	0.657643	0.5925926	0.4578696	0.1007793	1361
2y	i4d4grleeqmsci	0.5	51	0.094564	0.694656	0.6193922	0.4755556	0.0890903	1788
2y	d4rm2m	0.5	61	0.087336	0.652617	0.5028248	0.4836957	0.1042744	933
2y	d4grlecr	0.5	75	0.086922	0.517535	0.3603239	0.5266272	0.1612426	1352
2y	eqlev	0.5	50	0.086473	0.720625	0.6190476	0.4649243	0.079875	1418
2y	i4hplodoinequ	0.5	51	0.084321	0.718321	0.5987055	0.4731458	0.0810138	1576
2y	i4d4grleeqpe	0.5	51	0.082987	0.721633	0.5962374	0.4660634	0.079598	1788
2y	pe	0.5	66	0.080268	0.638085	0.4435737	0.4964912	0.1102927	1652
2y	d4grleeqmc	0.5	62	0.0802	0.672422	0.4896552	0.4896552	0.0974983	1479
2y	i4pe	0.5	65	0.079207	0.661102	0.4674385	0.4879154	0.1014501	1788
2y	hplofxreer	0.5	62	0.078008	0.680574	0.4884259	0.4678492	0.0934991	1154
2y	i4hpshpe	0.5	53	0.077579	0.721522	0.5571635	0.4661017	0.0796364	1788
2y	hplodocreq	0.5	52	0.076543	0.743294	0.5963489	0.4394619	0.0712767	1339
2y	ma20fxreer	0.5	50	0.075813	0.747495	0.6004902	0.4367201	0.0698137	1112
2y	d4gdpr	0.5	52	0.075281	0.748091	0.5976821	0.4581218	0.070694	1559
2y	bca	0.5	68	0.075264	0.642691	0.4212828	0.5017361	0.1088381	1746
2y	i4d4cpi	0.5	50	0.074082	0.757964	0.6121563	0.4538627	0.0673974	1788
2y	hplope	0.5	52	0.072724	0.743126	0.5662252	0.4602961	0.0723706	1557
2y	d4grleeqpe	0.5	54	0.070828	0.742521	0.5501672	0.4614306	0.0726139	1538
2y	i4hplodoinliq	0.5	79	0.069984	0.508705	0.2848948	0.5340502	0.1657403	1420
2y	hpshmcapgdp	0.5	50	0.067576	0.774746	0.6	0.4544335	0.0622141	1568
2y	i4hplope	0.5	50	0.065934	0.779367	0.5976845	0.4469697	0.0605044	1788
2y	hpshm2mgdp	0.5	54	0.065355	0.757437	0.538874	0.4557823	0.067645	961
2y	d4reqmsci	0.5	56	0.062663	0.754971	0.5114754	0.4588235	0.0685484	1563
2y	i4ma20d4cpi	0.5	79	0.061816	0.587298	0.2995659	0.5175	0.1310347	1788
2y	i4hpshgrleeqpe	0.5	58	0.060162	0.765132	0.512301	0.4515306	0.0650653	1788
2y	ma08m2mgdp	0.5	50	0.057945	0.793907	0.5623189	0.4369369	0.0557215	905
2y	ma20fxneer	0.5	68	0.05728	0.716581	0.4042056	0.4390863	0.0797244	1191
2y	i4hpshm2mgdp	0.5	56	0.056935	0.772259	0.5	0.4484605	0.062738	1737
2y	hpshcpi	0.5	50	0.054857	0.809091	0.5746951	0.4409357	0.051387	1684
2y	i4hpshcpi	0.5	73	0.054672	0.691604	0.3545586	0.4766537	0.0901884	1788
2y	d4grleeqmsci	0.5	64	0.050372	0.768101	0.4344262	0.4545455	0.0642703	1563
2y	ma20d4cpi	0.5	67	0.041929	0.782869	0.3862069	0.4307692	0.0587359	1559
2y	d4cpi	0.5	51	0.040901	0.851434	0.5506135	0.4273809	0.0388231	1678
2y	hplofxneer	0.5	57	0.038301	0.843002	0.4879121	0.4095941	0.0405754	1233
2y	hpshpe	0.5	53	0.037816	0.849234	0.5016556	0.4273625	0.039437	1557
2y	ed4rcreditp	0.5	72	0.036296	0.787555	0.3416989	0.4145199	0.0565379	1447
2y	d4rhousep	0.5	51	0.034977	0.874682	0.5582089	0.3912134	0.0313852	931
2y	hpshgdpr	0.5	51	0.034637	0.875815	0.5578231	0.4226804	0.0319827	1505
2y	hplom2mgdp	0.5	74	0.034358	0.766991	0.2949062	0.4526749	0.0645375	961
2y	hpshgrlecr	0.5	53	0.033887	0.869203	0.5181645	0.4014815	0.0331716	1420
2y	hpshdocreq	0.5	54	0.033699	0.870712	0.5212982	0.400936	0.0327508	1339
2y	ma20d4gdpr	0.5	50	0.031513	0.88806	0.5630252	0.4011976	0.0281568	1276
2y	i4ma08d4cpi	0.5	92	0.029948	0.529688	0.1273517	0.5432099	0.1567445	1788
2y	ma08fxreer	0.5	51	0.029786	0.889072	0.537037	0.4063047	0.028021	1142
2y	i4hplodoinequmc	0.5	67	0.025609	0.855507	0.3544715	0.4299803	0.0377609	1568
2y	d4fxreer	0.5	50	0.02211	0.918013	0.5393519	0.3955857	0.0202599	1151
2y	i4ma08d4gdpr	0.5	50	0.021469	0.921183	0.544787	0.4059081	0.0196347	1763
2y	ma08d4cpi	0.5	71	0.014542	0.907903	0.3157895	0.4065709	0.0230846	1635
2y	ma08fxneer	0.5	52	0.014398	0.943527	0.5098901	0.3860233	0.0136829	1222
2y	ed4reqmsci	0.5	91	0.014355	0.749813	0.1147541	0.4605263	0.0702512	1563
2y	hpshgrleeqpe	0.5	50	0.012865	0.951597	0.5315614	0.4015056	0.0118616	1545
2y	hpshreqmsci	0.5	50	0.011092	0.957686	0.5242718	0.4024845	0.0103525	1576
2y	d4fxneer	0.5	50	0.007408	0.971437	0.5186813	0.3763955	0.0067773	1231
2y	ma08d4gdpr	0.5	50	0.005007	0.981013	0.5274102	0.377027	0.0044918	1420
2y	d4grleeqpesh	0.5	96	0.004169	0.824916	0.047619	0.4354839	0.046595	1458
2y	i4d4doinequ	0.5	50	0.003606	0.985853	0.5098361	0.3936709	0.0033958	1563
2y	ma20m2mgdp	0.5	92	0.002725	0.923711	0.0714286	0.3846154	0.0186023	765
2y	ggb	0.5	98	0.002667	0.806595	0.0275762	0.4418605	0.0521546	1768
2y	hpshfxneer	0.5	99	-0.002404	1.36461	0.0131868	0.3	-0.0690186	1233
2y	i4hpshgrlecr	0.5	99	-0.003368	1.573475	0.0117474	0.2857143	-0.1005591	1763
2y	hpshgrleeqpesh	0.5	99	-0.003621	1.516918	0.0140105	0.2962963	-0.0934648	1465
2y	hpshfxreer	0.5	99	-0.004373	1.944598	0.0092593	0.2352941	-0.139056	1154
2y	i4hpshdoinequ	0.5	99	-0.00929	3.870564	0.0064725	0.1428571	-0.2492748	1576
2y	i4d4rhousep	0.5	99	-0.013121		0	0	-0.3857225	1737

Table A1. Results of the signalling approach on the stand-alone indicators (horizon 4 quarters, μ=0.5)

Horizon	Variable	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff	nobs
1y	i4hpshcreditpgdp	0.5	55	0.19592	0.480003	0.7535411	0.3427835	0.1425566	1763
1y	i4hplomcapgdp	0.5	55	0.195543	0.501613	0.7847025	0.3329327	0.1327058	1763
1y	i4hplodocreq	0.5	67	0.144978	0.500709	0.5807365	0.3333333	0.1331065	1763
1y	hplomcapgdp	0.5	69	0.143109	0.485451	0.55625	0.3456311	0.1415494	1568
1y	i4hpshgdpr	0.5	60	0.136782	0.570809	0.6373938	0.3048781	0.1046512	1763
1y	i4hplogrleeqpe	0.5	71	0.136669	0.480659	0.5263158	0.3448276	0.142926	1788
1y	i4hploreqmsci	0.5	75	0.136582	0.433262	0.4819945	0.3686441	0.1667425	1788
1y	i4hplocreditpgdp	0.5	90	0.135961	0.077032	0.2946176	0.7647059	0.564479	1763
1y	i4ma20creditpgdp	0.5	90	0.132419	0.083452	0.2889518	0.75	0.5497731	1763
1y	i4d4doinliq	0.5	63	0.130352	0.56176	0.5948905	0.2936937	0.1043364	1447
1y	i4ma08creditpgdp	0.5	88	0.123891	0.212012	0.3144476	0.5414634	0.3412365	1763
1y	hplocreditpgdp	0.5	52	0.123725	0.631516	0.6715329	0.2746269	0.0816691	1420
1y	ma20creditpgdp	0.5	79	0.121474	0.385485	0.3953488	0.3679654	0.1846747	1173
1y	i4d4gdpr	0.5	50	0.120418	0.661295	0.7110482	0.2746171	0.0743902	1763
1y	i4d4grlecr	0.5	89	0.118932	0.222537	0.305949	0.5294118	0.3291849	1763
1y	hplogrleeqpe	0.5	72	0.116744	0.511517	0.4779874	0.3362832	0.1304579	1545
1y	i4d4rcreditp	0.5	78	0.114244	0.45132	0.4164306	0.3567961	0.1565692	1763
1y	hploreqmsci	0.5	53	0.112277	0.655823	0.652439	0.2860962	0.0779744	1576
1y	i4d4cpi	0.5	50	0.109033	0.686367	0.6952909	0.2693133	0.0674117	1788
1y	pe	0.5	66	0.108473	0.581071	0.5178571	0.3052632	0.1018733	1652
1y	d4rcreditp	0.5	59	0.108427	0.639893	0.6021898	0.267423	0.0780657	1447
1y	i4ma20d4gdpr	0.5	50	0.104478	0.6952	0.6855524	0.2647702	0.0645434	1763
1y	ma08creditpgdp	0.5	51	0.099505	0.692758	0.6477273	0.2586989	0.0640087	1356
1y	i4d4grleeqmc	0.5	51	0.098118	0.700126	0.6543909	0.263398	0.0631711	1763
1y	d4grlecr	0.5	75	0.097619	0.521114	0.4076923	0.3136095	0.1213018	1352
1y	hpshcreditpgdp	0.5	59	0.097063	0.659037	0.5693431	0.2662116	0.0732539	1420
1y	i4hpshmcapgdp	0.5	51	0.097044	0.709692	0.6685553	0.2607735	0.0605466	1763
1y	i4ma08d4cpi	0.5	73	0.095835	0.564826	0.4404432	0.3093385	0.1074369	1788
1y	i4d4docreq	0.5	71	0.091523	0.596157	0.4532578	0.2957486	0.0955217	1763
1y	i4hplodoinliq	0.5	84	0.087798	0.383161	0.2846715	0.3842365	0.1912787	1420
1y	i4hpshdoinliq	0.5	59	0.085757	0.688776	0.5510949	0.2576792	0.0647215	1420
1y	hplodocreq	0.5	62	0.084209	0.682551	0.5305343	0.2627599	0.0670915	1339
1y	i4ma20d4cpi	0.5	82	0.083897	0.486662	0.3268698	0.342029	0.1401274	1788
1y	eqlev	0.5	50	0.083415	0.741371	0.6450512	0.2599725	0.0533434	1418
1y	i4hpshdocreq	0.5	79	0.082016	0.540448	0.3569405	0.3165829	0.116356	1763
1y	i4eqlev	0.5	58	0.081509	0.715122	0.572238	0.2593068	0.0590799	1763
1y	i4d4grleeqmsci	0.5	57	0.080294	0.722622	0.5789474	0.2593052	0.0574036	1788
1y	bca	0.5	54	0.07794	0.73654	0.5916666	0.2607099	0.0545243	1746
1y	hpshgrlecr	0.5	53	0.076321	0.744977	0.5985401	0.242963	0.0500052	1420
1y	d4rm2m	0.5	61	0.074379	0.710232	0.513369	0.2608696	0.0604408	933
1y	hpshmcapgdp	0.5	50	0.073197	0.769231	0.634375	0.25	0.0459184	1568
1y	i4hpshcpi	0.5	82	0.071749	0.533306	0.3074792	0.3217391	0.1198376	1788
1y	i4hplodoinequmc	0.5	65	0.071474	0.686688	0.45625	0.2718808	0.0677992	1568
1y	ma08m2mgdp	0.5	62	0.071424	0.706278	0.4863388	0.2640949	0.061885	905
1y	d4grleeqmc	0.5	65	0.070688	0.701649	0.4738562	0.271028	0.0641315	1479
1y	d4grleeqmc	0.5	67	0.070688	0.688771	0.4542484	0.2747036	0.067807	1479
1y	i4hpshm2mgdp	0.5	50	0.070487	0.766174	0.6028985	0.2444183	0.0458	1737
1y	i4pe	0.5	60	0.070413	0.735218	0.5318559	0.256	0.0540984	1788
1y	hplom2mgdp	0.5	80	0.069302	0.536394	0.2989691	0.320442	0.1185689	961
1y	hplope	0.5	60	0.068404	0.728967	0.5047619	0.2581169	0.0558047	1557
1y	i4hpshpe	0.5	53	0.06808	0.761391	0.5706371	0.2493947	0.0474931	1788
1y	hplofxreer	0.5	63	0.065987	0.728652	0.4863636	0.2442922	0.053651	1154
1y	i4hplope	0.5	57	0.060854	0.7781	0.5484765	0.2453532	0.0434516	1788
1y	d4gdpr	0.5	52	0.060316	0.799363	0.6012461	0.2449239	0.0390226	1559
1y	i4hpshgrlecr	0.5	73	0.059315	0.675375	0.3654391	0.2704403	0.0702134	1763
1y	i4hplodoinequ	0.5	66	0.059178	0.732272	0.4420732	0.2641166	0.0559948	1576
1y	i4d4reqmsci	0.5	56	0.056715	0.788927	0.5373961	0.2428035	0.0409019	1788
1y	ma20d4cpi	0.5	74	0.055796	0.678784	0.3474026	0.2661692	0.0686066	1559
1y	d4docreq	0.5	51	0.055555	0.811627	0.5898438	0.2220588	0.0339618	1361
1y	ma20fxreer	0.5	63	0.055076	0.763799	0.4663461	0.2315036	0.0444532	1112
1y	i4d4rm2m	0.5	51	0.052711	0.812522	0.5623189	0.2337349	0.0351166	1737
1y	d4grleeqpe	0.5	54	0.047767	0.8229	0.5394322	0.2398317	0.0337199	1538
1y	hpshm2mgdp	0.5	56	0.047171	0.816975	0.5154639	0.2364066	0.0345336	961
1y	ed4rcreditp	0.5	55	0.045435	0.831767	0.540146	0.2192593	0.029902	1447
1y	hpshpe	0.5	60	0.043789	0.808424	0.4571429	0.238806	0.0364938	1557
1y	ma20m2mgdp	0.5	66	0.042104	0.790193	0.4013605	0.2313726	0.0392157	765
1y	d4grleeqmsci	0.5	72	0.037761	0.786022	0.3529412	0.2489083	0.0422544	1563
1y	d4reqmsci	0.5	55	0.035451	0.858632	0.501548	0.2327586	0.0261047	1563
1y	ma20fxneer	0.5	77	0.03513	0.763674	0.2972973	0.2307692	0.0443712	1191
1y	hpshgdpr	0.5	62	0.035118	0.846758	0.4583333	0.2359736	0.0286646	1505
1y	hpshcpi	0.5	51	0.034884	0.873315	0.5507246	0.2278177	0.0229484	1684
1y	i4hpshreqmsci	0.5	53	0.034575	0.873925	0.5484765	0.2244898	0.0225882	1788
1y	d4cpi	0.5	51	0.03169	0.884977	0.5510204	0.225	0.02059	1678
1y	d4grleeqpesh	0.5	58	0.030921	0.867922	0.4682274	0.2291326	0.0240571	1458
1y	ma08d4cpi	0.5	80	0.02844	0.773854	0.2515152	0.2462908	0.0444559	1635
1y	i4d4grleeqpe	0.5	52	0.028	0.895255	0.5346261	0.2203196	0.0184181	1788
1y	d4fxneer	0.5	65	0.023191	0.883295	0.3974359	0.2099323	0.0198429	1231
1y	ma08fxreer	0.5	51	0.02252	0.916026	0.5363637	0.206655	0.0140105	1142
1y	ma08d4gdpr	0.5	50	0.021215	0.923572	0.5551602	0.2108108	0.0129235	1420
1y	hpshgrleeqpesh	0.5	59	0.01932	0.915385	0.4566667	0.2195513	0.0147731	1465
1y	ed4reqmsci	0.5	82	0.019311	0.819203	0.2136223	0.2412587	0.0346049	1563
1y	ma08fxneer	0.5	66	0.019231	0.9	0.3846154	0.2083333	0.016844	1222
1y	hpshdocreq	0.5	66	0.015868	0.917676	0.3854962	0.2095436	0.0138752	1339
1y	hplofxneer	0.5	50	0.015708	0.940715	0.5299146	0.1993569	0.0095759	1233
1y	d4rhousep	0.5	53	0.014152	0.945259	0.5170454	0.1978261	0.008782	931
1y	i4d4doinequ	0.5	70	0.010184	0.93674	0.3219814	0.2175732	0.0109193	1563
1y	hpshgrleeqpe	0.5	98	0.004606	0.755909	0.0377358	0.2553191	0.0494939	1545
1y	hpshfxneer	0.5	97	0.002349	0.89009	0.042735	0.2083333	0.0185523	1233
1y	i4ma08d4gdpr	0.5	75	0.002293	0.982775	0.266289	0.2030238	0.0027969	1763
1y	d4fxreer	0.5	53	0.002043	0.991598	0.4863636	0.192446	0.0013079	1151
1y	ma20d4gdpr	0.5	50	0.001611	0.993875	0.5261044	0.1961078	0.0009667	1276
1y	ggb	0.5	96	0.000875	0.957877	0.0415512	0.2112676	0.0070821	1768
1y	i4hpshgrleeqpe	0.5	99	-0.001134	1.1637	0.0138504	0.1785714	-0.0233301	1788
1y	hpshreqmsci	0.5	99	-0.00216	1.708333	0.0060976	0.1333333	-0.0747885	1576
1y	i4hpshdoinequ	0.5	99	-0.005443	2.190171	0.0091463	0.1071429	-0.100979	1576
1y	hpshfxreer	0.5	99	-0.006293	3.768737	0.0045455	0.0588235	-0.1318177	1154
1y	i4d4rhousep	0.5	99	-0.010058		0	0	-0.1986183	1737

Table A1. Results of the signalling approach on the stand-alone indicators (horizon 2 quarters, μ=0.5)

Horizon	Variable	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff	nobs
6m	i4hpshcreditpgdp	0.5	55	0.188807	0.51526	0.7790055	0.181701	0.0790351	1763
6m	i4hplomcapgdp	0.5	56	0.158959	0.573756	0.7458563	0.1662562	0.0635903	1763
6m	i4hploreqmsci	0.5	80	0.142793	0.389886	0.4680851	0.2315789	0.1264335	1788
6m	i4hplogrleeqpe	0.5	69	0.137859	0.520046	0.5744681	0.1843003	0.0791549	1788
6m	i4ma20creditpgdp	0.5	93	0.136295	0.069079	0.2928177	0.6235294	0.5208635	1763
6m	i4hplodocreq	0.5	67	0.131945	0.549394	0.5856354	0.1723577	0.0696918	1763
6m	i4d4rcreditp	0.5	79	0.129724	0.434215	0.4585635	0.2085427	0.1058768	1763
6m	i4hplocreditpgdp	0.5	91	0.127363	0.146193	0.2983426	0.4390244	0.3363585	1763
6m	i4ma08creditpgdp	0.5	91	0.124671	0.194092	0.3093923	0.3708609	0.268195	1763
6m	i4d4doinliq	0.5	52	0.121106	0.660903	0.7142857	0.13947	0.0427181	1447
6m	ma20creditpgdp	0.5	82	0.118943	0.376966	0.3818182	0.2153846	0.121608	1173
6m	hplocreditpgdp	0.5	52	0.118638	0.653971	0.6857143	0.1432836	0.044692	1420
6m	i4d4grlecr	0.5	93	0.118596	0.189967	0.2928177	0.3758865	0.2732206	1763
6m	hplomcapgdp	0.5	50	0.117435	0.676315	0.7256098	0.1472772	0.0426854	1568
6m	i4hpshgdpr	0.5	51	0.111094	0.688247	0.7127072	0.1425414	0.0398755	1763
6m	i4d4grleeqmsci	0.5	80	0.1101	0.46237	0.4095745	0.2026316	0.0974862	1788
6m	d4rcreditp	0.5	58	0.109747	0.654729	0.6357143	0.1406003	0.0438484	1447
6m	i4ma08d4cpi	0.5	89	0.107227	0.316653	0.3138298	0.2706422	0.1654968	1788
6m	i4d4cpi	0.5	50	0.107008	0.699739	0.7127659	0.1437768	0.0386314	1788
6m	i4d4docreq	0.5	92	0.103355	0.251707	0.2762431	0.3125	0.2098341	1763
6m	ma08creditpgdp	0.5	51	0.102188	0.695708	0.6716418	0.1361573	0.0373373	1356
6m	d4grlecr	0.5	74	0.101764	0.544651	0.4469697	0.1657303	0.0680972	1352
6m	i4d4grleeqmc	0.5	51	0.095316	0.71484	0.6685083	0.1379704	0.0353044	1763
6m	i4hplodoinliq	0.5	90	0.094141	0.246875	0.25	0.3070175	0.208426	1420
6m	i4hpshcpi	0.5	83	0.093344	0.46822	0.3510638	0.2006079	0.0954625	1788
6m	i4d4gdpr	0.5	50	0.092858	0.728916	0.6850829	0.1356674	0.0330015	1763
6m	i4ma20d4cpi	0.5	90	0.092673	0.329904	0.2765957	0.2626263	0.1574808	1788
6m	i4hpshm2mgdp	0.5	51	0.09095	0.716499	0.6416185	0.1337349	0.0341379	1737
6m	pe	0.5	66	0.089987	0.644052	0.505618	0.1578947	0.0501465	1652
6m	hpshcreditpgdp	0.5	63	0.084989	0.678421	0.5285714	0.1388368	0.0402452	1420
6m	hpshgrlecr	0.5	66	0.082757	0.664176	0.4928571	0.1413934	0.0428019	1420
6m	i4hpshgrlecr	0.5	66	0.08214	0.665904	0.4917127	0.1466227	0.0439568	1763
6m	i4hpshdoinliq	0.5	59	0.080134	0.71234	0.5571429	0.1331058	0.0345142	1420
6m	bca	0.5	61	0.077988	0.709668	0.5372341	0.1453237	0.0376491	1746
6m	ma20d4cpi	0.5	81	0.076462	0.535564	0.3292683	0.18	0.0748044	1559
6m	ed4rcreditp	0.5	50	0.075956	0.766288	0.65	0.1226415	0.0258896	1447
6m	i4d4rm2m	0.5	50	0.071397	0.769128	0.6184971	0.1257344	0.0261374	1737
6m	hplofxreer	0.5	67	0.068025	0.706559	0.4636364	0.129771	0.0344504	1154
6m	ma20fxreer	0.5	64	0.067613	0.724245	0.4903846	0.1246944	0.0311692	1112
6m	i4pe	0.5	60	0.065805	0.755025	0.5372341	0.1346667	0.0295212	1788
6m	ma08fxneer	0.5	85	0.063997	0.534565	0.275	0.1692308	0.0710311	1222
6m	d4gdpr	0.5	63	0.063443	0.749285	0.5060976	0.1356209	0.0304253	1559
6m	hplogrleeqpe	0.5	54	0.062845	0.786327	0.5882353	0.1358696	0.0258372	1545
6m	hplodocreq	0.5	62	0.062488	0.753671	0.5073529	0.1304348	0.0288664	1339
6m	ma20m2mgdp	0.5	66	0.062336	0.720432	0.4459459	0.1294118	0.0326797	765
6m	hplom2mgdp	0.5	80	0.062311	0.584592	0.3	0.1657459	0.0616876	961
6m	i4ma20d4gdpr	0.5	50	0.062073	0.802892	0.6298342	0.1247265	0.0220606	1763
6m	i4hplodoinequmc	0.5	67	0.061193	0.717307	0.4329268	0.1400394	0.0354476	1568
6m	i4d4reqmsci	0.5	57	0.059714	0.779877	0.5425532	0.1309371	0.0257917	1788
6m	hploreqmsci	0.5	53	0.059488	0.795031	0.5804598	0.1350267	0.0246206	1576
6m	d4rm2m	0.5	58	0.057907	0.779952	0.5263158	0.1269035	0.0250815	933
6m	i4eqlev	0.5	60	0.056129	0.783845	0.519337	0.1273713	0.0247054	1763
6m	i4hpshdocreq	0.5	82	0.055385	0.621711	0.2928177	0.1554252	0.0527593	1763
6m	hplope	0.5	67	0.054075	0.745074	0.4242424	0.1372549	0.0312819	1557
6m	ma20fxneer	0.5	81	0.053951	0.638211	0.2982456	0.1422594	0.0465415	1191
6m	i4hplope	0.5	56	0.05363	0.807952	0.5585107	0.1269649	0.0218195	1788
6m	ma08m2mgdp	0.5	62	0.053401	0.771831	0.4680851	0.1305638	0.0266964	905
6m	eqlev	0.5	52	0.05337	0.820101	0.5933333	0.1260623	0.0202795	1418
6m	i4hpshmcapgdp	0.5	51	0.046446	0.844319	0.5966851	0.119337	0.0166711	1763
6m	hpshcpi	0.5	56	0.045361	0.828007	0.5274726	0.1276596	0.0195836	1684
6m	ma08d4cpi	0.5	71	0.044729	0.763279	0.377907	0.1334702	0.0282714	1635
6m	i4hpshpe	0.5	52	0.041124	0.849879	0.5478724	0.1214623	0.0163168	1788
6m	hpshmcapgdp	0.5	50	0.041102	0.861016	0.5914634	0.1194581	0.0148663	1568
6m	d4cpi	0.5	52	0.039675	0.85997	0.5666667	0.1225962	0.0153256	1678
6m	d4fxneer	0.5	87	0.03936	0.622142	0.2083333	0.147929	0.0504473	1231
6m	ma08d4gdpr	0.5	52	0.037972	0.867328	0.5724138	0.1159218	0.0138091	1420
6m	i4d4doinequ	0.5	70	0.036335	0.803906	0.3705882	0.1317992	0.023034	1563
6m	d4docreq	0.5	95	0.034325	0.442222	0.1230769	0.1927711	0.0972531	1361
6m	hpshgdpr	0.5	60	0.033934	0.858977	0.48125	0.121643	0.0153307	1505
6m	i4hplodoinequ	0.5	78	0.033499	0.771419	0.2931035	0.138587	0.0281809	1576
6m	d4grleeqpe	0.5	86	0.032659	0.675332	0.2011834	0.1545455	0.0446625	1538
6m	hplofxneer	0.5	85	0.031963	0.704955	0.2166667	0.1326531	0.0353295	1233
6m	i4ma08m2mgdp	0.5	56	0.030818	0.873059	0.4855491	0.1124498	0.0128528	1737
6m	d4rhousep	0.5	93	0.030815	0.548043	0.1363636	0.16	0.065478	931
6m	ma08fxreer	0.5	55	0.030409	0.882633	0.5181818	0.1077505	0.0114282	1142
6m	hpshpe	0.5	60	0.027449	0.874192	0.4363636	0.119403	0.01343	1557
6m	d4grleeqmc	0.5	80	0.027173	0.790569	0.2594937	0.1314103	0.0245813	1479
6m	i4d4grleeqpe	0.5	51	0.026902	0.900833	0.5425532	0.1153846	0.0102392	1788
6m	d4fxreer	0.5	59	0.026469	0.888015	0.4727273	0.1063395	0.0107704	1151
6m	d4grleeqmsci	0.5	92	0.024934	0.631418	0.1352941	0.1619718	0.0532066	1563
6m	d4grleeqpesh	0.5	66	0.023135	0.878927	0.3821656	0.1207243	0.0130426	1458
6m	hpshgrleeqpesh	0.5	64	0.021305	0.896428	0.4113924	0.11883	0.0109802	1465
6m	hpshfxneer	0.5	98	0.018958	0.431267	0.0666667	0.2	0.1026764	1233
6m	hpshm2mgdp	0.5	50	0.018775	0.929152	0.53	0.1111111	0.0070528	961
6m	d4reqmsci	0.5	94	0.013538	0.671213	0.0823529	0.1538462	0.045081	1563
6m	hpshgrleeqpe	0.5	99	0.012952	0.370909	0.0411765	0.25	0.1399676	1545
6m	i4ma08d4gdpr	0.5	98	0.006929	0.686473	0.0441989	0.1428571	0.0401912	1763
6m	i4hpshreqmsci	0.5	57	0.006383	0.972414	0.462766	0.1078067	0.0026613	1788
6m	hpshdocreq	0.5	99	0.005978	0.593516	0.0294118	0.16	0.0584317	1339
6m	i4hpshdoinequ	0.5	51	0.004341	0.983214	0.5172414	0.1120797	0.0016736	1576
6m	ma20d4gdpr	0.5	79	0.003663	0.968988	0.2362205	0.1023891	0.0028593	1276
6m	hpshreqmsci	0.5	96	0.003017	0.868759	0.045977	0.125	0.0145939	1576
6m	ed4reqmsci	0.5	91	0.001543	0.969131	0.1	0.1118421	0.0030769	1563
6m	i4ma20m2mgdp	0.5	97	1.29E-05	0.995524	0.0057803	0.1	0.000403	1737
6m	ggb	0.5	98	-0.001704	1.160127	0.0212766	0.0930233	-0.0133116	1768
6m	i4hpshgrleeqpe	0.5	99	-0.002806	1.5275	0.0106383	0.0714286	-0.0337168	1788
6m	hpshfxreer	0.5	99	-0.003117	1.685824	0.0090909	0.0588235	-0.0364971	1154
6m	i4d4rhousep	0.5	99	-0.008951		0	0	-0.099597	1737

Table A1. Results of the signalling approach on the stand-alone indicators (horizon 6 quarters, μ=0.4)

Horizon	Variable	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff	nobs
18m	i4hpshcreditpgdp	0.4	61	0.106458	0.397179	0.658397	0.5156951	0.2184744	1763
18m	i4ma20creditpgdp	0.4	87	0.104704	0.095157	0.3053435	0.8163266	0.5191059	1763
18m	i4hplomcapgdp	0.4	55	0.099885	0.450207	0.769084	0.484375	0.1871544	1763
18m	i4hplocreditpgdp	0.4	87	0.098466	0.11187	0.2958015	0.7908163	0.4935957	1763
18m	i4d4grlecr	0.4	88	0.090866	0.167573	0.3034351	0.7162162	0.4189956	1763
18m	i4ma08creditpgdp	0.4	87	0.082896	0.193494	0.2919847	0.6860986	0.388878	1763
18m	i4d4doinliq	0.4	84	0.082165	0.280738	0.3548387	0.5789474	0.3004401	1447
18m	i4hplogrleeqpe	0.4	71	0.08057	0.41105	0.5253283	0.508167	0.2100685	1788
18m	i4hploreqmsci	0.4	76	0.079848	0.375965	0.4577861	0.5304348	0.2323363	1788
18m	hplomcapgdp	0.4	78	0.078874	0.3582	0.4261603	0.5474254	0.2451295	1568
18m	hplogrleeqpe	0.4	81	0.078276	0.325124	0.3819743	0.5705128	0.2688947	1545
18m	i4d4docreq	0.4	83	0.073146	0.31949	0.351145	0.5696595	0.2724388	1763
18m	ma20creditpgdp	0.4	79	0.071653	0.348543	0.3753943	0.5151515	0.2449043	1173
18m	i4hpshgdpr	0.4	82	0.068172	0.348289	0.3568702	0.5483871	0.2511665	1763
18m	hploreqmsci	0.4	75	0.062725	0.423074	0.4291667	0.508642	0.2040734	1576
18m	i4d4rcreditp	0.4	79	0.061779	0.40219	0.389313	0.5125628	0.2153422	1763
18m	hplocreditpgdp	0.4	88	0.057827	0.247989	0.230198	0.615894	0.331387	1420
18m	ma08creditpgdp	0.4	81	0.057781	0.379244	0.3350515	0.513834	0.2276983	1356
18m	i4hplodocreq	0.4	67	0.052761	0.50269	0.5362595	0.4569106	0.1596899	1763
18m	d4grlecr	0.4	90	0.051002	0.283652	0.2219321	0.5821918	0.2989077	1352
18m	i4hplodoinliq	0.4	86	0.048396	0.327223	0.2376238	0.5485714	0.2640644	1420
18m	d4rcreditp	0.4	81	0.045332	0.442782	0.337469	0.4657534	0.1872462	1447
18m	i4hpshdocreq	0.4	76	0.044846	0.481048	0.4026718	0.4678492	0.1706286	1763
18m	i4d4gdpr	0.4	63	0.03834	0.553928	0.5667939	0.4329446	0.1357239	1763
18m	i4hpshdoinliq	0.4	70	0.032942	0.543438	0.4455445	0.4225352	0.1380282	1420
18m	hpshcreditpgdp	0.4	74	0.032246	0.532638	0.4009901	0.4274406	0.1429336	1420
18m	pe	0.4	78	0.03129	0.513029	0.3394309	0.4525745	0.1547537	1652
18m	i4hpshmcapgdp	0.4	53	0.028804	0.59679	0.6870229	0.4147466	0.1175259	1763
18m	i4ma08d4cpi	0.4	92	0.022063	0.424701	0.15197	0.5	0.2019016	1788
18m	i4hplodoinequ	0.4	74	0.021661	0.571976	0.38125	0.4336493	0.1290808	1576
18m	i4ma20d4cpi	0.4	82	0.020572	0.545643	0.2833021	0.4376812	0.1395827	1788
18m	d4grleeqmc	0.4	86	0.017822	0.535044	0.2256637	0.4513274	0.1457155	1479
18m	bca	0.4	84	0.017453	0.548978	0.2471698	0.4425676	0.1390166	1746
18m	i4d4grleeqmsci	0.4	90	0.015909	0.509641	0.1688555	0.4545455	0.156447	1788
18m	hplom2mgdp	0.4	86	0.015734	0.53227	0.1951219	0.4444444	0.1457972	961
18m	hplodocreq	0.4	94	0.015461	0.446771	0.1171875	0.4736842	0.186903	1339
18m	i4ma20d4gdpr	0.4	50	0.014014	0.633227	0.6984733	0.4004376	0.103217	1763
18m	hplope	0.4	91	0.011415	0.52195	0.1314655	0.4485294	0.1505204	1557
18m	d4grleeqpe	0.4	86	0.010404	0.580893	0.2021505	0.4272727	0.124932	1538
18m	d4grleeqmsci	0.4	93	0.009658	0.530134	0.1178947	0.4516129	0.1477101	1563
18m	d4gdpr	0.4	87	0.009226	0.590595	0.2021277	0.4222222	0.1207469	1559
18m	ed4rcreditp	0.4	94	0.008929	0.523878	0.1042184	0.4242424	0.1457352	1447
18m	d4rm2m	0.4	95	0.008801	0.499811	0.0879121	0.4528302	0.1602257	933
18m	d4docreq	0.4	88	0.008502	0.589948	0.1846966	0.3954802	0.1170085	1361
18m	i4hpshcpi	0.4	79	0.007791	0.623944	0.30394	0.405	0.1069016	1788
18m	ma08m2mgdp	0.4	73	0.007664	0.629993	0.3483146	0.3991416	0.104114	905
18m	i4pe	0.4	98	0.006398	0.456161	0.0506567	0.4821429	0.1840444	1788
18m	d4reqmsci	0.4	98	0.006334	0.388072	0.0378947	0.5294118	0.225509	1563
18m	hpshpe	0.4	94	0.005783	0.542442	0.0775862	0.4390244	0.1410154	1557
18m	hplofxneer	0.4	98	0.005774	0.480603	0.0517241	0.45	0.1677615	1233
18m	eqlev	0.4	95	0.00367	0.595905	0.0864486	0.4204545	0.118621	1418
18m	i4d4grleeqpe	0.4	96	0.00284	0.594582	0.065666	0.4166667	0.1185682	1788
18m	ma20d4cpi	0.4	84	0.002711	0.645921	0.2177778	0.3858268	0.0971802	1559
18m	i4d4reqmsci	0.4	93	0.002617	0.625876	0.1069418	0.4042553	0.1061569	1788
18m	i4d4grleeqmc	0.4	92	0.002366	0.634383	0.1221374	0.4	0.1027794	1763
18m	i4eqlev	0.4	92	0.002366	0.634383	0.1221374	0.4	0.1027794	1763
18m	d4grleeqpesh	0.4	99	0.001699	0.528269	0.0204545	0.45	0.1482167	1458
18m	d4rhousep	0.4	99	0.000748	0.626302	0.030888	0.3809524	0.1027569	931
18m	ggb	0.4	99	0.000174	0.647368	0.0150094	0.4	0.0985294	1768
18m	hpshgrleeqpe	0.4	99	-1.11E-05	0.667453	0.0236052	0.3928571	0.091239	1545
18m	ed4reqmsci	0.4	99	-0.000403	0.698529	0.0210526	0.3846154	0.0807126	1563
18m	hplofxreer	0.4	76	-0.000818	0.670858	0.325228	0.3728223	0.087727	1154
18m	hpshcpi	0.4	99	-0.001202	1.005098	0.0059172	0.3	-0.0010689	1684
18m	ma20m2mgdp	0.4	99	-0.002134	0.923966	0.0138249	0.3	0.0163399	765
18m	i4hpshgrleeqpe	0.4	99	-0.002329	0.896591	0.0168856	0.3214286	0.0233301	1788
18m	ma20fxneer	0.4	99	-0.00245	0.890565	0.0182371	0.3	0.0237616	1191
18m	d4cpi	0.4	99	-0.002508	1.72208	0.0039604	0.2	-0.1009535	1678
18m	ma08d4cpi	0.4	99	-0.002659	1.096522	0.0103093	0.2777778	-0.0188583	1635
18m	hpshreqmsci	0.4	99	-0.002689	1.20438	0.0083333	0.2666667	-0.0379018	1576
18m	ma08fxneer	0.4	99	-0.002714	0.929062	0.0172414	0.3	0.015221	1222
18m	hpshm2mgdp	0.4	99	-0.002941	1.135509	0.010453	0.2727273	-0.02592	961
18m	i4hplope	0.4	93	-0.003525	0.726892	0.097561	0.3687943	0.0706959	1788
18m	hpshdocreq	0.4	99	-0.004017	1.033957	0.0182292	0.28	-0.0067812	1339
18m	d4fxneer	0.4	99	-0.004445	1.182333	0.0143678	0.25	-0.032697	1231
18m	hpshfxreer	0.4	99	-0.004591	1.296061	0.0121581	0.2352941	-0.0498012	1154
18m	ma08fxreer	0.4	99	-0.004731	1.315191	0.0121581	0.2352941	-0.0527969	1142
18m	i4hplodoinequmc	0.4	99	-0.005357	1.372029	0.0126582	0.24	-0.0622959	1568
18m	hpshgdpr	0.4	99	-0.005372	1.253756	0.0152505	0.2592593	-0.0457241	1505
18m	hpshmcapgdp	0.4	98	-0.005989	0.982084	0.0316456	0.3061225	0.0038265	1568
18m	ma20fxreer	0.4	99	-0.006091	1.455992	0.0128617	0.2105263	-0.0691499	1112
18m	hpshgrlecr	0.4	88	-0.006128	0.732159	0.1559406	0.3519553	0.0674483	1420
18m	hpshfxneer	0.4	99	-0.00625	1.572881	0.0114943	0.2	-0.0822385	1233
18m	hpshgrleeqpesh	0.4	99	-0.006863	1.507324	0.0136054	0.2222222	-0.0788017	1465
18m	i4d4doinequ	0.4	99	-0.00708	1.600797	0.0126316	0.2142857	-0.089617	1563
18m	i4d4cpi	0.4	99	-0.008472	2.548207	0.0075047	0.1428571	-0.1552413	1788
18m	d4fxreer	0.4	99	-0.008517	3.001825	0.006079	0.1176471	-0.1681913	1151
18m	i4hpshgrlecr	0.4	99	-0.008569	2.53753	0.0076336	0.1428571	-0.1543635	1763
18m	i4hpshreqmsci	0.4	99	-0.009701	3.539177	0.0056285	0.1071429	-0.1909556	1788
18m	ma08d4gdpr	0.4	99	-0.009807	2.350199	0.0097087	0.1481481	-0.1419927	1420
18m	i4ma08d4gdpr	0.4	99	-0.009817	3.524348	0.0057252	0.1071429	-0.1900778	1763
18m	ma20d4gdpr	0.4	99	-0.01085	2.330396	0.0108696	0.1481481	-0.1402531	1276
18m	i4hpshdoinequ	0.4	99	-0.011186	3.649635	0.00625	0.1071429	-0.1974257	1576
18m	i4d4rhousep	0.4	99	-0.013737		0	0	-0.2959125	1737

Table A1. Results of the signalling approach on the stand-alone indicators (horizon 6 quarters, μ=0.6)

Horizon	Variable	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff	nobs
18m	i4hplomcapgdp	0.6	50	0.125836	0.490909	0.8072519	0.4628009	0.1655802	1763
18m	i4hpshcreditpgdp	0.6	55	0.111673	0.433964	0.730916	0.4935567	0.1963361	1763
18m	i4hploreqmsci	0.6	51	0.066872	0.578738	0.7242026	0.4232456	0.1251472	1788
18m	i4d4doinliq	0.6	52	0.064416	0.575002	0.7146402	0.4016736	0.1231664	1447
18m	i4hpshgdpr	0.6	51	0.059752	0.595015	0.7175573	0.4154696	0.118249	1763
18m	i4hplogrleeqpe	0.6	50	0.057609	0.606084	0.7204503	0.4120172	0.1139187	1788
18m	hplomcapgdp	0.6	50	0.05437	0.605553	0.7109705	0.4170792	0.1147833	1568
18m	i4hpshmcapgdp	0.6	51	0.050944	0.611522	0.7061068	0.4088398	0.1116191	1763
18m	hplogrleeqpe	0.6	52	0.047225	0.60275	0.6888412	0.4174252	0.1158071	1545
18m	i4d4gdpr	0.6	50	0.046571	0.624641	0.7041985	0.4037199	0.1064993	1763
18m	hploreqmsci	0.6	50	0.043312	0.617902	0.6895834	0.414787	0.1102184	1576
18m	i4ma20d4gdpr	0.6	50	0.042167	0.633227	0.6984733	0.4004376	0.103217	1763
18m	hplocreditpgdp	0.6	50	0.031091	0.629099	0.6633663	0.3872832	0.1027762	1420
18m	i4d4rcreditp	0.6	50	0.029864	0.646962	0.6736641	0.3952968	0.0980761	1763
18m	i4d4docreq	0.6	59	0.022304	0.566607	0.5954198	0.4273973	0.1301766	1763
18m	ma20creditpgdp	0.6	52	0.021634	0.638996	0.6435331	0.3669065	0.0966592	1173
18m	i4hplodocreq	0.6	64	0.019657	0.531144	0.5667939	0.4432836	0.1460629	1763
18m	i4d4grleeqmc	0.6	50	0.017445	0.669523	0.6545802	0.3871332	0.0899125	1763
18m	ma08creditpgdp	0.6	51	0.012844	0.667505	0.6391752	0.3751891	0.0890534	1356
18m	hpshcreditpgdp	0.6	52	0.012392	0.665308	0.6361386	0.3740903	0.0895832	1420
18m	i4eqlev	0.6	50	0.00547	0.710657	0.6507633	0.3730853	0.0758647	1763
18m	eqlev	0.6	50	0.002888	0.710582	0.6425233	0.3782668	0.0764333	1418
18m	i4d4cpi	0.6	50	0.002721	0.719292	0.6491557	0.3712446	0.0731462	1788
18m	d4rcreditp	0.6	55	0.001885	0.673173	0.6104218	0.3644444	0.0859372	1447
18m	i4hpshdoinliq	0.6	50	0.001852	0.703633	0.6336634	0.3610719	0.0765649	1420
18m	d4docreq	0.6	50	0.000629	0.714481	0.6385224	0.3507246	0.0722529	1361
18m	i4d4reqmsci	0.6	52	-0.003986	0.706114	0.6172608	0.3755708	0.0774723	1788
18m	pe	0.6	50	-0.004045	0.717454	0.6260163	0.371532	0.0737111	1652
18m	hplodocreq	0.6	52	-0.004686	0.718743	0.625	0.3587444	0.0719632	1339
18m	i4hpshreqmsci	0.6	52	-0.007133	0.728241	0.6247655	0.3683628	0.0702644	1788
18m	hpshmcapgdp	0.6	50	-0.007456	0.739452	0.6329114	0.3694581	0.0671622	1568
18m	i4d4grleeqmsci	0.6	51	-0.011636	0.737095	0.6172608	0.3655556	0.0674571	1788
18m	i4hplodoinequ	0.6	52	-0.014662	0.730432	0.6020833	0.3748379	0.0702693	1576
18m	d4grleeqmc	0.6	53	-0.016082	0.730268	0.5973451	0.3760446	0.0704327	1479
18m	bca	0.6	50	-0.018076	0.756021	0.6113207	0.3656885	0.0621375	1746
18m	d4rm2m	0.6	58	-0.018209	0.672849	0.5494506	0.3807107	0.0881062	933
18m	i4hpshdocreq	0.6	69	-0.018487	0.552663	0.4790076	0.433506	0.1362854	1763
18m	ma08m2mgdp	0.6	51	-0.021746	0.746935	0.5917603	0.3590909	0.0640633	905
18m	hplope	0.6	51	-0.021914	0.743298	0.5883621	0.3635153	0.0655063	1557
18m	i4hpshpe	0.6	53	-0.025605	0.733065	0.5684803	0.3668281	0.0687296	1788
18m	hpshm2mgdp	0.6	51	-0.025918	0.760926	0.5888502	0.3588111	0.0601638	961
18m	ma20fxreer	0.6	50	-0.025995	0.776529	0.6012862	0.3333333	0.0536571	1112
18m	d4grleeqpe	0.6	50	-0.027655	0.774089	0.5935484	0.3589077	0.056567	1538
18m	i4ma20creditpgdp	0.6	87	-0.028416	0.095157	0.3053435	0.8163266	0.5191059	1763
18m	d4gdpr	0.6	52	-0.029146	0.783025	0.5957447	0.35533	0.0538546	1559
18m	i4hplocreditpgdp	0.6	85	-0.030263	0.160506	0.3167939	0.7248908	0.4276702	1763
18m	i4hplope	0.6	50	-0.032285	0.801624	0.6003752	0.3463204	0.0482219	1788
18m	i4ma08d4cpi	0.6	50	-0.03339	0.808388	0.6022514	0.3444206	0.0463222	1788
18m	i4ma08creditpgdp	0.6	53	-0.034994	0.75719	0.5553435	0.3583744	0.0611537	1763
18m	i4pe	0.6	60	-0.036048	0.716969	0.5234522	0.372	0.0739016	1788
18m	i4d4grlecr	0.6	87	-0.036427	0.193409	0.3129771	0.6861925	0.3889718	1763
18m	hpshgrlecr	0.6	50	-0.036513	0.80033	0.5841584	0.3319269	0.0474198	1420
18m	d4grlecr	0.6	74	-0.040152	0.512554	0.4046997	0.4353932	0.1521092	1352
18m	i4d4grleeqpe	0.6	50	-0.040355	0.813782	0.5816135	0.3429204	0.0448219	1788
18m	d4reqmsci	0.6	50	-0.042243	0.808722	0.5705263	0.3505822	0.0466794	1563
18m	i4hpshm2mgdp	0.6	50	-0.046456	0.817288	0.5622568	0.3396005	0.043688	1737
18m	hplofxreer	0.6	62	-0.046989	0.718314	0.4893617	0.3569845	0.0718891	1154
18m	i4hplodoinequmc	0.6	51	-0.047007	0.81586	0.5590717	0.3468587	0.0445627	1568
18m	hpshpe	0.6	50	-0.04863	0.819422	0.5560345	0.3412699	0.0432609	1557
18m	d4cpi	0.6	50	-0.052877	0.855061	0.570297	0.3348837	0.0339302	1678
18m	hplom2mgdp	0.6	50	-0.054539	0.843598	0.554007	0.335443	0.0367958	961
18m	hpshcpi	0.6	50	-0.057958	0.866063	0.5601578	0.3321638	0.0310949	1684
18m	d4grleeqmsci	0.6	51	-0.059013	0.868219	0.5578948	0.3345959	0.0306932	1563
18m	ed4rcreditp	0.6	55	-0.063634	0.848868	0.5235732	0.3125926	0.0340853	1447
18m	i4ma20d4cpi	0.6	64	-0.063974	0.757152	0.4577861	0.359352	0.0612535	1788
18m	i4hpshgrleeqpe	0.6	50	-0.066612	0.903559	0.5590994	0.3197425	0.0216441	1788
18m	i4d4rm2m	0.6	50	-0.067378	0.880291	0.5350195	0.3231492	0.0272367	1737
18m	hpshgdpr	0.6	51	-0.067591	0.901816	0.5533769	0.3273196	0.0223362	1505
18m	hpshdocreq	0.6	50	-0.069265	0.905188	0.5494792	0.3075802	0.020799	1339
18m	hplofxneer	0.6	50	-0.069844	0.90087	0.5431035	0.3038585	0.0216201	1233
18m	d4rhousep	0.6	50	-0.071702	0.919071	0.5521235	0.2954545	0.017259	931
18m	ma08fxreer	0.6	50	-0.072326	0.913343	0.5440729	0.3070326	0.0189415	1142
18m	ma20d4cpi	0.6	50	-0.074268	0.9155	0.5377778	0.3071066	0.01846	1559
18m	i4hpshcpi	0.6	70	-0.077387	0.721992	0.3939962	0.3703704	0.0722719	1788
18m	ma08d4gdpr	0.6	50	-0.078548	0.941539	0.5436893	0.3027027	0.0125619	1420
18m	i4ma08d4gdpr	0.6	50	-0.079667	0.942981	0.5400763	0.309628	0.0124074	1763
18m	i4hplodoinliq	0.6	75	-0.080428	0.591972	0.3292079	0.4018127	0.1173057	1420
18m	ma20fxneer	0.6	56	-0.081757	0.892155	0.4863222	0.2996255	0.023387	1191
18m	ma20d4gdpr	0.6	50	-0.082151	0.955172	0.5407609	0.2979042	0.0095029	1276
18m	i4d4doinequ	0.6	50	-0.086002	0.954141	0.5221053	0.313924	0.0100213	1563
18m	d4fxreer	0.6	50	-0.086932	0.962435	0.5258359	0.2937182	0.0078798	1151
18m	ma08fxneer	0.6	51	-0.090006	0.965394	0.5143678	0.2920065	0.0072275	1222
18m	ma08d4cpi	0.6	51	-0.090065	0.962518	0.5113402	0.3046683	0.0080322	1635
18m	hpshgrleeqpe	0.6	50	-0.0925	0.984618	0.5214592	0.3048933	0.0032752	1545
18m	hpshgrleeqpesh	0.6	51	-0.093487	0.978086	0.5102041	0.3057065	0.0046826	1465
18m	d4fxneer	0.6	50	-0.094324	0.986378	0.5143678	0.2854864	0.0027894	1231
18m	i4hpshgrlecr	0.6	58	-0.096034	0.922901	0.4503817	0.3142477	0.017027	1763
18m	ma20m2mgdp	0.6	50	-0.099038	0.988113	0.4930876	0.2860962	0.0024361	765
18m	ed4reqmsci	0.6	50	-0.100264	1.000268	0.4989474	0.3038462	-0.0000566	1563
18m	hpshreqmsci	0.6	50	-0.10136	1.012886	0.50625	0.3018633	-0.0027052	1576
18m	d4grleeqpesh	0.6	50	-0.101941	1.005209	0.4954545	0.3006897	-0.0010936	1458
18m	i4d4rhousep	0.6	50	-0.115581	1.074593	0.4961089	0.2811466	-0.0147659	1737
18m	i4hpshdoinequ	0.6	50	-0.116314	1.074477	0.4916667	0.2895705	-0.014998	1576
18m	i4ma08m2mgdp	0.6	52	-0.123972	1.077076	0.4494163	0.2806804	-0.0152321	1737
18m	hpshfxneer	0.6	51	-0.145556	1.192428	0.4425287	0.2479871	-0.0342513	1233
18m	hpshfxreer	0.6	50	-0.169788	1.31862	0.4164134	0.2322034	-0.0528919	1154
18m	ggb	0.6	93	-0.182826	0.927895	0.0750469	0.3174603	0.0159898	1768

Table A2. Performance of the benchmark Logit model over different forecasting horizons (μ = 0.5).

Model	Forecasting Horizon	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff
Benchmark	8 quarters	62	0.34	0.19	84.43%	74.76%	38.99%
Benchmark	6 quarters	68	0.32	0.20	80.95%	65.83%	37.83%
Benchmark	4 quarters	67	0.30	0.29	83.54%	45.21%	26.15%
Benchmark	2 quarters	74	0.29	0.28	80.80%	28.21%	18.41%

Notes: See notes to Table 2.

Table A3. Performance of the benchmark Logit model using different values for the parameter μ (forecasting horizon 6 quarters).

Model	μ	Threshold (percentile)	U	NtSr	%Predicted	Cond Prob	Prob Diff
Benchmark	0.5	68	0.32	0.20	80.95%	65.83%	37.83%
Benchmark	0.4	69	0.23	0.19	79.83%	67.06%	39.06%
Benchmark	0.6	65	0.22	0.23	83.47%	62.74%	34.74%
Benchmark	0.7	53	0.14	0.37	91.88%	51.57%	23.57%
Benchmark	0.3	72	0.13	0.17	74.51%	69.27%	41.27%
Benchmark	0.8	53	0.07	0.37	91.88%	51.57%	23.57%
Benchmark	0.2	81	0.06	0.11	57.14%	77.27%	49.27%